Underpinning the vital role of the forest-based sector in the Circular Bio-Economy

WoodCircus

Underpinning the vital role of the forest-based sector in the Circular Bioeconomy

D2.1 Fact Finding – WP2 progress report

WP no and title:	WP2 – Analysis of the state of the art and data from desk studies/workshops and interviews
Responsible Author(s):	Giovanni Tosi, Cosmob Francesco Balducci, Cosmob Mariapia D'Anghela, Cosmob Erkki Verkasalo, Luke
Contributor(s):	Anne-Christine Ritschkoff, VTT Tiina Pajula, VTT Andreas Kleinschmit, FCBA Asta Partanen, nova-Institut Javier García Jaca, Tecnalia Mike Burnard, Innorenew Uwe Kies, Innovawood
Date:	26 July 2019
Version:	Version 1.0, Public

General Information about the project

Duration:	November 1st 2018 – October 31st 2021
Type of Project: (CSA)	EU Horizon 2020 Coordination and Support Action Project
Consortium:	17 Partners from 7 European countries

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 820892.

SUMMARY

LIST OF FIGURES

LIST OF TABLES

Introduction

The main objective of WP2 was to assemble the existing knowledge and good practices on wood processing technologies and value chains for the recovery (quantities and qualities) and product potential based on side streams of wood product industries (in the first hand) as well as know-how and experience on waste recycling and management within wood-based industrial sector and building with wood. The scope was to have an updated state of the art, from the technical and regulatory point of view, about the recovery and recycling processes and organization of value chains in the different regions EU and extra EU countries) based on fact finding and review on current practices.

Structured into three tasks, WP2 has been executed and interlinked in parallel with WP3 for mutual exchange of results on fact finding and current practices with criteria development and evaluation of good practices. COSMOB and LUKE are the responsible WP Leaders, with further contributions from Regional Lead Partners (RLP) and companies in the consortium. The working methods used include literature surveys, sub-regional expert interviews and webinars, SWOT analysis, visits to facilities, data and market assessments, review workshops (in close exchange with WP3, WP5 and WP6). The various collected data within these three tasks about good practices, supply chain initiatives and numerous company cases will be organized and delivered to the other WPs in the form of a database. Furthermore, selected datasets will be prepared and submitted to the EC Raw Material Scoreboard of RMIS system facilitated through direct exchange with the JRC at the end of WP2.

Task 1.1 Raw material categories and product potential

The objective is to identify and assess different types of wood-based raw materials, processed and recovered, in the project reference area and sub-regions for the basis of evaluating good practices and know-how for cross-border transfer of competence. Analysis and communication of key material and process factors determining the quantities and qualities and product potential from side streams and recovered wood is performed, taking into account such factors as wood species, physico-mechanical characteristics, chemical characteristics and contamination, and needs of further processing technology and product requirements. In parallel, an analysis will focus on existing definitions and classifications on processed and recovered wood, according to international, national and regional regulations and standards, also related to wood waste disposal and management. This activity results in a catalogue of different raw material groups considering availability, capability and potential uses for primary products and side stream utilization among the reference industries, and represents a valid prerequisite

for the determination of typologies and best practices on side streams and wastes.

Task 1.2 Side stream processing and recycling techniques

The main objective is to provide a detailed overview on available technologies and existing theoretical and practical knowledge on wood processing techniques, wood recovering and recycling, with the aim to identify the wide spectrum of good practices in terms of optimal technologies and uses of resources and process efficiency in woodworking, with a special focus wood chains in construction. Sawmilling, wood-based panels, building, bioenergy and selected biorefinery industries are in the focus. An articulated list of relevant bibliographical references (scientific & grey literature) and industry cases is collected. Furthermore at least 10 visits to specialized industries in different sub-regions of the project are conducted with the aim to describe the existing and to identify promising technologies and good practices.

Task 1.3 Resource efficiency in value chains

The main objective is to review the know-how and practices on resource efficiency and its upgrade regarding yield, grade and relative value of main products and side streams among the reference industries, in order to assess their current status and innovation perspectives in the business and competitiveness development. The current and perspective value chains covering supply, production, marketing and distribution of side streams, recycled products and wood-based and hybrid wastes are mapped and analyzed for each sub-region of the project. In addition to materials and products, the analysis covers industrial actors, enterprise networks and public stakeholders in order to provide full assessment of operational performance, economic viability, competitive ability and cluster (triple helix) collaboration for the selection of development needs and good practices in innovating new products and services and optimal structure of value networks in the reference industrial sectors. For the background data, the current market situation is explored for volumes and prices using international trade statistics and published market development estimates in relevant product groups and selected expert interviews.

1. Methodology

The first part in the fact finding process was the elaboration of a general analysis of the state of the art based on literature reviews, official sources such as reports, statistics, regulations. The objective of this phase was to provide a clear picture of what is the situation in different European regions involved to the project, regarding: 1) classification and definitions of processed and recovered wood based on national and regional regulations and

standards, in relation to the disposal and management of wood waste, 2) value chains, material flows and stakeholders.

The second part of the analysis was focused on the involvement of the stakeholders aiming at obtaining information on the quality and quantity and product potential (material recovery or energy generation) from lateral flows and recovered wood. In particular, two instruments were used: 1) organization of workshops that involved the participation of project representatives and stakeholders, 2) interviews with pre-mailed questionnaire forms addressed to the stakeholders involved in the wood-based side stream utilization and waste management chain. In the next stages of the work, a particular emphasis and attention will be put on countries like France, in order to collect additional and more comprehensive information and data.

2. Analysis of the state of the art

2.1 Classifications of waste according to national and regional regulations

Italy

In February 1997 Italy adopted the National Framework Law (National Decree n° 22/1997) the so called «Ronchi Decree » aimed at the implementation of the European directives 91/156/EEC on waste, 91/689/EEC on hazardous waste and 94/62/EC on packaging and packaging waste, and oriented at reorganising the basic framework conditions and the strategic outlook for Municipal Solid Waste in the whole country.

The legislative Decree n. 22, which represents the standard reference framework for the classification and management of waste, introduces a **new system of classification** of wastes based on:

- their origin (distinguishing between **urban waste** and **special waste**)
- and on the danger (distinguishing between **hazardous** and **non-hazardous** waste).

The Ronchi Decree identifies four priority objectives:

1. Reduction the quantity of goods (for example packaging) destined to become wastes at the production level
2. Encourage as much as possible the re-use and the recycling of the goods/raw materials with the waste differentiation process;
3. Waste-to-energy (energy production from waste) for unrecyclable waste;
4. Planting in a controlled landfills the waste which cannot be incinerated and/or the residues of that treatment process.

Legislative Decree 22/1997, with the later regulations that have modified and integrated it, constitutes the general discipline of the subject.

The current legislation (N° 152/2006) follows the Ronchi Decree waste classification. In particular[1]:

The urban waste (Par. 2 Article 184 of D. 156/06)

Urban waste is defined as waste that, even if cumbersome, comes from homes; moreover it includes waste of any kind or origin, lying on roads and public areas or on roads and private areas subject to public use or to maritime and lake beaches and on the banks of water courses; it includes vegetable waste from green areas, such as gardens, parks and area cemetery and waste from exhumations and extinctions, as well as other waste from cemetery activity.

Special waste (Par.3 Article 184 of D. 156/06)

The special waste includes:

a) Waste from agricultural and agro-industrial activities;
b) Waste deriving from demolition, construction, as well as hazardous waste deriving from excavation activities;
c) industrial waste, without prejudice to the provisions of article 185, paragraph 1, letter i);
d) Handicraft waste;
e) Waste from commercial activities;
f) Waste from service activities;
g) Waste deriving from the recovery and disposal of waste, sludge produced by water purification and other water treatments and from the purification of waste water and fume abatement;
h) Waste deriving from health activities;
i) Machinery for deteriorated and obsolete equipment;
j) Motor vehicles, trailers and the like out of use and their parts;
k) Fuel derived from waste;
l) Waste deriving from the mechanical selection of urban solid waste.

The refusal may cease to be considered as such when it has undergone a **recovery** operation, including **recycling** and preparation for **re-use**[2]

[1]Ecocerved, Camera di Commercio di Fermo. *Manuale per un comportamento corretto nella classificazione dei rifiuti speciali.* Ottobre 2012.

[2]Following the transposition of the directive 2008/98 about *recovery*, Italy differentiates the terms re-use and recycling. The term, *re-use* means all operations that allow the re-use (for the same purpose) of products that have not yet become waste; while the term *recycling* refers to recovery operations that allow the reprocessing of waste materials, so as to obtain

ie when the substance or object is commonly used for specific purposes or there is a market or demand for that substance or object, the substance or object meets the technical requirements for specific purposes and respects the existing legislation and standards applicable to the products and when the use of the substance or object will not lead to overall negative impacts on the environment or human health

Hazardous waste and the European Waste Catalogue (CER)

The various types of waste are coded according to the European list of waste -so-called CER[3] - referred to in Decision **2000/532/EC** and subsequent amendments.

"Hazardous substance" means any substance classified as dangerous according to Directive **67/548/EEC** and subsequent amendments: this classification is subject to updates, as research and knowledge in this field are constantly evolving. The classification of hazardous waste is based on the introduction of the decision 2000/532/ CE:

- On the origin

The waste is classified as dangerous because it is dangerous itself and in particular derives from its origin substantially attributable to the fact that these wastes have one or more of the hazard characteristics set out in Legislative Decree n. 152/06

- On the content of hazardous substances

- They are identified as dangerous with specific or generic reference to dangerous substances contained, only if the substances reach certain concentrations.

According to the D. 152/06 (article 184, paragraph 5), are **hazardous wastes** marked with a special asterisk in the list **CER2002**.

