



Absorbing the Potential of Wood Waste in EU Regions and Industrial Bio-based Ecosystems — BioReg

D1.2: STATE OF THE ART TECHNICAL REPORT



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To the attention of the Research Executive Agency

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BioReg project proposes to create a platform of stakeholders who can influence and develop their regions towards bio-based industries and products. The project runs from January 2017 to December 2019, it involves 8 partners and is coordinated by "le CABINET D'ETUDES SUR LES DECHETS ET L'ENERGIE" (CEDEN). More information on the project can be found at <http://bioreg.eu/project/>.

ABSTRACT

The amount of wood waste generated in the EU28 was estimated at 60 Mt in 2010, 48% of which was used in energy sector, followed by recycling waste in wood-based panels industry or other material applications, and less than 1% of wood waste was landfilled. Most of wood waste is generated in wood processing industries, construction & demolition, packaging, paper industries and municipalities.

This report analyses the present wood waste market in Europe, focusing on the most sustainable value chain existing in countries like UK, Sweden, Germany and Austria, where the wood waste recycling industry is already well developed. The value chains will be assessed considering the present collection systems, pre-treatment and refining technologies adopted, with the aim of extending these "shining examples" to other EU regions where most of the wood waste produced is still discarded to landfills.

EXECUTIVE SUMMARY

This document provides an assessment of the current state-of-the-art technologies for wood waste valorisation intended as a useful reference for the three recipient regions selected: Normandy (France), Lublin (Poland), Alentejo and Lisboa (Portugal).

As demonstrator case studies, European regions have been selected, such as Gothenburg (Sweden); Karlsruhe, Baden-Württemberg (Germany); Lombardy (Italy); Emilia-Romagna (Italy); North West England (United Kingdom); Vorarlberg and Styria (Austria). These regions have set up wood waste recovery systems at different stages of the wood waste value chain including different wood waste sources, sorting, collection, treatment, and wood waste recycling and recovery. The document will analyse the state-of-the-art technology of wood waste value chains successfully developed in demonstrator regions, as well as the different classification systems in each country involved in the Bioreg project.



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ABBREVIATIONS

CA: Amenity recycling centres
 CSR: Corporate Social Responsibility
 C&D: Construction and demolition
 C&DW: Construction and demolition waste
 EC: European Commission
 EN: European Norm
 EPF: European Panel Federation
 EU: European Union
 HWRC: household waste recycling centres
 ISO: International Organization for Standardization



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MDF: Medium-density fibreboard
MS: Member States
Mm3: Cubic millimetre
Mt: Millions of tons
MSW: Municipal Solid Waste
NIR: Near Infrared spectroscopy
OSB: Oriented strand board
t: tonnes
RDF: Refuse-derived fuel
WRA: Wood Recycling Association
WKI: Fraunhofer Institute for Wood Research Wilhelm-Klauditz-Institut
XRF: X-ray fluorescence

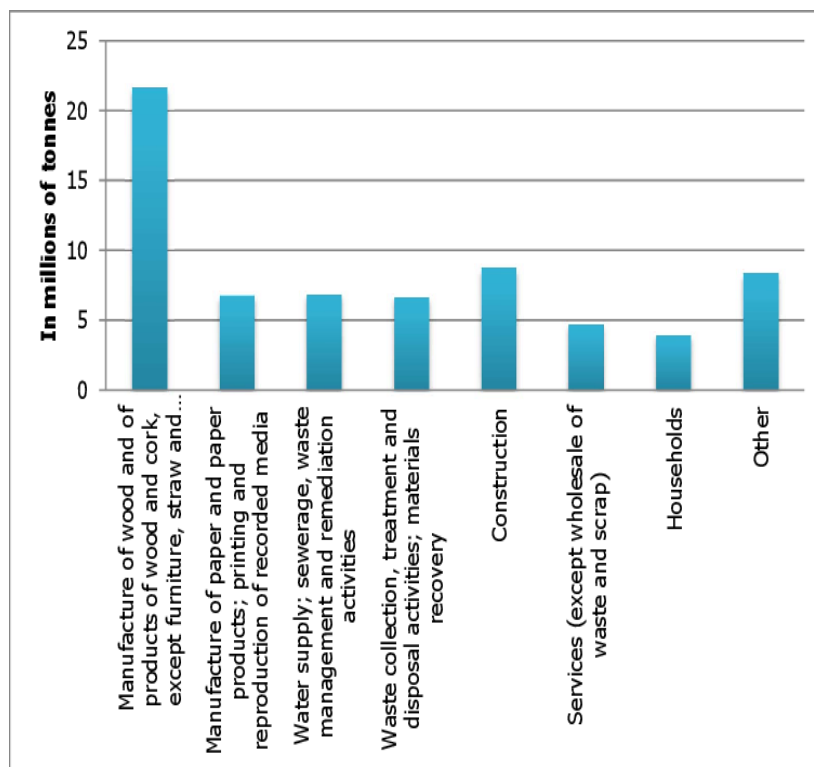
1. INTRODUCTION

In 2010, European technical available supply of wood was 720.6 Mm3. The forest sector's capacity to source wood to the wood processing industries is limited to about 150 Mm3/year (Mantau et al., 2010). However, economic mobilisation and high utilisation already cause market shortage of wood in some EU regions. The potential wood shortfall in EU is estimated to be 50 million m3/year in 2020 and 80 million m3/year in 2030 (FAO). Therefore, valorisation of wood waste by reusing/ recycling is a relevant and important way forward to ease the burden on wood supply and to meet increasing demand for wood. The important factor to drive wood valorisation in EU is the renewable energy policies, which have led to a growth in the prices of wood fibre and pellet; and the increasing interest of biomass sources in the bioenergy industries.



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WOOD WASTE GENERATION IN EUROPE



According to Eurostat waste generation statistic from 2010, around 60 Mt of wood waste was generated in the EU28. The Figure 1. shows generation of wood waste in Mt per industry for this year. Over 94% of the wood waste was generated by economic activities other than households. The largest wood waste-producing sector being the “Manufacture of wood and of products of wood and cork except furniture; manufacture of articles of straw and plaiting materials” with 32% of the total, followed by “Construction” (13%); “Waste management / water supply” (10%); and “Manufacture of paper and paper products” (10%). The sector for “furniture, jewellery, musical instruments, toys” produced 2.2 Mt (3.3%) (Bilsen, 2015).

Figure 1: Generation of wood waste in the EU28, by economic activity in 2010 (Eurostat, 2010).

There are different kinds of wood waste that can be transformed in higher value products. Wood waste from packaging industries such as pellets usually remain in a perfect condition when they are disposed. Wood products and furniture manufacturers generate the cleanest wood waste in form of sawdust, offcuts, and dust. In general, these materials can be landfilled, burned or used for impregnation of hazardous waste. Processing of 1,000 kilos of wood in the furniture industries lead to 45% waste generation. Likewise, the processing 1,000 kilos of wood in sawmill, the amount of waste is 52% (Bioenergy Consult, 2018). Another kind of wood waste is generated in lumber yards and pulp mills. One problem with reusing wood waste from logs is that they are contaminated with metal and/or are too large, so they are often landfilled. Bark is removed from logs prior to processing; it is usually burned for energy recovery or sold to a dealer. Some bark falls off the trees in the log yard where it becomes mixed with soil; this dirty material is often landfilled. Wood waste generated by pulp mills and lumber yards contains more foreign material and moisture than that generated by wood products manufacturers since it usually is not kiln dried and is handled outdoors. The yearly amount of used wood in the EU is 52.3 Mm³, but 36.4 Mm³ is recovered by collection systems. 32% of this amount is used for material applications; 37% for energy; and 30% is still disposed without recovery (Bilsen, 2015) across Europe..



To enhance the added-value of the recycled wood waste, the Waste Framework Directive (2008/98/EC) was developed in 2008 and offers a guide for basic concepts and definitions related to the waste

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management. It explains the concept end-of-waste criteria that it is used as a guideline to determine when a waste cease to be a waste and becomes a secondary raw material. This waste hierarchy is presented in Figure 2.

Figure 2: Scheme of the European Waste Framework Directive

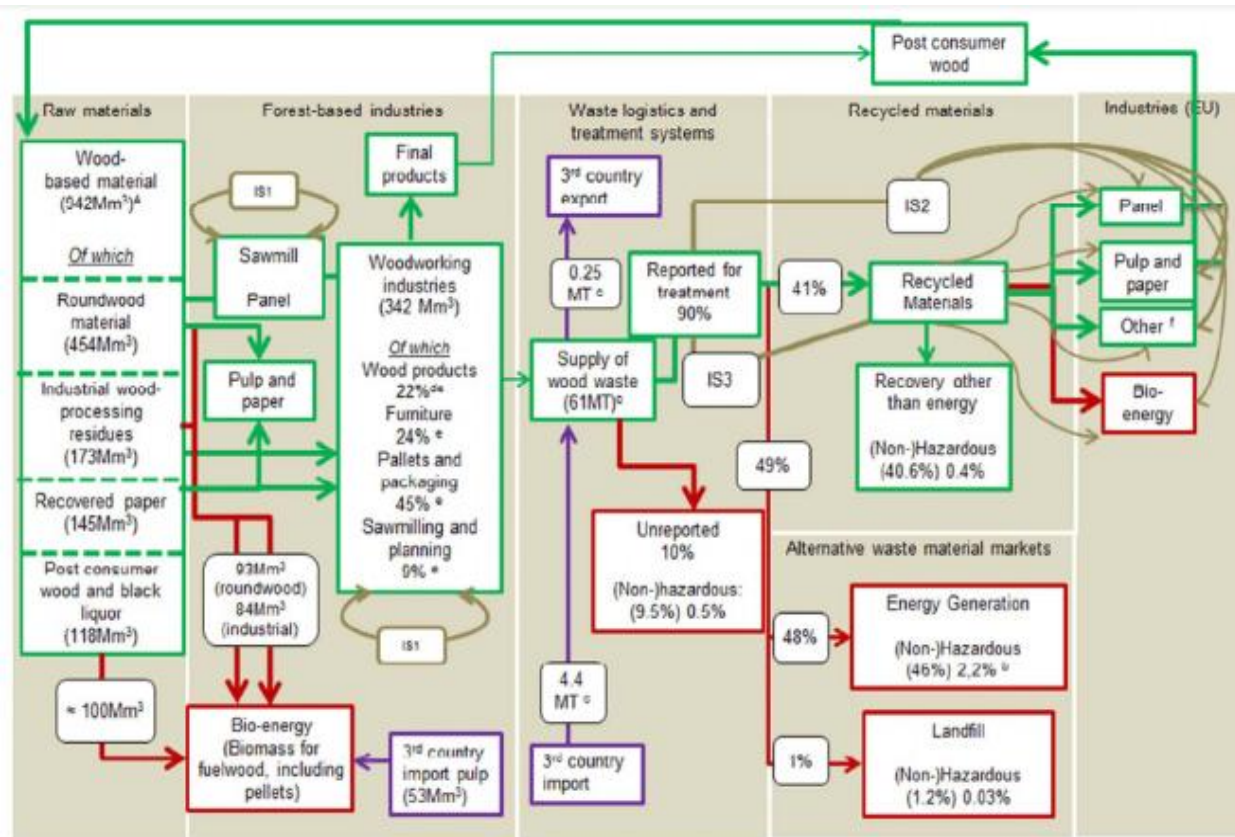
As illustrated by the figure above, recovering energy from waste is only appropriate for waste that cannot be prevented, reused or recycled with less greenhouse gas emitted. The implementation of several EU directives is leading to an increasing demand for wood waste and better separation of wood waste fractions from bulky waste and C&DW. However, collection of used wood for recycling is not yet very well developed in some EU countries and great amounts of wood waste are still being landfilled. The main end-uses for recovery of wood waste are: wood-based panel industry, energy generation, animal bedding, mulches, and coverings.

Figure 3 provides an overview of the wood waste market and divides the life cycle of wood as a resource into different market segments. This life cycle starts at the forestry industry, flows through the various wood processing industries, and ends up being used in a final product. Then the figure demonstrates wood waste logistics and its treatment systems and continues with possible applications of wood waste in different recycled materials. The data for recycling materials in 2013 shows that 41% of wood waste was recycled into materials, 48% incinerated and 1% landfilled.

Figure 3: Wood waste flows schema (Ecorys, Indufor (2013), Eurostat forestry statistics (2013), Waste generation statistics (2010) and Structural business units (2011))



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Source: Ecorys, Indufor (2013), Eurostat forestry statistics (2013), waste generation statistics (2010) and structural business units (2011).

Used colors: Green lines represent flows stimulating the circular economy, Red lines represent flows discouraging the circular economy. Purple lines represent trade flows. Brown lines indicate industrial symbiosis (type 2 and 3) exchanges. Note: the percentages reflect the share of the total supply of wood waste (61 Mt is 100%).

"Biomass" include all woody by-products of forest managements, such as limbs, leaves, needles, tops and leaves;

industrial symbiosis streams are not shown here in order to maintain a clear overview.

⁴ Indufor has calculated the use of all wood-based raw materials as roundwood equivalent (RWE, over bark) in order to make them comparable. The idea is similar to the tonnes of oil equivalent (toe) for energy but here done for the use of wood. For instance the use of bio-energy is calculated as the use of wood in cubic metres (instead of e.g. toe; Joules) and the use of recovered paper is also calculated in cubic metres of roundwood, instead of tonnes.

^{4a} Treatment of hazardous wood waste for energy generation includes incineration disposal (0.06 Mm³) and energy recovery (1.28Mm³)

^{4b} 2010 figure

^{4c} The manufacture of products of wood, cork, straw and plaiting materials includes the production of veneer sheets and wood-based panels, assembled parquet floors, other builders' carpentry and joinery (such as roof frame elements, doors, windows, shutters and their frames, stairs, railings and prefabricated buildings), wooden containers, and other wooden products such as handles, clothes hangers, household utensils and kitchenware, as well as basket-ware and the production of fire logs and pellets.

^{4d} 2011 figure and based on production value

^{4e} E.g. animal bedding

THE MARKET FOR WOOD WASTE

In general, the data on wood waste market are limited and not well available for all the European regions. The EU is the world's largest market for wood energy, and imports of woody feedstock continue to grow. The wood pellet



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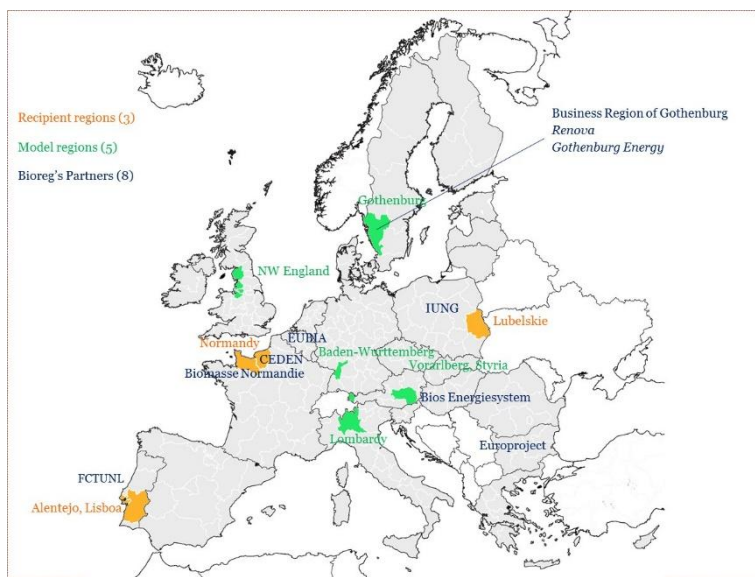
market is growing strongly in Europe due to incentives for biomass power and heat from local authorities (Pellicert, 2012). Wood waste trade largely occurs in Western Europe, as these countries have already established wood recycling sectors and relevant consumer base. However, some countries favour material recovery (France, UK, Ireland, Italy) while others favour energy recovery (Germany, Finland, Sweden). Some countries export or import a significant portion of wood waste, for example, Belgium imports more than 1 Mt of wood for the panel industry and for energy. Italy (for wood panel) and Sweden (for energy) are also among the largest importers of wood waste in Europe. France is the country that exports the most wood waste in Europe (over 1 Mt), ahead of England and the Netherlands. Due to the objectives of production of renewable energy in England and plants projects in progress in this country, very important amounts of wood waste could be imported in England in the coming years.

2. OBJECTIVE

The 1.2 deliverable aims to provide an insight into successful techniques and strategies for wood waste use in some selected demonstrator regions. The identified case studies take place at different stages of the wood waste value chain; therefore, they intend to describe the different levels of the process as well as the state-of-the-art technologies used for each of the stages of the value chain. The steps in a value chain for wood waste involve: production, storage, collection, transport, grading, treatment, processing and valorisation of wood waste.

The objective of this report is to assess the present development of wood waste recycling in European countries, and to determine the best practices of most relevant aspects influencing a wood waste valorisation system. For this reason, the most appropriate figures and tables targeted by this report are:

1. The wood waste grading systems in force in different EU Member States.
2. The most developed wood waste collecting, processing, and recycling strategies in EU.
3. Identification of successful practices of wood waste recycling in demonstrator regions, that could serve as an example for less developed regions (recipient regions), see Picture 1.



Picture 1: Countries involved in the Bioreg

project



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3. CLASSIFICATION OF WOOD WASTE

3.1 EUROPEAN CATALOGUE

Beyond the regulation of the Waste Framework Directive and the classification in the waste catalogue (see Table 1), there are different criteria that can be used to classify wood.

Table 1: Classification of wood waste according to the European Waste Catalogue

3	Wastes from wood processing and the production of panels and furniture, pulp, paper, and cardboard		
03 01	Wastes from wood processing and the production of panels and furniture		
	03 01	01	Waste bark and cork
	03 01	04*	Sawdust, shavings, cuttings, wood, particle board and veneer containing hazardous substances
	03 01	05	Sawdust, shavings, cuttings, wood, particle board and veneer other than those mentioned in 03 01 04 03 01 99 Wastes not otherwise specified
	03 03 Wastes from pulp, paper and cardboard production and processing		
03 03	03 03 01	Waste bark and wood	
	03 03 02	Green liquor sludge (from recovery of cooking liquor)	
	03 03 05	De-inking sludges from paper recycling	
	03 03 07	Mechanically separated rejects from pulping of waste paper and cardboard	
	03 03 08	Wastes from sorting of paper and cardboard destined for recycling	
	03 03 09	Lime mud waste	
	03 03 10	Fibre Rejects, fiber-, filler- and coating-sludges from mechanical separation	
	03 03 11	Sludges from on-site effluent treatment other than those mentioned in	
	03 03 99	Wastes not otherwise specified	
15	Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified		
15 01	Packaging (including separately collected municipal packaging waste)		
	15 01 03	Wooden packaging	
17	Construction and demolition wastes (including excavated soil from contaminated sites)		
17 02	Wood, glass and plastic		
	17 02 01	Wood	
	17 02	Glass, plastic and wood containing or contaminated with hazardous substances	
	04*		
Wastes from waste management facilities, off-site wastewater treatment plants and the preparation of water intended for human consumption and water for industrial use			
19 12	Wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified		
	19 12	Wood containing hazardous substances	
	06*	Wood other than that mentioned in 19 12 06	
	19 12 07		
Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions			
20 01	Separately collected fractions (except 15 01)		
	20 01	Wood containing hazardous substances	
	37*	Wood other than that mentioned in 20 01 37	
	20 01 38		

Other possible classification of wood waste could be according to its type, source, producer and/or recycling techniques used, shown in the Figure 6. Wood waste can be distinguished on the physical aspect:



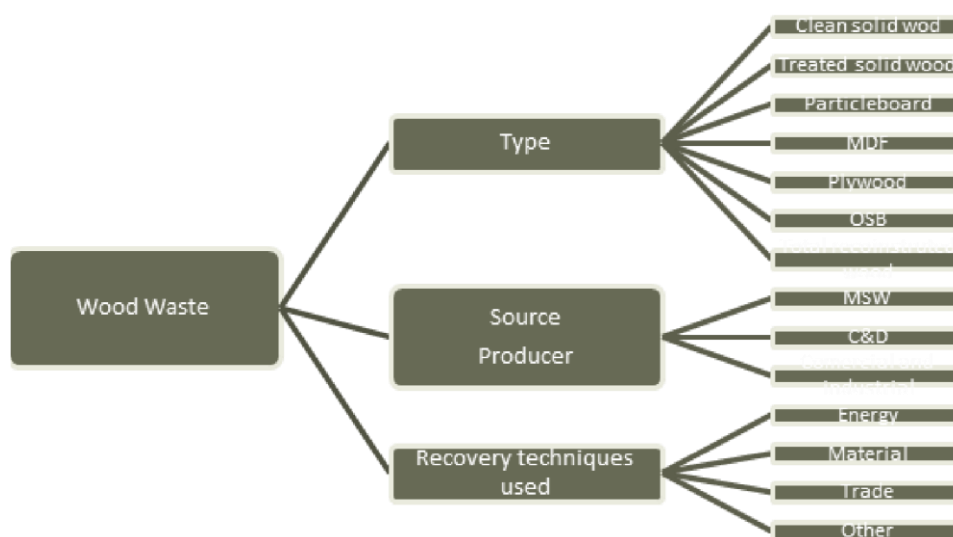
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- Railway ties or poles, black, with possible odour of diesel: creosoted wood
- Fences of greenish colour: wood treated with metallic compounds, arsenic,
- Lumber of yellow colour: treated wood of construction/demolition,
- Pallets, boxes: very weakly adjuvant wood
- Windows framework: wood may contain high levels of lead and zinc (paint).

The distinction between different categories of wood can be based on the chemical composition about thresholds at international level such as EN standards and ISO, or at national level, for example Decree 2910 B or the End of Waste decree in France, EPF (European Panel Federation) which sets threshold for recycled wood or German and Austrian Ordinances.

There is a wide range of wood waste types, as shown in the Figure 4. For example, particle board are made out of wood chips, sawmill shavings, sawdust, synthetic resin or other suitable binder, which is pressed and extruded. Plywood is manufactured from sheets of cross-laminated veneer and bonded under heat and pressure with durable, moisture-resistant adhesives. By alternating the grain direction of the veneers from layer to layer, panel strength and stiffness in both directions are maximized. Other structural wood panels include oriented strand board and structural composite panels. Oriented strand board (OSB) is similar but uses machined wood flakes offering more strength. All of these are composite materials that belong to the spectrum of fibreboard products. Medium-Density Fibreboard (MDF) is generally denser than plywood. It is a product made by breaking down hardwood or softwood residuals into wood fibres often in a defibrator, combining with wax and resin, forming panels by applying high temperature and pressure.

Figure 4: Classification of wood waste (EUBIA, 2017)



In the United Kingdom, the Wood Recyclers Association (WRA) for example has developed a classification system for wood waste in four grades as presented in Table 2.



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Table 2: UK wood waste classification and grades

Grade	Typical Sources of Raw Material	Typical Materials	Typical Non-Wood Content Prior to Processing
Grade A – "Clean" Recycled Wood	Distribution. Retailing. Packaging. Secondary Manufacture e.g. joinery. Pallet Reclamation	Solid softwood and hardwood. Packaging waste, scrap pallets, packing cases, and cable drums. Process off-cuts from manufacture of untreated products.	Nails and metal fixings. Minor amounts of paint, and surface coatings.
Grade B – Industrial Feedstock Grade	As Grade A, plus construction and demolition operations and Transfer Stations.	May contain up to 60% Grade A material as above, plus building and demolition materials and domestic furniture made from solid wood.	Nails and metal fixings. Some paints, plastics, glass, grit, coatings, binders and glues. Limits on treated or coated materials as defined by Waste Incineration Directive
Grade C – Fuel Grade	All above plus Municipal Collections, Recycling Centres Transfer Stations And Civic Amenity Recycling sites	All of the above plus fencing products, flat pack furniture made from board products and DIY materials High content of panel products such as chipboard, MDF, plywood, OSB and fibreboard.	Nails and metal fixings. Paints coatings and glues, paper, plastics and rubber, glass, grit. Coated and treated timber (non CCA or creosote).
Grade D – Hazardous Waste	All of the above plus fencing, trackwork and transmission pole contractors.	Fencing Transmission Poles Railway sleepers Cooling towers	Copper / Chrome / Arsenic preservation Treatments Creosote

3.2 WOOD WASTE CLASSIFICATION ON NATIONAL LEVEL

All European countries have translated the EU Waste Framework Directive into national legislation following the basic requirements and the different grading systems are adopted by MS. All classifications propose a clean wood category, however based on different approaches in terms of definition or limit values; and a category of hazardous waste that must be disposed of. Moreover, all classifications concern creosoted, impregnated wood waste with metal salts and with autoclave. The definition of impregnated wood remains subject to interpretation, since some impregnated wood, especially for private households, has no longer contained arsenic or creosote since 2004 but copper and organ halogen complexes. Some classifications are set by law - Germany, or at least approved by public authorities - Finland. In other cases, the classification was set up by a professional organisation- United Kingdom. In France, for example, the classification is accepted by the various actors but is not defined or officially recognized. In Netherlands, the National Waste Plan gives a minimum standard for processing for all three categories. The minimum standard for A (and B) wood is recovery and includes various options (recovery of material, recovery of products, main use of waste as a fuel or other means to generate energy). The Netherlands gives no preference between the options and the criteria work on a case-by-case status.

The classifications distinguish, depending on the case, one or two intermediate categories, with also similar criteria:

- Class "B" or "2" includes wood waste which do not contain heavy metals in higher proportion to the virgin wood (EUBIONET) or very few (German AII classification which includes particle boards in particular) and do not contain organo-halogenated or preservation treatment. It is also called low-adjuvanted wood



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waste. In fact, it corresponds “more or less” to the definition of biomass b(V): “wood waste except for wood waste which may contain halogenated organic compounds or heavy metals because of treatment with wood preservatives or coating and which includes such wood waste originating from construction and demolition waste”;

- Class "C" or "3" (and German Class AIII) includes treated wood with preservation treatments and contains metals in higher proportion than virgin wood, and organ halogen. Refer to deeply adjuvanted wood waste (excluding hazardous waste).

In general, classifications favour the noblest classes for material recycling (panel industry) and other classes for energy. In practice, the panel industry is more demanding than energy: no fibreboard, a lot of solid wood, wood packaging, etc. The harmonized classification proposed by DEMOWOOD (European program finished in 2016) has not managed to be established in Europe.

Table 3: Wood classification criteria in some European countries (CEDEN, 2016)

		Natural wood (untreated or insignificant)	Slightly adjuvanted wood (glues, varnishes, paints, coatings ...)		Impregnated wood (CCA, CCB or creosote), soiled wood
European Classification of Wastes (Commission No 94/3 / EEC of 20 December 1993. In France: Decree No 2002-540 of 18 April 2002 Annex II to Article R. 541-8 of the EC)	Status	Non-hazardous waste			Hazardous waste
	Waste code	15 01 03 (wood packaging), 03 01 05 by-products of sawmills	03 01 05 (particle board, etc.), 17 02 01 (construction, demolition), 19 12 07, 20 01 38		03 01 04*, 15 01 10*, 17 02 04*, 19 12 06*, 20 01 37* (wood waste containing hazardous substances)
French classification. Non-regulatory, widely accepted by professionals but unsatisfactory: approach in progress at national level to adapt this classification.		A	B		C
		Clean wood not adjuvanted or very weakly adjuvanted, e.g.: pallets with agglomerated dice	Wood "weakly" adjuvanted, ie under the thresholds of pollutants fixed by article 541.8 of the Environmental Code.		"Strongly" adjuvanted wood (impregnation with metallic salts, creosoted wood), i.e. above the thresholds of pollutants fixed by article 541.8 of the Environmental Code.
		2910 A If end of the waste" approach	2910 B If compliance with the thresholds of the decree of September 2013 for clean wood waste or very weakly adjuvanted wood or if EOW approach for adjuvanted wood waste. 2971 (CSR)		2770 (incineration of hazardous waste), 2771 (incineration of non-hazardous waste)
Netherlands		A	B		C
		Unpainted and untreated wood	Not falling under category, A-or C, including painted, varnished and glued wood		Impregnated wood treated timber where sometimes substances are used (pressurized) in order to extend the lifetime of the product
German Classification. The		All	All	AIII	AIV



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classification leans on the European waste catalogue (2002)		Clean wood	Without organochlorine	With organochlorine		Hazardous waste
			Deep treatment			Deep preservation treatment
United Kingdom (source WRA)		A	B	C		D
		Clean wood	60% A + construction wood + furniture	A + B + municipal waste, recycling platforms		Hazardous waste
COST E31		1	2a	2b		3
		Clean wood	No deep treatment	No deep treatment		
Finland (classification EUROBIONET III: leans on standard ISO 17 725		A	B	C		D
		Clean wood	Construction wood excluded and excluding preservation treatment	Excluding preservation treatment		Preservation treatment
DEMOWOOD proposal		DW O	DW I	DW II	DW III	DW IV
		Pulp mill, panel board, energy (2910 A(Fr), A (Finl.), EN ISO 17225-1	Panel board, energy (2910 B(Fr), Class B (Finl.), EN ISO 17225-1,17225-1.2.2, 17225-1.3.2 (used wood)	Panel board, energy (CSR - EN 15359 (Fr), class C (Finl.), EN 15359 if in compliance with threshold clean wood (ISO 17225-1)	Energy only. Incineration of non-hazardous waste (Fr.), Class C, EN 15359 "incineration"	Hazardous waste
Corresponding normative framework	Energy	TC 335 biofuels: Virgin wood and wood waste, excluding wood waste which may contain halogenated organic compounds or heavy metals due to treatment with wood preservatives or coatings and in particular wood from construction and demolition.		TC 343 RDF: Includes non-hazardous wood waste. Hazardous waste excluded.		Not applicable
		EN ISO 117225-1 EN ISO 117225-1.2.2 EN ISO 117225-1.3.2				
	Standard EN 15 359 et EN 15 357 (définitions, catégories)					
	Panel board	EPF standard for delivery conditions of recycled wood				Excluded from the EPF standard (poles, sleepers ...)