The types of waste in the wood sector

The typologies of wood waste include the wood shavings and wood scraps, packaging materials, sludge and painting water.

Some types of residues are present across the various production sectors in particular:

- wood scraps and untreated chips
- glues and adhesives (residues)
- paints (residues)
- painting booth sludges
- slats of painting booths

---

new products, substances or materials to be used both for new purposes and for the same for which they were conceived.

[3] The ERC is the common reference nomenclature for the European Community, and aims to coordinate and improve all activities related to waste management.

- ashes, slag, combustion powders
- dirty sawdust of solvents and/or inks and/or paints
- containers dirty with solvents, inks, paints, glues

In addition, there are some sectors that are characterized by the presence of specific residues. In particular, the production of semi-finished products in wood (the plywood and particle board industries) is characterized by the presence of formaldehyde, glues and adhesives, acetone, organic sludge with metals, other organic sludges, diluents and or cleaning solvents, and to a lesser extent panel residues, thermoplastic resins etc. The production of wooden packaging is strongly characterized by the presence of fiber and wood pulp residues;

The furniture and wooden furniture industry is characterized above all by the prevalent presence of solvent residues, thinners and paint strippers used for the painting, polishing and cleaning of furniture: acetone, formaldehyde, xylenes, diluents and/or cleaning solvents paint strippers, and paint thinners.

The following table contains the list of typical waste typologies related to the wood sector.

Table 1 Wood waste classification according to CER

CER	DESCRIPTION
03	**Wastes from wood processing and panel production, furniture, pulp, paper and cardboard**
03 01	**waste from wood processing and panel and furniture production**
03 01 01	scraps of bark and cork
03 01 04*	sawdust, shavings, cutting residues, wood, particle board and veneers containing dangerous substances
03 01 05	sawdust, shavings, cutting residues, wood, particle board and veneers other than those mentioned in 03 01 04
03 01 99	waste not otherwise specified
03 02	**waste from wood preservation treatments**
03 02 01*	products for wood preservation treatments containing non-halogenated organic compounds
03 02 02*	products for wood preservation treatments containing chlorinated organic compounds
03 02 03*	products for wood preservation treatments containing organ metalling compounds
03 02 04*	products for wood preservation treatments containing inorganic compounds
03 02 05*	other products for conserving wood containing dangerous substances
03 02 99	products for conservative wood treatments not otherwise specified
03 03	**waste from the production and processing of pulp, paper and cardboard**
03 03 01	scraps of bark and wood
03 03 02	sludge recovery of maceration baths (green liquor)
03 03 05	sludge produced by the deinking process in paper recycling
03 03 07	mechanical separation waste in pulp from paper and cardboard waste
03 03 08	waste paper and cardboard selection destined to be recycled
03 03 09	waste sludges containing calcium carbonate
03 03 10	waste fibre and sludge containing fibres, fillers and coating products generated by the processes of mechanical separation
03 03 11	sludges from on-site effluent treatment other than those mentioned in 03 03 10
03 03 99	waste not otherwise specified
15	**Packaging waste, absorbents, rags, filtering materials and protective clothing**
15 01	**packaging (including urban packaging waste subject to separate collection)**
15 01 01	paper and cardboard packaging
15 01 03	wooden packaging
17	**Waste of construction and demolition operations**

17 02 17 02 01 17 02 04*	**wood, glass and plastic** wood glass, plastic and wood containing or contaminated by dangerous substances
19 **19 12** 19 12 06* 19 12 07	**Waste from waste treatment plants, plants treatment of wastewater outside** **wastes from mechanical waste treatment (eg sorting, shredding, compacting, reduction in pellets) not otherwise specified** wood containing dangerous substances different wood than that mentioned in 19 12 06
20 **20 01** 20 01 37* 20 01 38	**Urban waste (domestic and waste produced by activities Commercial and industrial and the institutions)** **fractions subject to separate collection** wood containing dangerous substances different wood than that mentioned in 20 01 37

Source: Our elaboration on CER catalogue[4].

UK

The Wood Recyclers Association has developed a grading structure for UK derived, non-virgin wood for recycling into products, feedstocks and fuels: the WRA grading structure.
The purpose of the grading structure is to provide a simple and common understanding as to what grade of material is suitable for each main market sector.

Table 2 UK wood waste classification and grades

Grade	Typical Markets	Typical Sources of Raw material	Typical Materials	Typical Non-Wood Content Prior to Processing
Grade A- "Clean" Recycled Wood	A feedstock for the manufacture of professional and consumer products such as animal bedding and horticultural mulches. May also be used as a fuel for renewable energy generation in non WID* installation, and for the manufacture of pallets and briquettes.	Distribution. Retailing. Packaging. Secondary Manufacture e.g. joinery. Pallet Reclamation.	Solid softwood and hardwood. Packaging waste, scrap pallets, packaging cases, and cable drums. Process off-cuts from manufacture of untreated products.	Nails and metal fixings. Minor amounts of paint, and surface coatings.

[4] CER catalogue available at http://www.ccrifiuti.it/doc/cer.pdf

Grade B- Industrial Feedstock Grade	A feedstock for industrial wood processing operations such as the manufacture of panel products, including chipboard and medium density fibreboard (MDF)	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
Grade C- Fuel Grade	Biomass fuel for use in the generation of electricity and/or heat in WID** compliant installations	All above plus Municipal Collections, Recycling Centers, 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 fiberboard	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	Requires disposal at special facilities	All of the above plus fencing, track work and transmission pole contractors.	Fencing Transmission Poles Railway sleepers Cooling towers	Copper / Chrome / Arsenic preservation Treatments Creosote

UK Government Legislation

Businesses are affected by a range of legislation relating to how they produce, handle and treat the waste created both directly by their employees and within their workplace in general.

Key among these is the duty of care. This places a legal responsibility on businesses to ensure that they produce, store, transport and dispose of their business waste without harming the environment. The duty of care applies to all controlled waste, which includes both household and commercial & industrial, or C&I waste.

Duty of care

The requirements of the duty of care apply to the storage and transport of waste, including needing to check a business waste is being dealt with by an authorized waste carrier. Businesses must also complete waste transfer notes to document all waste they transfer from their site. Waste and recycling management services for businesses are offered by both waste management companies and

local authorities. An increasing number of councils are providing business, or trade, waste collection services.

Permitting

Businesses which are involved in waste management are also subject to the environmental permitting regime. In England this means they could have to apply for an environmental permit or, for some activities, an exemption from permitting. In Scotland and Northern Ireland, the system is managed by waste management licensing and pollution prevention and control permitting.

Producer responsibility

Several pieces of government and European legislation also place further responsibilities on businesses. These include producer responsibility legislation such as the Waste Electrical and Electronic Equipment (WEEE) Directive, the Packaging Waste Directive, the Batteries Directive and the End- of-Life Vehicle (ELV) Directive. As well as placing a financial responsibility on the manufacturers of new products to fund the collection, treatment and recycling of waste materials, certain types of business often have a major role to play as a key avenue for the return of material. For example, retailers selling more than one pack of four AA portable batteries a day have a legal obligation to provide free in-store take-back of any waste portable batteries from end users.

Landfill tax

However, businesses are largely unaffected directly by the major legislative drivers which aim to divert waste from landfill and recycle more such as the European Waste Framework Directive and the Landfill Directive. Instead, the main push for them to divert material from landfill comes from landfill tax, a levy which must be paid on every tons of waste sent to landfill.

Germany

Waste management legislation is based on European law, German federal law, the regional laws of the federal states and the statutes of the local authority waste management services. The main pillar for the management of Wood Waste is the ordinance on the **Management of Waste wood.**

The Ordinance laid down specific requirements for the recycling and energy recovery as well as for the disposal of waste wood on the basis of the Closed Substance Cycle and Waste Management Act[5]. These requirements provide a sustainable support for the environmentally sound recovery of waste wood and ensure that

[5]German Law Archive. https://germanlawarchive.iuscomp.org/?p=303

pollutants are eliminated from the economic cycle.
In the Ordinance, waste wood includes residues from the working and machining of wood and derived timber products as well as used products such as wood packaging, palettes, furniture and waste wood from demolition. The Ordinance covers all the common methods of waste wood management such as preparing waste wood for the production of derived timber products, the production of active carbon or industrial charcoal and synthesis gas and the energy recovery of waste wood as a substitute fuel. If waste wood cannot be recovered, it must be disposed of using thermal processes. **Land filling is not permitted.**

Table 3 Classification of recycled wood in Germany

Group	Classification	Examples	Treated	Contaminated	Hazardous
A I	Untreated recovered wood	Wooden packaging material e.g. palettes, wooden cases. Building and demolition wood. Wooden bulky rubbish of residential waste fraction	no	no	no
A II	Treated recovered wood	Building and demolition wood Wooden bulky rubbish of residential Doors, windows Residues from construction wood Wood from concrete casing	yes	no	no
A III	Contaminated recovered wood	Railway sleepers Transmission poles oil impregnated	yes	yes	no
A IV	Hazardous recovered wood	Piles and poles salt impregnated Chemical treated wood waste CCA and CCB	yes	yes	yes

The Closed Substance Cycle and Waste Management Act (KrW-/AbfG) considerably extended the scope of waste law as compared to earlier legislation. Under the heading "closed substance cycle"

the Act also includes all waste recovery measures relevant to the waste sector. The provisions in the Closed Substance Cycle and Waste Management Act[6] that in many cases had to be kept general need to be specified for individual waste flows by means of more detailed provisions in order to ensure legal and investment certainty in the enforcement of the law.