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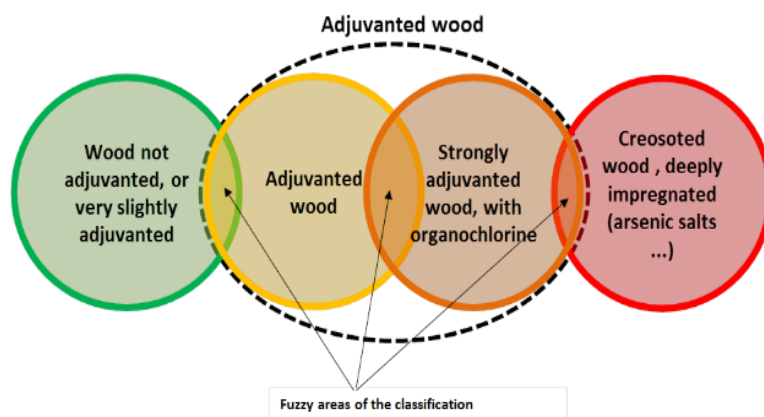


Figure 5: Diagram illustrating the difficulty of a classification by categories of wood (CEDEN, 2016)

Whatever the classification and the accuracy of the definition of each category is, there is often a blurred area between low-adjuvanted and more highly adjuvanted wood waste, especially when waste is not well separated by category at source. The figure 5 illustrates the difficulty of perfectly framing the categories of wood. However, this harmonization seems necessary to develop the valorisation of these secondary raw materials and it seems necessary, as has been done as part of DEMOWOOD, that the classifications are based on the standards in force (ISO 177225 For biofuels, EN 15357: 2011 for CSR), which constitute a harmonized European or even international framework. However, these standards do not concern material.

4. WOOD WASTE VALUE CHAIN

The wood waste value chain includes steps from generation of wood waste to its valorisation, including transport, collection, treatment and processing. Numerous actors are concerned throughout the whole value chain (Figure 7). The state-of-the-art technologies in the model regions aim to highlight good practices and success factors in some of the stages of the value chain. The figure 6 shows an example of a value chain and it is followed in this report. The next chapters are dedicated to the 3 steps of the presented value chain and offer available strategies and methods for particular steps with economic data; and best practices are concluded in form of table after each stage of value chain.

Figure 6: Value chain followed in this report



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Figure 7: Example of wood waste management value chain (Bioreg, 2017)

Main value chain	Production	Feedstock provision	Suitable / processed products	Distribution	Post-processing	Valorisation	By-products
Supporting chain	Collectivities	Collecting sorting	Processing Refining	Storage and distribution equipments Handling	Processing Refining	Energy (electricity, heat, cold, syngas)	Undersize particles, ashes
	Industries	Collecting sorting	Blending	Deal	Blending	Recycling : panel industry	
	Building Demolition Renovation	Collecting sorting		Transport		Re use	
Value chain actors		Waste companies	C&D	Transport companies	Industrial OEM	Energy operators	Cement works
		Building recyclers	Waste operators	Logistic companies		Panel industry	Waste treatment
		Brokers	Manufacturers		Manufacturers		Civil engineering (road infrastructures)
			End users and subsidiaries				
			Engineering, research and development	Engineering, research and development	Engineering, research and development	Engineering, research and development	Engineering, research and development

4.1 WOOD WASTE PRODUCTION AND COLLECTION

According to Eurostat (2010) EU28 generated 61 Mt of wood waste, 97% of it generated was non-hazardous (see Table 4).

Table 4: Absolute wood waste generated (total, hazardous and non-hazardous) in 2010 (Eurostat)

2010	Total	Hazardous waste	Non-hazardous waste
EU-28 total and top 5 wood waste producers	In million of tonnes		
European Union (28 countries)	60.95	1.78	59.18
Finland	12.28	0.04	12.24
Germany	10.81	1.08	9.73
France	8.95	0.08	8.87
Italy	3.76	0.01	3.75
Poland	3.51	0.00	3.50



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Wood waste is generated mainly in woodworking industries, construction and demolition, and packaging. The types of produced waste include small wood fragments such as chips, sawdust and shavings as well as larger assortments like trimmings, rejects or offcuts. These wastes often contain additives or contaminants because wood may have been painted or treated during the manufacturing process.

Table 5: Volume of wood waste treated (total, hazardous and non-hazardous) in 2010, 2004-2010 change (%)

In millions of tonnes	Total	2004-2010 % change	Hazardous	Non-hazardous
EU-28	55.05	109%	1.46	53.59
Finland	10.46	201%	0.02	10.45
France	8.87	108%	0.00	8.87
Germany	9.92	347%	1.15	8.77
Italy	4.25	-0.03%	0.01	4.24
Poland	5.04	442%	0.00	5.04

Source: Eurostat waste statistics (2010)

The Table 5 shows the total volume of treated wood waste in 2010. According to Eurostat waste statistics (2010), the supply of wood waste to be used in the wood-based industries comes predominantly from the manufacture of wood, cork, straw and painting materials (21.7 million m³, including sawmilling, wood-based panels, logs and pallets), construction products (8.8 Mt), paper and packaging materials (6.8 Mt including pulp), material recovery (6.7 Mt) and services (4.7 Mt), excluding wholesale of waste and scrap. Besides that, there are other important 'waste generating industries', often regionally specific, such as ski manufacturing in Austria or clog manufacturing in the Netherlands.

At the beginning of the value chain, the wood waste is collected and sorted according to the quality grade, which was mentioned in the previous section 3. Based on the grade, the wood waste can be recycled into panels or pellets, incinerated with energy recovery, or treated at special facilities. Wood waste can be collected via several routes depending on its source, amount and grade. Household wood waste is usually collected at household waste recycling centres or via the council's bulky waste collection (in the case of furniture), where this is available. Wood waste from C&D and C&I sources can be collected either by waste management companies in skips or can be taken to be processed directly by the producer. There are also several informal wood waste disposal routes such as burning in small scale boilers either by the producing company or its employees.

A report prepared by the UK Wood Recycling Association (WRAP) in 2012 has identified four possible collection strategies:

- **Wood recovery in composting** – it has been identified that many larger scale composters already receive significant tonnes of wood waste and are likely to have the sites and facilities that might be suitable for wood recovery. The current fate of wood waste managed by composting facilities was explored, along with a review of the options for composters wishing to provide collection points for wood recovery.
- **Local Authority Civic Amenity Recycling Centres (CA)** – with an increasing focus on small business recycling services, the current network of CAs are likely to provide suitable collection points for non-domestic wastes, including wood waste.



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- **Collection clusters for SME wood businesses** – Skip based collections are the main route for recovery of wood waste to be cost effective. However, little is known about the fate of wood waste arising from smaller businesses which do not produce enough wood waste to make skip-based collections viable. With many small wood businesses operating, the option of collection clusters was explored based on undertaking collection rounds using commercial bins for collection of wood waste.
- **Reverse logistics for wood sector businesses** – Deliveries of wood products to wood sector businesses were matched with a service for the collection and back haulage of wood wastes. This enables wood suppliers to provide a collection hub to aggregate larger quantities of wood for supply to other markets, or to use as feedstock or fuel themselves, where the cost of recovering the wood waste directly from customers would be higher.

4.1.1 IMPACT OF BEST PRACTICES

Table 6: Production and Collecting of wood waste

OBJECT/ AIM	MEAN	TARGET	POSITIVE IMPACTS
REUSE: furniture, beams, timbers	Repair centres, recycling centres	households and enterprises	Carbon storage, money savings, virgin biomass preservation
Encourage sorting on site (by optimising the place)	Compartmentalized skips	Enterprises	Increase valorisation rate
Forcing producers to recycle	Extended producer responsibility/ take back obligations	Producers of furniture such as: Eco-mobilier and Valdivia	Increase valorisation rate
Encourage producers to sort	Sorting platform and collecting centre for waste from construction and demolition	Enterprises of construction and demolition (production/collecting/sorting) and waste companies (collecting/sorting)	Increase valorisation rate

While a decade ago most wood waste was reused and recycled locally, the situation has changed, and significant volumes are now being shipped across Europe. wood waste trade predominantly occurs in Western Europe, in countries with established wood recycling sectors and relevant consumer base - the panel industry, energy sector, or other users. However, the most European countries have particle board (or chipboard) production facilities, not every producer is using wood waste, because there are long transportation distances of the supply chain. Other reasons are: there is enough supply of affordable virgin wood locally, or producers are targeting high quality panels and the use of wood waste is limited to small volumes of the highest quality material only.



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Supply and demand imbalance is reflected in regional gate fees across Europe

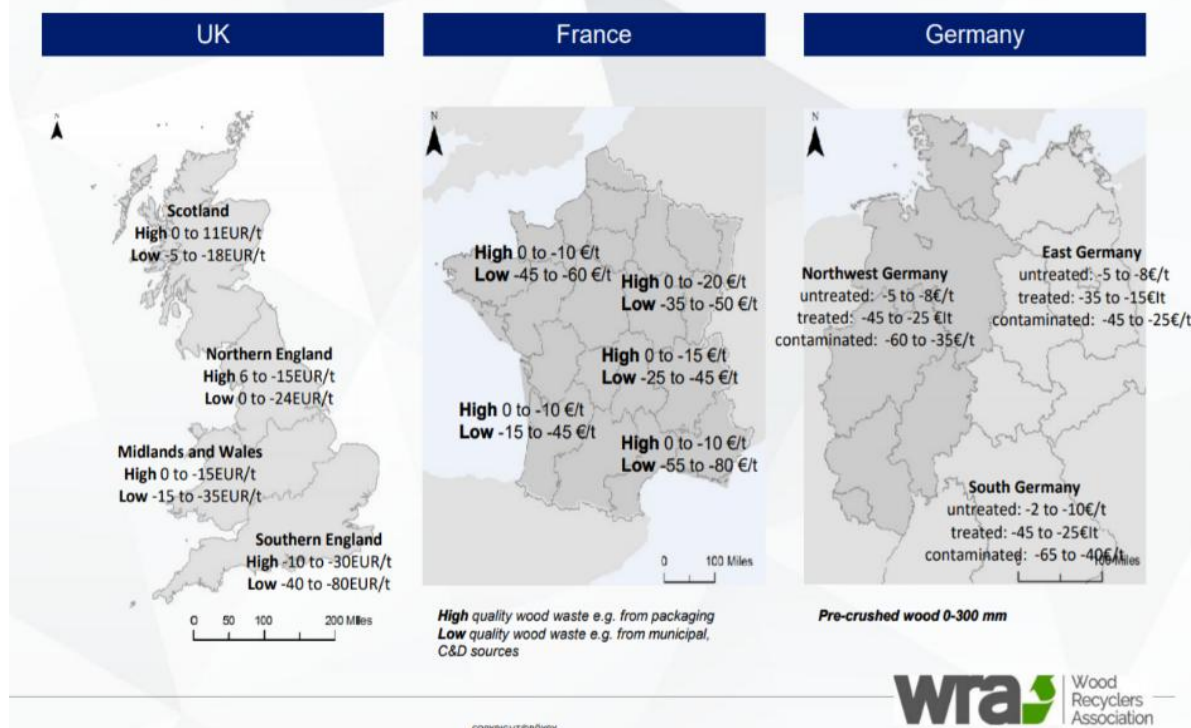


Figure 8: Regional gate fees across Europe (Figure taken from WRA - POYRY report)

Since wood waste has a high bulk-to-value ratio, most of the wood residues is traded between neighbouring countries. Nevertheless, important exemptions on this general pattern exist, e.g. wood waste shipments between Belgium and Italy. The figure 6 shows typical wood waste trade flows in Europe. The wood waste trade of around 4 million tonnes between EU-nations in 2011. According to Eurostat, the largest exporters to other EU-28 countries in 2013 were Germany (793.4 t), Belgium (461.9 t) and Poland (393.6 t), whereas the biggest intra-EU importers in that year were also Germany (1,380 t), closely followed by Belgium (1,325 t), Austria (632 t) and Italy (510 t). Whenever trade with non-EU-28 countries does happen, it is mostly through imports. EU-28 imports of wood waste from non-EU countries dwarf exports both in quantity and value. The largest exporters to non-EU countries in 2013 were Germany (35.7 t) and France (25 t).¹³⁴ Largest importers from non-EU countries in 2013 were Sweden (438.5 t), Germany (281 t), Finland (194 t) and Italy (144.8 t). Imports from outside the EU have exceeded exports to non-EU countries since 2003, mainly driven by the boost in demand for wood waste by the particle board industry (especially in Italy).¹³⁵ Another important driver of demand has been the energy generation industry due to EU renewable energy policies, which we will discuss in the next sections. The figure 9 shows some gate fees into wood processing sites in UK, France and Germany.

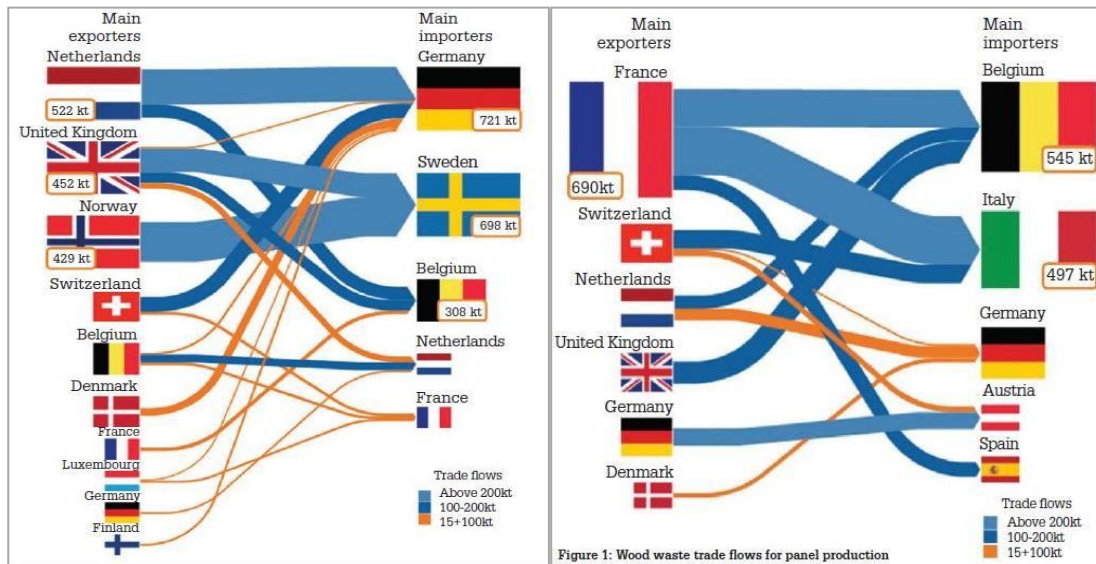
Most of exported wood waste originates in Eastern France, with the northeast supplying predominantly to Belgium and the southeast to Italy. Exports to Spain are notably higher than in the past, reaching up to 200,000 tons, compared to almost half that quantity in recent years (Bilsen, 2015).



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Figure 9: Wood waste stream in Europe for energy (to the left) and panel industry (to the right)

(Source: WBPI – POYRY)



4.2 WOOD WASTE SORTING AND PROCESSING

Before wood waste can be recycled, and after it is collected by wood recycling specialists, it is essential that waste is sorted. The price of wood waste depends on its quality, so the sorting and grading are required to meet the expected wood quality. Sorting is designed in the collection system by pricing incoming wood waste according to its content. This gives waste producers price incentives to keep lower grade wood waste separate. The wood waste is then subject to a range of sorting and grading processes. Wood waste is often sorted according to its grade as it is shown in the Table 2.

The type of waste collection determines the extent of sorting efforts in the sorting plants. The separation of treated wood and other contaminants from wood waste is based on visual, mechanical, magnetic or gravity sifting techniques. These are done at different steps along the wood waste processing chain. As proportions of wood waste in feedstock increase, physical and chemical contamination challenges become more profound. With ever-increasing use of panels in furniture and construction, the general quality of wood waste is decreasing. Sorting and removal of unwanted types of wood and other contaminants, such as MDF and preservative-treated material, prior to chipping, is extremely important for these end-uses. There is a growing need to improve physical screening and sorting prior to chipping to reduce chemical contamination in wood used for particleboard production. To overcome these challenges, panel producers requiring large volumes of wood waste have invested heavily in processing facilities (WBPI, 2015).

Wood waste in the packaging industry is either reused internally or collected by a waste collector for sorting and on-selling to industry through a collector. The packaging industry also sells directly to other companies as it produces large quantities of high-quality wood waste.



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Most of the processing techniques and equipment used for sorting have two main objectives: to result in a granulometry adapted to the way of valorisation (not concerned when it comes to reuse) or to improve the final quality of the product in relation to the requirements of the outlet. The main way to prepare wood waste for sorting is a shredding, often followed by a screening, applied on platform. A less frequent used in panel industry, is from upstream processes of the production are mechanized sorting centres for mixed waste with or without manual sorting (sorting table) and optical sorting.

4.2.1 SHREDDING, SCREENING AND EXTRACTION OF NON-FERROUS METALS ON PLATFORMS

Wood waste is shredded and screened. These sites require handling equipment (grapple shovels, telescopic shovels, loaders), one or more fix or mobile shredders (slow, rapid) and screening equipment.

Picture 2: Site of "double shredding" and screening (CEDEN, 2016)



- **Handling:** Sites require handling equipment to feed the shredding equipment. They can be shovels equipped with a grapple or bucket loaders. Bucket loaders also feed shredders and screens, manipulate material (fine fraction, shredded material) and load trucks for evacuation. The main manufacturers are: DOOSAN, CATERPILLAR, CLAAS, JCB, CASE, LIEBHERR, BOBCAT, NEX HOLLAND, MANITOU, MASSEY FERGUSON.
- **Shredding:** The aim of grinding/shredding is to reduce the particle size of incoming wood waste and to facilitate the removal of iron. Slow grinding often precedes rapid grinding, to avoid breakage on the rapid grinder and improve the recovery of metals. The shredders are generally "with hammers" and are equipped with one or more magnetic rollers enabling the removal of the ferrous. The two shredders are arranged in series with conveyor belts which convey the material from the slow shredder towards the fast shredder.

Picture 3: Slow shredder DOPPSTADT DW 3060 Biopower and fast shredder AK 535, in series, and, on the right, hammers (CEDEN, 2016)



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The rapid shredder is generally equipped with a grid disposed upstream of the grinding member to calibrate the final product. The meshes of these grids vary between 80 and 250 mm in general. The smaller the mesh, the more the grinding creates "fine fraction" and the greater the quantity of metals recovered. The flow rate is lower with a small mesh grid. For wood waste, the grids used are often wide mesh (250 mm). The main manufacturers are: DOPPSTADT, BANDIT, WILLIBALD, JENZ, HAMMEL.

- **Screening** is not always applied because. Depending on the requirements of the end user, the shredded material can be directly recovered. When the screening is applied, operators usually have a simple drum screen, which separates the incoming product into a fine fraction and a coarser fraction. The meshes are round or square and in general between 10 and 30 mm. The drum is replaced when the mesh must be changed.

Picture 4: Mobile drum screen DOPPSTADT SM 620 (CEDEN, 2017)



Adjustment of material feed rate and drum rotation influences the amount of fine fraction recovered. The star screens are little used for wood waste and are more concerned with green waste. The main manufacturers are: KOMPTECH, DOPPSTADT, TIM, POWERSCREEN, WILDCAT, etc.

4.2.2 MECHANISED SORTING

Less widespread, the mechanized sorting allows a finer sorting thanks to the succession of several separation equipment, and sometimes manual sorting tables. There are two main situations:

- The mechanized sorting chains which aim to separate mixed waste from economical activities and municipalities (wood, plastic, ferrous...), which equip sorting centres.
- The mechanized sorting chains for the processing of wood waste only, which equip the manufacturers of wood panel ("wood panel industry") or industries producing energy from wood waste.

- **Mixed waste sorting centres**

The sorting centres generally perform a pre-sorting by means of a grapple or a clamp mounted-up on a shovel. The pre-sorted wastes are introduced into a hopper feeding a separation chain: slow shredding, screening, densitometry sorting, ballistic sorting, manual sorting table, optical sorting (near infrared in general), aeraulical sorting, over-band for extraction of ferrous metals, Eddy current for separation of non-ferrous, flip-flop screens. The chain allows to separate different materials: wood, heavy inert, cardboard, plastics. Optical sorting and manual sorting make it possible to separate different categories of wood (based mainly on the colour). Conveyor belts allow different materials to flow from one piece of equipment to another. Since the sorting is confined in a



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building, the sites have systematically equipment for renewal and treatment of the air. The main contractors in France in designing and constructing these installations are VAUCHE, NEOS, ARVAL, IRIS, HANTSCH, AKTID, RMIS.

Picture 5: Pre-sorting (to the left) and sorted wood on a mechanized sorting centre



- **Sorting in Panel industry (recycling and energy)**

In this case, wood waste arrives raw from the waste separation sites, construction sites. To prepare this wood waste, the industrial has a sorting line integrating shredders, screens, over band, Eddy currents, aeraulic sorting, ballistic sorting (stones, glass), tub, fines particles aspiration, etc. This sorting chain is comparable to the mechanised centres for mixed waste (mentioned before in this document). The screening dust is recovered in energy, with the fines of sanding of the panels, or evacuated in cement plant. In the case of manufacturers who receive wood waste already pre-processed, the sorting line does not include the grinding and screening steps, already carried out in other sites. In some cases, the manufacturer has optical sorting equipment (e.g. KRONOSPAN), and even X-ray fluorescence spectrometer (XRF) tests to detect heavy metals and eliminate certain streams.

- **Energy producers and industrialists producing energy for their own needs from wood waste**

Wood waste to energy plant also apply complementary treatments (screening, etc.) to the shredded products delivered. In general, operators of heat and/or power generation equipment (industrial, energy producers) operate a post-treatment, which is designed to meet the technical requirements of combustion equipment or Emissions (smoke and ash). This post-processing is naturally less advanced than for the wood panel producers which receive non-pre-treated wood waste.

4.2.3 FOCUS ON OPTICAL SORTING TECHNIQUES

Two main techniques based on optical methods are used to detect contaminants in wood and to separate different types of wood waste: Near Infrared spectroscopy (NIR) and X-ray fluorescence (XRF). NIR sorting relies on the detection of molecules while the XRF detects atoms. The optical sorting makes it possible to improve the quality of the resource to respond as closely as possible to the requirements of the various current users, or even to allow new outlets permitted by the improvement of the quality of the outgoing products. Initially, optical sorting must allow the wood to be separated from the rest of the waste. Secondly, it also aims, when necessary, to separate the wood waste into categories: wood covered with a finish (melamine, paint, varnish, etc.), raw wood, fibreboard, etc. NIR and XRF should allow in a short term, to go further in the separation of wood waste types. The mechanised sorting centres for mixed waste contain generally optical sorting equipment to separate, among



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others, the wood fraction. The technology does not yet appear to be mature enough to separate the fibreboard (unwanted by the panel industry) from the rest of the wood.

For NIR, some experiments in the DEMOWOOD project showed that it was possible to separate clean wood when it was mixed with glued wood waste (panel residues) and wood waste coated, with some efficiency, in the accepted fraction and the ejected fraction. However, sorting decreases in efficiency when polluted parts present polluted and unpolluted surfaces simultaneously. To solve this problem, the pieces must be crushed to smaller pieces. But in this case, the sensors have more difficulty identifying the parts and ejecting them. For NIR, the main manufacturers are TITECH (Norway), Pellenc (France), RTT Steiner (Germany).

For XRF, tests have shown that the technology can detect wood inorganic preservative (detection of copper and chromium). For XRF, the main manufacturers are Brucker (USA), Spectro (Germany), Pellenc (France). There is portable equipment, such as those used in mining to detect certain metals.

Other technologies for separating wood can be mentioned: laser-induced breakdown spectroscopy, Field Asymmetric Ion Mobility Spectrometry, spectral resolution thermography, and chemical staining. These technologies are currently poorly developed for wood waste and are mainly based on fixed element analysis or requiring preliminary operations (heating, destruction of part of the sample).

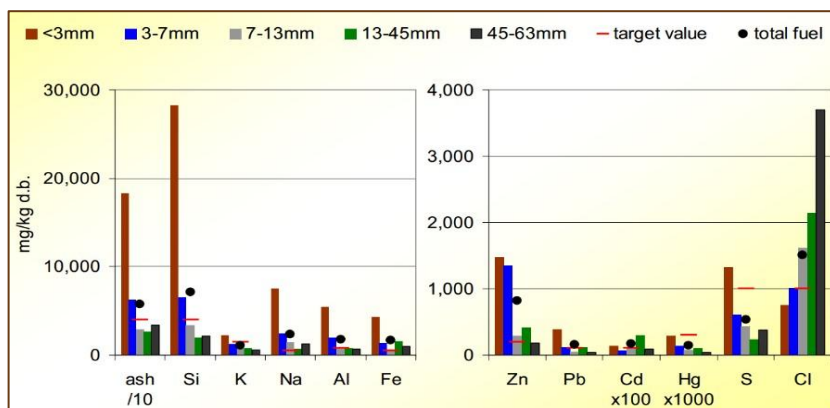
4.2.4 SCREENING INCIDENCE ON THE CHARACTERISTICS OF WOOD WASTE

There are studies on impact of wood waste composition before and after screening have been carried out by: Thomas Brunner from BIOS ENERGIESYSTEM, tests made in 2004 (Austria); BIOMASSE NORMANDY's tests in 2007 (France); SRBTP's studies from 2015 to 2016 (France); ECIRBEN (France); and Dr. Magnus (Sweden).

- Thomas Brunner from BIOS ENERGIESYSTEM, tests made in 2004¹

Brunner and Al's tests in 2004, show the positive incident impact during the screening (except for chlorine), on sieved wood waste's quality, in terms of physic-chemical composition and at the combustion behaviour. Following Brunner's tests, most undersized particles contain some pollutants particularly in the smallest.

Figure 10: Compounds contents depending on the granulometry (BiosEnergieSystem, 2004)



The tests have also showed that the size of the shredder's grill has also an impact: smaller cells bring even more undersized particles after the screening step and allow retrieving more ferrous or non-ferrous metals (when the shredder is well equipped). These 2 statements have been also noticed during ECIRBEN's tests.

1



Table 7: Results of 2 grindings-screenings with different grills' cells size on the shredders (100 & 150 mm) - (BiosEnergieSystem, 2004)

	100mm screen basket		150mm screen basket	
fuel	6,400 kg	76.0%	12,200 kg	83.2%
undersized fuel (<10mm)	1,700 kg	20.2%	2,100 kg	14.3%
iron metals	290 kg	3.4%	340 kg	2.3%
non-ferrous metals	30 kg	0.4%	20 kg	0.1%
Total	8,420 kg	100.0%	14,660 kg	100.0%

- **BIOMASSE NORMANDIE 's tests in 2007**

Construction industry's wastes shredding and screening tests carried out by BIOMASSE Normandie in 2007 show that the pollutants (metal) are concentrated in the undersize particles less than 2,8mm and the extraction can remove from 30 to 51% of the pollution excluding 11 to 16% of the mass. The characterisation study held by SRBTP in 2015-2016 doesn't show any relevant differences between sieved and non-sieved wood waste at 20 mm or 10mm. However, it has been noticed a higher level of pollutants in undersized particles (< 2 mm).

- **ECIRBEN**

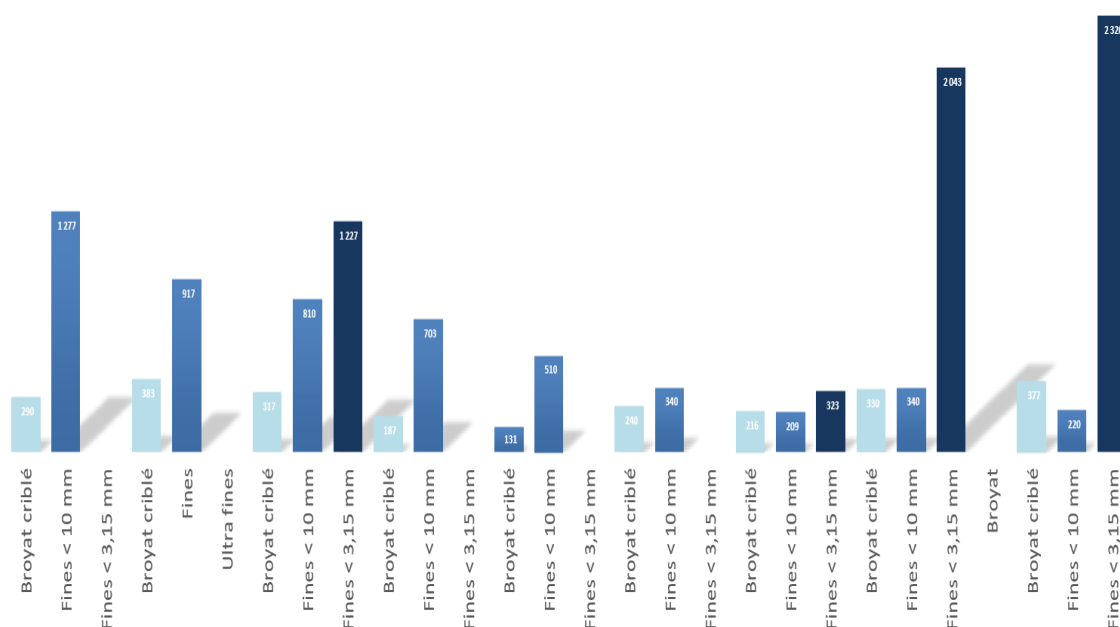
The ongoing ECIRBEN study in France, led By Biomass Normandie and CEDEN, showed in 2016 that:

- representativeness of the samples on the non-screened wood waste is not easy to get because of the undersize particle which is not well spread out in the pile of wood waste; this problem is not seen as much as within shredded or screened samples;
- a smaller cell at the exit of the shredder increases the proportion of the undersize particles (up to 25-30% with 80mm cell versus 15-20% with a 250mm cell) but then the concentration effect in the undersize particle is less marked.
- the positive incident of the physic-chemicals final shredded undersize particles (except for chlorine): pollutants (particularly lead and zinc) are concentrated in undersize particles less than 3,15mm, which are 60-65% of the mass of the 10mm undersized particles.

Figure 11: Zinc content (in ppm) shredded samples and undersized particles between 10 - 3,15mm (ECIRBEN, 2016)



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Finally, during the tests of wood waste combustion made in Sweden, Dr. Magnus BERG specifies that the undersize particles, which represented 7% of the mass of the fuel, are responsible of 40% of the metal deposit and 10% of chlorine deposit: the results of these tests confirm that the undersize particles fraction concentrate more pollutants.

Wood waste from different sources should be assessed, classified and segregated to ensure appropriate handling and processing for recovery or disposal and specific end uses.

Non-hazardous wood waste requires little or no treatment or processing. It needs to be adapted to the appropriate size for being integrated into the final product. Table below shows that the volume of wood waste treated in the EU-28 has more than doubled between 2004 and 2010. More than 90% of waste is treated in some form, most likely because over 97% is non-hazardous and thus easily treated.

4.2.5 IMPACT OF BEST PRACTICES

Table 6: Impacts of best practices in value chain: Sorting and processing of wood waste

OBJECT/AIM		MEANING		TARGET		POSITIVE IMPACT
Improve product in view of meeting outlet requirements	Extraction of undesirables	Manual/visual sorting	Manual, shovel equipped with pliers	wood waste undesirables	Framework windows, doors	Reduction Zn, Pb in sorted products
					outdoor wood waste	Reduction of heavy metals
					Sleepers, fences	Reduction of benzo (a)pyrene



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	Separation of material	Mechanical sorting	Shredding, screening, over band, eddy current. Innovative solution for windows: mechanical treatment for (chipping, milling) for coating and chemical treatment for preservatives	Other undesirables	Plastics, glass, padded, ferrous, non-ferrous.	Visual improvement makes possible to achieve requirements of outlets and to separate wood from other materials
	Separation of material	Optical sorting	NIR	wood waste undesirables	MDF	possible to separate fibre panel to meet requirements of panel board industry
			XRF		Polluted wood	possible to separate polluted wood to meet requirement of outlet.
	Particle size reduction	Shredding	Low rapid shredder fitted with sieves, Specific low shredder	Rough wood waste		Lead to appropriate particle size. Consequence: avoid resorting to screening step- money saving
	Fine particle extraction	Screening	Trommel, stars screen	Shredded wood waste		Improve screened product, possible to meet requirements of outlet, % of particle smaller than 3.15 mm
	Blending	Blends of different grades of wood waste	Loaders	Rough wood waste and prepared wood waste		Production of a mixed product: possible to meet certain conditions: moisture, solid wood rate, MDF rate, clean wood rate, fine particle rate
Improve environmental impact and human health impact	Protect operators from dust	Stationary and electric equipment	Shovel, loader, shredders, screens	All along the step of sorting/ treatment		Reduction of consumption of fossil fuel / noise. Money savings. Reduction of dust emission. Improvement of human health
		Shredding, screening, loading	Confined equipment's, aspiration pipe system, water aspersion			
		Extraction	Endless screw			
		Individual protection equipment	Helmet category 3, glasses			



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4.3 WOOD WASTE VALORISATION

The last step in the value chain is valorisation of wood waste. The requirements of wood waste are specific to each way of valorisation. However, many undesirable parameters are common, such as heavy metal, chlorine and others. In this project, the wood waste is used in three main industries: recycling in wood-based panels, paper and paperboard and energy. However, other methods of wood waste valorisation are available in this chapter, which are not so common in Europe.

The information in the Figure 12 from 2007 shows that in Europe, the two main types of utilisation of wood waste are recycling and energy use. Almost 40% of the recovered wood is used as particle board raw material. In Italy, Belgium and UK the use of wood waste for particleboard was 70%, 60% and 56% respectively and in France, Spain and Denmark about 1/3 of the total raw material basis. Part of the wood waste is not utilised but put in landfills, mainly in France, the UK and Spain. The share of landfilled wood can be expected to decrease due to the EU Landfill Directive (Indufor, 2015).

Energy and particleboard manufacturing are two industries that compete themselves almost directly, even if the wood waste requirements are different: The energy sector requires a material with low contamination, reduced metal content and reduced chlorine to ensure energy generation with reduced atmospheric emission. The panel industry is interested more to the physical quality of wood waste favouring solid wood. The following figure provides data about wood waste consumption in Europe for energy and panel industry (CIBE, 2017).

Figure 12: Utilisation of wood waste in some EU countries

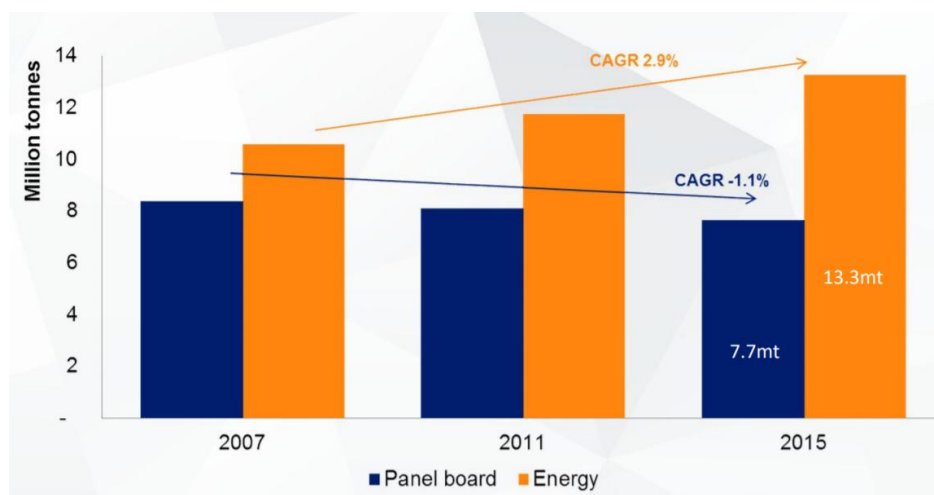
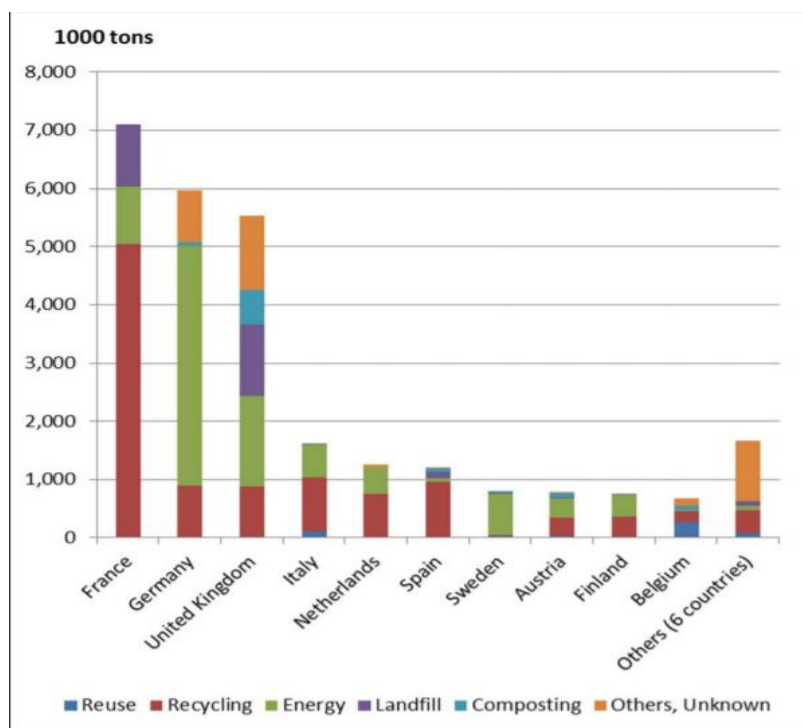


Figure 13: Wood waste consumption in Europe for energy and panel board (CIBE, 2017).



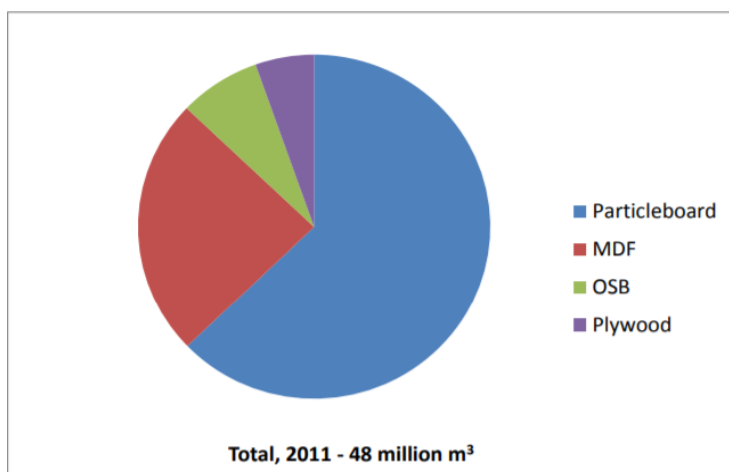
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Source: COST Action E31 programme 2007

4.3.1 RECYCLING WOOD WASTE FOR THE WOOD BASED PANEL INDUSTRY

EU wood-based panel production was around 48 million m³ in 2011. Particleboard production is by far the largest accounting for almost two thirds of the total panel output followed by MDF, OSB and plywood. Germany is both the largest producer and the largest consumer of particleboard in Europe. Most of the trade occurs within the European countries, as particle board is, to a large extent, consumed by European industries for further processing into furniture, and the transport costs for a product like particle board is very high in relation to its price (EPF, 2011).



Source: 1) EPF Annual Report; 2) FEIC Annual Report

Figure 14: EU wood-based panels production (2011)

The EPF sets maximum levels in the wood waste used in the composition of panels. The EPF standard also sets maximum levels of undesirable elements 2% and moisture 20% (see table below).



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Table 9: Limit values in wood waste in the panel industry (EPF recycled wood standard)

Elements / Compounds	Limit values (mg/kg recycled wood)
Arsenic (As)	25
Cadmium (Cd)	50
Chromium (Cr)	25
Copper (Cu)	40
Lead (Pb)	90
Mercury (Hg)	25
Fluorine (F)	100
Chlorine (Cl)	1000
Pentachlorophenol (PCP)	5
Creosote (Benzo(a)pyrene)	0,5

Germany and France are the leading producers of particleboard in Western Europe (see Table 11). EU particleboard production was to about 31 million m³ in 2011 (Indufor,2011).

Table 10: Wood waste consumption in particleboard production (WBPI)

Country	Particleboard production 2013, '000m ³	Share of wood waste in raw material mix	National consumption of wood waste in panels, '000 tonnes
Germany	5,600	30%	1,400
France	3,811	22%	680
Italy	2,652	95%	2,150
United Kingdom	2,012	52%	890
Austria	1,840	35%	550
Spain	1,465	32%	390
Belgium	1,250	70%	850
Sweden	600	0%	-
Portugal	590	25%	130
Switzerland	370	0%	-
Denmark	316	67%	180

Tonnes as received with typical moisture content 20-25%

France and Germany have experienced increasing prices for all wood feedstocks, driven by increasing competition from bioenergy during the last decade. However, there is still no significant shift towards the use of wood waste in particleboard production due to concerns over panel quality. France has become the key supplier of wood waste for panel production in neighbouring Belgium and Italy, while domestically the share of wood waste used in the raw material mix remains still low. However, French panel industry has committed in 2017 to use 500 000 tons of wood waste in addition compared to the current situation.

Northern Italy is leading in Italian particleboard industry, and many producers are well positioned to be sourced from France. Some of the largest one of these have established railway infrastructure to transport wood waste over long distances and have regular deliveries from the neighbouring countries. The fibreboard, unwanted by the panel industry due to their lack of structure, could be used in the manufacturing process of the particle board.



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4.3.2 PAPER AND PAPERBOARD

Paper is produced by the compression of fibres. The total paper consumption in the EU27 was 80.5 million tonnes in 2011 (Indufor, 2015). The fibres used are usually natural and composed of cellulose. The most common source of fibres is pulpwood, wood chips, particles or residues by mechanical and/or chemical process. The value of the paper recycling sector is estimated to be around EUR 97.1 billion, with paper for recycling accounting for about 70% of raw materials used in Europe's paper industry due to voluntary initiatives from industry on top of legislative measures.

Pulp and paper industry can be a recycling route for wood waste. However, the recycled material must be of high quality. Otherwise, it can be always used as an additional source of energy for paper industries' biomass boilers. For pulp recycling, the main requirements are as follows (source DEMOWOOD):

- Exclusion of wood preservatives;
- Exclusion of toxic metals in the cycle of matter;
- Separation of impurities (metals, plastics);
- Importance of the origin of wood waste and species: softwoods are preferable (maximum hardwoods 2%).

4.3.3 ENERGY

Bioenergy can be understood as energy produced from biomass, which means the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste.

Wood wastes are burned in industrial plants, for the production of electricity and heat (CHP), only heat or electricity, sometimes associated with the production of cold. Wood waste can be burned as bulk waste ("waste to energy" plant) or separated and thus burned alone or with other fuels (co-incineration): coal, biomass. As for the recycling of the panels, the waste wood is sorted and more or less treated (at least one shredding).

The regulations differ from one European country to another and depending on the type of installation. In general, waste wood is not considered as biofuels. Therefore, the quality criteria regulating the use of waste wood for energy are related to the European Waste Catalogue. The IED Directive applies to incineration and co-incineration plants. Regarding the quality of wood waste, the thresholds and parameters used to qualify clean wood are not the same from one country to another. For incineration, there are no thresholds for incoming wood waste. As a general rule, and with the exception of clean waste wood or wood waste having undergone an "end of waste" procedure, energy recovery must comply with the Industrial Emissions Directive (The same constraints as for waste incineration).

Waste wood which are in compliance with the definition of the biomass b(V) of the IED directive are considered as biomass. Concerned waste wood are mainly cuttings of the second transformation of waste, particle board. In this case, this resource can be valorised in plants of which constraints are less strong. In France for example, regulation takes account these wastes but sets threshold for heavy metal in the wood (rubric "2910 B" of the regulation on installations with impact on the environment).

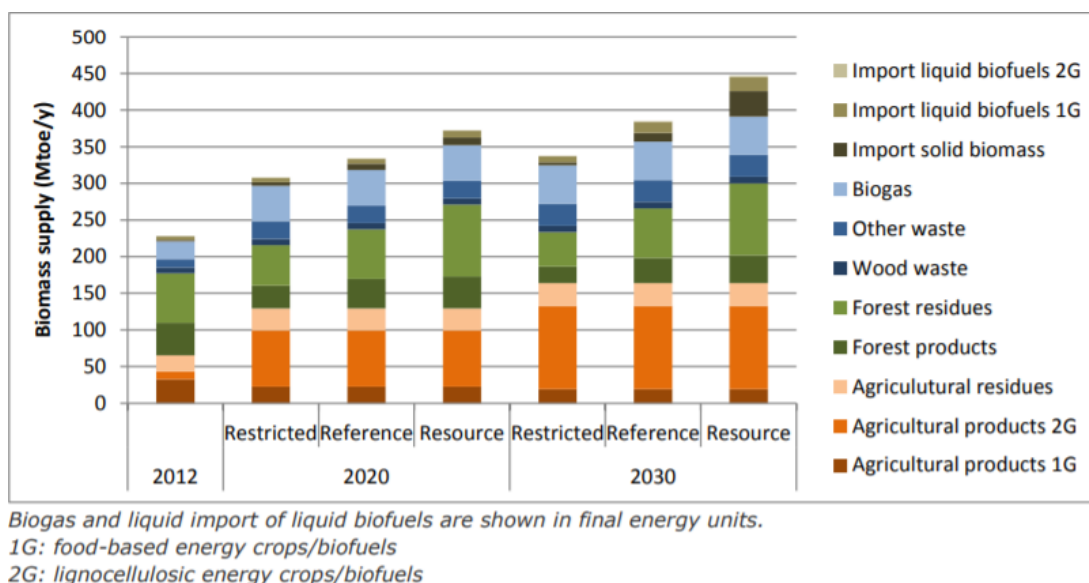
In 2010, according to the statistics the amount of energy supplied from wood and wood waste was about 390 million m3 in the EU27. However, the supply of wood and wood waste for forthcoming years depends on forest



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management. As shown in the figure 15, the domestic supply in the EU28 in 2030 ranges between 338 Mtoe in the Restricted scenarios to 391 Mtoe in the Resource scenario (EC, 2017).

Figure 15: Overview of estimated biomass potential for bioenergy in the EU28 in 2010, 2020 and 2030 (EC, 2017)



Wood wastes are burned in industrial plants, to produce electricity and heat (CHP), only heat or electricity, sometimes associated with the production of cold. wood waste can be burned as bulk waste ("waste to energy" plant) or separated and thus burned alone or with other fuels (incineration): coal, biomass. As for the recycling of the panels, the wood waste is sorted and treated (at least one shredding).

According to Eurostat, the share of renewable energy in the Gross inland energy consumption in the EU was around 10% in 2011, where the most important sources was wood and wood waste with the share of 48% of the total consumption of all renewable energy in EU. The figure 16 shows that Baltic and Nordic countries spent the most of wood waste and wood of all national consumption of renewable energy in EU. The table 11 subcategorized the wood fuels used for primary energy production (Pelkonen et al, 2014).

Figure 16: Share of wood and wood waste in gross inland consumption of renewable energy in the European Union (2011) by Member States. (Eurostat (2014))



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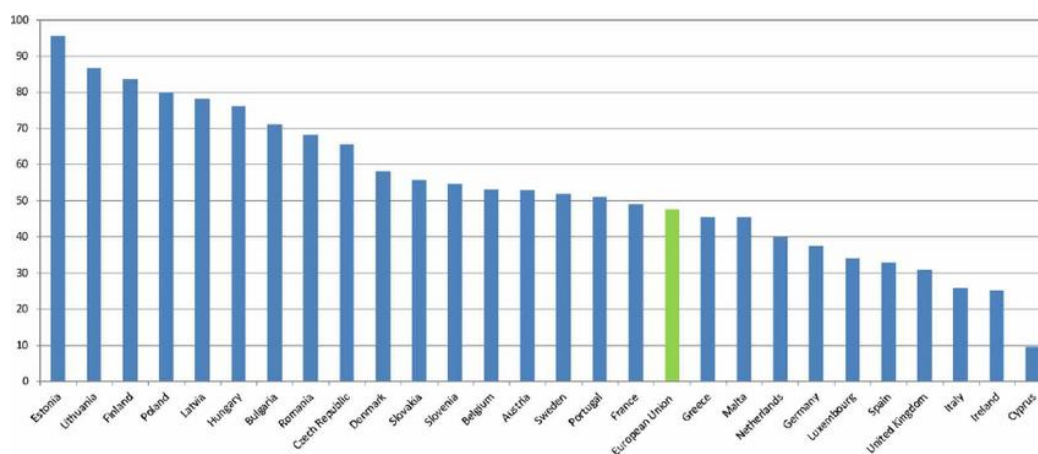


Table 11: Wood fuels for primary energy production in the EU by sub-category

Wood fuels used for primary energy production in the European Union by sub-category (2011). Data source: Eurostat.

Wood (fuelwood from forests)	49%
Wood waste (solid by-products from forest industries)	17%
Black liquor	15%
Other wood and wood waste (e.g. recycled wood)	20%
Wood fuels, total	100%

4.3.5 OTHER METHODS OF RECOVERING WOOD WASTE

Syngas production

Some gasification plants use a portion of wood waste in their supply (e.g. CHO Power in Morcenx, SOPREMA in Strasbourg, in France, or Goteborg Energi) but the technology is still not mature (technical difficulties, high costs). Some large-scale gasification plants, like the 20MWth plant in Sweden, represent the most recent development status of this end use strategy. The GABOREC project, which began in 2015 and was carried out by INSA VALOR in Lyon, aimed to produce renewable energy (heat, syngas) from low-adjutant wood waste.

Ethanol production

Wood waste, with certain type of pre-treatments, could be substituted to virgin wood for the biochemical production of ethanol, with comparable yields to the use of virgin biomass. Many activities have been carried out in this direction. One of them is reported by the DEMOWOOD project.

Chemical industry

Works involving the chemical and pharmaceutical industry: production of vitamins, medicines, solvents, fertilizers, polymers, succinic acid (ETH Zurich).

Alternative re-use



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The European program WRING (2016-2020) aims to improve the rate of wood waste recovery in Europe, by developing alternatives to the recovery of wood waste in the form of particles or shredded products. In France, for example, some associations (as part of social insertion) repair old furniture to give them a second life.

Re-use after deep sanding (University of Nantes-FCBA / Thesis / CAREWOOD Project)

The CAREWOOD project (Cascade REcycling of Wood) aims to study the interest of a first stage of recycling without destructuring solid wood waste, which would allow a new life cycle before grinding for recycling or energy recovery. Under this project, a thesis is being carried out on the recycling of solid wood waste, after a machining stripping/sanding, to manufacture jointed laminated wood elements. This solution comes up against the difficulty of extracting wood waste the elements of enough length (pieces of framework, joist, etc.). The technical feasibility of manufacturing products like elements based on virgin plaquettes used in carpentry is now established. Several criteria including the economic viability of the concept remain to be established. It is therefore possible that a part of solid wood waste from demolition sites may be valorised tomorrow in view of their value and Escape collection. For example, the picture below shows a window profile from demolition wood waste, a prototype produced by a Slovenian carpenter, a partner of the CAREWOOD project, the company MSORA.



Picture 6: Stripping of wood waste for manufacturing profile windows (source DEMOWOOD)

It should be noted that some of the demolition timber are already recovered and reused by artisans and demolition companies, but quantities are difficult to estimate.

Disposal and bad practices

Where wood waste is not recovered, it is disposed of in incinerators without energy recovery or landfill. On the other hand, open burning of wood waste is still a common practice, as well as domestic use (chimneys) in France or England, for example: both practices are extremely harmful in terms of atmospheric emissions.



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4.3.6 IMPACT OF BEST PRACTICES

Table 12: Conclusion of the best practices for the valorisation step in the value chain.

OBJECTIVE/ AIM		MEANING	TARGET	POSITIVE IMPACT
Improve supplied pre-treated wood wastes on the valorisation site (post-treatment)	Post-treatment (the wood waste supply does not always meet with final requirement of outlet)	Shredding, screening, ferrous and nonferrous removal, NIR, XRF...Blending. These treatment steps are like those encountered on sorting/treatment dedicated platforms.	Rough wood waste or pre-treated wood waste	Ensures the final achievement of requirements of the outlet. Especially requirements of combustion/incineration and production of used wood-based panels.
Energy recovery	Get a good energy efficiency	CHP: heating valorisation (industrial supply, district heating network...) Resort to condensation.	Operators (energy companies), technologies providers	Economies savings, positive environmental impact (fossil fuels substitution).
	Ensure gas treatment	Beyond classical equipment (boiler volume, staged combustion, SNCR, SCR, coal, lime, bag filters, electro-filters, resort to condensation.	Municipal authorities (tenders), energy companies (operators), consultancy	Respect of emissions thresholds, positive environmental impact.
	Ensure disposal of ashes: in agriculture or in forest, cemetery, concrete, ceramics, road infrastructures.	Improve quality of ashes: shredding, screening, ferrous and nonferrous removal (eddy current, over band), chemical extraction of heavy metals...	Operators (energy companies)	Positive environmental impact (preservation of virgin resources, substitution of chemical nutrients) and money savings (no resort to landfilling)
Recycling	Maintain quality of wood waste-based particle board panel (recycling "to infinity" could lead to pollution of recycled panel board).	Monitoring and control of wood waste supply on site (optical sorting XRF, NIR). Dilution with clean wood or virgin wood just in case, or valorisation in energy for process.	Operator (panel industry), technologies providers	Positive environmental impact (formaldehyde emissions...), respect of thresholds (panel board), sustainability/relevance of cascade use.



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5. DEMONSTRATION REGIONS

5.1 GOTHENBURG (SWEDEN)

Region Västra Götaland (Western Sweden) is the second largest in terms of population of Sweden's counties and it is subdivided into 49 municipalities (kommuner). Its population of 1,616,000 amounts to 17% of Sweden's population. The formal capital and seat of the governor of Västra Götaland County is Gothenburg.



Picture 7: Location of region of Gothenburg

The Göteborg Region Association of Local Authorities (GR) is a co-operative organisation uniting thirteen municipalities in western Sweden. The member municipalities are Ale, Alingsås, Göteborg, Härryda, Kungsbacka, Kungälv, Lerum, Lilla Edet, Mölndal, Partille, Stenungsund, Tjörn, and Öckerö. Combined, the population of these municipalities is about 1 000 000. The task of the association is to promote cooperation over municipal borders and provide a forum for the exchange of ideas and experience within the region. GR focuses on such issues as: regional planning, environment, traffic, job market, welfare and social services, competence development, education, and research. GR works closely with Business Region Göteborg, which is the common resource for trade and commerce issues in the Göteborg region. According to the definition in the Swedish Environmental Code, waste is any matter or object that the bearer disposes of, intends to dispose of, or is obligated to dispose of.

THE RESPONSIBILITY OF MUNICIPALITIES AND HOUSEHOLDS

The municipalities are responsible for the collection of any household waste not covered by producer responsibility and for its transport to waste treatment plants for recycling or disposal to landfill. This applies to both waste from households and similar waste from restaurants, shops, offices, etc. Waste must be handled in an environmentally responsible manner. Every municipality is required to have its own waste and sanitation ordinance, which consists of a waste plan and regulations for waste management. The waste plan should include details of how the municipality intends to reduce the amount of waste and the danger posed by it. Preparation for reuse is also part of the municipal responsibility. The municipalities are also working to promote the prevention of waste and its recycling, despite this not yet being their statutory responsibility.