The Ordinance defines specific requirements for substance recycling and energy recovery and for the disposal of waste wood on the basis of the Closed Substance Cycle and Waste Management Act. At the same time, these requirements are harmonized with the requirements to be adhered for the management of waste wood pursuant to chemicals and hazardous substances law as well as the provisions governing the keeping of waste recovery and disposal records. The following regulations are particularly relevant:

- both residual woods from industry and wood products that have become waste are classified as waste wood in this Ordinance.
- The Ordinance identifies the current recovery procedures for waste wood, namely the processing of waste wood for the manufacture of derived timber products, the manufacture of active carbon/industrial charcoal, the production of synthetic gas as a chemical raw material and the energy recovery of waste wood. Other possible recovery paths are not regulated by the Ordinance but are also not excluded so that this does not stand in the way of incorporating new recovery paths and innovative recovery procedures for waste wood.
- The requirements in the Waste Wood Ordinance define high-quality substance recycling and energy recovery procedures.

Wood waste must be assigned to one of four waste wood categories depending on the level of pollution, from A I (waste wood in its natural state or only mechanically worked) to A IV (waste wood treated with wood preservatives, e.g. railway sleepers, hop poles, etc.) Instead of elaborate and uncertain sampling and analysis provisions, assignment to the respective category can occur on the basis of origin and in accordance with strict requirements for keeping waste wood separate and bans on mixing waste woods. To simplify assignment, the Ordinance contains a general rule to be assumed for the common types of waste wood. In the case of a mixture of different waste wood categories, the mixture must always be assigned to the category subject to the most stringent provisions.

In order to ensure safe recovery, the waste wood categories A I to A IV are then allocated to the individual substance recycling

[6] Federal Ministry for the Environment, Natura Conservation and Nuclear Safety (2011). Closed-loop waste management.

paths; energy recovery is governed by the provisions of the Federal Immission Control Act and the statutory ordinances issued on the basis thereof. Waste wood containing PCBs is classified as a "special category" if its PCB content is more than 50 mg/kg. Waste wood containing PCBs must be disposed of in accordance with the PCB/PCT Waste Ordinance – only thermal treatment procedures come into question.

The waste wood categories A I to A IV may be used for the manufacture of active carbon/industrial charcoal and the production of synthetic gas as well as in incineration and gasification plants that are licensed pursuant to the Fourth Ordinance on the Implementation of the Federal Immission Control Act and with regard to emissions are subject to the Seventeenth Ordinance on the Implementation of the Federal Immission Control Act. During these procedures, the organic pollutants contained in the waste wood are completely destroyed due to the high temperatures. Heavy metals are bound as solid in the residues or dispersed during waste gas purification.

Only certain pollution-free or low-pollution waste woods can be considered for use in manufacturing derived timber products. Compliance with this requirement is guaranteed by binding pollutant limit values, including relevant sampling and analysis provisions, for the wood chips produced for use as raw materials for the manufacture of derived timber products. Waste wood processed in this manner for the derived timber products industry ceases to be waste and can be processed there as a primary raw material. In the context of the energy recovery of waste wood, use of waste wood in installations where fodder is dried in direct contact with the installation's exhaust and flames is restricted to waste wood category A I. This ensures that fodder contamination is ruled out.

With regard to inspections and monitoring, the Waste Wood Ordinance is geared towards strengthening the personal responsibility of the installations, supplemented by moderate independent inspections and monitoring. The focus is on the operators of waste wood treatment installations that are obligated to allocate the waste wood to the given recovery paths. This allocation process is to be monitored regularly. This system of internal and independent monitoring is supported by documentation and reporting obligations. This provision produces a high level of precautionary environmental protection with the greatest possible personal responsibility while at the same time being enforcement-friendly.

Spain

According to the Law 22/2011[7] there are different classification of wastes depending on the origin, composition, dangerous. The following table describes the different classification of wastes by categories.

Table 4 Waste classification in Spain

Composition	Origen	Danger
Organic residue	Domestic waste	Inert waste
Inorganic waste	Commercial waste	Hazardous waste
Residue mix	Industrial waste	No hazardous waste
Hazardous waste	Bio-waste	
	Construction and demolition waste	
	Sanitary waste	
	Mining waste	
	Radioactive waste	
	Animal waste	

Source: Ley 22/2011, de 28 de julio, de residuos y suelos contaminados.

Focusing of wood waste, an important role is played by the Spanish Association of Wood Biomass Managers "ASERMA" (Asociación Española de Gestores de Biomasas de Madera) that is a reference within the sector and since 2007, thanks to its partners, can provide data on waste and other products they manage; In more detail, through a simple survey of associated companies, ASERM provides important annual information on the wood area.

In the following table, there is the classification of wood waste for Spain proposed by Ministry of Agriculture, Food and Environment[8] the that specify the typology of wood waste according to the origin and the destiny of wood waste.

[7] Ley 22/2011, de 28 de julio, de residuos y suelos contaminados. [Available at: http://smartleges.com/es/biblioteca-de-leyes/ley-22-2011-de-28-de-julio-de-residuos-y-suelos-contaminados/2014780]

[8]Ministerio de agricultura, alimentación y medio ambiente. (2012) DIseño metodologico para la clasificación de productos recuperables de los residuos de madera, orientado a potenciar enfoques de gestión, producción y consumo más sostenibile. Madrid. [Available at: https://www.miteco.gob.es/images/es/Informe%20residuos%20madera_29112010_para%20editar_tcm30-193004.pdf]

Table 5 Wood waste classification in Spain

Category	Description	Origin	Destiny
1	Clean wood residue, wood residue in its natural state or from mechanical work (without chemical compounds)	Waste of packaging and scraps of manufacture that have not been painted or treated. Waste wood from felling and machining. Wood furniture in its natural state.	The recovery of the waste (recycling): board industry, horticulture
2	Wood waste treated with non-hazardous compounds. May contain non-halogenated organic compounds and does not contain preservatives	Waste, pallets, packaging, boards, furniture, doors and frames from the wood industry that do not contain hazardous pollutants	The material recovery (recycling) of the waste
3	Residue from wood that has been treated with halogenated organic compounds and does not containt preservatives	Pallets with composite materials, furniture with organic compounds halogenates, bulky waste (mixed)	Energy recovery (biomass) Incineration with energetic recovery Incineration without energy recovery
4	Residue of wood treated with preservatives as well as other wood residues that due to their contamination cannot be assimilated to any of the previous categories	Waste wood demolition and restoration as beams, windows, exterior doors, wood impregnated for extreme structures. Railway sleepers, telephony and light poles, fences. Impregnated garden furniture, Wood waste for industrial use	Energy recovery (biomass) Incineration with energetic recovery Incineration without energy recovery

2.2 Value chains and stakeholders involved

General

The value chains of wood-based side streams and waste wood include different steps from production to valorization, including sourcing, processing, transport, storage and distribution to the market. The term wood supply chain involves the logistics system from timber to final product that is delivered to a customer; the term means the deliveries and links between customers, suppliers and shippers in the forest business. In addition to the practitioners, the value

chains are labelled by stakeholders such as machine, equipment and material suppliers, private and public financing bodies, decision makers in public administration, regulation and support to the economy and regional development, organizations and societies of research, development and innovation, etc. The construction sector is largely responsible for the resources used in Europe and is the dominant user of wood products, therefore value chains of buildings and their resource efficiency are at the core of side streams and waste approach.

In the Waste Wood Supply Chain three processes are included: wood waste collection, transportation (road, rail or water) and sorting and processing. Wood waste comes mainly from industry, construction, and demolition, as well as packaging and a numerous actors are involved in the whole value chain[9]. However, differentiation of side streams and wastes in the value chain are many times challenging. According to a common interpretation

Resource efficiency from an industrial point of view involves materials, energy, work, capital and entrepreneurship in the supply, production and distribution of both primary products and side streams. Raw material, product and energy flows and their efficient and responsible utilisation and upgrading in value chains, are of crucial importance. The first aim of efficiency in wood processing is to maximise yields for volume and grades while optimising the net market value of primary products, such as sawn timber, plywood of other wood-based panels, within the limits of material and energy resources and minimum resource expenses. The second priority is to produce as much side stream material as possible, such as bark, chips, saw and grinding dust, shavings, flakes, cut-offs etc. either as raw materials for other industries, for bioenergy production in the mills themselves, or sold to other users to gain more value for the enterprises and stakeholders involve. A similar philosophy is applied through the further processing steps in wood-based value chains, such as furniture, joinery, prefabricated housing, building element manufacturing, and demolition wastes. Closed loops toward minimum environmental loading and high degree of cascading and recyclability are targeted in material and energy flow. This is in the line of using the Earth's limited resources in a sustainable manner while minimizing impacts on the environment, allowing to create more with less and delivering greater value with less input (The Roadmap to a resource efficient Europe by 2050).

[9] Garcia, C. A., & Hora, G. (2017). State-of-the-art of waste wood supply chain in Germany and selected European countries. *Waste management*, *70*, 189-197. Available from: https://www.researchgate.net/publication/320005202_State-of-the-art_of_waste_wood_supply_chain_in_Germany_and_selected_European_countries.

Woodworking industries primarily include sawmilling, plywood, wood panel, furniture, building component, flooring, particle board, molding, jointing and craft industries as well pre-fabricated house and element manufacturing. Novel products, markets and stakeholders involved inevitable imply new supply and value chains, enterprise networks and collaboration, raw material and process integration, storage and transportation logistics and scaling the production at different steps for optimal build-up of industrial ecosystems and value-add. Depending on the region and case, production plants and processing enterprises may form different value chains where the degree of integration, concentration and decentralization varies.

Competing uses of raw material side streams is a matter of discussion between stakeholders and decision makers. The EU's waste management directives set pressure for policies in side stream and demolition waste control, urging the development of new options for recycling in companies. Industrial raw material and semi-product uses of bark and chip, dust, shavings and flake form materials include particle, fiber and MDF boards and different forms of bioenergy. The role of packaging industries, chemical industries and advanced Biorefineries is increasing in the utilization of side streams both for techno-chemical bulk products (e.g., adhesives, surfactants, dispersion agents, liquid fuels) and consumer products with specific functionalities (e.g., foods and nutritive agents, health promoting products, detergents and cosmetics).