Households are responsible for separating and depositing waste at available collection points. They must also follow the municipality's rules for waste management.

THE RESPONSIBILITY OF PRODUCERS AND BUSINESSES

In Sweden, producer has responsibility for: recyclable paper, packaging, electrical and electronic waste, tyres, cars, batteries and pharmaceutical products. Producers are responsible for collecting and disposing of end-of-life



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products. This means that there must be suitable collection systems and treatment methods for recycling. Producer responsibility is also intended to encourage producers to develop products that are more economic with resources, easier to recycle and do not contain substances which are harmful to the environment. Businesses are responsible for disposing of non-household waste and waste that is not covered by producer responsibility.

WASTE HIERARCHY

The waste hierarchy has been incorporated into the Environmental Code. According to the legal text, anyone who operates a business or carries out an action shall be conservative with use of raw materials and energy and utilize opportunities to: reduce the amount of waste, reduce the amount of harmful substances in materials and products, reduce the negative effects of waste, and recycle waste.

TREATMENT METHODS

Waste treatment methods are: material recycling, biological treatment, energy recovery and landfill.

Hazardous waste can be treated using one or more of these methods, depending on its characteristics. Recycling means that the waste will be used as replacement for another material. Preparation for reuse is also a recovery operation. According to the definition, this refers to cleaning or repair that enables products that have become waste to be reused. Material recycling reduces environmental impact at the same time as it saves energy and natural resources. Biological treatment closes the eco-cycle and returns nutrients to the soil. The waste is treated through anaerobic digestion (i.e. treatment without access to oxygen) or composting (i.e. treatment with access to oxygen, which is known as aerobic treatment). Anaerobic digestion produces digestate and biogas, which can be used as a vehicle fuel. Compost is a soil conditioner which can be used in gardens, parks and landscaping. Energy recovery is a method ideally suited for waste which cannot be recycled in any other way. At the same time, energy recovery generates both district heating and electricity. Landfill is a treatment method for waste that cannot or should not be recycled. Landfill entails waste being stored in a manner that is safe in the long-term. Sending organic or combustible waste to landfill is prohibited.

REGIONAL CONTEXT OF GOTHENBURG

RENOVA

The Renova Group is owned by ten municipalities in western Sweden: Ale, Gothenburg, Härryda, Kungälv, Lerum, Mölndal, Partille, Stenungsund, Tjörn and Öckerö. Their mission is to work with the owner municipalities in taking responsibility for waste and recycling over the long term. They aim to deliver community benefit through business activities and to actively contribute to sustainable development within our owners' region. The Group consists of the parent company Renova AB and subsidiary Renova Miljö AB. The parent company is the owner-municipalities' own waste expert and carries out tasks directly allocated by them. The subsidiary Renova Miljö AB operates on a competitive market and offers complete solutions in waste and recycling to businesses, municipalities and other public enterprises in the owner's region. Their main goal is to always be able to offer the market's best range of services within our industry, with environment, quality and customer service remaining paramount.

The company offers: Collection and transportation of all types of waste and recyclable materials, Environment-friendly waste management, Services for property owners and the construction industry and Advice and training.

Owners are the municipalities (Figures 2015):

- Sales Renova Group: MSEK 1,140



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- Number of employees: 780
- Treated waste: 830 000 t
- District heating produced: 1,504,000 MWh
- Electricity produced: 270,000 MWh
- Number of heavy vehicles: 220

The Renova region serves close to 1 Million inhabitants and their industries. Renova receives wood waste from industry and households. The industry is mainly building, construction and demolition waste. Many building and demolition sites source separate their wood waste on site. This is also encouraged by pricing at Renova and in national legislation. All wood waste fractions or any waste-to-sorting fractions are sent to central sorting plants such as Skräppekärr and Högsbo where the wood is separated into treated and non-treated wood. Also, any mistakenly impregnated wood that comes with the waste is sorted out and sent directly to the Waste to-Energy plant in Sävenäs.

Households also source separate wood waste at central waste sorting stations (Återvinningscentraler, ÅVC). The fractions are usually wood waste and impregnated wood. The wood waste is taken to the same sorting plants where the wood is separated into treated and non-treated wood. Again, also any mistakenly impregnated wood that comes with the waste is sorted out and sent directly to the Waste to-Energy plant in Sävenäs.

SORTING PLANTS

At the sorting plants waste fractions are put on ground on hard surfaces and sorting is done by wheel loaders today. These are about to be exchanged for electrical sorting cranes to further improve environmental performance. Treated wood waste is sorted out into one pile and untreated into another. Other waste fractions are sorted out for further material and energy recycling purposes.

Batchwise the wood is crushed into smaller sizes. Treated wood is then sold for Energy recovery mainly to produce energy for the pulp and paper industry. Untreated wood waste goes to energy recovery in biomass Combined heat and power plants (CHP). Where the energy recovery is taking place depends on legislation and environmental permits. Biomass plants can emit flue gas with higher concentration of potentially environmentally influencing gases such as SOx. Therefore, not as much flue gas treatment is needed in a biomass plant as in a Waste-to-Energy plant, and the untreated wood waste is sold as a fuel to biomass CHPs while a Waste-to-Energy plant needs to charge to treat wood waste. Renova prioritizes waste that needs Energy recovering in a Waste-to-Energy plant for environmental reasons and therefore finds good reason to put the effort of sorting out wood waste from other waste.

Renova's waste-to-energy plant at Sävenäs in Gothenburg is one of the world's most advanced facilities for the incineration of waste to produce heating and electricity. Around 300 trucks deliver waste to the plant daily. The waste is burned in three furnaces and the thermal energy generated is then transformed into electricity and district heating.

From every tonne of waste combusted today, we recover 3.3 MWh of energy in the form of electricity and district heating. 60 percent of our electricity production is labelled as biofuel-based origin. Every year, the waste-to-energy plant provides 30 percent of district heating in the region's network and 5 percent of the electricity needs of Gothenburg's population. The flue gases from the combustion process are cleaned in several stages and are well within the EU's requirements when emitted. Adjacent to the waste-to-energy plant is a reception facility for impregnated wood waste. This is a sorting and chipping plant for any impregnated wood such as sleepers (cross-ties), discharged telephone and electricity poles and demolition wood. The impregnated wood is crushed and delivered by conveyor belts directly into the Waste-to-Energy bunker. Approximately 20 000 tons of impregnated



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wood is energy recycled at the plant per year. Some wood is probably left in the residual Waste-to Energy fractions both in industrial and commercial waste and in household waste. This goes to the Waste-to Energy plant in Sävenäs and is Energy recycled there. In the region of Göteborg there are also several other sorting plants owned by private companies that also sort out wood waste. Local and regional waste plans are produced by local governments in municipalities. These focus on municipal waste and aim to treat waste in the most cost-effective and environmentally benefitting way, The EU Waste hierarchy is the obvious guideline. In the Göteborg region there is also a regional waste plan that sets out recycling targets and collection numbers. It is called A2020. There is also a national waste plan with the same aims.

National legislators also use various economical steering incentives for waste. For example, Sweden is one of only two countries within the EU that included their municipal Waste-to Energy into the EU-ETS. Landfilling is not allowed for any organic waste, therefore less than 1 % of the MSW is landfilled. There is also a landfill tax of about 50 € per ton. To our knowledge there is no major panel industry in the region. However, Pulp and paper is one of the larger industry segments in Sweden.

MARIEHOLM TREATMENT FACILITY FOR BIOLOGICAL WASTE

The treatment facility for sorted food waste is located at Marieholm in Gothenburg. After being pulverised, compressed, strained and mixed with liquid food waste, the final product of this treatment facility is slurry suitable for biogas production. The pre-treatment facility for biological waste is an important step towards increased biogas production. Garden waste is crushed and composted to produce various types of soils suitable for grass lawns, for different cultivation purposes. The composted waste is mixed with sand, peat and other ingredients to produce the perfect mixes and the products are sold to the public and industry.

DISTRICT HEATING

In the Gothenburg Region the energy utility Göteborg Energi, owned by the City of Gothenburg, operates district heating in municipalities Gothenburg, Partille and Ale. The network is also interconnected with municipalities Kungälv and Mölndal with their respective utilities. District heating is a convenient, trouble-free form of heating. The district heating network is 1350 km long and provides heating to more than 90 % of all apartment blocks in Göteborg and approximately 12,000 single-family houses. District heating is also good for the environment. This is because it is for the most part taken from waste heat, i.e. surplus heat from other industrial processes that would otherwise be lost to the air and sea.

CASE STUDY

There is a Pallets-deposit-refund system in the country. However, Renova recently started also sorting out pallets that are not included in the system. These are sold for reuse and/or refurbishment for recycling and helps Renova reach the targets of more reuse according to the waste hierarchy. Renova has taken part in several research projects to increase recycling. Some results show that biogas production of wood waste is not economically or environmentally feasible today. Borås University Fermentation do research on yeast production from cellulose. The yeast may serve as nutrition for the fish industry. There are research projects on Textile production by regeneration of cellulose. An interesting company in Gothenburg is Meva Energy AB, which provides a cyclone gasification process that can turn e.g. saw dust to biogas. For more information - <http://wood.wastew.mevaenergy.com/>



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GoBiGas (Gothenburg Biomass Gasification Project) is a major Göteborg Energi project set out to build a plant to produce biogas via the gasification of biofuel and waste from forestry. The aim of the GoBiGasproject is twofold: partially to demonstrate the possibilities with gasification technology AND partially to build a plant which can provide for the growing need for renewable and CO₂-neutral biogas. Phase 1 of the project is partly being funded through a grant from the Energy Agency in the amount of 222 million SEK. While the GoBiGas project continues, so does the research and development of a smaller gasification plant at Sweden's Chalmers University of Technology.

At GoBiGas, biogas is extracted via thermal gasification of the raw materials of the forest, such as branches, stumps and forest residue. Biofuel is transformed into a combustible gas, syngas, which is purified and upgraded to a biogas, with a quality that is comparable to natural gas. This means that both gas types can be mixed in the same gas grid. Since biogas is produced from renewable sources, it does not contribute to an increase in the emissions of carbon dioxide. To this point wooden pellets and different wooden fractions such as chips and bark have been tested.

CONCLUSION

Sweden sorts wood into different fractions. For the most polluted, impregnated wood there are environmental permits to incinerate it and convert to heat and power. Waste to energy in Sweden are among the most efficient in Europe. Sweden is among countries having the highest conversion rates of amount of waste turned into energy. Less polluted wood wastes are used bio CHP (Combined Heat and Power Plants) and also in energy recycling in pulp and paper processes. Trials with material recycling of wood for the board industry used in furniture production and building industry are ongoing.

BADEN-WÜRTTEMBERG (GERMANY)

Baden-Württemberg is one of the economically most competitive regions in Europe. The population is over 10 million and the quantities of wood waste reach nearly 1 million tons (8 million tons for whole Germany). Germany generates around 8,4

million tons of wood waste: 2 million tons are recycled in panel industry (rising market) in Germany (stable), Austria and Czech Republic. Energetic valorisation concerns 6,3 million tons of wood waste (all types), burnt in 76 plants! After of the end of support of EEG for biomass plants, Germany must find new way of valorisation or disposal for wood waste: landfill banned, incineration too expensive and already saturated, co-combustion very complicated, panel industry limited in capacity and in quality. Given the maturity of the market and the evolution of regulation (EEG), there has been no commissioning since 2008 in Germany!

Picture 8: Location of Baden-Wurttemberg



Source: www.mygeo.info



Source: www.deutschland-navigator.de

REGULATION

Germany has a specific text on the recovery of wood waste: Decree on the requirements for the recovery and disposal of wood waste of 15 August 2002. The Ordinance sets out requirements for the recovery and disposal of wood waste. The wood

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waste Management Ordinance of 2002 establishes a very thorough classification of wood waste. The Ordinance establishes the list of wood waste, according to the European classification of waste, in each class.

The wood waste Ordinance is a very thorough act, which has allowed the development of the collecting of wood waste and its valorisation 15 last years. As part of this text, a classification has been set up, which split wood waste in 4 categories, depending of the origin and quality of wood. According to the classification, different valorisations are recommended. Unlike France for example, classification is applied in a regulatory framework, and rely on the European classification of waste (European Waste Catalogue of 2002).

Table 13: German classification (wood waste ordinance, 2002)

Category All corresponds in fact at the definition of the biomass b(V) of the Industrial Emission Directive “wood waste with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood preservatives or coating and which includes, in particular, such wood waste originating from construction and demolition waste”.

Column 1		Column 2				Column 3
No.	Recovery method	Permissible waste wood categories				Special requirements
		A I	A II	A III	A IV	
1	Processing of waste wood to wood chips for the manufacture of derived timber products	Yes	Yes	(Yes)		The processing of waste wood from category A III is only permissible if varnishes and coatings have been largely removed by pretreatment or will be largely removed during processing.
2	Production of synthetic gas for further chemical use	Yes	Yes	Yes	Yes	Recycling is only permitted in installations licensed for this purpose under Article 4 of the Federal Immission Control Act.
3	Manufacture of active carbon/industrial charcoal	Yes	Yes	Yes	Yes	Recycling is only permitted in installations licensed for this purpose under Article 4 of the Federal Immission Control Act.

In France unlike Germany, ICPE regulation sets thresholds on heavy metals above which wood waste are not acknowledged as biomass (ICPE rubric 2910-B).

Since 2005, pre-treatment of municipal and industrial waste is compulsory in Germany: waste must be sorted, burnt or composted. What remains can only be landfilled if the organic matter, content does not exceed 5%. The Renewable Energy Sources Act or EEG (first text in 2000) is a series of German laws that originally provided a feed-in tariff (FIT) scheme to encourage the generation of renewable electricity.

Under the terms of the EU Renewable Energy Directive (Directive 2009/28/EC), Germany has committed to a legally binding target of sourcing 18 percent of its gross final energy consumption from renewable energy sources. The central pillar of the German renewable energy regime is the fixed feed-in tariff system (guaranteed tariff for 20 years) combined with a guaranteed right of access to the grid for renewable energy projects. Grid operators must connect renewable energy plants to their grid and remunerate generators for all the energy they feed into the grid according to the fixed FIT system.

For the biomass ordinance (31 December 2011), the wood waste is considered as follow: wood waste of categories AI and AII are full acknowledged as biomass; and wood waste of categories AIII and AIV are only acknowledged if used in a plant licenced on or before 28 June 2004.

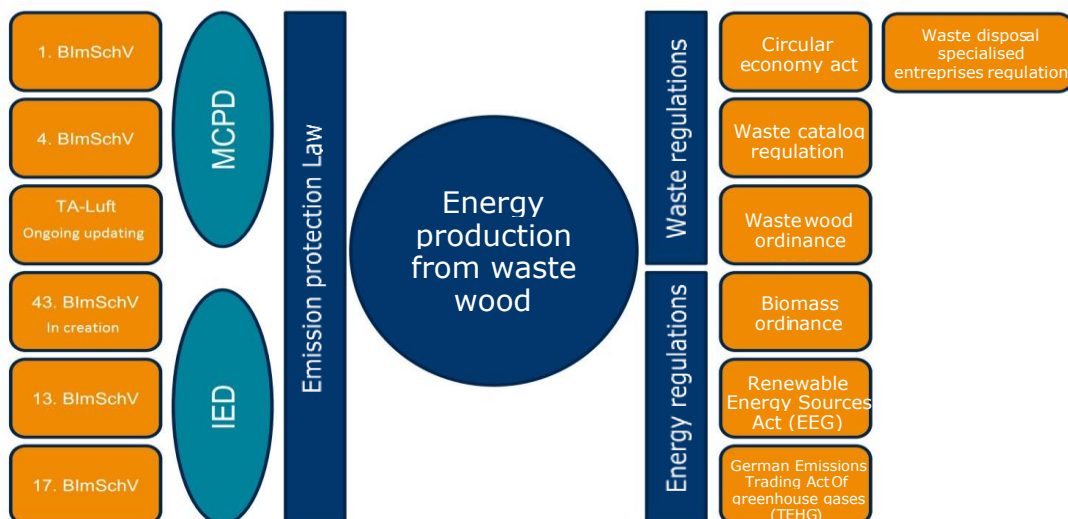
Renewable Energy Sources Act in the version as amended on 31 December 2011 restricted payment of the renewable remunerations to the wood waste categories AI and AII. In view of the limited availability of wood waste and the rapid increase in the number of power plants, a review report in 2011 on the effects of the Renewable Energy Sources Act recommended that no further incentives should be provided for the commissioning of new wood waste fired power plants².

² BAV. Waste wood recycling in Germany. English edition. 2015.



In conclusion, energy recovery from wood waste in new plants (beginning operations after 1 January 2013) is no longer eligible for remuneration under the Renewable Energy Sources Act (EEG).

Figure 17: Legal regimes to produce energy from wood (Source: STEAG)



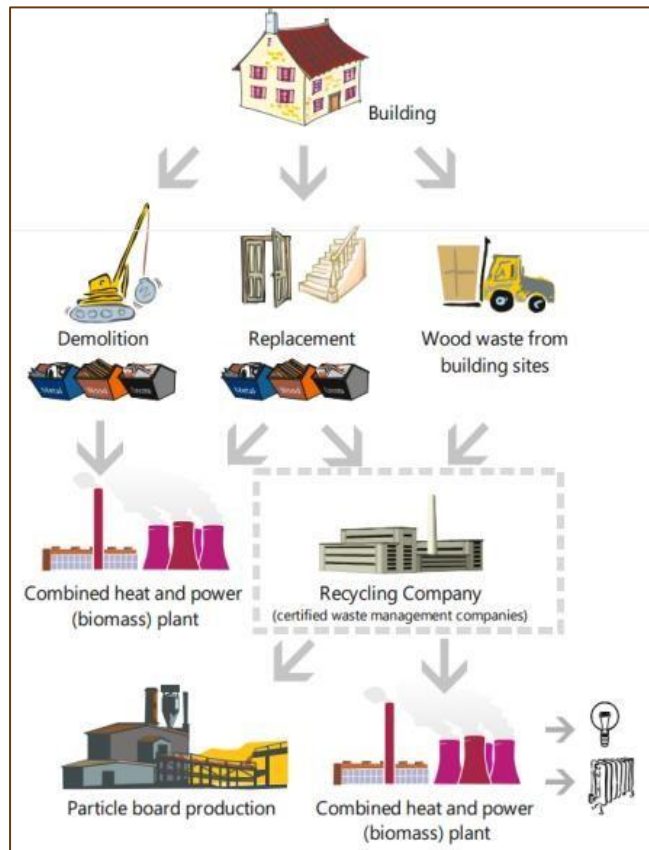
Germany continues to provide a stable regulatory framework for renewable energy projects. After the scheduled nuclear exit, renewable energies are the only choice for clean and more environmentally friendly power and a substantial and steady increase of renewable generation capacities in Germany is likely. In addition, renewable energy projects have the full political support of the German government. The established FiT system grants reliable revenues, allowing for long-term financial planning. Besides, for many years Germany has been using the RAL-GZ 428 standard for wood waste in energy recovery, which has stimulated the recycling of this waste.

Beyond the national framework, each Land applies its own policy. Sorting is the rule in Germany. Wood waste from households is collected separately in collecting point, which is used for simultaneous production of electricity and heat (cogeneration). Wood waste from companies and mainly packaging is separated at source, collected and disposed of recycling companies for material recovery (panel). Wood waste from the construction industry is collected separately. They can be directed directly to cogeneration plants or through packaging facilities, before energy recovery (cogeneration) or material recycling (panel). The intact elements (timber) have a real value and are reused in woodwork or sawmills (source COWAM).

Figure 18: Wood waste management organization in Germany (Source: DEMOWOOD)



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MARKET TREND

In Germany, general trend in 2016-2017 is the following one according to the expert Annick Gerné (STEAG):
Material recovery - up to now - relatively constant:

- Manufacture of particle board on national territory – constant, indeed decrease
- Manufacture of particle board abroad - increasing (Czech Republic, Poland, Austria) - Energy recovery - relatively constant:
- Wood-fired thermal power stations (no new constructions since 2008) ○ Wood-fired power stations (no new constructions since 2006) ○ Boiler
- Co-incineration in plants (very low)

In 2016, the fee for reception of wood waste (categories AIII and A IV) has increased. Given that the feed-in tariff will not be renewed after the end of the contract (20 years), according to government, operators of the first plants commissioned in the early 2000s will have to offset the reduction in revenues by an increase in the wood waste (> 30-35 €/t). In fact, operators in energy began to prepare wood waste producers for increased costs in the coming years... In the current state of the costs of disposing of wood waste, from 2020 only plants with heat and power production (with efficient heat valorisation) will remain financially attractive.

Regarding production, quantity on the market is up:

- Intensive sorting and separation of by-products make it possible to increase the quantities of wood waste (Sometimes also from western countries like England, Netherlands)



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- The phasing-out of power stations and the lengthening of revision durations due to the age of the power stations lead to a reduction in the consumption of wood waste.

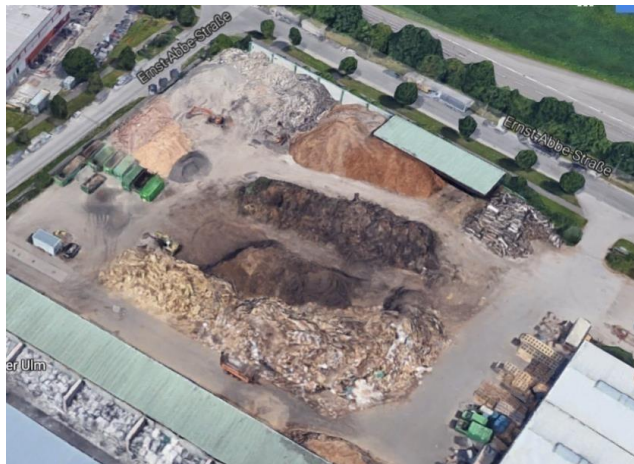
Germany is a net importer of wood waste. The greatest volumes come by far from the Netherlands with an import volume of 333 000 tons amounting to about 50 % of total imports. In contrast, the quantities exported, predominantly to the Netherlands, are very little. The reason for this high demand for wood waste in Germany the use of wood waste for electricity (and heat) production which has been promoted within the feed-in tariff system the Renewable Energy Sources Act with rather rewarding tariffs between the years 2000 and 2008. Overall the trade of wood waste mainly takes place with bordering countries what is since a long-distance transportation of wood waste is not economically feasible.

COLLECTING/SORTING/TREATMENT/SUPPLY

Several sites exist for the grouping, sorting and treatment of wood waste. BEB has a site in Karlsruhe to prepare wood waste depending of the valorisation.

Holz-recycling Ulm

The wood waste platform operated par the company HRU, at ULM, gathers and treats 20 000 tons of wood waste from categories A I to A IV are extracted from municipal collections each year (Bulky waste), from the construction industry and from other commercial sources. Depending on the quality of the recycled material, this is thermally recycled in a nearby wood-fired heating plant or fed to the material recycling of, for example, the chipboard industry both in Germany and abroad.



Picture 9: Wood waste platform Holz-recycling (HRU) – ULM (Baden-Wuerttemberg)

VALORISATION

Energy

In the region of Baden-Wuerttemberg there are 56 plants in operation for a total installed electric capacity of 178 MWel. The plants provide heat to district network (Ex: Ulm) or industrial (Ex: Koelher in Khel). Some of them are fed with waste, RDF (refuse-derived fuel), biomass included wood waste.

In ULM and Karlsruhe, about 250 000 tons of wood waste are valorised in 4 biomass plants.

EnBW Biomass GmbH, located in Karlsruhe, guarantees the supply of biomass power plants. EnBW Biomass GmbH guarantees the supply of biomass power plants in which EnBW AG is involved. In addition, EnBW supply selected external customers with biomass fuels and wood for material recycling.

EnBW is involved at 50 % in Fernwärme Ulm GmbH which manage the district heating network of ULM.

Recycling in panel industry



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According to EPF (European panel federation), Germany uses 35% of wood waste to produce particle board. The area of Baden-Württemberg has several industries which produce particle board, as well as some industrials close to the limits of the region (less than 30 km).

Table 14: Panel industry in Baden-Württemberg and nearby (CEDEN according to EPF)

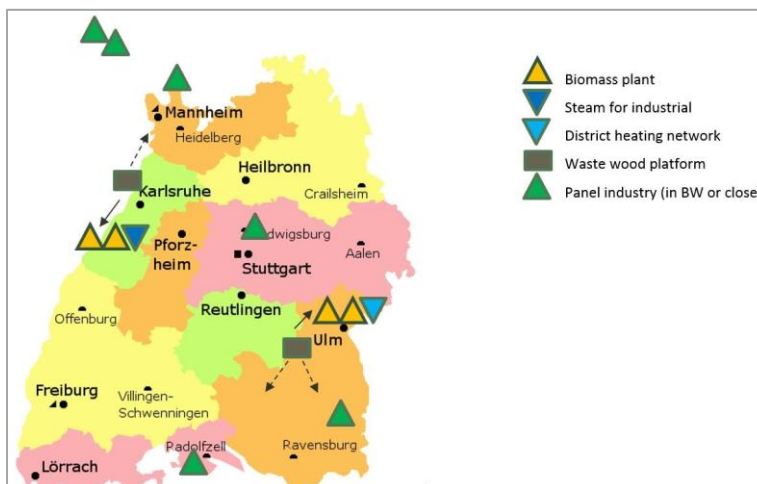
Company	Location	Region	Type of panel
ELKA	Morbach	Close to BW	Particle board
WERSALIT	Oberstenfeld	In BW	Particle board
NOLTE	Holzwerkstoff	In BW	Particle board
PFLEIDERER	Leutkirch	In BW	Particle board
HOMANIT	Losheim	Close to BW	MDF
SONAE INDUSTRIA	Eiweiler	Close to BW	MDF

The presence of these industrials allows for recycling part of the production of wood waste.

Synthesis

The following map presents, in part, the organisation of wood waste management in Baden Wurttemberg.

Figure 19: Organization of wood waste management in Baden-Wurttemberg (CEDEN)



Other

To accompany the development of valorisation of biomass and wood waste, Baden-Wurttemberg can rely in particular on:

KIT (wood wastew.kit.edu)

The Karlsruhe Institute of Technology, briefly called KIT, was created by the merger of the Forschungszentrum Karlsruhe GmbH and the University of Karlsruhe (TH) on 1 October 2009. The KIT combines the tasks of a state university Ofancial and human resources with maximum efficiency. The scientists of KIT communicate



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the contents and results of their work to society. The KIT has led works on combustion wood, gasification and biomass.

EIFER (wood.wastew.eifer.kit.edu)

More than ten years ago, EDF and the University of Karlsruhe (now: Karlsruhe Institute of Technology, KIT) decided to establish a common research institute devoted to energy and the environment in Karlsruhe, called EIFER, European Institute for Energy Research. The actions led by EIFER are presented in the following scheme (source EIFER).

Cluster portal of Baden-Wurttemberg

The region of Baden-Wurttemberg has a cluster called Cluster portal Baden-Wurttemberg (wood.wastew.clusterportal-bw.de/en/). The Karlsruhe region hosts numerous companies and research institutions operating in energy efficiency. Together they form the energy cluster. The value chain focuses on the connection between IT and the energy industry, on increasing energy efficiency, and the use of new technologies for biomass and geothermal energy production.



Picture 10: Location of case studies

The Energy Forum Karlsruhe is a strong regional cluster initiative consisting of about 75 companies and approximately 40 research and development institutions, all of them operating in the energy sector but with differing focuses. It combines the knowledge of more than 270 experts in the energy sector. Its goal is to ensure a rapid transfer of competencies and knowledge of research and development results to the companies there, to enable them to develop new products, services and markets in this field.

CASE STUDIES

We feature 3 case studies identified in Baden-Wurttemberg county:

- A wood waste sorting platform (Karlsruhe) linked to a biomass plant located in Khel
- Two biomass (wood waste) plants connected to a district heating network in Ulm
- A biomass plant located in Odenwald which prepares wood waste on-site. This plant has been visited on July 7 by CEDEN, BIOMASSE NORMANDIE and BIOCOMBUSTIBLES SAS (industrial from Normandy). At this occasion, a round table has been organised by CEDEN and STEAG.

CASE STUDY 1: SORTING PLATFORM LINKED TO A BIOMASS PLANT

The paper mill KOEHLER located in Khel has a subsidiary BEB (Biomass Energie Biomass) located at Karlsruhe and in charge of the collecting and sorting of wood waste to feed the industrial in wood chips (wood waste) for its own need of energy.