Industrial symbiosis or ecosystem is a whole of several enterprises where companies complement and provide added value for each other by utilizing effectively raw materials, technology, service and energy. Side stream or waste generated in the production of a company can be a raw material for another company, as a result, the material changing from a cost item to valuable factor of production. In the recent scientific literature, industrial ecosystems have been understood in a large context, not only as material circulation but also sharing knowledge and insight between the stakeholders to generate new ideas and innovations. Business ecosystems to be built around industrial symbioses provide more added value using less natural resources than in traditional industrial value chains, utilizing materials and waste flows more efficiently with less energy, water and amount of wastes. Business ecosystems are understood differently in various contexts, but finally the group of agents, i.e. members of ecosystem should share the business values and revenue logic. The ecosystems are under development in side-stream utilization and recycling business in many regions in Europe, however, well-functioning examples already exist both on concentrated, integrated and decentralized solutions.

It is essential that scaling of production volume affects essentially the organization of sourcing raw materials or semi-

finished products, manufacturing, deliveries and logistics. In a large-volume production of bigger companies, the structure of actor network, needs of collaboration and optimal location of manufacturing and storage steps are different than in a specialized production of SMEs. Management of value network, ownership of the companies, collaboration models, and readiness to incentives, resources and commitments to investment and development actions vary between large and small companies, being often linked with the degree of concentration, integration and decentralization.

Italy

The supply chain of wooden packaging in Italy operates primarily with the production of the consortium producers at RILEGNO, a large group of actors that moves the circular economic system in Italy.
Rilegno is the National Consortium for the collection, recovery and recycling of wood packaging that works within the system CONAI (National Packaging Consortium) and they have designed a dense supply chain network that helps consortium producers to identify the collection points of their products wastes and how the proper transportation logistics to the recycling centers can be maintained.

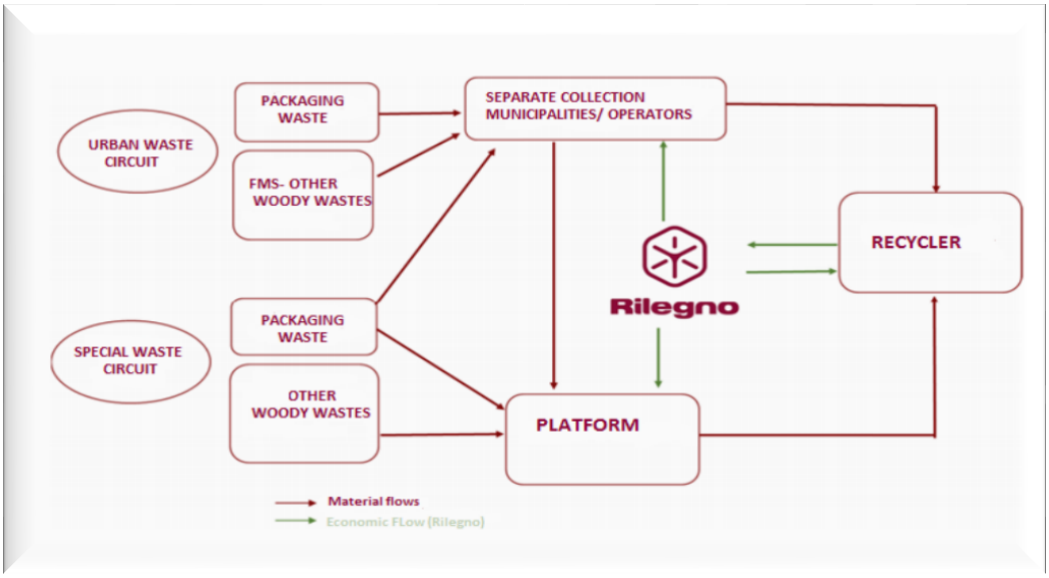
The fulcrum of the recovery system is the network of consortium platforms, to which private companies and municipal administrations can deliver post-consumer wood packaging free of charge. In particular, 1.987 are the members of Rilegno, with a network of over 400 platforms affiliated with RILEGNO that take care of organizing the start of recycling of waste wooden packaging that comes from commercial, craft and industrial activities collection platforms, widespread throughout the territory serving the industrial and commercial fabric. In particular:

- Producers (270) manufacturers and importers of materials for wood packaging
- Processors intended as manufacturers and importers of:
    - Pallets and pallet repairers (852)
    - Industrial packaging (634)
    - Food packaging (219)
    - Recyclers/recoverers (11)

Rilegno has established collaborations and profitable synergies with:

- 1. Private operators: recognized as Platforms;
- 2.Individual municipalities: their aggregations or environmental managers (subjects of public and private sectors responsible for policies and plans development of wood waste collection and recovery systems.

Figure 1. Wooden packaging management supply chain



Source: Rilegno (2018). Rapporto 2018 Progetti, Innovazioni, Prospettive.

The platforms affiliated with the Consortium are located mainly in the Regions of Northern Italy. Lombardy, is the most covered Region followed by Emilia Romagna, Veneto, Sicily and Lazio. The concentration of recyclers in the northern area affects logistics costs, as a result also of the progressive development and implementation of public collections and the activation of new platforms for collection in the entire Center-South. In 2018 there was a strong increase in coverage in the South with 13 new conventions. In addition to the agreements with the Municipalities, Rilegno has signed agreements with 416 public and private platforms that carry out, directly and/or on behalf of the Municipalities, the collection and withdrawal of wood on the territory, guaranteeing the subsequent start-up to recycling. All the national territory is "covered" by platforms affiliated with the Consortium where it is possible to confer packaging waste; of these at least 165 withdraw post-consumer wood from differentiated collection also from the public service operators affiliated with the Consortium according to the ANCI-CONAI agreements.

Recycling is carried out almost exclusively by the producers of wood-based panels (chipboards of various thicknesses and thin MDF) that receive the material and transform it into products to be used in the furniture wood sector and, to a lesser extent, used for elements for new packaging Wood.

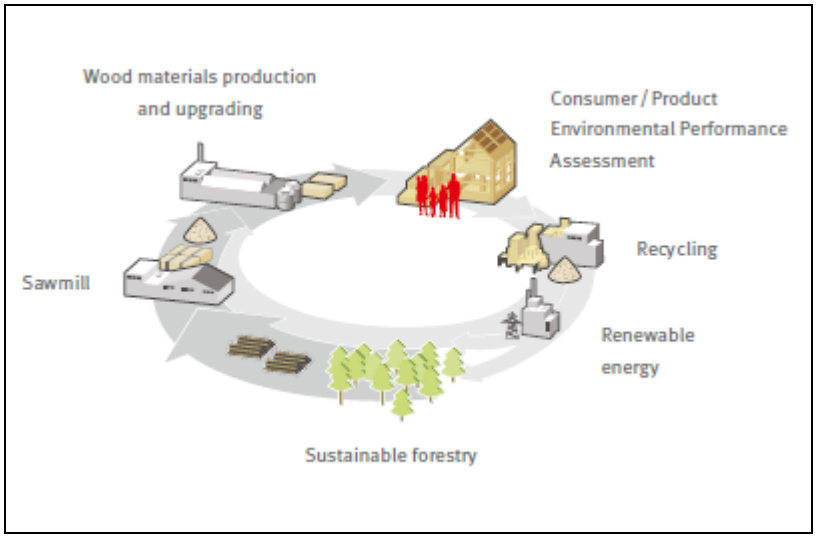
At the beginning of the supply chain, different platforms are selected/contracted to carry out the first selection and volume reduction of the waste wood (e.g. pressed, crushed, shredded or chipped). The main goal of this first treatment is to optimize the transportation of the raw material but also, to deliver functional and ready materials for the subsequently processing in the recycling facility. Additionally, the collection platforms are able to collect other types of waste wood from the furniture industry, construction and demolition, scraps from the wooden packaging industry and other wooden artefacts. The various types of primary, secondary and tertiary wooden packaging came from around 2,000 small and medium-sized enterprises, present throughout the national territory, a cause of the high fragmentation of the market, as in an environment of strong competition. To these are added hundreds of small activities dedicated to the recovery and reconditioning or regeneration of used pallets. Once their function is over, wood packaging that has become waste is collected mainly from private surfaces (85-90%) such as industry, commerce and large-scale distribution, being packaging mainly used for handling and transporting goods.
A part of the flows entering the recycling companies and not directly attributable to the operators of the consortium network, is entirely managed by them and the relative data communicated annually to RILEGNO: the quantities of post-consumer packaging sent for recycling are therefore detected mechanical (production of wooden agglomerates, cellulosic pulp, wood-cement blocks for building, elements for pallet assembly) and present within the aforesaid heterogeneous wood-matrix flows. Wood waste managed by third parties is not subject to periodic product inspections, but can be compared with those managed by the consortium system, at least in consideration of the CER codes used for recovery. The information on the physical and product characteristics deriving from the consortium operations, which derive from frequent and repeated inspections on the flows of wood waste delivered in the agreement to the same recycling companies, make it possible to obtain information that is also functional for the identification of the packaging waste component present in the flows sent for recycling outside the RILEGNO system, or in third-party management.

Germany

The supply chain of wood in Germany sees different actors has the main subject in the management of wood waste and recycling. Several facilities exist for the management of wood waste. The recycling of processes wastes is carried out by **private companies** that manage all the processes (collection, sorting and treating) or by third-

recycling companies[11]. In the first case, the company collect the wood waste and after the processing of these waste they re-introduce the wastes in the production cycle in order to improve the use of recycled material in the production process.

Figure 2 From the three to the product- a closed cycle

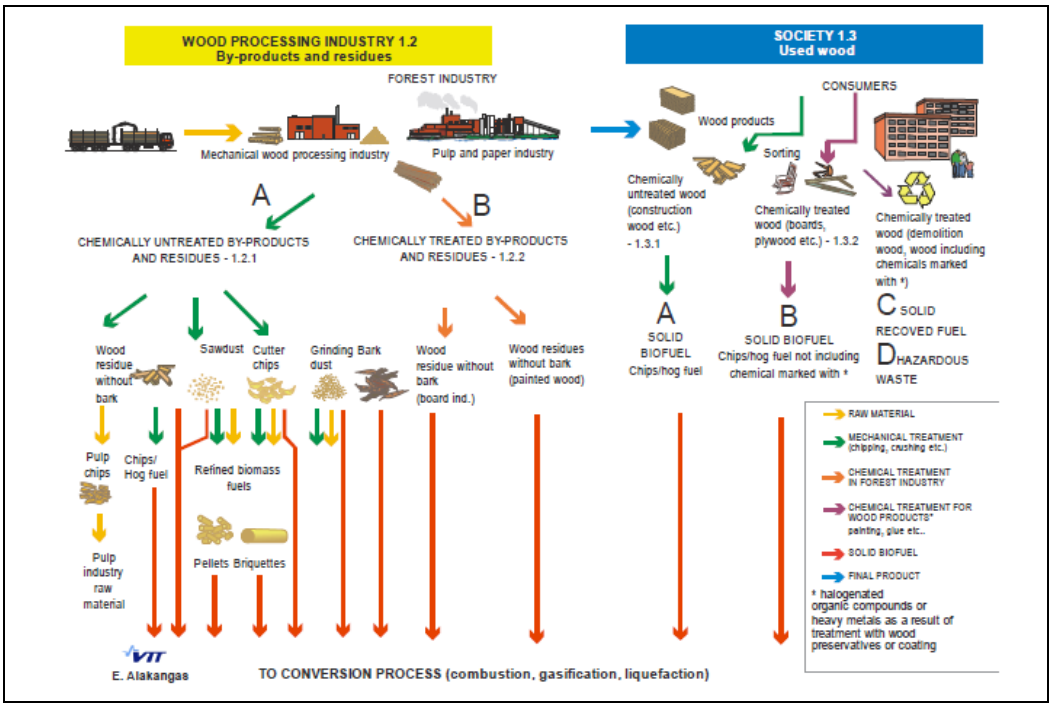


Source: Egger, Environment & Sustainability. Sustainable construction and healthy living with Egger wood-based materials

In the case of third companies, the main roles are to collect the wastes from different collecting points available for customers in order to deliver them in some collection centers. The aim of the collection centers is to collect the wastes and transport them in recycling facilities where they are classified, sorted and treated in a correct way (cleaned and reduced in size). The last step is to submit the wastes to an incineration facilities to generate **electricity and heat** (co-generation).

[11] Garcia, C.A., Hora, G. State-of-the-art of waste wood supply chain in Germany and selected European countries. Waste Management (2017).

Figure 3 Classification of the industrial by-products and residues and used wood



UK

The Wood waste arises in UK from different sources[12]:

- construction and demolition: solid wood, particleboard, imported elements, Oriented strand boards (OSB)
- packaging: pallets
- municipal: sawn off-cuts, wood based panels, surfaced wood
- joinery and furniture manufacture: Solid wood and particleboard

Producers of wood waste dispose it in landfill or through wood processors/recyclers or waste management companies. The actors involved in the management of wood waste are[13]:

- the composters, aimed at recovery wood in composting, have their logistic network that permit them to collect the wood waste from collection points
- Local Authority Household Waste Recycling Centers (HWRC) aimed at collecting wastes for residents, limited for wood sorting
- Collection clusters for small and medium enterprises: building collection routes at sufficient density to ensure viability

[12] Department for Environment Food & Rural Affairs (2012) Wood Waste Landfill Restrictions in England.

[13] Department for Environment Food & Rural Affairs (2013). Wood Waste Landfill Restrictions in England: Call for Evidence.

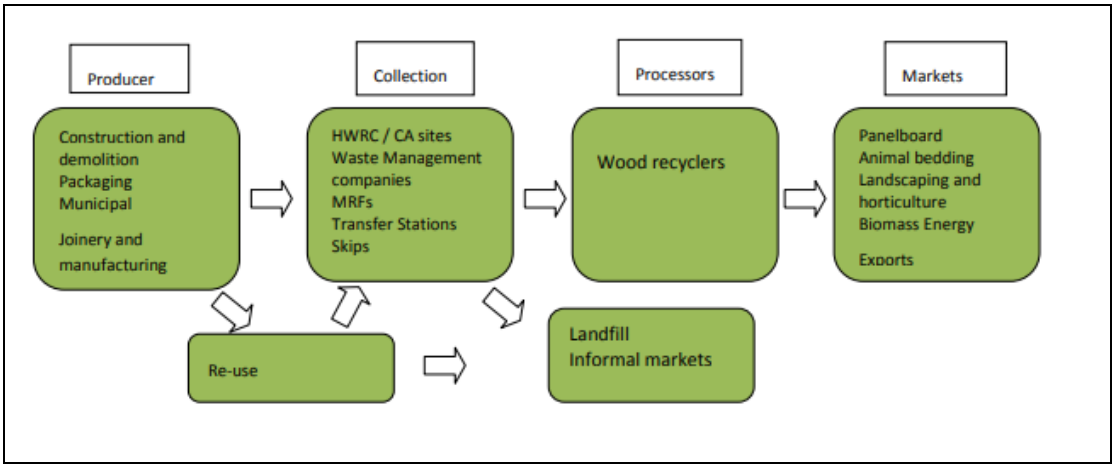
for that do not produce sufficient wood waste to make skip based collections viable[14].

- Reverse Logistic, aimed to reducing cost of transportation, by using existing transport movements to return wood waste to a collection point for processing to end markets but these practices are not completely implemented yet.

The main markets in the wood waste industry in the UK are:

- Panelboard industry and biomass/energy production
- animal/poultry bedding; mulches (soil conditioners and composting), equine surfaces and pathways and coverings
- There is also a growing export market (for recovery) in wood waste

Figure 4 Wood waste supply chain in UK



Source: Department for Environment Food & Rural Affairs (2012) Wood Waste Landfill Restrictions in England

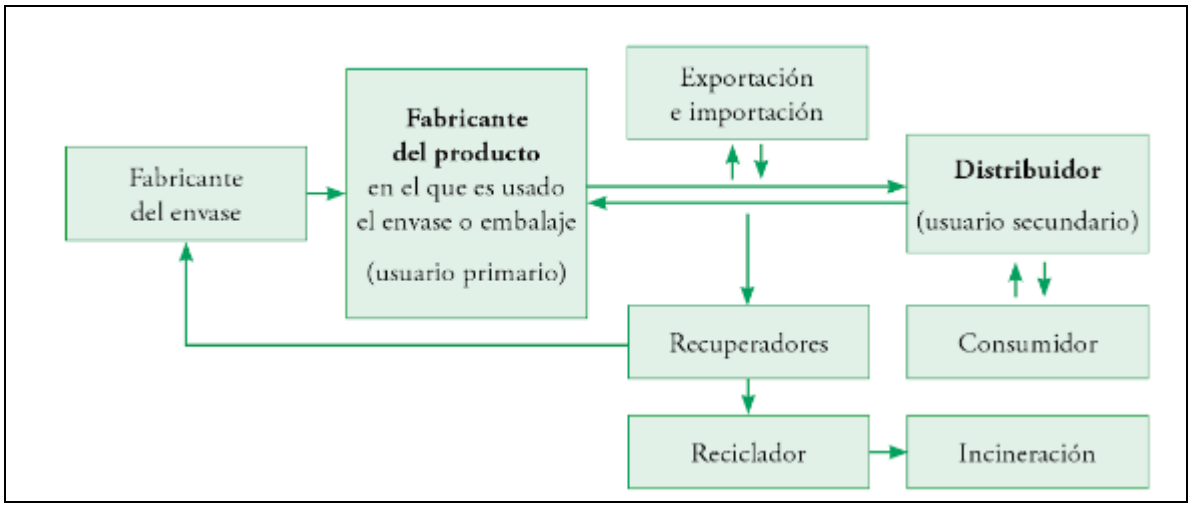
Spain

Spain has transposed the directive 94/62/ce in the Law 11/97, 24 of April, on packaging and its waste. The afore mentioned law has as a universe of affectation all packaging for domestic, industrial or commercial use. Ecoembes, as a non-profit society, invest everything that enters as wastes by selling material in the recovery of packaging for subsequent recycling.

The next figure show the life cycle of the recovery of wooden packaging.

[14] WRAP (2012). The business Case for the Wood Waste Collection Hubs.