BEB, Biomass Energie Baden: collecting wood waste



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BEB, Biomass Energie Baden, located in Karlsruhe is a subsidiary of Koehler Energy Group (paper Mill located in Kehl in Baden- Wurttemberg).

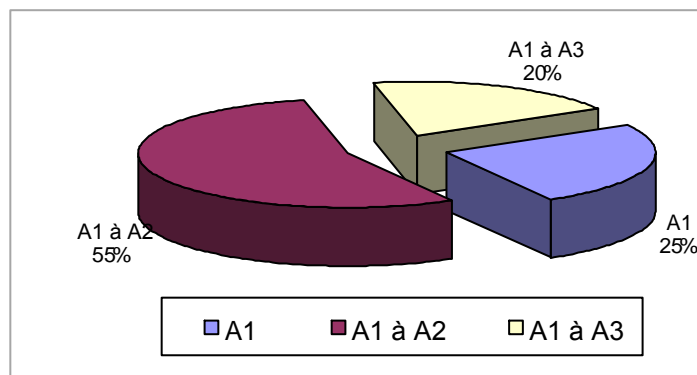
Picture 11: Wood waste platform BEB Bioenergie Baden – Karlsruhe (Baden-Wurttemberg) (Google Earth)

The main characteristics are reminded hereinafter: 2 ha, included a facility of 5 000 m², processing capacity: 200 000 t / year of wood, loading rate: 45%, i.e. 90 000 t / year of wood, 2 sorting and grinding lines: 20 t / h (operating).

Origin of wood: Collecting point, Door-to-door (bulky) collections, Transport of goods (industries), Retailers and supermarkets, Supply distance: 70 to 100 km, Operation by "batch" according to the arrivals of raw material and Dusts oriented towards cement plants.



Figure 20: Distribution of categories of wood waste



Picture 12: Organization of the

site (CEDEN)

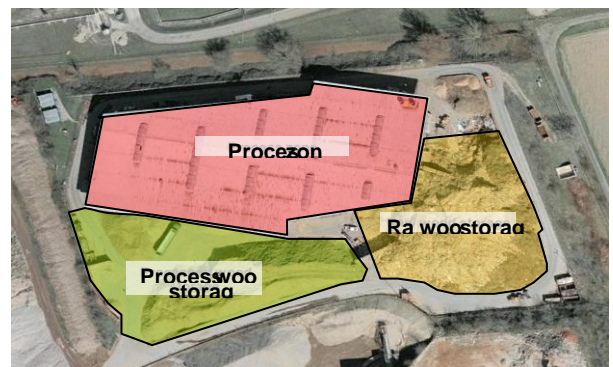
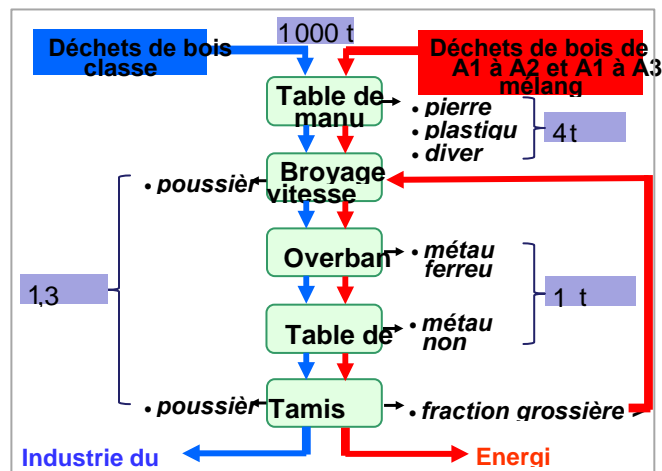


Figure 21: Mechanical and manual sorting process of wood waste (source CEDEN according to BEB)



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2 biomass plants feeding a paper mill (KOEHLER) in energy

Table 15: Characteristics of the biomass plants

	Unite 1	Unite 2
Combustion	Fluidizing bed	Grate
Fuel	Waste wood	Waste wood
Class	AI AIV	AI AII
Tonnage	110 000 t/an	40 000 t/an

B E B owns and operates two biomass heating plants fuelled with wood waste at the site in Kehl and a processing site for wood waste in Karlsruhe. The biomass combined heat and power plants produce electricity and process steam simultaneously using cogeneration technology:

- Electricity feed-in according to the Renewable Energy Sources Act (EEG)
- Supply of the paper production of the paper factory Koehler Kehl with process steam



Picture 13: The two biomass plants (to the right) and the paper mill (to the left)

CASE OF STUDY 2: BIOMASS LINKED TO A DISTRICT HEATING NETWORK AT ULM



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ULM has two biomass plants commissioned in 2004 and 2012 to replace coal. The 2 plants feed heat to a district network and produce electricity.

- BIO-khw-I (2004)

The plant burns 120 000 t of wood: 50 % of virgin wood, 45 % of wood waste class A1-A3, and 5 % of wood waste class A4. Wood is collected within a radius of 50 km.

The plant is equipped with the following procedural units. The fuel is delivered by trucks. Beginning with the receiving station consisting of 2 moving floors the fuel is conveyed in to 4 storage silos. From there the fuel arrives in the boiler area via a multi stage conveying system. The thermal part consists of grate firing system. Steam generator and flue gas cleaning. In addition to the technical equipment of the power plant as: backpressure steam turbine, water-/steam-cycle, electrical instrumentation and control system also the complete civil part. Ash and clinker are buried in old salt mines.

- The gas treatment

The main characteristics are: injection of urea into the furnace of the boiler + recycling of the secondary air, multi-cyclones, quench cooler + injection of activated charcoal and lime, and bag filters

- The heating networks

The main characteristics are: Length of 115 km, Steam 180°C -16 bars and Superheated water 110°C - 4 bars.

Picture 14: Installation and equipment (CEDEN)



- BIO-khw-II (2012)

The plant burns 60 000 t of wood: virgin wood, bark, wood waste class A1 and A2. The biomass plant owns a natural circulation steam generator and a downstream flue gas cleaning system. The biomass is premixed in the fuel storage area and fed via the fuel feed device to the feed openings of the biomass-fired plant. The proven firing system and boiler concept is specially designed for the combustion of biomass. The generously



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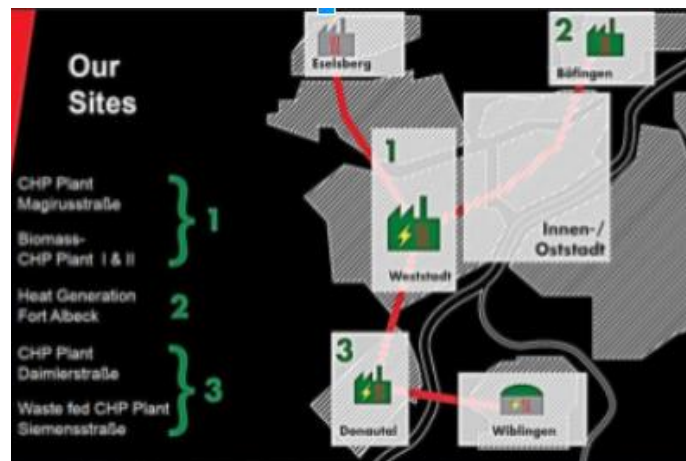
dimensioned furnace with downstream radiation pass ensures excellent burn-out of the flue gases. The grate stoker furnace is supplied with combustion air via separate primary air/secondary air systems. The steam generator taps the heat of combustion from the flue gas and produces superheated steam that supplies the steam turbine arranged downstream. In addition, heat for the district heat network is removed from the system.

Picture 15: Wood waste energy plant (Biomass plan I and II) located at ULM (Google Earth)



The district heating company of the city of ULM relies on several sources of energy, and biomass, thanks to the 2 biomass plants. The biomass, including wood waste, contributes to 57% of the fuel.

Figure 22: Scheme of the district heating of ULM (<https://dbdh.dk>)



CASE STUDY 3: BIOMASS PLANT BODENWALD

The main interest of this plant is, unlike most of other plants, the preparation of wood waste fuel onsite. Indeed, bulk wood waste are collected in an area of 70 km and brought on the plant site. Here, wood waste is processed very merely, to be burnt for production of electricity. Besides, the consortium BKO which operates the plant, includes as a shareholder a public society AWN which oversees waste collecting in the area. Thus, BKO ensures, at least in part, the wood waste supply.



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This plant has been visited on July 7 by CEDEN, BIOMASSE NORMANDIE and BIOCOMBUSTIBLES SAS (industrial from Normandy). At this occasion, a round

table has been organised by CEDEN and STEAG. The current members of BKO created in 2003 to operating the plant are:

- 88.4% STEAG New Energies GmbH
- 10.0% Abfallwirtschaftsgesellschaft of the Neckar-Odenwald-Kreises (AWN)
- 1.6% Various private investors

Picture 16: Bulk wood waste about to be prepared on the site of the power plant (CEDEN)

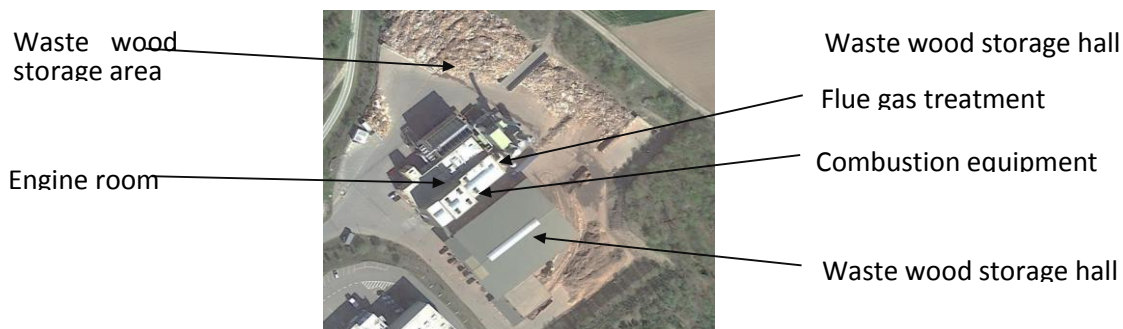


Suppliers

- Number of suppliers (2016): approximately 70 to 80 suppliers with different quantities
- Municipal wood waste: approximately 33% of wood waste is supplied by municipal enterprises (17 000-20 000 t/y)
- Contracts: approximately 60% of the suppliers have contracts, of which 60% are communal enterprises
- Capacity of suppliers (2016): approximately 60% of the total quantity is supplied by 10 suppliers with more than 1,000 t / y

The power plant has been commissioned in 2003 and cost 21 M€.

Picture 17: Site's organisation



The main characteristics of storage fuel are:

- Storage area: approx. 2.5 ha, including access roads, fire lines to be kept free, preparation area and storage area necessary for the operation of the plant, etc.
- Storage capacity: up to 30 000 m³, which corresponds to approx. 5.800 - 6.000 t
- Facilities: 2-wheel loaders and one shredder. Lindner (40 t / h)

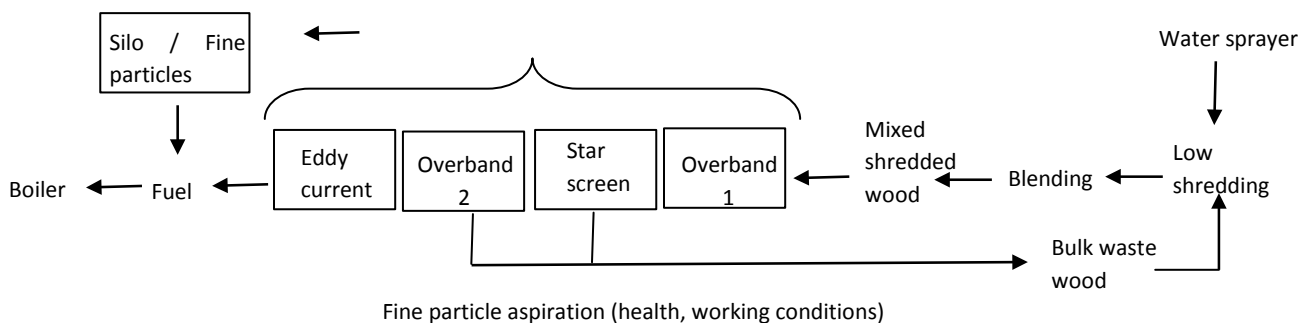


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Preparation and supply of fuel

The main characteristics are: Reception silo with 3 moving floors, Separation of impurities and foreign fractions, an overlap separator, two ferrous material separators and a non-ferrous material separator and various extensions for fire and dust protection (Confinement, aspiration, central fire detection).

Picture 18: Fuel chain preparation (photo and scheme: CEDEN)



- Combustion and fuel gas treatment: The combustion is realised in a grid boiler with 3 courses. Unlike fluidized bed, the grid allows combustion of heterogeneous fuel. The facility is equipped with SNCR (NOX treatment), a cyclone, a quench before a gas scrubber, a bag filter. Lime and active coal are injected in the quench.
- Ash: Ashes are stored in the hangar and then used in landfills (30 € / t) for bottom ash in the adjoining AWN landfill and in salt mines filling for fly ash (90 €/t).

CONCLUSION

Baden-Wurttemberg is a model region in Europe for the management of wood waste for several reasons. The German context is suitable and incentive:

Ordinance of wood waste (2002) which have given to the relevant actors a clear framework, allowing them to undertake projects with a visibility in long term.

- ✓ Landfill forbidden
- ✓ Incentive feed-in tariff
- ✓ Necessity of stop using coal and decision to stop nuclear
- ✓ Long experience of district heating network with incineration of municipal waste
- ✓ Long experience of separated collecting and recycling

The region of Baden-Wurttemberg has assets conferring it the status of model region:



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- ✓ Presence of facilities for sorting of wood waste (Karlsruhe, Ulm)
- ✓ Presence of 4 biomass plants consuming wood waste (at least 250 000 tons per year)
- ✓ The region hosts several districts heating network, included ULM
- ✓ The region hosts several industrials producers of wood panel and numerous industrials with high needs of steam
- ✓ At last, the region hosts several technical and research centres (KIT, EIFER...) which can accompany the development of the valorisation of wood waste.

5.3 LOMBARDY and EMILIA ROMAGNA (ITALY)

Lombardy and Emilia-Romagna host 14 million of inhabitants form an area considered as one of the richest regions of Europe. Quantities of wood waste reach nearly 1 million tons (4,4 million tons for the whole Italy).

Like Flanders, Italy has set up a system of green certificates and feed-in tariffs for renewable electricity, and a minimum share of renewable energy in. Since 1 January 2012, Italy has prohibited the landfilling of combustible waste with a calorific value greater than 13 MJ / kg.

Italy is one of the three European countries that started early on the road to the end of waste status for high-quality CSR. Italy has early also introduced a CSR standard: UNI 9903. wood waste is mainly used in the panel industry in Italy (89% according to WKI) thanks in particular to an organisation for the optimized collection of wood waste.



Picture 19: Location of Lombardy and Emilia-Romagna in Italy

COLLECTING IN ITALY

Wood packaging marketed in Italy in 2015 amounts to 2 billion 672 thousand tons. Of these, over 1 million 715 thousand tons were recovered and recycled, the equivalent of 64% of the material on the market. Recycled wood is transformed into chipboard and semi-finished wood products for the furniture industry: the data comes from Rilegno, the Italian consortium in charge of the collection, recovery and recycling of wooden packaging.

Rilegno is the Italian National Consortium for the Recycling of Wood Packaging, and it is the body in charge of collection of wood packaging and also other types of wood waste. This way of collecting is unique in Europe. Rilegno collects wood waste both from sorted waste collection operated by municipal waste management companies, and from private operators collecting the wood from industries and large stores. The members of the consortium are companies producing waste packaging, the raw material providers, importers, and the local operators of wood waste recycling.



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Companies that utilize wood packaging, waste management companies, local administrations, and private collectors deliver their waste by the waste collection platforms of the consortium, which in turn guarantee the sorting and the recovery of the waste. The waste is then sent to the recycling industries, to be cleaned and ground in small particles, thus becoming a new raw material for industrial use.

The collection system is quite complex and requires substantial funding. Every year the consortium invests about €20 million: €2 million are dedicated to waste sorting, €8 million to the financial support for recycling platforms, and over €10 million to the transportation of the material to recycling plants, which are mostly located in northern Italy. This way, Rilegno provides a wood waste collection and recovery service for 4,272 Italian municipalities, covering 38.5 million of inhabitants, 65% of the national population. Such a widespread coverage is made possible by 700 conventions signed with private operators, municipalities, town congregations and environmental managers.

In addition to guaranteeing the recycling of commercial wood waste (pallets, fruit and vegetable crates, industrial boxes and cages), Rilegno also takes care of household wood waste thanks to an agreement with Anci (the National Association of Italian Municipalities). Rilegno was established by the legislative decree 22/97 and is regulated by the Unified Environmental Bill 152/2006 with subsequent modifications. Its role is to organize and carry out the recycling and recovery of wood packaging and other kinds of wood waste (such as doors, window frames, furniture, etc.) from the urban environment.

In 2016 RILEGNO has recycled more than 1,627,000 tons of wood waste and the amount is growing, together with the growth of primary packaging which is expected to increase by 3.5% in 2018. As of today, 63% of all waste wood packaging is collected and reused by the recycling process.

COLLECTING/SORTING/TREATMENT/SUPPLY

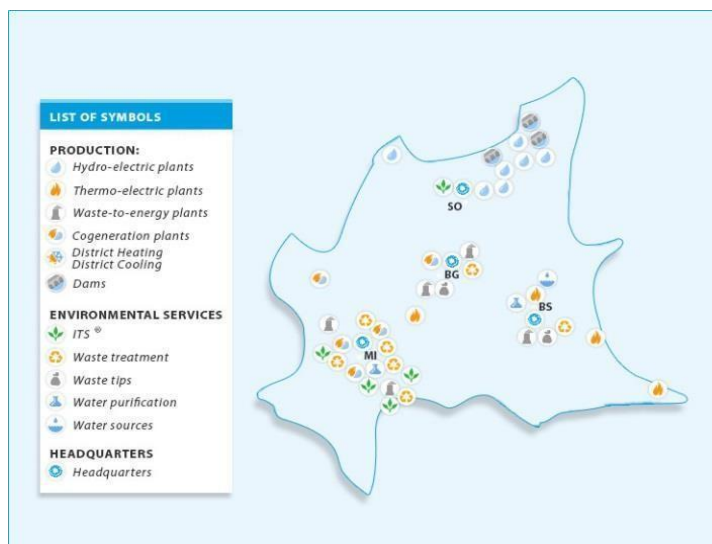
The collecting of wood waste is mainly taken over by RILEGNO, but other entities exist, and in particular ECOLEGNO, in Northern Italy, which collects wood waste for the industrial MAURO SAVIOLA (panel production).

VALORISATION

- Energy

There is no waste to energy plant dedicated for wood waste identified in Northern Italy, according to our research. The plants which produce renewable energy are supplied with biomass, municipal waste or refuse derive fuel (RDF) from municipal waste or industrials.

Picture 20: Location of plants for energy production in Lombardy



- Panel industry

Wood waste is valorised in panel industry, very present in Northern Italy and in particular in Lombardy and Emily Romagne. The panel industry in Italy is the one in Europe which use the part the most important of wood waste in the production of the panel. Some plants use 100% of recycled wood in their process. It is hence an opportunity for valorising wood waste locally.



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The main industrials involved in wood panel production identified in the two regions or nearby are:

- MAURO SAVIOLA (recovery wood) / ECOLEGNO for the collection of wood waste (FRATI LUIGI (recovery wood) / VALORI for the collection of wood waste (4 platforms)
- GRUPPO TROMBINI (recovery wood)
- SAIB (recovery wood)
- INVERNIZZI (100 % poplar hence no wood waste)
- XYLOPAN (100 % poplar hence no wood waste)

The two last industrials currently use only virgin wood.

- Lombardy Energy Cluster / Platform Energy Cluster- <http://ple.energycluster.it/home>

ENERGY CLUSTER is a production system to the energy service, the only officially recognized by the Lombardy Region, which is based on deep-rooted traditions and skills throughout the territory. The cluster aims to develop research, innovation and training thanks to the presence, together with enterprises, business associations, universities, knowledge and research centres, specialized institutions, public administration.

- ASSOPANNELLI (Milan)

It is the National Association of the panel maker and in semi-finished wood. Group 100 companies operating into 4 product groups: panels chipboard, MDF, OSB, plywood, blockboard, semi-finished products for industry of furniture. Assopannelli is member of FEDERLEGNO-ARREDO

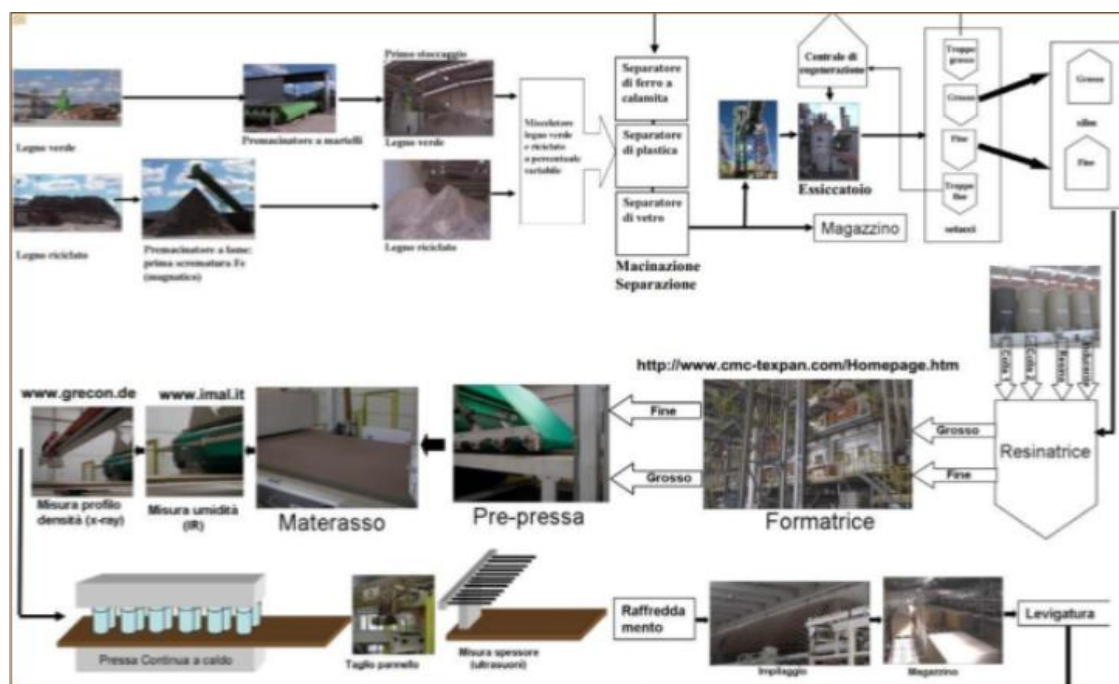
- CMC-TEXPAN (Lombardy) - <http://cmc-texpan.com/>

CMC TEXPAN offers a wide array of forming systems, designed for the production of panels with high performance mechanical properties and very fine surface layers, suitable for melamine paper coating or even for direct lacquering.

Figure 23 : Example of a panel production chain based in wood waste (source TEXPAN)



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SUPPORTS IN ITALY

- IMAL-PAL- <http://wood.wastew.imalpal.com>

The group has a long experience in wood particle preparation, gluing and resination, on-line quality controls, process controls, board handling and in particular for its continual innovation. The group has spent the last few years developing and investing in forming and continuous press technology to complete its range of products and to become a reliable and competitive partner for the supply of complete lines for the production of PB, MDF, OSB, insulation board, pellets and pallet blocks. The systems and equipment of the IMAL- PAL group may be found in virtually every PB, MDF and OSB production plant around the world.

- COSMOB- <http://wood.wastew.cosmob.it>

COSMOB is a specialized centre for the timber industry - furniture, which supports companies in the supply chain in their processes to developing competitiveness, providing technological solutions and services in the fields of quality, research and innovation, design, specialized training. COSMOB is involved in a European project called ECAMOB (Enhancing the cascade use of wood by integrating an intensified mobilisation of forest resources)

CASE STUDIES

ECOLEGNO ET GRUPPO SAVIOLA: 100 % OF wood waste IN PANEL BOARD

- Collecting

Mauro Saviola Group collects and processes 1.5 million tons of post-consumer wood material per year: it is the first operator on the Italian market to develop the recycling of wood. There are two major factors:

- The collaboration with municipalities and local municipal utilities. Service of collection of postconsumer wood Group is based on collaboration with more than 1000 municipalities. An



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organized and widespread system able to satisfy the different requirements of producers of wood waste.

- The network of collection centres Ecolegno. A network of platforms located close to the major urban centres, aimed at obtaining a more significant recovery of wood waste. Each collection centre is equipped with means with spider and containers to be left on deposit at the company.

Centres are mainly located in Northern Italy, and in Lombardy and Emily-Romagna.

Table 15: Location of platforms/centres ECOLEGNO



The Saviola Group is the only one to use 100% recycled wood on the entire range of particle board. Every year SAVIOLA turns 1.5 million tons of recycled wood.

Not all the wood waste can become Panel: the raw material is carefully selected and only wood that has certain health characteristics is accepted. It is used wood from: Wood construction and building demolition, Pallets, Chips, Old Furniture, Packaging, Processing residues and Fruit boxes.

Wood incoming undergoes rigorous qualitative controls, distinguishing also the basis of origin (foreign or domestic). This is to ensure supplies by chemical and physical requirements framed in accordance with the highest safety standards.

- **Transformation of wood waste in both panel and energy**

The transformation technologies of the Mauro Saviola Group can treat all the collected wood waste (packaging, processing scraps, broken furniture, construction shipbuilding material, etc.).

Once undergone all the qualitative verification, the material is subject to a careful selection process and cleaning, which separates the wood from any other foreign material. The first step is therefore to separate everything that inevitably ends up in the waste collection along with the wood: from the sand of the construction site to the nails which end up in the bin.

This technology is a real "factory in the factory", an entire industrial process - purely mechanical - dedicated to the cleaning material. The "traps", in fact, allow separating everything that is not wood, without using chemical solvents or reagents of any kind: the tub to sink inert materials, such as stones, the magnets to attract the iron, the centrifuges that operating a gravity separation, etc. Even the materials other than wood are destined for recycling. All production waste (iron, plastic, paper, aluminium, glass, present in the incoming wood), once separated, are then forwarded to the companies that recycle them. Recycling of iron reaches up to 20 000 tons per year.

- **Auto-Power**



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The woody part not exploitable derived from screening and cleaning of the material is burned to power the processes. But only wood that cannot be recycled - and only that - is reused as biomass for selfsupply. It thus produces electrical and thermal energy to be used in the production cycle, so as to drastically reduce the consumption of fossil fuels. The emissions from combustion are regulated by electrostatic filters capable of capturing dust and organic substances with a very high efficiency.

CONCLUSION

Lombardy / Emily-Romagna is a model region in Europe for the management of wood waste for several reasons:

- ✓ The Italian context is suitable and incentive
- ✓ Landfill restriction
- ✓ Green certificates
- ✓ Specific collecting of wood waste (Rilegno but also private companies as ECOLEGNO or VALORI)
- ✓ Wood panel industry with the higher rate of recycled woods for production of panel in Europe
- ✓ The region of Lombardy / Emily-Romagna has assets conferring it the status of model region:
- ✓ Presence of numerous centres for collecting wood waste
- ✓ The region hosts several panel industrials of which at least 3 currently use recycled wood
- ✓ Besides, the region hosts several associations, clusters and industrials (Assopannelli, Lombardy Energy Cluster, Texpan) which can accompany the development of the valorisation of wood waste.

5.4 NORTH-WEST ENGLAND (UNITED KINGDOM)

Around 4.3 million t of timber waste (not including "green waste") is annually generated in the UK. This wood waste comes from several different sources including:

- Construction

wood waste from all sorts of building sites – including new builds and refurbishments – amounts to around 0.85mt per year (2010). Most wood waste on these sites end up in the skip along with all the other rubbish. The size of skips used typically range from 6 cubic yards (yd3) up to 40 yd3 (called "rolonofs"), but the most common size used is 8 yd3. The big challenge with construction wood waste is that it is very variable. It consists of all sorts of different wood-type waste, including off-cuts of solid wood, broken pallets, bits of laminated chipboard, plywood, MDF and preservative-treated off-cuts. This makes construction wood waste harder to recycle conventionally, because in general these different kinds of wood wastes must be recycled differently. However, this also creates a perfect opportunity for Community Wood Recycling, because our small scale, people-driven approach allows us to hand-sort wood and find the best use for each piece.