Figure 5 Life cycle of the recovery of wood packaging

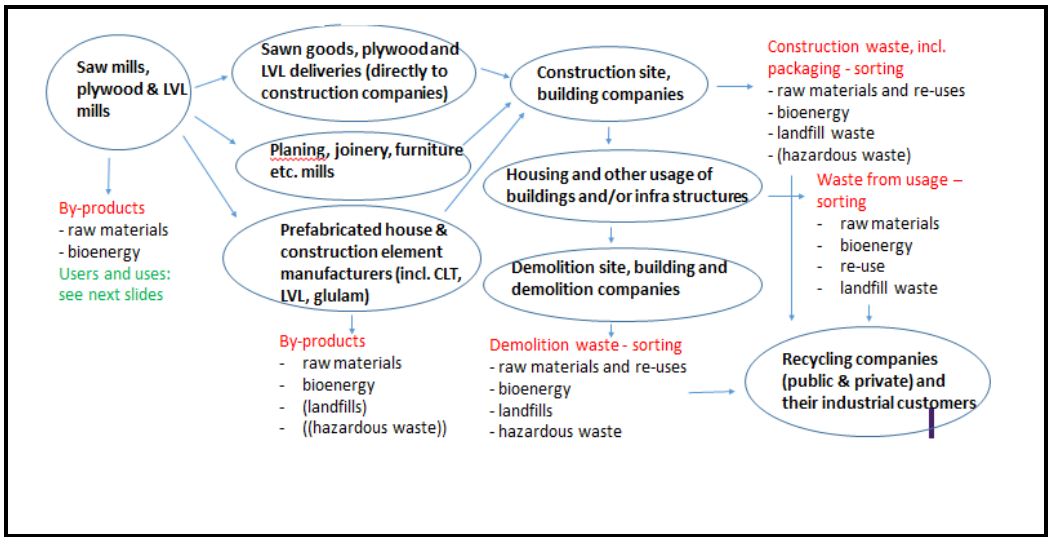


Source:Cabeza, D. (2012). Logística inversa en la gestión de la cadena de suministro. Marge books.

Finland

Value chains of side-streams and waste management in northern Europe based on wood products are driven both by the suppliers and by the users, covering the network of wood product industries, green field construction, building demolition and recycling organizations (Figure 6).

Figure 6 Value chains of side streams and wood-based wastes driven from construction in Finland



Different to Central and Southern Europe, the role of saw mills is the most important in Northern Europe as the supplier of their by-products, and pulp and paper mills and big heating and power plants are the definitely largest users. In parallel, the consumption of the few particleboard and fiberboard industries is smaller, although they use nowadays only saw dust, shavings, off-cut pieces and bark from saw and plywood mills because of their good availability and lower price compared with round wood from the forest.

The availability of construction and demolition wastes is limited to the vicinity of larger cities; they are few because of the smaller population. Long transportation distances, unprofitable collecting and quality concerns of these wastes have hindered the development of recycling business. Accordingly, the recovery practices may be less developed in comparison to other countries in Europe, but well adapted to the supply and demand[15].

In Finland, the main products starting from saw mill and veneer chips are chemical, mechanical and semi-chemical pulps and the resultant versatility of paper and paperboard grades. The market of green chips is steady, albeit the considerable fluctuation in market prices, and the demand is growing further due to the announced and prospective investments in pulping. The market of other side-streams, mainly saw dust, dry chips and bark is more problematic and dependent on the demand of and public subsidies to the bioenergy sector. There are three pulp mills that continuously use saw dust in the integrated production of different packaging papers and paperboards, and approximately 30 wood pellet factories throughout the country that use mainly saw dust and planer shavings as their raw material.

Combined heat and power plants (CHP) of the municipal energy companies and forest industries are important users of wood residues and bark, and wood product industries are commonly co-owners of the plants. However, the utilization rate of CHP plants varies much according to the demand of heat and market price of electricity, strongly affecting the market price and demand of wood residues and bark. Other factors affecting negatively to the markets are public subsidies of alternative bioenergy sources, such as forest chips and logging residues, import of forest chips, wood residues and bark, long transportation distances and high transportation costs, and lack of alternative large-scale uses. There is locally some demand of side stream materials for green infrastructure building, landscape management, soil improvement, horse stables and other animal houses.

[15] Garcia, C.A., Hora, G. State-of-the-art of waste wood supply chain in Germany and selected European countries. Waste Management (2017).

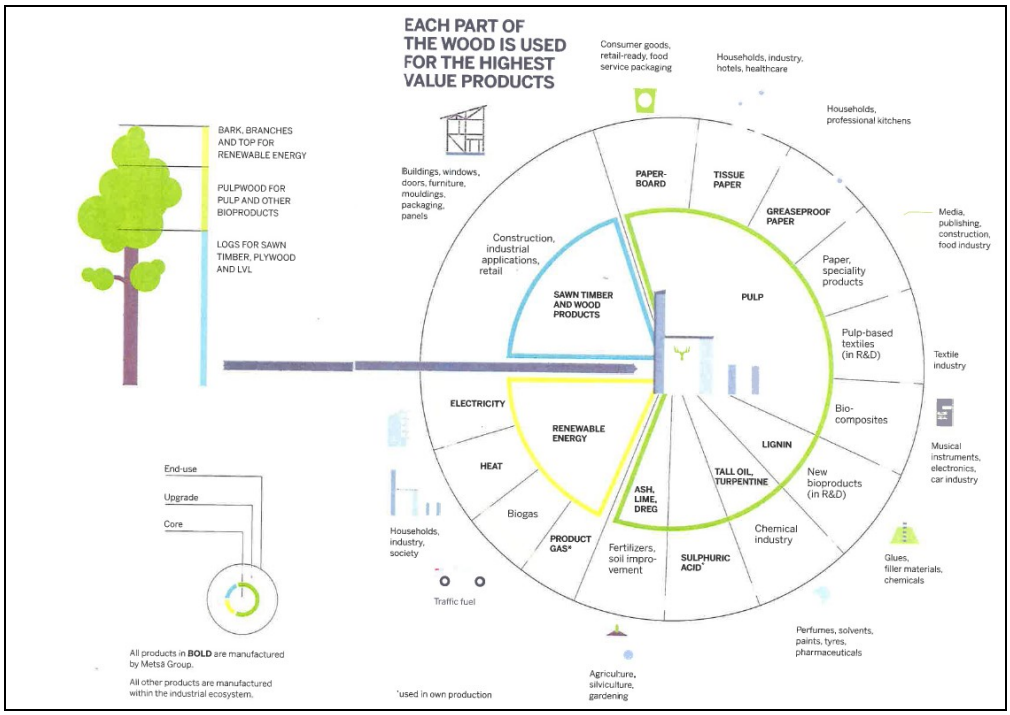
The newest biorefinery products from side streams comprise mainly pyrolysis oil for replacing light heating oil in heating plants and industries, and liquid fuels from saw dust for vehicles (tall oil, bioethanol), their demand being based on the obligation to mix renewable fuels to petroleum and diesel in land vehicle traffic (E10, E15, biodiesel). There are only a few ready-to-market products that aim to Business-to-Business markets (BtoB). However, wood lignin based adhesives and paints were recently started to produce, replacing their phenolic components, and biodegradable packaging materials from wood fibers were launched for food, beverages and catering. In Business-to-Consumer market (BtoC), some wood fractions, such as extractives from knot wood and inner bark of spruce and pine are used in small amounts in nutritional, medical and skin care products and cosmetics.

The following five value chains are typical in Finland to demonstrate different industrial ecosystems of side stream utilization where wood product industries are strongly involved:

1. Value chain of biorefinery located on the site or in the vicinity of a large manufacturer of chemical forest products which receives side streams from wood product industries and supplies further-processing industries with its basic products and all industries on the site with different infrastructure service. Example: UPM Pietarsaari; UPM saw mill delivers chips to UPM sulphate pulp mill, one part of saw dust to Billerud kraft and sack paper mill and bark and one part of saw dust Alholma Kraft CHP plant; UPM supplies Billerud with a part of kraft pulp; UPM provides total green water, waste water and sludge management, security service, wood yard operations, RDI platform, etc.
2. Value chain of biorefinery where several chemical industries of large corporation procure raw materials, including side streams, with long-term contracts from a number of wood products industries in a larger area which belong to the company or are independent companies, and supply further processors with their basic products and side streams. RDI platform is strong. Example: Metsä Group, Fig. 1.
3. Value chain of a large wood product company with both basic production, further processing and possibly an energy plant. The use of side streams in own production and energy plants is maximized and only chips is supplied to chemical forest industries. RDI is managed by the company itself. Example: Koskisen Oy, Fig. 2.
4. Value chain of several wood product companies in an industry park where SME companies build a local mutual network based on the basic products, further processed products and bioenergy. Collaboration potential is then maximal. Triple Helix based RDI platform can be innovative and flexible. Example: Woodpolis Kuhmo, Fig. 3.
5. Value chain of an individual wood product industry with none of or limited further processing. Side streams are sold after sorting or up-grading to other companies located

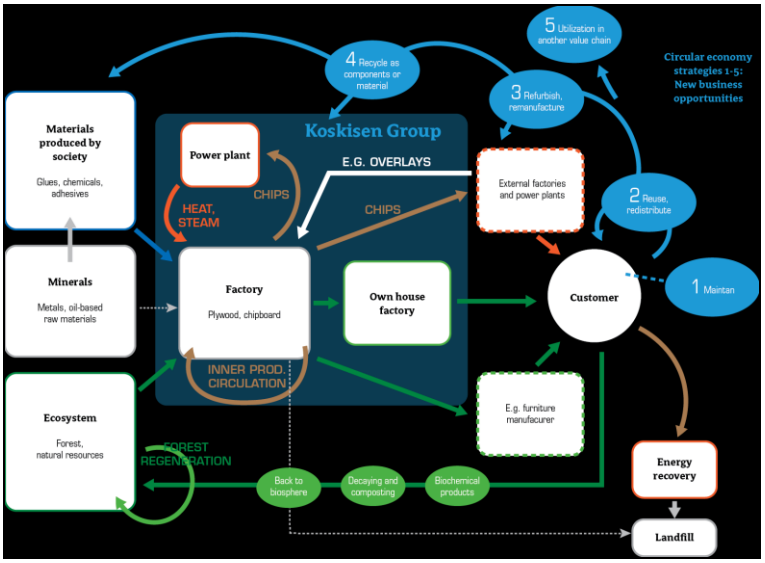
outside the site. Resources for RDI are typically limited. Example: Virtual saw mill, Fig. 4.

Figure 6 Value chain of integrated forest industry company



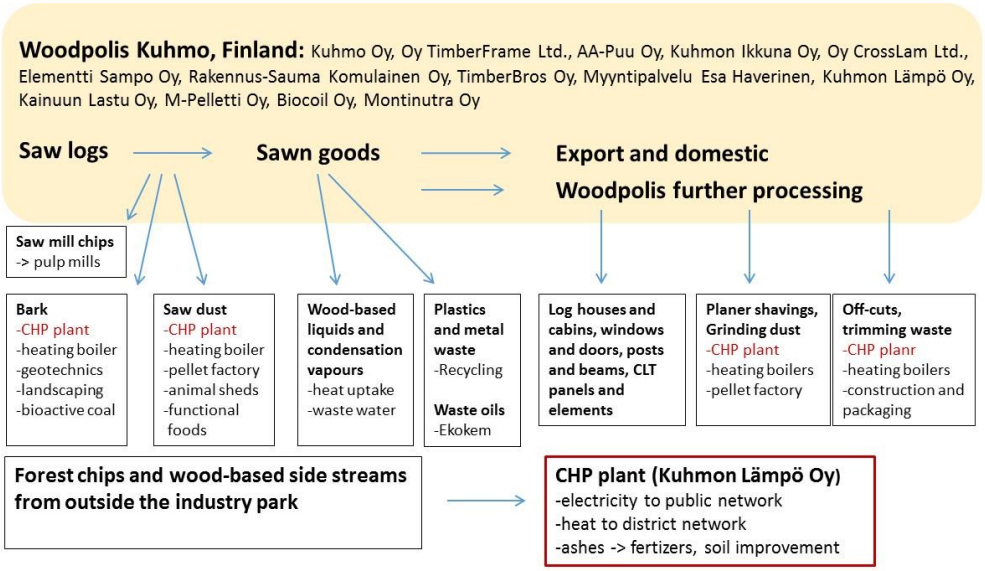
Source: Metsä Group

Figure 7 Value chain of wood products industry company



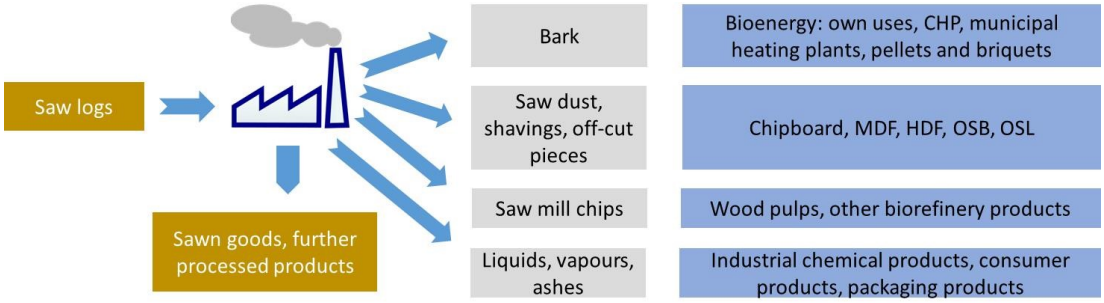
Source: Koskisen Group

Figure 9 Value chain of industry-park based wood product industries



Source: Verkasalo et al. 2019

Figure 10 Value chain of individual sawmill



Source: Verkasalo et al. 2019

All in all, wood-based side-streams are an important part of business income of wood product industries in North-European countries. In Finland, they currently constitute 15% of the revenue of large and medium-sized saw mills, and 7-12% of the income of plywood industries. On average 30–55% of their roundwood ends up to side-streams depending on the final product. Of the logs with bark, saw mills obtain, on average, 42-54% sawn timber, depending on species, log size, region, saw mill technology and sawing set-up, and their side-streams consist of fresh and dry wood chips (28-32%), saw dust (10-15%) and bark (10-12%.

Side-streams have a smaller role among furniture, building joinery, component and element manufacturers (including CLT) and pre-

fabricated house and log house industries, and their volumes and economic significance are less known through statistics and research. Side-streams of further processing are typically made up of planer shavings, saw and sanding dust and different-sized off-cut pieces and trimming wastes. Plywood, veneer and LVL industries generate fresh side-streams in log debarking and trimming, bolt rounding and peeler cores and fresh-cutting of veneer sheets, and dry side-streams after veneer drying in final cutting, edge-trimming and sanding. Processing birch or spruce at plywood mills provides, on average, 58% or 65% veneer for plywood, 16% or 12% rounding waste, 10% or 7% peeler cores, 3% off-cuts and 13% bark and dust, respectively.

Some wood-based side-streams include adhesives, surface treatment substances and wood impregnation chemicals. All wood product industries generate also smaller amounts of wood ashes as well as waste liquids and condensed vapors in drying, modification and treatment processes, which include water and different chemical substances, their origin being at least partly in wood and/or bark.

The main factors found to influence the use of forest biomass and side-streams are international and national policies, resource availability, networking of different industries, competitiveness of fossil products and fuels, and consumer behavior, but the optimal allocation of side-streams depends on the targets and country-specific circumstances. Wood chips, sawdust, and bark are considered the most valuable side-streams because of their relatively high quality and solid form, but to date they have been mostly used in energy generation and partly in pulp and wood-based panel production in Europe.

In Finland, the industry structure is dominated by chemical pulping and energy generation, with 60% of the wood-based side streams used for energy generation but less than 1% for chipboard and fibreboard production. However, a range of new potential uses should be available in the chemical, biofuel, modified wood and composite industries, along with the growing interest for side-stream utilization. Here, the main drivers were identified as shortage of roundwood resources in the future, availability of side stream resources (also through energy efficiency improvements), emerging markets for wood-based products, savings in raw material costs, climate change mitigation, cascading use of biomass and circular economy, and, finally, the EU policies.

3. Fact finding workshops: main outcomes

3.1 Warsaw workshop for EU13

The first Workshop was held in **Warsaw**, Poland, 30th of January - 1st of February 2019. The aim was to gather preliminary information on recycling, waste wood management and side stream valorization activities from both technical and regulatory point of view in the EU13 countries (EU13 referring to Bulgaria, Croatia, Cyprus, Czech Republique, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia as countries which joined the EU after 2004). The workshop participants, including project representatives and stakeholders, established a preliminary overview of the current situation of wood-based value chain management in the EU13 countries.

During the fact finding discussions between stakeholders and project representatives, two groups with separate sessions gathered together to answer the pre-set questions and share state-of-art information, opinions and perspectives. Stakeholders from Poland, Romania, Slovenia, Slovakia and Ukraine and project representatives from Finland, Slovenia, Germany and France participated. Many findings were similar in Group 1 (Side streams in the wood processing value chains) and Group 2 (Recycling/waste management, side stream valorization). The main findings that emerged in these sessions were the following:

- The lack of official data available about the side streams, waste wood and recycle wood or value-chain flows in EU13 countries.
- The lack of regulations to define the side streams, post-consumer or pre-consumed wood products, contamination level etc. in EU13 countries. No descriptions are available to define which side streams go for energy production, which are used for recycled products and which are used for landfilling.
- The lack of technological development especially in the recycling of waste wood and valorization of side streams for value added product development.
- In EU13 countries, the companies and other stakeholders are still not aware about circular bio economy. They need demonstration about why Circular bio economy is important for the future development of their countries. Wood residues and wastes are basically used for energy purposes in public and private sectors, but they are far behind in terms of technology and legalization of energy polices. Progress of cascading needs demonstration, technology transfer and good practices.

Group 3 was focused on the influence of policies on circular wood-based economy in the different countries. It was established that among the EU13 countries, the starting point is very fragmented – the countries and regions are in very different stages in side stream utilization and waste management. The main finding was that there is a need for movement towards better collaboration and closing the gaps in the knowledge chain, present and educate what are the advantages and opportunities in circular economy for the wood sector and boost the role of wood sector in bio-economy. Overall policy is a very interrelated and complex topic, it changes utilizing incentives rather than sets restrictions. Policies toward more bureaucracy are not wanted. Across the discussions, the lack of data and information was a common hindering factor.

Strengthening the wood sector and its role in bioeconomy

A common consensus was that the agricultural sector is seen a priority compared to forest sector. Agriculture is typically the main sector of economy in EU13 and it is seen as the main contributing sector to bio-economy. Importance of forest sector is not acknowledged and, generally, there is a lack of strategies for forest and wood-based industries. Forest sector needs to be made more visible among the bio-economy sector. Forest sector is typically based on small entities, such as family owned sawmills. Supporting networking and partnering would be important, as the wood working industries would be motivated by facilitated and informative conversations and discussions.

Unawareness and need for information

Especially the SMEs and entrepreneurs are not aware of circular economy, and there is also unawareness among the politicians and decision makers as well as the final market players and consumers. Circular economy strategies or roadmaps do not seem to exist, but they were felt as options to support the transition to circular economy. Especially the information on cascade use, secondary and pre-treatment processing, wood residues, side and waste streams as well as new products and business models would be useful if they were provided in an open, public database.

A classification and standardization system for wood residues, waste wood and side streams and potential to create high-value products was valued in the discussions. In many cases, wood is exported as round wood rather than adding value to it before export. Quality certificates were seen as an important tool if they were supervised properly. Overall, the lack of data was highlighted as an issue across the value chain: availability and uses of raw material, logistics, export, amount and uses of side and waste streams, etc.

Social factors

The markets and consumers do not value wood-based products; especially housing made of wood is not perceived with safe, modern, unique or fancy way of living, and recycled wood-products are not felt safe to use. For consumers, the main factor is the price of the product. For wooden products, the price needs to be lower with the same properties that the alternative products provide, or have better properties with a slightly higher price. The consumers need to be educated on environmental impact and sustainability to attend to the current state of lack of markets. Public sector should promote wood use and help the raw material establish a respected role. In addition, labelling of wooden products similarly like the energy efficiency labelling of machines could be seen as a positive tool to support the education process and creation of market demand. For example, the label could describe the circularity index of the product.