- Demolition

Each year, demolition also generates around 1mt (2010) of wood waste. The price of demolishing a building is usually heavily influenced by the value of the materials that can be salvaged.

In terms of recycling wood, their working practices are dictated by issues around speed and H&S. Previously, workers would have been happy to clamber up dangerous heights to cut down floor joists with a chainsaw, but nowadays it is very likely that a building will simply be taken down by large excavators with demolition claws and the material loaded straight into rolonofs for sorting at a waste transfer station. The result is that



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less wood is saved; because it is not viable to hand sort it from the other demolished material. Like construction industry wood waste, it is of poor quality because it consists of so many different types of wood – and it will probably be mixed with plasterboard, plaster laths or other contamination.

- **Wood processing and manufacturing**

This includes wood waste from timber mills, joinery shops and from fencing, furniture and other wood products manufacture and is estimated to total around 0.4 Mt (2010) per year.

Such businesses generating relatively small volumes of wood waste will usually have little trouble in finding people to take it away for firewood in winter and will use skips to dispose of the rest. Because this wood waste is relatively clean and unmixed, it is much easier to recycle than construction or demolition wood. Some of the larger businesses producing this kind of wood waste reduce their disposal costs by having their own wood-fired heating systems. Often, any sawdust or shavings generated from untreated wood will end up at a local farm to be used as low-quality cattle bedding. Increasingly, sawdust is seeing use recycled as ‘heat logs’ – compressed sawdust briquettes that burn hotter than logs and leave very little ash.

- **Pallets and wooden packaging**

This amounts to around 1mt (2010) per year and include packaging waste – such as crates, boxes and cable reels and a large proportion of the estimated 56 million (2009) pallets in the UK that are broken or just can’t be reused. Pallets are the easiest – and therefore cheapest – of all wood waste to recycle. They are usually ‘clean’ (untreated) and easy to handle (they can be loaded/unloaded by forklift), so every wood recycling company wants them and increasingly accepts them for free.

Regulations were introduced in 1998 to force companies that generate more than a certain amount of this wood waste to recycle a proportion of it. If a company can’t do this themselves, they are obliged to buy PRN’s (packaging recovery notes). These PRN’s are issued by the government to the end users of wood waste (such as the chipboard or biomass fuel industry) based on how much wood waste they recycle; they in turn sell them on to obligated companies.

• **Municipal wood waste**

At around 1mt, this includes all the wood in the domestic waste stream that ends up at local tips (household waste recycling centres) where it is either mixed with the general rubbish and taken to landfill/incineration or separated into containers and taken to a wood recycler. Very little re-usable material comes from this waste stream. It consists of items like broken furniture, old kitchen units, old fencing materials and bits of shed, much of which is preservative-treated or painted. Consequently, it is the lowest quality of all the different wood wastes.

In 1992, less than 2% of all wood waste was recycled, but about 20 years ago technical developments in the chipboard industry meant that manufacturers could use a proportion of recycled wood in the ingredients for new chipboard (previously, it was made just from virgin timber). That stimulated the market for recycled woodchip and that’s when wood recycling pretty much began in the UK. Since that time other applications for woodchip have been developed.

For ease of understanding, we divide the wood recycling industry into 2 parts; high-volume wood recyclers (that simply chip all the wood they get) and community (low-volume) wood recyclers like us that focus on reuse.



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The Wood Recyclers Association, a trade body made up of most of these high-volume wood recyclers, estimates that in 2011 around 2.8mt (or 60%) of all wood waste generated in the UK was recycled. To help find the most appropriate use for the recycled wood and provide guidance to those wanting to dispose of it, the WRA divides wood waste that comes into their yards into several grades; with each grade usually subject to a different gate fee:

- **Grade A:** “Clean” recycled wood – material produced from pallets and secondary manufacture etc and suitable for producing animal bedding and mulches.
- **Grade B:** Industrial feedstock grade – including grade A but mixed with construction and demolition waste; this is suitable for making panel board.
- **Grade C:** Fuel grade – this is made from all the above material plus that from municipal collections and civic amenity sites and can be used for biomass fuel.
- **Grade D:** Hazardous waste – this includes all grades of wood including treated material such as fencing and track-work and requires disposal at special facilities.

However, many operators simply define wood waste as ‘clean’, ‘dirty’ – or mixed. The woodchip produced is largely used in the following ways:

- **Chipboard and MDF**

Around 38% (c.1.1mt, 2010) of all recycled wood is used in the manufacture of particleboard. There are five chipboard factories in the UK, located in Devon, North Wales, Merseyside, Northumberland and Ayrshire in Scotland. The industry still uses imported and home-grown virgin timber but absorbs more recycled woodchip than any other application.

To maintain the purity and consistency of their product and ensure that the (high tech and very expensive) manufacturing process is reliable, they want the cleanest, most uniform feedstock.

Hardwood, preservative-treated or painted timber, laminated boards, MDF or more than the smallest quantity of chipboard cannot be used to make new chipboard. And of course, the chip must be free from other contaminants, such as metal, grit, glass, plastic, or plasterboard.

- **Wood as energy**

Trees absorb carbon dioxide whilst they grow, so burning wood for energy is considered ‘carbon neutral’. In 2010 around 0.55 Mt (c. 19%) was consumed in this way, the majority in power stations to generate electricity. For example, Slough and Drax (N Yorkshire) power stations are coal-fired but have had some of their boilers converted to accept wood and they burn more than 100,000 t a year of recycled woodchip.

Over the last few years, wood fired power stations have come on stream in south Wales, on Teeside and in Lockerbie, Scotland. Because of a government incentive scheme (called Renewable Obligation certificates) that offer financial incentives to generators to use biomass to produce ‘sustainable’ energy, more and more power stations are being commissioned to use this feedstock. In fact, the industry predicts that once all the planned biomass facilities fire up, there will not be enough wood waste to supply them.

In addition to electricity generation, there are a growing number of schools, public, industrial and commercial buildings – and even homes – that have installed woodchip or wood pellet heating systems. As the cost of fossil fuels continues to climb, and environmental laws get tougher (and taxes higher), it is expected that using wood to heat buildings will become ever more popular.



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The new power stations will be equipped with 'scrubbers' that can remove potential pollutants before they are released into the atmosphere, so they can burn a wider range of chip, including chipboard (that contains formaldehyde glue), painted wood – and even preservative-treated timber. The older power stations and smaller wood-fired boilers are not fitted with such equipment, so they should only be burning chips made from clean wood (although some contamination does get through).

Because of these technical limitations and insufficient demand at home, an increasing amount of low-grade chip is now being exported overseas where wood-burning power stations are equipped with superior combustion and pollution control technology. This has led to a rapid increase in demand and a fall in the gate fees charged by wood chipping firms.

- **Animal bedding**

This ranges from low grade, coarse woodchip for cattle stalls to very high-quality dust-free chips suitable for sensitive, very expensive racehorses.

Bedding should be made only from clean softwood chips. So, the best feedstock is pallets and packaging waste.

It should not contain sheet materials or painted/treated timber – as these could poison animals if ingested. In 2010 0.5mt (17%) of recycled wood was used for bedding.

- **Mulches, compost and coverings**

Around (5%) 0.15mt of recycled woodchip is used as garden and landscaping mulch. Used to suppress weeds and help the soil retain moisture, it is drier and therefore does not rot down as quickly as mulches made from tree bark or virgin woodchip. Coloured mulches are also becoming popular.

Woodchip is also added to green waste compost. A plant's leaves contain mostly nitrogen, whereas wood is mainly carbon. Adding woodchip improves the carbon/nitrogen balance – essential for good compost. Much of this compost is relatively low quality and is used as 'soil improver' on farmland. Woodchip is used for paths and tracks on farmland and in countryside car parks, and the lowest grade chip is used as a cover for landfill sites. Wood recyclers will probably make mulches using the lowest quality of wood waste they can get away with, and mulches invariably contain at least a small amount of sheet materials, painted and preservative-treated wood.

- **Paths, rides and arenas**

Woodchip can be used for forest paths and rides and for horse gallops and arenas. The chip does not have to be so clean and can contain preservative-treated wood (which is an advantage because it does not break down so quickly) and small amounts of sheet materials. It must be free from metal, glass or grit – which could be dangerous to horse and rider. In 2010 0.092mt (3%) of woodchip was used in this way.

- **Exports**



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THE CHALLENGES OF WOOD RECYCLING

In 2010 estimates, 0.54mt (18%) of woodchip were exported abroad, mainly for use as fuel

High volume wood recycling is expensive; a new chipper can cost anything between £120,000 and £250,000. Then, to take out the ferrous (screws, nails, bolts etc.) and non-ferrous metal (hinges, door furniture etc.) expensive magnets and eddy-current separators will be needed, along with a screen to 'size' the woodchip correctly for each of the above uses. Obtaining suitable premises, licensing, additional equipment, insurances and other costs mean that wood recycling is a capital-intensive business.

As the chipboard, wood-for-fuel, and most bedding markets only pay around £40–£80 per tonne for woodchip, to make their businesses pay wood recyclers need to process huge quantities of wood waste. To get these volumes and to keep costs as low as possible, they focus on servicing organisations that are high-volume generators of wood waste such as skip and pallet companies, distribution companies and large furniture or wood products manufacturers. They don't really want lots of small loads arriving in builders' skips, so they don't usually service the building industry directly, so they aren't in direct competition with us community wood recyclers.

Rather than going direct to a wood recycler, the relatively small skip loads from building sites are far more likely to be taken to a waste transfer station. The traditional wood recycling industry as described above makes a fantastic contribution to waste reduction by recycling huge quantities of wood waste that might have been landfilled. However, Community Wood Recycling believes that this precious resource should be cherished and reused for as long as possible before ending its life as woodchip, so we work hard to ensure that any wood which is still suitable for use goes back to the community. Community wood recycling complements high volume wood recyclers by providing organisations that generate relatively low volumes of wood waste an environmentally and socially superior way of dealing with their waste.

UK REGULATION FOR WOOD WASTE MANAGEMENT

- Environment Agency Permit required up to 50,000 t p/a (Exempt from Waste Management License)
- Reducing within 3 years to 25,000 t (under review)
- Waste Management License will be required for volume
- The UK environmental legislation 1990 'Duty of Care Regulations'
- UK Waste Packaging Regulations 1997
- PPC Regs 2002
- EWC Jan 2002
- WID 2004
- Hazardous Waste Regs July 2004
- Call for evidence 2013

REGIONAL CONTEXT (NORTH WEST ENGLAND)

Picture 21: Location of North West England (in red) in the Great Britain & Ireland map



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For waste and recycled wood to make a significant contribution to biomass energy in the North West its availability, suitability and the barriers associated with it must be evaluated. There is a large amount of confusion over using wood waste for biomass such as which materials are classed as wood waste, which categories of waste can be used for fuel and the legislation which applies to wood waste. 9 Defra 2007. Waste Strategy for England 10 Waste Reduction and Recycling Ltd, 2007. 11 Defra 2008. Wood waste as a Biomass fuel 12 JBT Waste Services 2008. 5 The following work has previously been carried out to help to provide more detailed information on wood waste:

‘Waste Protocols Project’ – Environment Agency, October 2007

The project tried to develop a Quality Protocol to help define the regulation on ‘waste’ wood and help remove the confusion over using wood waste as a resource. A Quality Protocol could not be established due to fact that there was too much variation in the standards of wood recovery and the quality of wood waste varied too much.

‘Wood waste as a Biomass Fuel’ – DEFRA, April 2008

This report was written in response to the Government’s ‘Waste Strategy’ report in 2007 where wood waste was identified as a priority material for the recovery of energy. The report provides information to help progress the development of wood waste as a resource.

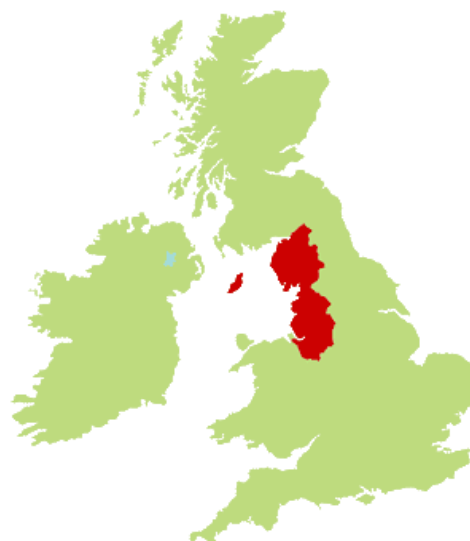
‘UK Biomass Strategy’ – DEFRA, May 2007

This is a strategy written by the government in response to the ‘2005 Biomass Task Force Report’ to try and bring together current UK Government Biomass policies for energy, transport and industry.

CASE STUDIES

Picture 22: Some of the products manufactured by Touch Wood

Emerge is network of wood recycling social enterprises providing an efficient and cost-effective collection service for all types of wood waste from all sorts of building sites. Touch wood is part of the Emerge 3R charity and it is operated by Emerge Recycling. This initiative started in April 2013 as a member of the National



Wood being brought back to our yard to be sorted for resale and reuse



Large herb box: High level planters



Scaffold board farm shop display unit



Garden picnic bench



This project has received funding from the European Union under the Erasmus+ programme.

Community Wood Recycling Project (NCWRP).

The wood is brought back to their depot in Manchester, where then it is sorted and divided between stock for sale and stock for the workshop. The team produces very high standard products for sale to the public. The following map shows the main areas covered by Touch Wood: primary the Greater Manchester area (orange) but also the surroundings to a lesser extent (green).

They collect all types of waste timber, wood composites, furniture, wooden items (regardless of type, condition or contamination — except creosoted). Nails, screws, door furniture, fixings, pallet fastenings and other metal contamination pose no problem. They also take other potentially reusable material, such as ducting, insulation and spare fixings.

Normal collection hours are between 9am and 5pm — although earlier/later collections can be arranged. Around 90% of our collections are carried out within 48 hours of notification. There is currently no minimum charge, but to make it environmentally and financially cost-effective they try to collect full loads.

To help fulfil your environmental obligations, Site Waste Management Plans and inform staff, customers and shareholders, we provide monthly analysis of the timber collected from your site. They also keep informed their suppliers, through a Site Reuse and Recycling Summary outlining what has happened to the actual wood collected.

HADFIELD

Hadfield Wood Recyclers is one of the largest and oldest wood recyclers in the UK, with more than 35 years in the industry. It handles wood waste for many national and international waste management companies, local authorities and other public-sector bodies as well as businesses from all industries, including construction, waste and retail. The company recovers around 250,000 t of wood waste in total a year, recycling it into a range of products including animal bedding, arena and play surfaces, panel board feedstock, as well as biomass wood chip. Approximately 35,000 t of that wood waste collected comes from a network of 20 household waste recycling centres (HWRCs) around Greater Manchester operated by Viridor.

Hadfield, which also has sites in Middlesbrough and Essex, has held the contract since 2004, when it initially signed five years deal to process around 7,000 t of wood an agreement that was renewed in 2009 when Hadfield signed on for an addition five years.

Vicki Hughes, group business development director for Hadfield Wood Recyclers, said: " We have been working with Viridor and its predecessor for a number of years now and have seen a huge increase in the amount of wood waste being diverted from landfill and sent to us for recycling. We have done a lot of training on their sites to educate operatives as to what wood waste materials can be recycled and this has contributed to the growth, along with a general increase in recycling awareness overall."

Patrick Kileen, operations manager at Viridor, added: "As part of the Greater Manchester Recycling and Waste Management contract with the Greater Manchester Waste Disposal Authority we are aiming to achieve a recycling rate of 50% and will be diverting at least 75% of waste away from landfill, by 2015. Hadfield has played a key part in assisting us meet this target and we look forward to further developing this relationship in the future."



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BARTON CH PLANT

The Barton CHP plant is part of the UK project initiative to increase biomass energy plants which count recovered wood among their feedstock. The UK currently has in operation about seven biomass energy plants, but based on their best estimation, there could be as many as 23 by 2019, representing a massive 2.5 million t increase in wood waste capacity.

Picture 23: Map of operational and planned biomass plants for the UK
(WOOD RECYCLING Spring/Summer 2016)



The plant will be designed to have an operational life of at least 25 years and will provide equivalent renewable energy for more than one-third of the homes in Trafford. It is planned that the plant will also provide low carbon heat via a district heating network to the local vicinity further improving the efficiency of the plant and delivering a competitive alternative or complement to conventional fossil fuel sources of heating.

The plant will deploy the latest technology and will be fuelled primarily by recycled wood. It is proposed that a small element of solid recovered fuel is also utilised to maintain fuel flexibility. The biomass element of the fuel would exceed 90%. About 200,000 t of biomass would be consumed annually.



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Picture 24: Digital view of the Barton plant project

Following a Public Inquiry into the proposal and a further hearing in the high court, the project received planning consent in April 2014. The proposed combined heat and power plant site occupies an area of vacant land on the south side of the Manchester Ship Canal. The United Utilities Davyhulme Wastewater Treatment Works is located west and south of the site and Barton High Level Bridge is located to the east. Land on the opposite side of the canal has been developed with the Salford Community Stadium hosting the Salford Red

Devils rugby league matches. Port Salford has also been granted consent on land to the north of the proposed site.

Picture 25: Location of the Barton plant close by the Manchester Ship canal



Access to the site is taken from the end of Trafford Way to the rear of the Trafford Soccer Dome.

Figure 24 shows the Gantt Chart with the following steps for the project:

Figure 24: Gantt Chart of the Barton CHP project



THE BENEFITS

Energy for homes and businesses: The plant will be designed to have an operational life of at least 25 years and would provide the equivalent renewable electricity to meet the average needs of up to 37,000 homes. As well as generating electricity, it is planned that the plant will supply renewable heat via a district heating network to industry and business. As has been demonstrated elsewhere in the UK, this technology provides energy security and sustainability that can often lead to attracting inward investment and development in the



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area, which can ultimately lead to job security and creation and improve the local economy. This will reduce the amount of energy otherwise required to heat premises in nearby locations that would ordinarily burn fossil fuels for heat generation.

Community and local benefits: The c.£70m investment also offers potential contract opportunities for local businesses during construction and operational phases. It is expected that over 100 construction jobs would be created during the two-year construction period and 15 permanent operational posts would be available. Ongoing supply and maintenance work would also be required at the plant.

The 20MW development would make a significant contribution towards helping the UK meet its national renewable energy targets.

CONCLUSION

North West England in the UK is a model region because:

- ✓ It disposes of significant volumes of timber and wood waste
- ✓ Regulations are in place for the utilization of wood waste based on its grade (e.g. Renewable Obligation)
- ✓ Some of the largest and most ancient wood waste recycling plants are located in this area (Harfield)
- ✓ North West England has examples and case studies of industrial initiatives for use of wood waste both for biomaterials (small volumes, high value) and energy (large volumes, lower value)

We should take into consideration that:

- Regulatory framework still evolving, to fill some of the gaps that are still present
- By 2019 the biomass power plants will increase (+2,5 Mt planned), leading to a better wood waste management in the region.

5.5 VORARLBERG (AUSTRIA)

The overall framework conditions for waste management are defined in the Austrian Waste Management Law from 2002 (WML 2002). Based on the WML 2002, several ordinances have been issued since. The most relevant ordinances in terms of wood waste are the amendment of the landfill ordinance in 2004 (which disallows the disposal of waste with more than 5 % (weight) organic carbon), the recycling wood ordinance from 2012 (which defines the framework conditions for the reuse of wood waste) and the waste incineration ordinance from 2010.

The ban of waste with an organic carbon content > 5 % (weight) from landfilling implies that all wood waste has to be either reused/recycled or, if a reuse/recycling is not possible or too expensive, burned in designated heating or combined heat and power plants. Since the commencement of the landfill ordinance, the amount of landfilled waste decreased significantly while the recycling ratio of organic waste increased dramatically.

The recycling wood ordinance was prepared with the aim to increase the recycling rate of wood waste (i.e. to increase the share of wood waste that is reused in new products). The ordinance sets limits for harmful substances



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in the wood waste. Wood waste that exceeds any of the limits must not be reused. Wood waste that is eligible for recycling can be used in the panel industry and similar industrial branches. The ordinance promotes high efforts in wood waste sorting and treatment, since the maximum share of wood waste that can be recycled in a product increases with increasing quality (e.g. decreasing contents of harmful substances). Wood waste with halogenated organic compounds or wood preservatives is excluded from the use in new products.

The waste incineration ordinance defines the framework conditions for waste incineration plants, including wood waste combustion plants. Besides emission limits the ordinance also includes regulations for process parameters such as combustion temperatures and residence time of the flue gas. The WIO is based on the respective EU directives (2000/76/EG and 2010/75/EU).

The Austrian Waste Management System is divided into two areas of responsibility. Municipal waste and waste from commercial operations that is similar to municipal waste is managed by the nine Austrian provinces while waste from commercial operations and municipal businesses with other than typical municipal waste streams (e.g. water treatment plants) is managed at federal level.

For municipal waste, two different systems are established. A collection system is used for household waste, packaging waste, bio waste, glass waste, small metal waste (cans and similar items) and cardboard and paper waste while a bring-it-yourself system is used for large metal waste, hazardous waste (oil residues, solvents, paint etc.) and bulky waste (e.g. furniture, construction material etc.), which can be handed over at designated waste collection centres (usually, cardboard and paper waste, packaging waste, small metal waste, glass waste and bio waste can also be handed over at these centres). Wood waste from municipal sources is usually part of the bulky or construction waste stream. The wood waste is sorted into different categories (untreated wood, treated wood) and handed on to designated wood waste treatment facilities.

Regarding non-municipal waste, each commercial operation or municipal business is legally obligated to register all waste streams (with the respective waste code and the annual amount generated) in a national data management system (EDM). In addition, all industrial or municipal operations that collect, treat, reuse/recycle or burn waste have to register the respective waste streams that are handled within their operations. This way, the complete path of each waste stream from source via collection/treatment to final use or disposal can be followed. However, data is not always entered correctly or even missing so especially data regarding the final use of the waste is not always available or clear.

The current state of the Austrian waste management system is evaluated in form of a federal waste management plan, which is issued every five to six years. The document includes waste statistics, sets mid-term targets for waste prevention, collection, treatment and recycling ratios and provides strategies to reach these targets. The actual federal waste management plan was released in a preliminary form in early 2017. The final form is expected to be issued in the second half of 2017. According to the WMP, the annual amount of wood waste generated in Austria is about 1,130,000 tons in 2015. This number does not include wood residues like bark, wood chips, shavings, cuttings or saw dust that is directly used at the site of generation (mostly for heat and power generation). No specific targets dealing with wood waste are included in the current plan but there is a general target that aims for a reduction of waste streams from commercial operations.

REGIONAL CONTEXT OF VORARLBERG

Like the federal waste management plan the nine provinces issue their own waste management plans, which deal with municipal waste. The actual waste management plan of Vorarlberg was issued in 2016. The amount of wood waste generated in Vorarlberg is about 48,000 tons. Like the numbers for Austria, this number does not include wood residues like bark, wood chips, shavings, cuttings or saw dust that is directly used at the site of generation (mostly for heat and power generation). No specific targets for wood waste are defined in the current WMP of



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Vorarlberg but the sorting and treatment quality for bulky waste, which also includes wood waste, shall be further improved in the future.

Vorarlberg features one medium scale wood waste incineration plant with a capacity of about 15,000 tons per year. This amounts to almost a third of the annual wood waste generation in Vorarlberg. However, since this plant is located close to the German and Swiss border, also wood waste from these countries (mainly Switzerland) is incinerated in the plant. There is no particle board industry in Vorarlberg, so a large amount of wood waste is transported to a large particle board manufacturer in Tyrol, the province east of Vorarlberg and other particle board manufacturers. A small amount of the wood waste is also used in composting.

CASE STUDIES

In the context of a national demonstration project, an innovative wood waste-fired combined heat, cooling and power plant based on an ORC process was put in operation by the company Häusle GmbH in Fussach (Vorarlberg, Austria) in March 2002. The plant uses exclusively quality-sorted wood waste (wood waste treatment with ferrous and non-ferrous metal separation) and represents a combination of a biomass combustion unit, an ORC (Organic Rankine Cycle) and a low-temperature absorption chiller realised for the first time in this form.

Häusle GmbH is a limited liability company that is specialised in waste collection, treatment and reutilization. The wood waste incineration plant with a capacity of about 15,000 tons of wood waste per year is located close to the Lake Constance. The plant was the first of its kind in Austria and has been operating for 15 years now.

WOOD WASTE RECOVERY AND SOURCE

The plant uses wood waste of the categories A I (natural/untreated wood) and A II (coated wood waste such as panel boards, furniture etc. without wood preservation agents and without halogenated organic compounds) according to the German wood waste ordinance.

The main sources of the wood waste are: municipal bulky waste from waste collection centres, demolition wood, packaging (pallets etc.) and other used wood products. The first three categories make up for the main share of the wood waste utilized at the Häusle plant.

The supplier of the wood waste is Häusle itself since it collects wood waste in several waste collection centres. The main suppliers to these centres are demolition companies that bring their demolition wood to one of Häusle's collection centres. There, the wood waste is pre-sorted by using an excavator with a grab. This way, large impurities or pieces with a low wood content are removed. If possible, the wood waste is also divided into different qualities (mechanically treated wood like pallets and chemically treated wood like boards, furniture etc.), since the less contaminated mechanically treated wood waste is usually sold to particle board factories. The pre-treated waste is then transported to the wood waste treatment plant at the CHP plant.

STAGE IN THE WOOD WASTE VALUE CHAIN

The path of the wood waste from waste to energy includes the following processes at the Häusle wood waste CHP plant:

- Collection at several waste collection centres
- Pre-sorting to different wood waste categories
- Multi-step treatment of the pre-sorted wood waste (categories A I and A II) in the wood waste treatment plant
- transport to the fuel bunker of the CHP plant



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- Combustion in the CHP plant for the generation of heat and electricity and, via absorption chiller, also chilled water

Most of the wood waste stream is sorted by Häusle in its waste collection centres, a small share comes already pre-sorted to the collection centres.

AVAILABLE ART TECHNOLOGIES RELATED DO THE DIFFERENT USES OF WOOD WASTE

To achieve a high availability of the incineration plant, a multi-step treatment of the wood waste is required. Following a visual reception control, the wood waste is grinded, sorted and ferrous and non-ferrous metals and other impurities are removed. The treatment plant has a capacity of 50,000 tons per year and was the first of its kind in Austria.

The treatment plant comprises a total of six treatment steps:

1. Coarse grinding
2. Ferrous metal separation
3. Fine grinding
4. Ferrous metal separation
5. Non-ferrous metal separation
6. Fine particle separation



Picture 26: Picture of the wood waste treatment plant (front) and the wood waste-fired CHP plant in Fussach, Vorarlberg

Picture 27: Typical wood waste used in the incineration plant prior (left) and after (right) treatment



Especially the removal of non-ferrous metals is very important for a smooth operation of the incineration plant. By reducing the content of impurities and metals with a low melting point (especially aluminium) the fuel feeding and ash conveying systems and the grate can be prevented from damage. Additionally, the danger of slagging (caused by melting ashes or metals) in the combustion zone and the thermal oil boiler can be minimized. The analysis of the treated wood waste shows significantly lower contents of Cl, S and metals compared to untreated wood waste and an ash content far below 3 wt. %. This way, erosion problems and dust emissions can be minimized and the costs for ash disposal can be reduced.

WOOD WASTE-FIRED CHP-PLANT WITH ABSORPTION CHILLER

The plant has a nominal electrical output of 1,150 kW and produces approximately 8,200 MWh/a of green electricity which can be fed into the public grid. Beyond that the plant supplies a nearby factory with chilled water (hot water is used to feed an absorption chiller: approximately 23,000 MWh/a). The remaining usable energy (approximately 19,000 MWh/a) is fed into a district heating network.



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The biomass-fired combined heat, cooling and power plant consists of a Low-NO_x combustion chamber with a horizontal reciprocating grate specially designed for wood waste, a thermal oil boiler with a thermal oil economiser (nominal capacity 6,200 kW_{th}) equipped with an automatic cleaning system, a hot water economiser (nominal capacity 1,000 kW_{th}), a flue gas cleaning system consisting of a cyclone followed by a bag house filter with integrated dry sorption, the ORC module and a low-temperature absorption chiller.

To enable a high availability of the waste incineration plant, the fuel heat input of the Low-NO_x combustion chamber is with 9,750 kW about 20% higher than the designed heat output of the plant (7,800 kW). The low-NO_x-operation is achieved by an optimized geometry of the combustion chamber (enabling long residence times in the zone), an optimized control of the primary and secondary combustion air (air-staging) and a flue gas recirculating system in combination with thermal oil-cooled combustion chamber surfaces for temperature control. The final design is a result of comprehensive CFD simulations. It enables a proper mixing of unburned flue gas, secondary combustion air and recirculated flue gas and thus an even temperature distribution in the combustion chamber. This way, hot spots can be avoided which reduces emissions and the risk of slagging in the plant.

The CHP plant uses thermal oil as a heat carrier. This way, the input temperatures required for the ORC (about 300°C) can be reached at low pressure. The thermal oil system features redundant pumps (two electrically driven and one diesel-driven emergency pump) to achieve a high level of availability and operational safety. In order to minimize the risk of melted ashes and ash deposits at the boiler surface, the thermal oil boiler features a radiant heating section and a separate convective heating section (including a thermal oil economizer). The convective heating section is equipped with a shot cleaning system, which prevents the formation of deposits on the convective heat surfaces and thus increases the period between maintenance outages and the efficiency of the boiler.

The flue gas exiting the thermal oil economizer enters a warm water economizer. The pre-heating of the two heating mediums increases the efficiency of the whole plant significantly.

To meet the emission limits according to the Austrian waste incineration ordinance and the EU Directive 2000/76/EC (later replaced by 2010/75/EU), the plant is equipped with a SNCR-unit for NO_x removal, a flue gas cleaning system and a continuous online CO, NO_x and dust emissions measuring system. The SNCR-unit was retrofitted a few years after the plant was put in operation, due to problems with frequent NO_x-peaks in the flue gas. The flue gas cleaning system comprises a multi-cyclone for coarse fly ash separation and a highly efficient baghouse filter for fine fly ash separation. The dust concentration after the baghouse filter is below 3 mg/Nm³ (based on dry flue gas with 11 Vol% O₂). The flue gas temperature at filter inlet is monitored and controlled to prevent the emission of volatile heavy metals (especially Pb). For the efficient removal of acid components like HCl, HF and SO_x a dry sorbent (a mixture of Ca(OH)₂ and activated charcoal) is injected upstream the baghouse filter. The cleaning of the filter bags is done by pressurized air. The coarse and fine fly ash is collected in a container and disposed of in a landfill. Due to the high heavy metal contents in the ashes, their use as a fertilizing agent is not possible. Regarding gaseous and particulate emissions, the plant keeps the strict limiting values according to the respective EU guideline without problems.

The principle of the power generation by means of the ORC process corresponds to that of the conventional water steam process, with the substantial difference that instead of water an organic working fluid with special thermodynamic characteristics is used - therefore the name Organic Rankine Cycle. The ORC process is a closed cycle, which relates to the thermal oil cycle and the district heating circuit by heat exchangers.

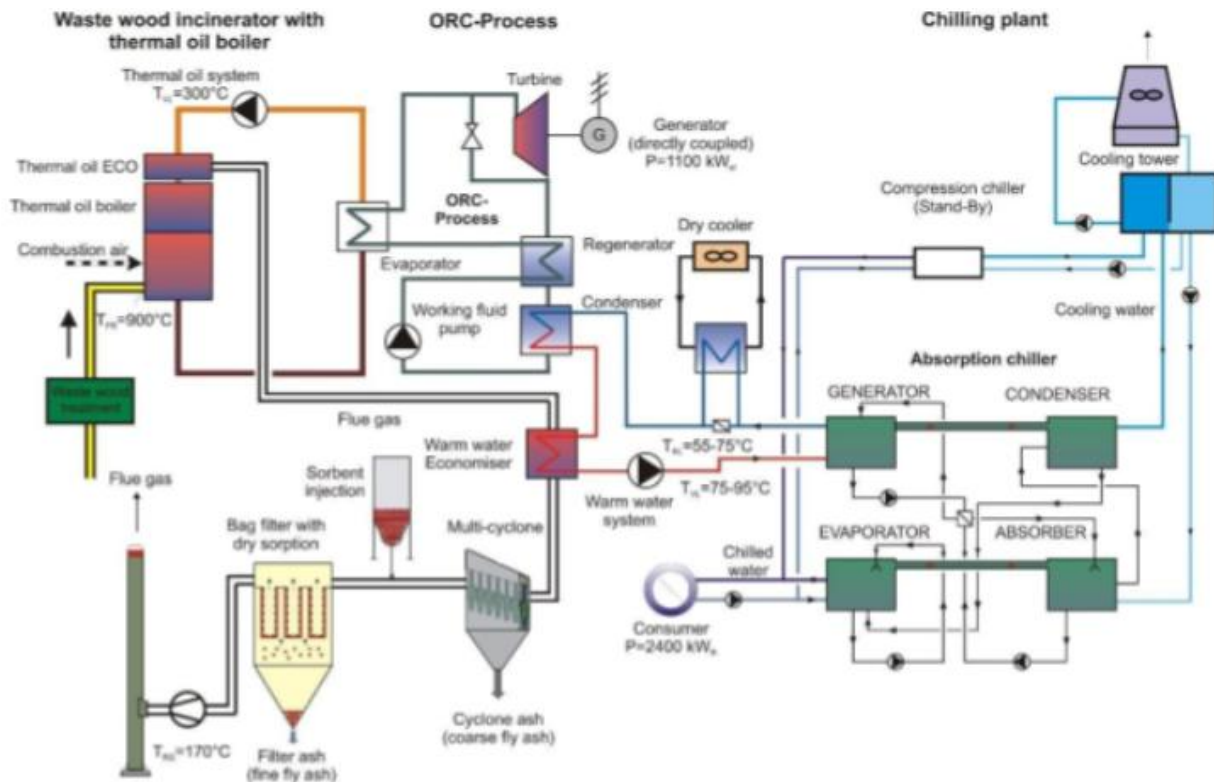


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Apart from the ORC process the low-temperature absorption chiller represents the second substantial unit of the combined heat, cooling and power plant. The heat produced in the combined heat and power plant is fed by a network of pipes to the absorption chiller. The installed chiller (refrigerant: weak lithium bromide water solution) has a nominal chilled water capacity of 2,400 kW_{th} and supplies chilled water with a constant temperature of 5°C.

The overall plant represents the first biomass-fired combined heat, cooling and power plant based on an ORC process world-wide. The overall scheme of the plant is shown hereafter.

Figure 25: Schema of the waste incineration plant at Häusle in Vorarlberg, Austria



OPERATIONAL KNOWLEDGE

In principle, the wood waste treatment plant works properly since the quality of the treated wood waste is enough for a continuous and failure-free operation of the incineration plant. However, the operation of the treatment plant is often stopped by larger metal pieces which block the first or the second grinding step (metal pieces may slip through the first grinding step because the clearance between the cutting elements is rather large). Another problem is the fact that the capacity of the grinding steps is higher than the capacity of the last step, the non-ferrous metal removal. Compared to the demand of the incineration plant (some 2 tons per hour), the treatment plant is oversized, but the fact that the plant is only in operation during the day (due to noise prevention regulation) and the frequent unscheduled stops may lead to capacity problems, especially when additional wood waste designated for the board industry is also treated in the plant. As mentioned above, the plant treats only wood waste of the categories A I and A II, wood waste containing halogenated organic compounds or wood preservatives cannot be treated.



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Since the commencement of the recycling wood ordinance, Häusle sees a tendency towards lower wood waste qualities, since many former suppliers of high-quality wood waste supply their wood waste directly to recycling industries like the particle board industry.

WOOD WASTE-FIRED CHP-PLANT

Due to the over sizing of the combustion chamber, the availability of the wood waste incineration plant reaches about 7,500 hours per year. In 2002, about half a year after the start of operation, a leakage in the thermal oil-cooled secondary combustion chamber lead to a fire that destroyed the combustion chamber, the thermal oil boiler and economiser and large parts of the boiler house. The reason for the leakage was a wrongly dimensioned expansion joint, which lead to frictions and finally to cracks in the thermal oil cooling coils. The spilled thermal oil entered the primary combustion chamber which lead to an uncontrollable fire that finally destroyed large parts of the plant. In 2003, the plant was rebuilt with an improved design of the thermal oil boiler system that prevents the recurrence of any spills into the combustion chamber.

Since then, the plant is, apart from scheduled maintenance stops, in continuous operation. Due to the multi-step treatment of the wood waste that removes most of the metals and other impurities, slagging in the combustion chamber or deposit formation on heat exchanger surfaces is not a problem. Still occurring deposits on the convective boiler surfaces are sufficiently removed by the shot cleaning system. There were some problems with NO_x-emissions in the past but since the implementation of a SNCR-unit in the post combustion chamber the emission limits can be kept without problems. There are no problems with heavy metal emissions in the flue gas, since the dust emissions are very low (< 3 mg/Nm³).

CAUSE OF ITS SUCCESS

There are several factors that caused the success of the wood waste incineration plant of Häusle. One important factor at the time the project was initiated was the increased feed-in tariff for biomass-fired CHP plants in Austria (the period with increased feed-in tariffs ended 2015). Another one was the fact that, with the absorption chiller, a constant base load for the heat demand was given, leading to better economic feasibility compared to a power only generation plant. Moreover, the plant was also funded by the Austrian Bank for Infrastructure (Kommunalkredit) with 30% of the investment costs.

Today the legal framework conditions that prohibit the disposal of wood waste on landfills provide a rather constant supply of wood waste. The recycling wood ordinance, however, put some pressure on the wood waste to energy market, since many wood waste suppliers try to supply their wood waste to the particle board industry.

CONCLUSION

The case study shows that even in a region with a lack of typical wood waste recycling industry, a successful and efficient utilization of wood waste is possible. Technically speaking, the comprehensive wood waste treatment is key to the continuous operation of the wood waste incineration plant. Moreover, the specific design of the combustion chamber and the thermal oil boiler and enough flue gas cleaning system including SNCR allow for an operation with low emissions.

Economically speaking, the electricity generation in an ORC and the constant heat demand of the absorption chiller connected to the plant via district heating network guarantee a constant stream of revenues, which is, besides the use of wood waste as a fuel, the basis for an economically feasible operation.

The ban of wood waste from disposal on landfills generally promotes the utilization of wood waste in Austria. The recycling wood ordinance promotes reuse over thermal utilization, which leads to a decrease of the quality of wood waste designated for combustion.



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STYRIA (AUSTRIA)

The overall framework conditions for waste management were already described in the chapter dedicated to Vorarlberg region. Like the federal waste management plan the nine provinces issue their own waste management plans, which deal with municipal waste. The actual waste management plan of Styria dates from the year 2010. The amount of wood waste generated in Styria, based on 2015 data, is about 157,300 tons. Like the numbers for Austria, this number does not include wood residues like bark, wood chips, shavings, cuttings or saw dust that is directly used at the site of generation (mostly for heat and power generation). No specific targets for wood waste are defined in the latest WMP.

Styria features one medium scale wood waste incineration plants with a capacity of about 15,000 tons per year. This amounts to 10% of the annual wood waste generation in Styria. There is no particle board industry in Styria, so a large amount of wood waste is transported to a particle board manufacturer in Carinthia, Salzburg and Tyrol. A small amount of the wood waste is reused in furniture and building construction and in composting.

CASE STUDIES

It is difficult to find a specific success story in Styria, since there are no big players in the region. However, the overall statistics of Styria give a good example, how legal framework conditions can lead to a successful utilization of a waste stream that was often landfilled 15 years ago. In 2015, 100% of the wood waste collected was reused/recycled or thermally utilized. About 83.5% were reused or recycled, while 16.5% were thermally utilized (see following table and figure).

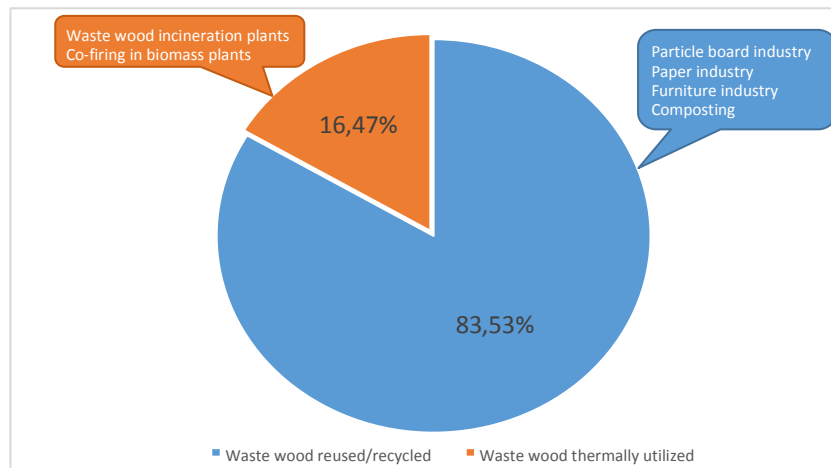
Table 16: Wood waste sources and their end use in Styria

Source	Total t/a	Reuse/ recycling t/a	Composting t/a	Thermal utilization t/a
<u>Municipal</u>	<u>32.500</u>	<u>22.400</u>	<u>200</u>	<u>9.800</u>
<u>Trade and Industry</u>	<u>52.800</u>	<u>36.400</u>	<u>400</u>	<u>16.000</u>
<u>Saw dust, shavings, untreated</u>	<u>67.800</u>	<u>67.800</u>	<u>0</u>	<u>0</u>
Cuttings, untreated	4.200	4.20 0	0	0
<u>Total</u>	<u>157.300</u>	<u>130.800</u>	<u>600</u>	<u>25.900</u>
	100,00%	83,15%	0,38%	16,47%



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Figure 26: Pie chart for wood waste utilization in Styria



Most of the wood waste is reused in the particle board industry, some mechanically treated wood residues may be used in the local paper industry and about 600 t are composted. Besides reusing and recycling, wood waste is incinerated in the lone Styrian wood waste incinerator or, if only mechanically treated (sawdust, shavings, cuttings) wood waste is used, co-combusted in biomass heating plants.

WOOD WASTE CATEGORY AND SOURCE

All categories of wood waste, from A I to A IV according to the German wood waste ordinance are generated in Styria. About 53% can be categorized as "A I" (natural/untreated wood), about 30% as "A II" (coated wood waste such as panel boards, furniture etc. without wood preservation agents and without halogenated organic compounds), and about 17% as "A III" (wood waste with halogenated organic compounds but without wood preservation agents). The amount of wood waste categorized as "A IV" is negligible.

The main sources of the wood waste are: municipal bulky waste from waste collection centres, demolition wood, packaging (pallets etc.), residues from the wood processing industry, other used wood products.

Municipal wood waste is usually part of the municipal bulky waste. This kind of waste is collected in municipal waste collection centres which are located all over Styria. Most of the Styrian communities operate at least a collection centre for recyclable municipal waste, some communities also operate collection centres for hazardous municipal waste. Following figure shows the location of all municipal waste collection centres. With such a dense net of collection centres, the return rate for bulky waste (and other non-hazardous or hazardous waste categories) is very high.

Industrial waste is mainly collected by waste collection and treatment companies. These companies collect the wood waste either at the source (demolition sites, industries) or operate their own collection centres. The wood waste collected is usually pre-sorted and then grinded. Depending on the further use or designated end-user, further treatment steps (metal separation, additional grinding) are performed. Since the commencement of the recycling wood ordinance the demand for high quality wood waste, which is usable in the particle board industry,



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has been increased significantly. To achieve such high wood waste quality, sorting at the source is usually inevitable. Therefore, sorting at the site of generation has been increased recently.

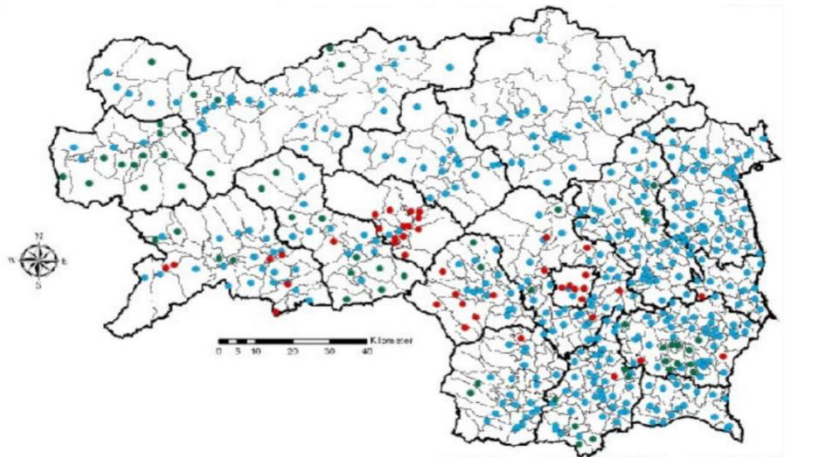



Figure 27: Waste collection centres (blue), hazardous municipal waste collection centres (red) and communities that share waste collection centres (green) in Styria.

STAGE IN THE WOOD WASTE VALUE CHAIN

There are different ways of reuse/recycling and thermal utilization performed in Styria and therefore different processes involved:

- Collection and sorting:

- a. for high quality wood waste, a sorting at the site of generation is required in order to avoid the contamination of chemically untreated wood waste such as palettes, saw dust, shavings etc. with chemically treated wood waste or other waste
- b. other industrial wood waste and municipal bulky wood waste is collected at municipal or commercial waste collection centres and sorted there
- c. some specialised companies collect old furniture or wood used in building construction to restore and reuse them in their original function  Treatment:
 - a. high quality wood waste is either treated (grinding, metal separation) at collection centres or directly at the end user (large particle board manufacturers often have their own wood waste treatment plants)
 - b. wood waste that is designated for thermal utilization is usually treated at the collection centres (grinding, metal separation) and transported as chipped material to the enduser (heating or CHP plants)
 - c. heavily contaminated wood waste is transported to specialised incineration plants (the thermal energy is used for heating or power generation)
 - d. old furniture or construction wood (e.g. wooden beams used for roof construction) designated for reuse is treated individually according to requirements of the final product

- End-use:



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- a. particle board industry
- b. paper industry (mainly wood residues that are not categorised as waste as they are directly used at the site of generation)
- c. fuel for heating and CHP plants
- d. furniture, wood for building construction

AVAILABLE ART TECHNOLOGIES RELATED DO THE DIFFERENT USES OF WOOD WASTE

The technologies used are depending on the end use of the wood waste and include:

1. sorting technologies (necessary for all utilization paths)
2. grinding technologies (necessary for use as fuel and use as base material for particle board and similar products)
3. metal separation technologies (necessary for use as fuel and use as base material for particle board and similar products)
4. combustion technologies (necessary for thermal utilization)
5. restoration technologies (necessary for re-use as furniture or construction material)

OPERATIONAL KNOWLEDGE

Since we focussed on the general use of wood waste in Styria, operational knowledge has not been an issue for this case of study.

Since one of the main paths for wood waste recycling in Styria is the use as a base material in particle board production or similar products, the general requirements according to the recycling wood ordinance are listed below:

- limiting values for the following components: As, Pb, Cd, Cr, Hg, Zn, Cl, F, PAK (EPA)
- the higher the share of the wood waste in the product, the lower the limiting value
- exclusion of wood waste with halogenated organic compounds or other hazardous materials
- frequent sampling and analysis of the wood waste (the number of samples and the frequency of analyses per year is dependent on the amount of wood waste utilized)
- detailed monitoring of the type and amount of wood waste used in the manufacturing process

CAUSES OF SUCCESS

One key to the success are the current legal framework conditions that prohibit the disposal of wood waste on landfills (landfill ordinance) and promote the use of wood waste in wood products such as particle board, plywood or OSB (recycling wood ordinance). These ordinances and the Austrian Waste Management Law also promoted the establishment of a dense net of municipal waste collection centres and the foundation or expansion of commercial waste management operations. The short distances to the next waste collection centre for private



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suppliers and the wide range of waste management services commercial and industrial wood waste suppliers can choose from enable an easy and convenient manipulation, sorting, treatment and end-use of wood waste in Styria.

CONCLUSION

The situation in Styria shows that with the right legal framework conditions the reuse/recycling or thermal utilization of wood waste can be promoted successfully. But not only the legal regulations themselves are important but also the establishment of a waste management system, that covers municipal (via waste collection centres of the communities) and commercial/industrial wood waste (via wood waste management operation and services) streams and provides the infrastructure and logistics needed to collect, sort and treat the wood waste streams in a way that the highest possible added value for the communities and industries can be generated.

6. RECIPIENT REGIONS

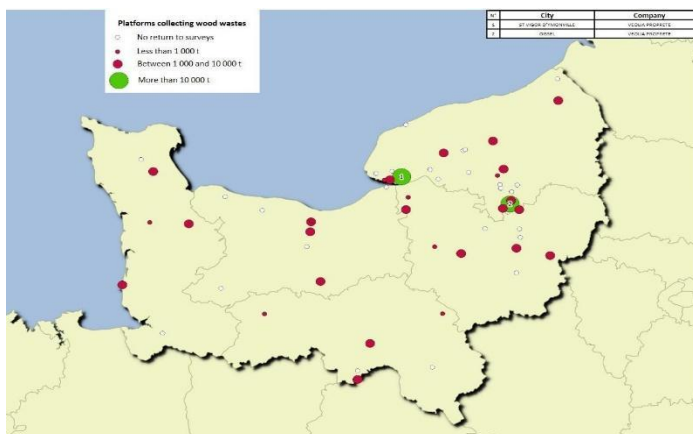
6.1 NORMANDY (FRANCE)

There is a national strategy on renewable energy funding especially for biomass with substantial subsidies provided to collective and industrial boiler plants. This strategy has led Normandy to be one of the most developed regions in France regarding wood-fuel energy. Recently, the use of wood wastes in such installations has been allowed and the region needs to take benefits of the situation to lower the tension on natural resources and learn from model regions to implement a local wood waste value chain. Investigations carried out the past years showed that a significant amount of wood waste escapes the traditional waste collection model and even when these wood wastes are collected, some of them are still sent in landfills. Indeed, unlike its European neighbours such as Germany, the French regulation does not forbid the landfill of combustible wastes including wood. Moreover, the low landfill taxes in France turn out to be weakly deterrent.

WOOD WASTE CHARACTERISTICS

Flows knowledge and valorisation method regarding wastes wood in Normandy is relatively accurate and reliable due to several studies led the past years (particularly with the ECIRBEN Project).

Wood wastes arising have been evaluated to 300 000 tons a year with half that is identified and transits through the 58 collecting and conditioning platforms. The map below shows the location of the different platforms.



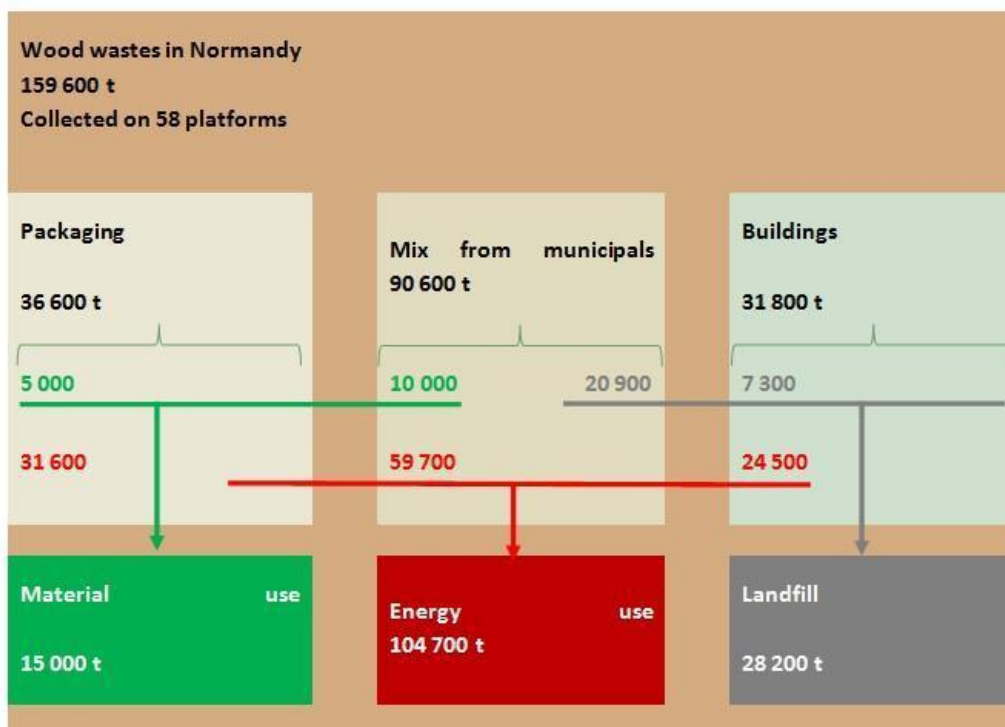
Picture 28: Location of wood waste platforms (Biomasse Normandie)



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The diagram below presents the collected wood wastes flows and their uses. Approximately 140 000 tons of wood don't transit through platforms and are partly burned in the open air, in domestic heat equipment or illegally left in the nature.

Figure 28: Collected wood wastes flows and their uses (Biomasse Normandie)



Wood waste following a material use, around 15 000 t/year, are sent to UNILIN in Belgium. A flow of almost 30 000 tons of wood wastes, mainly mixed, is buried within the different non-hazardous waste's storage centres.

Regarding the technologies able to process wood wastes, few wood chips suppliers or wastes collectors are already equipped with ambulant machinery such as slow and high-speed shredders, screen machines and metal splitters in Normandy. A high-efficiency sorting centre is also operated in Oissel near Rouen. Apart from these flows, the paper mill of UPM, located in Grand-Couronne near Rouen, remains the main energy outlet for wood wastes. It consumes 80 to 85 000 tons of wood wastes generated in Normandy in a CHP plant.

CONCLUSION



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Normandy has been selected as a recipient region due to its unused wood waste potential. In fact, a large amount of wood waste is currently exported, uncollected, incinerated or sent to landfills due to a lack of outlets or a non-dissuasive regulation. Only 25 % of wood waste have a regional use exclusively for energy.

6.2 LUBESKY (POLAND)

Lubelskie is the third largest province in Poland, and eighth in terms of population (of 16 regions in Poland). In 2015 region produced 385 thousand t (table 1) of municipal waste (fifth position in the country) which is 180kg per inhabitant (second smallest result, only Świętokrzyskie has a smaller result).

Table 17: Municipal Waste in Poland 2005-2015 (Source: Main Statistic Office in Poland 2016)

WOJEWÓDZTWA VOIVODSHIPS	2005		2010		2014		2015	
	w tys. ton in thous. tonnes	na 1 mieszkańca w kg per capita in kg	w tys. ton in thous. tonnes	na 1 mieszkańca w kg per capita in kg	w tys. ton in thous. tonnes	na 1 mieszkańca w kg per capita in kg	w tys. ton in thous. tonnes	na 1 mieszkańca w kg per capita in kg
POLSKA	9352	245	10044	263	10330	268	10864	283
POLAND								
Dolnośląskie	893	309	994	346	943	324	987	340
Kujawsko-pomorskie	448	217	515	249	546	261	593	284
Lubelskie	338	155	338	157	382	177	385	180
Lubuskie	280	277	297	294	328	321	334	328
Łódzkie	639	248	669	264	642	256	658	263
Małopolskie	630	193	766	232	764	227	796	236
Mazowieckie	1500	291	1573	301	1399	263	1660	311
Opolskie	255	243	260	253	268	268	278	279
Podkarpackie	346	165	360	171	381	179	418	196
Podlaskie	268	223	243	204	275	230	286	241
Pomorskie	587	267	683	306	695	302	703	305
Śląskie	1307	278	1380	298	1552	338	1520	332
Świętokrzyskie	185	144	200	157	199	157	209	166
Warmińsko-mazurskie	313	219	328	230	363	251	390	271
Wielkopolskie	862	256	915	268	1045	301	1070	308
Zachodniopomorskie	502	297	523	309	549	320	577	337

a Dane szacunkowe. Od 2014 r. pozycja obejmuje odpady odebrane od wszystkich właścicieli nieruchomości i uznawana jest za odpady wytworzone ze względu na objęcie od 1.07.2013 r. przez gminy systemem gospodarowania odpadami komunalnymi wszystkich właścicieli nieruchomości.

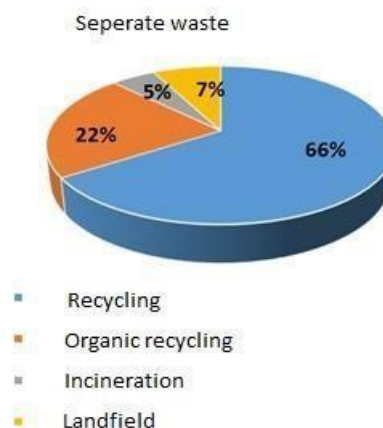
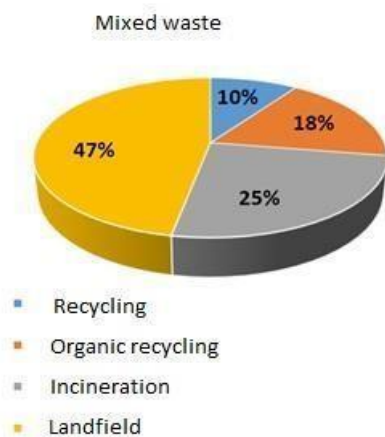
a Estimated data. From 2014 includes waste collected from all inhabitants and is considered to be waste generated because of covering by municipalities from 1.07.2013 all real-estate owners with municipal waste management system.

There is no data about wood waste treatment. According to Statistic office in Lublin (report "Management of municipal waste in the Lubelskie voivodeship in 2015") waste treatment depends on the way of collection. Separate waste collected in 2015 was 20% of total municipal waste, 80% - mixed waste (average in Poland 76.6%). Most mixed waste went to landfill (47%), only 10% was recycled, 25% incinerated. In a case of selective waste, 66% was recycled, only 7% landfilled, 22% was composted.

Figure 29: Municipal waste management in Lubelskie (source: Statistic Office in Lublin, 2015)



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WOOD WASTE CHARACTERISTICS

According to data from Marshal Office in Lublin based on waste list EU 2000/532/EC in region in 2015, 105 378 t of wood waste were produced. Most of them was from group 03 ("Waste from wood processing and the production of panel and furniture, pulp, paper and cardboard") - 91% of total wood waste. Construction and demolition waste constituted only 7%. Most of demolition wood waste is reused or used as a fuel. Municipal wood waste issued in households for storage (wood waste packaging) or incinerated in home heating systems.

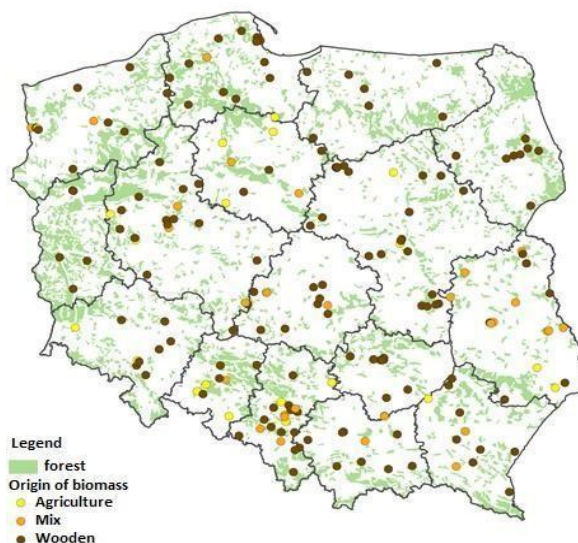
In the local utility service (Zakład Usług Komunalnych) in Puławy wood waste is not a huge problem. Its quantity is small, most of it is from bulky waste (old furniture). Wood waste is manually sorted, then milled and used as a fuel.

Table 18: Wood waste generated in 2015 in

Total	105 378,3253
030101	39,5000
030104*	8,6000
030105	90 894,0300
030301	11,4800
150103	3 283,7119
150105	816,0115
150106	869,4066
170201	7 051,4336
170204*	489,8967
191206*	0,0450
191207	1 849,3800
200307	64,8300

Lubelskie
(source:
Marshal
Office in
Lublin)

Picture 29:
Pellet and
briquette
company
in Poland



Two cement plants in the Lubelskie region are used to incinerate waste. There are 17 pellet and briquette companies.



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Picture 30: Thermal power plants and cement plants in Poland (Source: Waste Management Plan 2022)



Wood waste management is not well developed in the region. Lubelskie has two cement plants, which are used for incineration of waste including wood waste. Figure 3 shows cement plants and thermal power plants in Poland.

CONCLUSION

In the end of 2013 in Lubelskie there were 10 biogas plants (Szymańska, Lewandowska, 2015), half of them being agriculture biogas plants, one based on biogas from landfill, four of them based on biogas from wastewater treatment plants.

Polish state of bio-economy for the year 2011 has been characterized in the work of Igliński et al 2011. There are over 100 energy crop plantations of the area of at least 5 ha each, 44 pellet and/or briquette producers, over 100 biomass thermal power plants of power of at least 0.5 MW, 40 biomass and coal cofiring thermal power plants, 39 bio-fuel producers of capacity of 1 million dm³/year, 80 biogas power plants located at municipal waste sites, 56 biogas power plants located at sewage treatment works, 8 agricultural biogas power plants, one municipal waste incinerator, and 46 medical waste incinerators.

Region has a great potential for bio-economy development. In the Regional Innovation Strategy 2020 sustainability, environmental protection and modern use of natural resources are important points. Wood waste management is not developed, for that reason the region can use and effectuate good practices and solutions from the model region.

6.3 ALENTEJO AND LISBOA (PORTUGAL)

In Portugal, in 2014, the households generated 4.7 million of tons of municipal waste (453 kg per inhabitant per year) from which 4.07 million ton were mixed municipal waste and 0.64 million ton (61 kg per inhabitant per year) were selectively collected. Businesses generated 11.3 million of tons of waste (agriculture, industrial and health services or hospital wastes). The integrated and individual systems for the management of specific flows of waste, through which the manufacturers responsibility for the management of waste is transferred to a specific licensed entity, collected 1.9 million tons of waste (+1.5%, on comparison with 2013) from which 68.7% were driven to recovery (INE, 2016).

Regarding municipal waste, the region of Lisbon accounted for 28% of the total municipal waste produced in Portugal in 2013 (APA, 2015) and the region of Alentejo accounted for only 8% of the total municipal waste

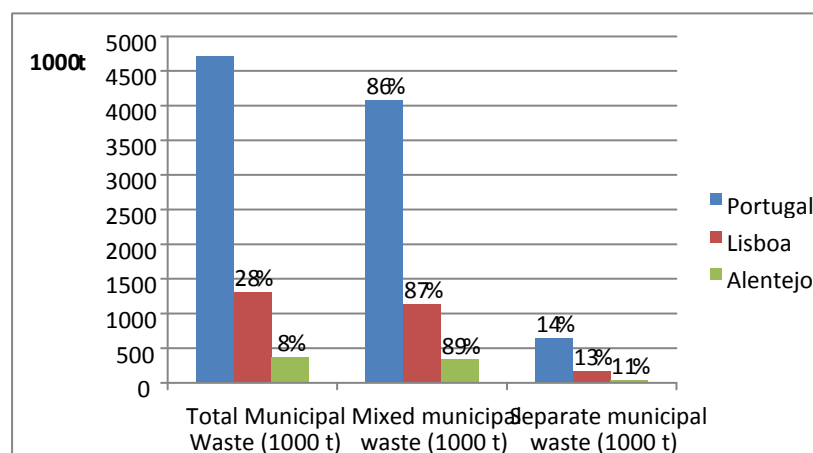


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produced in Portugal in 2013 (APA, 2015) (Figure 41). The municipal waste production per region is linked with the population (Lisbon population is 27% of the total population in Portugal and Alentejo population is 7% of the total population in Portugal), and with the business activity (Lisbon business activity accounts for 28% of the total business activity in Portugal and Alentejo business activity accounts for 7% of the total activity in Portugal). In the Lisbon region, 1.30 million tons of municipal waste were produced (465 kg per inhabitant per year), 1.14 million ton were mixed municipal waste and 0.17 million tons were selectively collected (60 kg per inhabitant per year). In the region of Alentejo, less municipal waste was produced (0.37 million tons) but the amount per inhabitant per year was higher

(500 kg per inhabitant per year) than in Lisbon region and the average in Portugal. Mixed municipal waste accounted for 0.33 million ton and 0.04 million tons were selectively collected (only 53 kg per inhabitant per year, less than in the Lisbon region and the average in Portugal).

Figure 30: Municipal waste produced in Portugal in 2013 and its management (APA, 2015).

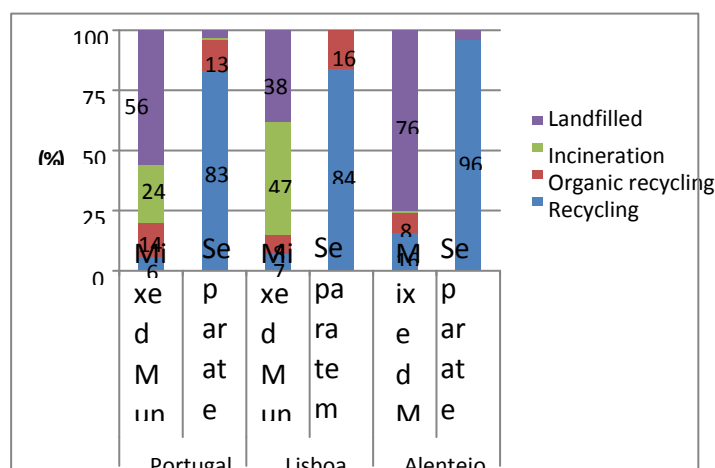


In 2013, only 14% of the total municipal waste produced in Portugal was selectively collected (Figure 1). In Lisbon region, the percentage was similar (13% of the total municipal waste produced in Lisbon) but in Alentejo, only 11 % was selectively collected (APA, 2015). Most of this selectively collected waste is for multi-material recovery (83% in Portugal, 84% in the region of Lisbon and 96% in the region of Alentejo)(Figure 2).The remaining selectively collected waste, in Lisbon, was organically valorised (16%), similar to what is observed for the average Portugal (13% organic valorisation). In the case of Alentejo, the fraction not used for multi-material recovery (4%) was landfilled. Regarding the undifferentiated waste, in 2013 the majority of the municipal waste, in average Portugal, was disposed off on landfills (56%), although such destination is the worst option on the recommended hierarchy of operations on waste management. In Lisbon less mixed waste was landfilled (only 38%), but in Alentejo, the amount is significantly higher (76%). On average Portugal, 24% of the mixed waste is converted into energy, less than in Lisbon (47%). In Alentejo the mixed waste to energy doesn't have expression (less than 1%). In average Portugal, 16% is organically valorised but only 6% is recycled. In Lisbon, only 8% is organically recycled and 7% recycled. In Alentejo, 8% is organically recycled and 16% is recycled (Figure 2) (APA, 2015).

Figure 31: Municipal waste management in Portugal in 2013 (APA, 2015).



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Concerning the business sector, it was generated or operated 11.3 million of tons of waste, from which 80% was driven to recovery operations. Most of those wastes generated by business are non-hazardous (10.7 million tons, 95%). Only 5% of those wastes are hazardous wastes (0.6 million tons). Manufacture and waste management businesses accounted most of the waste generated (INE, 2016).

Concerning wood waste management activities, there is not a clear overview of how those wastes are being managed by each region and how these wastes are treated. Most of the information related with wood waste is given for the country, but some estimation can be done for each region based on the sectorial activities linked with wood. However, given the structure of the current waste management activities in each region, it is plausible that wood waste management activities follow a similar pattern to the one described in Figures 40 and 41-. There is also not a clear strategy in each region for the management of wood waste. As it is also observed for other wastes, each region follows a national strategy described in the national plan for the management of wastes (PNGR - Plano Nacional de Gestão de Resíduos).

WOOD WASTE CHARACTERISTICS

The total amount of wood waste produced in Portugal, in 2014, was 0.27 million tons, which corresponds to only 3.3% of the total waste being collected in Portugal. In the region of Lisbon, 67 thousand tons of wood waste were produced (equivalent to 0.81% of the total waste produced in Portugal and to 25% of the total wood waste being produced in Portugal). In the region of Alentejo, only 27 thousand tons of wood waste was produced (equivalent to 0.32% of the total waste produced in Portugal and to 10% of the total wood waste being produced in Portugal (INE, 2016)).

Most of the wood waste source in Portugal comes from the commercial and industrial use (150 thousand tons, equivalent to 55% of the total wood waste produced). But there is no precise knowledge on the amount of the commercial and industrial wood waste being produced in the regions of Alentejo and Lisbon. It was estimated, based on the number of industries and activities in both regions, that Lisbon region produces 42 thousand tons of commercial and industrial wood waste (62% of the total wood waste being produced in Lisbon), and that Alentejo region produces 10 thousand tons of commercial and industrial wood waste (39% of the total wood waste being produced in Alentejo). The amount of wood waste from municipal collection in Portugal accounts for 44 thousand tons (16% of the total wood waste being produced in Portugal). In Lisbon region the amount of wood waste from municipal collection is only 4 thousand tons (6% of the total wood waste being produced in Lisbon). In Alentejo region the amount of wood waste from municipal collection is 11 thousand tons (41% of the total wood waste being produced in Alentejo). The source of municipal wood waste in each region is known because it is linked with companies that collect wastes. Wood waste from construction and demolition activities is residual, only 11 thousand



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tons were produced in Portugal in 2014 (4% in total wood waste produced in Portugal). However, there is no clear information on the amount of these wood wastes being produced in Alentejo and Lisbon. Based on the business activities in this sector it was estimated a production of 3 thousand tons of wood waste from construction and demolition activities in Lisbon region (4% of the total wood waste produced in this region) and 750 tons in Alentejo region (3% of the total wood waste produced in this region). wood waste from other sources accounts for 68 thousand tons in Portugal (25% of the total wood waste being produced in Portugal). There is also no information on the amounts being produced by other sources in Lisbon and Alentejo region. So, an estimation was made based on the business activities. The estimation accounts for 19 thousand tons being produced in Lisbon (28% of the total produced in this region) and only 5 thousand tons in Alentejo (17% of the total wood waste being produced in this region). There is some information on the collection of the wood waste per sectorial activity in Portugal but not in the regions of Alentejo and Lisbon. Table 14 provides this information.

Table 19: Wood waste generated in 2014 in Portugal per sectorial activities (INE, 2016) (in red the hazardous wood wastes)

Sectorial activities	wood waste (t)		Percentage to total wood waste produced in Portugal
Wood transformation: sawmill, panel industry, carpentries, joineries...	03 01 01	47 925	17.5
	03 01 04	248	0.1
	03 01 05	30 347	11.1
		78 520	28.8
Building, demolition	17 02 01	10 902	4.0
	17 02 04	12	0.004
		10 914	4.0
Waste management plant	19 12 06	21	0.008
	19 12 07	67190	24.6
		67211	24.6

The information about the wood waste from packaging is inconsistent when looking into the different data obtained by several administrative offices, and at this stage it was decided not to provide it. The information about the municipal wood waste is not defined per code, however the statistics indicate a total of 44 thousand tons being produced (equivalent to 16% of the total wood waste produced in Portugal).

Regarding the quality of wood wastes, the only classification that currently exists is the separation between non-hazardous and hazardous wood wastes. The production of hazardous wood waste (wood waste that needs treatment or that it goes to landfill) is low. In Portugal total of 299 tons of hazardous wood waste were produced. In the regions of Lisbon: 83 tons, in Alentejo region: only 21 tons. The percentage of hazardous wood wastes is therefore also very low, only 0.1%, either in average Portugal and in the regions of Lisbon and Algarve, regarding the total amount of wood waste being produced.

AVAILABLE ART TECHNOLOGIES RELATED TO THE DIFFERENT END USES OF WOOD

The recovery of the wood wastes is high. On average in Portugal, 89% is being recovered. But information relating the amount being recovered per region is lacking. However, there is no knowledge on how the wood waste is being reused to more than half of the wood waste recovered (156 thousand tons, 57% of the total wood waste).



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Yet, knowledge of the behaviour of the Portuguese population, indicates that part of those wastes are being reused either for household storage or in-home heating systems. Reuse of wood waste as material represents 28% of the total wood waste being produced in Portugal (77 thousand tons). Statistics of Portugal indicate that 10 thousand tons of wood waste are being recovered for energy (3.5% of the total wood waste) (INE, 2016). Yet, part of the collected wood waste with unknown use is in fact being used for energy (especially in households).

Regarding the treatment options, especially to the hazardous wood waste, there is currently a survey being done to obtain this information in the processing units that are receiving and collecting these types of wastes.

OPERATIONAL KNOWLEDGE

There is in Portugal several facilities that can receive wood waste and provide added value to it and when no other reuse is possible, landfill is also an option. In 2014, 32 landfills were active in Portugal with a capacity of 23.3 billion tons. In Lisbon region, there are 4 active landfills and in Alentejo 5 active landfills. To receive the wood wastes for recycling and treatment there are in the country several eco-centres. In the region of Lisbon there are 17 eco-centres, in the region of Alentejo there are 24 eco-centres.

To organically valorise the wood wastes, there are currently in Lisbon region five units working and in Alentejo 3 units working. In Lisbon, 2 units are centres for mechanical and biological treatment of wastes (anaerobic digestion and compost), 2 units are centres for mechanical and biological treatment of wastes (compost), and 1 unit is a centre for biological treatment of wastes (anaerobic digestion and compost). In Alentejo, 1 unit is a centre for mechanical and biological treatment of wastes (anaerobic digestion and compost) and 2 units are centres for mechanical and biological treatment of wastes (compost).

To treat the hazardous wastes there are 2 enterprises in Portugal that have competences to do it. Both are in the central part of the country (Chamusca, Santarém), located 50-150 km to Lisbon and Alentejo regions. In the region of Lisbon 4 incinerators are active to receive and incinerate hazardous wastes. In the region of Alentejo there are no facilities to incinerate hazardous wastes.

To valorise the wood waste to materials there are currently in Lisbon region 4 pellet and briquettes companies and 29 wood panel industries. In Alentejo, there are 3 pellet companies and 2 wood panel industries. In the North of Portugal (Mortágua), located 200 km to Lisbon and Alentejo region, there is a biomass power plant (10MW) that receives mostly forest residues. In Lisbon and Alentejo region there are other biomass power plants (0.1 MW) but those power plants are linked to companies are functioning with biomass wastes from those companies (e.g, in Alentejo, with olive oil wastes).

The most problematic issues encountered in Portugal, regarding wood waste, is the reuse of hazardous wood waste as non-hazardous wood waste. Deleterious emissions can be a problem and population health can be affected.

DEVELOPED SECTOR IN WOOD WASTE MANAGEMENT

Wood waste management is not well developed in both regions and in Portugal. However, it is well known that wastes (non-hazardous) from wood transformation: sawmill, panel industry, carpentries, joineries...are collected and reused to produce pellets, briquettes as well as wood panels. This sector is well organized to reuse as much as possible and add value to the wastes.



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CONCLUSION

Lisbon and Alentejo regions present a great potential for bio-economy development. They have available plants for the exploitation of the wood, either for material, energy or to landfill. But, management of those wastes in each region needs to be improved.

Knowledge on the number of wood wastes being produced in both regions, either non-hazardous or hazardous waste, exists. But information related with the wood waste sources in each region, as well as the type of recovery in each region, is missing. Information on what type of recovery is being used for each type of wood waste source exists but this information is given to the country and not to each region. Knowledge about the treatments applied to hazardous wastes is also needed. The better knowledge of the wood waste panorama in each region, will help to suggest options for improvement regarding wood waste use and applications. For that reason, the regions studied in Portugal can use and effectuate good practices and solutions from the model regions. For this, it is mandatory that more data of wood wastes in those regions need to be collected, a task that will be continuously updated until the end of the BioReg project, by cross linking data from companies with data from statistics.

7. GENERAL INFORMATION ABOUT THE WOOD WASTE IN EUROPEAN COUNTRIES

The following table provides information about wood waste in some European countries. The countries concerned by Bioreg (Germany, UK, Italy, France, Sweden) are presented in detail in the previous chapter.

Table 20: Modes of wood waste recovery in some European countries.

Country	Mode of valorisation
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Belgium	<p>Belgium imports large quantities of wood waste (more than 1 million tons) to power its panel industry (UNILIN) and its cogeneration plants. Green certificates and a high rate of use of wood waste in panel industry allowed Belgium to reach a high level of wood waste valorisation.</p> <p>The waste policy is performed on the basis of different implementation plans. Biomass is discussed in several of them, including the Implementation Plan on Wood, that covers:</p> <ul style="list-style-type: none"> - Secondary processing of wood waste (plate production, wood processing); - wood waste from the final processing: wood waste that is released during the production of furniture, packaging, timber, joinery; - wood waste from businesses: construction and demolition wood, packaging, furniture; - wood waste from households: construction and demolition wood, furniture, garden wood such as wood fences or wood garden houses; - Wooden railway sleepers. <p>It is recognized that biomass, as part of the renewable energy targets, offers a large potential for energy production. It is also recognized that this places recycling of certain waste streams under strong pressure, for this reason burning biomass is subject to restrictions.</p> <p>The destination of clean wood waste in Belgium is in principle raw material for industry, unless it is not considered of use. Contaminated wood waste can be used for the energy market. There is an internal negotiation about the sourcing of material to avoid competition in resources.</p>
Finland	<p>The forest resources in Finland have been steadily increasing and this development is predicted to continue. The forest resources are used mostly in chemical and mechanical forest industries. The by-products from the mechanical forest industry are used in the chemical industry, and there are optimised inner cycles in the chemical industry (e.g. use of black liquor). The residual streams are used mostly for energy production, which supports the total efficiency of the industry. Most of the products from chemical industry are exported as pulp, paper and board. The mechanical industry exports mostly timber and plywood.</p> <p>While Direct use of wood for energy is lower than in the EU, and the use of wood for pulp industry much higher, energy use of wood industry by-products is very significant, due to an optimised integrated wood use especially in pulp and paper industry.</p> <p>Energy recovery only: boilers for classes A and B. Classes C and D for incineration. Finland aims to respect the cascading use of wood waste.</p>
Switzerland	<p>Switzerland mainly recycles wood waste into energy (district heat networks) and does not recycle material. A large part of wood waste is exported to Italy (panel) or Germany (energy). According to a study carried out in 2014 in the country, the current management is considered to be coherent with regard in particular to environmental criteria, despite the low material valuation.</p>
Ireland	<p>220,000 tons of non-hazardous wood waste recovered in 2010, from sorting facilities, construction and public works. Ireland does not import and export wood waste.</p> <p>The main sources were outputs from mechanical waste treatment facilities, packaging waste, construction and demolition (C&D) waste and municipal waste. Relatively minor amounts of segregated wood waste were reported as exported or imported for recovery or disposal. Wood waste may also be disposed of in mixed C&D and municipal waste streams. It should be noted that virgin residual wood from forestry, sawmills and similar, which is classed as a by-product rather than a waste, is not included in this figure.</p> <p>The three primary uses of wood waste noted from the National Waste Report 2010 dataset were general</p>

Country	Mode of valorisation
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	<p>recovery applications, recovery in composting processes and the use as a fuel.</p> <p>The following types of wood are considered as waste (and are subject to regulatory control unless the holder demonstrates, to the satisfaction of the relevant competent authority, that the material meets applicable byproduct or end-of-waste status criteria):</p> <ul style="list-style-type: none"> - discarded treated and untreated wood products. In this context, treatment means the application of chemicals (paints, laminates, varnishes, and preservatives) to enhance the performance of the product or other artificial impregnation or coating; - off cuts, shavings, chip, and dust arising from the processing of treated wood; - any virgin wood mixed with the above; and - any wood separated, segregated, or otherwise obtained from mixtures of the above. <p>In general wood waste is subject to regulatory control unless the material meets by-product or end-of-waste criteria. It must be managed in accordance with waste law and waste management facilities must hold the necessary authorisations.</p> <p>Material recovery: 62%, energy recovery: 32%.</p>
Netherlands	<p>The Netherlands consume half of their wood waste production (the rest is exported), mainly for energy production.</p> <p>In 2010, in The Netherlands, 450,000t of wood waste was used for energy generation, while less than 200,000 tons were recycled for chipboard and other materials production. The National Waste Plan gives a minimum standard for processing for all three categories. The minimum standard for A (and B) wood is recovery. Minimum recovery for A and B wood includes various options:</p> <ul style="list-style-type: none"> - Recovery of material; - Recovery of products; - Main use of waste as a fuel or other means to generate energy. <p>The Netherlands gives no preference between the options. The criteria work on a case-by-case status. Postconsumer (clean) wood waste from within the Netherlands is waste until the moment of further processing. It should be destined for useful recovery, which includes both material recovery and energy use as main use.</p>
Germany	<p>In Germany, a trader country, there is a trade deficit of wood fibre. In 2010, the flow of wood fibres to Germany was 67 million m3 while the exports were 60.4 million m3. This trade deficit is mainly generated by recovered wood and paper, wood-processing and pulp industries. In other sectors, i.e. sawmill and woodbased panel and paper industry, exports are higher than imports. Moreover, Germany is the largest paper producer (and also consumer) in Europe and therefore also the largest importer of pulp in Europe. Also, it is Europe's largest consumer and producer of particleboard.</p> <p>In Germany, it is not allowed to dispose untreated municipal solid waste (including wood) in landfills. Thus, practically no industrial wood waste is disposed in landfills. Germany has set up in 2002 a wood waste ordinance which has allowed and accompany the valorisation of wood waste. For 10 years, the market is mature in Germany, with end-users (panel industry and energy) which absorb the whole resource of wood waste.</p> <ul style="list-style-type: none"> - Recycling material = 20% (class A1-A2) = around 2 Mt. Panel industry after transit in sorting facilities: BTP, industry, packaging - Energy recover = 80% (classes A1 - A 4) = around 6 Mt. 76 plants (last commissioned in 2008).

Country	Mode of valorisation
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	<p>Cogeneration plants: building and municipal waste. Mature market.</p> <p>Landfilling of banned organic products.</p>
France	<p>In France, an important part of wood waste is disposed of in landfill and more than 1 million tons could be valorised if landfilling was banned (according to national wood waste plan). An important part of wood waste streams are exported in Belgium and Italy given the fact the French current demand (mainly panel factories) does not allow to valorise the whole resource. In France, only 3 or 4 plants valorise important flows of wood waste (UPM Kymmene, Plaine du Rousillon, Norske Golbey), compared to 76 in Germany!</p> <p>Valorisation: 79%, of which 57 in material recycling (Panel industry: 1.8 Mt / year, of which 1 Mt exports (Belgium, Italy ...) and 22% in energy.</p>
UK	<p>The waste management hierarchy from the EU Waste Framework Directive was transposed into UK law, through the Waste (England and Wales) Regulations in 2011. The hierarchy of waste management follows this order: prevention, preparing for re-use, recycling, other recovery (e.g. energy recovery through incineration and pellet production), and disposal. Except for lower grade wood waste, energy recovery is considered in this case a better environmental option than recycling.</p> <p>Increase in the share of wood waste separated (+0.8 Mt between 2009 and 2012).</p> <p>"Call of evidence" in 2013 to consider the ban on wood waste in landfills.</p> <p>According to the WRAP, less than 1 Mt buried in landfill out of a total of about 4.5 Mt. At least 2/3 of sorted wood waste is valued: 46% panel (of which England 90%), 20% energy.</p> <p>WKL evokes 55% of material recovery.</p>
Austria	<p>Austria is similar to Finland in that forestry and wood processing industries form central elements of its economy. However, compared to Finland, the share of wood used for pulp and paper production is lower and the energy use of wood is higher. The share of black liquor of the total energy production is about 15%. Moreover, the use of the Austrian forest resources is close to its maximum sustainable level, and thus in order to increase the wood use, more efficient management of the resources, recycling and cascade use, would need to be emphasised.</p> <p>Since 1991, all municipal waste and various types of waste (including wood waste) incineration plants have been connected to heating networks.</p> <p>The ban of waste with an organic carbon content > 5 % (weight) from landfilling implies that all wood waste has to be either reused/recycled or, if a reuse/recycling is not possible or too expensive, burned in designated heating or combined heat and power plants. The recycling wood ordinance was prepared with the aim to increase the recycling rate of wood waste (i.e. to increase the share of wood waste that is reused in new products), in line with the hierarchy of waste management of the waste directive.</p> <p>In 2010, incineration represents an energy production for district heating of 26 000 GWh, of which 8 500 of RDF, which contain 85% of wood waste.</p> <p>Austria also uses wood waste in the panel industry and imports part of it, mainly from Germany.</p>
Italy	<p>As in Flanders, Italy has set up a system of green certificates: a minimum share of renewable energy in the production of energy is imposed. The producer pays a tax if the green energy rate is not high enough.</p> <p>Since 1 January 2012, Italy has prohibited the landfilling of combustible waste with a calorific value greater than 13 MJ / kg. Italy is one of the three European countries that started early on the road to the end of waste status for high-quality CSR. The country has early also introduced a CSR standard: UNI 9903.</p> <p>Italy has set up a system of efficient collecting of wood waste, through RILEGNO, but also through private companies linked to panel industry. The presence of an important panel industry has oriented wood waste towards recycling. According to WKL, material recovery reaches 89% in Italy.</p>



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