Political drivers, regulations and incentives

Climate change is not seen as a main driver for policy makers in EU13. In some of the countries it is present in the discussions, but not a driver. For example, new buildings are not seen as potential CO2 storages. The policy makers should be influenced with science-based facts and arguments. Corruption was highlighted as a problem in several discussions, for example in cases relating to current certificates and lack of overall and accurate data.

In the discussions, it was also established that there are problems relating to EU regulations. The regulations are officially implemented, but in many cases not actually practiced or followed. However, there was a consensus that following the EU regulations would be useful and necessary. For example, landfilling is still authorised and does not support the utilization of side streams. It could be generalized, that the forests are not sustainably managed and harvested. In conclusion, there is a need for regulations and actual implementation of them.

Overall, incentives were preferred over restrictive policies. Incentives would be needed for both wood construction and utilization of recycled wood. Good examples of existing incentives were given, for example in Slovenia, there is a governmental system called Green Ordering for wood construction to support building wooden houses. Public procurement could be the promotor in the transition to circular economy and initiate change in the industries as well. Good incentives could be refund systems or ecotax-systems. Nonetheless, it is important that enhancing regulation and implementing different incentives would not add to the amount of

bureaucracy – rather lower it. It would be necessary to coordinate policies within the forest sector and make sure to take into consideration the regional, national, European and external markets.

The main findings of the general discussion of the workshop are summarized in Table 6.

Table 6 General findings in Warsaw workshop

• Creating a good database on side streams of companies (by-products, wastes)
• There is a lack of proof of concepts, the lack of data and pilots hinders the process and interest among investors and companies
• There is a difference in strategic thinking and operative solutions between bigger and smaller companies (e.g., international particle board and furniture companies vs. saw mill and packaging product companies)
• There are regulations missing, mostly in the sense of the lack of classification, standardization and labelling, but there is a lot of bureaucracy, thus there is a need to reduce red tape
• There is a lack of awareness of availability of side stream markets and opportunities and development needs to create markets
• The idea of industrial ecosystems and value networks of companies is not really there
• B2B needs to be improved … a need for collaboration and new partners to find incentives
• Public procurement is a good tool to promote side stream usage

3.2 Helsinki workshop for saw mill industries

The second workshop was held in Finland on 10th of April, 2019. The focus was in the role of sawmill and wood product industries for value chains of side products: the present business models, partnerships and cooperation in the production and utilization of side streams.

Table 7 summarizes the main findings in the value chains of wood product industries emerged during the workshop:

Table 7 Main findings in Helsinki workshop

Strengths and competitive advantages	Challenges and bottle necks
- Fresh wood chips is a very wanted wood raw material for pulp, paper and paperboard mills due to the long, high-quality fibre and well-established end-uses. The market price is now moderately good and competitive for all trading parties. The situation of other side-streams is fluctuating, the prices have been generally low but they have recently increased. - The side streams and by-products of saw mills are more uniform of quality than those of other side-stream materials or forest chips. The quality can be further improved by sorting for different purposes of use, e.g. 1. burning, 2. biorefining, 3. small volume production of high-value products, e.g. medicinal or nutritional substances or consumer cosmetics. - Wood as a whole is a renewable, climate smart and healthy material, which advance the demand of both basic products and side streams.	- The lack of knowledge about alternative and future uses and their profitability of side streams among saw mill industries. - The need to assess which prices the customers are really willing and capable to buy. Until now the uses of side streams are strongly steered by the public support. - Pure wood saw dust is as good a raw material as wood chips, but its image should be raised more in order to improve the demand and the value chain. The demand and prices are also dependent on the price of emission allowances. - (As a consequence of lobbying by the forest industries), public support is directed to forest chips but not to side streams of saw mill. Note that forest energy could not compete with saw mill residues without public support, because its supply chain is too expensive. - CHP production is currently at low level. Power transmission costs are a big problem. This requires for example a city grid close to the mill. Generally, the efficiency of small scale electricity production is low. - Production of wood based panels is not competitive because they are now domestic market products with limited market size and a lot of import, and the competition from other use (e.g. energy use) raises the raw material price to too high level. - There are difficulties in getting funding for the development activities of small companies.
Prospects and future options	**Obstacles and threats**
- Economical assessment on which new products and at which size category the production is profitable would benefit the strategic decisions among the companies. - The companies need proof-of-concepts where the functionality of technology, business unit integration, and market prospects are clarified. - Policies made by tax money have a big role: abolition of the support for peat, stumps and logging residues would increase the demand of side streams. - Voluntary emission trading: carbon trading with wood, carbon credit, production of sawn timber for carbon	- Too little human and financial resources for the RDTI work. Saw mills do not have enough economical resources or know-how on side-stream development. Therefore, there is a need for public input and a concentrated center of excellence. - New innovations that work on a small or pilot scale have not been made enough to work on industrial scale. - The benefits of work of RDTI projects are usually available only for the participating companies. They could be also manufacturers of machines and industrial equipment. - New products need big investments in relation to the production volume which is a risk for the profitability. - Production of unprofitable products from the side streams may happen, if there is not enough knowledge of the markets or

sink, long-term carbon storage in wooden buildings, low carbon footprint. - Promotion of wooden constructions especially in public procurements would support both the demand of the main products of saw mills but also side stream utilization and product development for the construction sector. - Increasing need to replace plastics with sustainable, naturally degradable materials calls for considerable use of side streams and recycled materials.	technology. - Public policies and regulations should be predictable, as stable as possible and not restrict the future opportunities related to technical development and launching of new products. - Lobbying by the competing industries, e.g. plastic or concrete industries, inhibits the market development. - Possible regulation of wood burning is an economic risk. Allowable emission values of wood burning are getting tighter. - There is a potential risk of not to assess wood as renewable raw material – discussion and future definition of carbon sinks vs. sustainable cuttings.

The most successful technologies and product groups deployed to utilize the side streams of the sawmill and wood product industries:

- Local biorefinery is an interesting option but the profitability depends on the choice of right technology, increase of production volume to an adequate level and proof-of-concepts to convince investors and industries. Biorefineries need big investments, but inexpensive funding may not be available.
- Production of bioethanol and cellulose based textile fibers need to be high volume production and require investments from big companies and government subventions.
- Composite products are an interesting option if saw dust is possible to be utilized as filler. Wood plastic composite (WPC) has the problematic plastic part, which should be replaced by some biodegradable material.
- There are numerous valuable compounds in the bark but their separation and purity are challenging.

The most promising customer groups and uses to utilize the side streams of the sawmill and wood product industries, either now or in the near future

- Energy production of the big growth centers after the renewal of the plants to get rid of coal and heating oil. They could use all the saw dust and bark from the saw mills of southern Finland in the future, but the national economic aspect needs to be assessed.
- CHP production would be a reasonable way for electricity production from the point of view of national economy. Condensing heat could be used for drying of other side products.

- Finland is the pioneer country in the bioethanol and biodiesel production, however, the market is fully driven by the Biofuel obligations scheme (BOS) and national targets of liquid biofuels.

The main best practices emerged during the workshop:

- Good overall management of raw materials, side streams and all kinds of wastes through integrated procurement and supply of different wood-based materials – in large integrated industries in particular
- Wood industry park approach and regional solutions provides local markets and profitability
- Triple Helix collaboration in RTDI and policy/regulation implementation, rather large number of active companies and public stakeholders (in some regions)
- High utilization rate of raw materials and close-to-zero generation of wood-based wastes (almost closed loop).
- Approach of carbon sink principle and renewable bioenergy in wood product industries
- Local CHP-plants producing renewable energy. In the larger scale also the security of energy supply increases.
- Projects to reach the same level in electricity and heat production as in Central Europe and Baltic countries using investment aids, feed-in tariffs etc.
- Profitable drying technology for saw dust and bark to increase the value in energy generation and lower the transportation costs, efficient treatment of combustion gases to improve the recovery of energy from the side stream materials and highly improved the resource efficiency.
- Projects to start bioethanol and bio-oil industries in the side-stream utilization
- Projects to start industries based on activated carbon and bioactive coal
- Utilization of knot wood: sorting of chips gives knot fraction which is a suitable raw material for medicinal and cosmetics products

4. Interviews and questionnaires

4.1 Structure and involvement of stakeholders

Interviews were done and questionnaires were presented to different stakeholders following three different methodologies to collect information: face to face during visits to facilities, telephone interviews or direct compilation by the recipient. The stakeholder individuated by partners were associations or federations, companies, public organizations, municipalities and other actors

involved in the value chain of side streams and wood waste management.

For this purpose, two different versions of the questionnaires were elaborated: a short version with the essential information to collect and a long version to present the answers more detailed. The typologies of questions used were: open-ended questions, multiple choice questions and questions based on a Likert Scale. The decision to use two different questionnaires was justified by the need to adapt the questionnaire to the channels of data collection, the competences of the stakeholders interviewed and the level of involvement in the value chain of side stream utilization and wood waste management. The choice allowed flexibility to apply the fixed structure of questionnaire and customize the interviews in order to optimize the collection of data. By the way, the written questionnaire represents a reference to follow during telephone interviews or face to face in order to guarantee the collection of the essential information. In fact the essential information regarded:

1. Resource efficiency and value chains of wood products industries and use of lateral flow
2. Recycling
3. Policy impacts on companies and their strategy and innovation towards circularity

In particular, the information regarded the following topics:

- The role of the stakeholder in the wood value chain;
- Types of processed material with special focus on the physical, mechanical and chemical characteristics and presence of contaminants;
- Methods of recycling of wood-based side flows and relative opportunities (recovery and power generation)
- Recycled quantities and efficiency percentages;
- Technologies used during processing waste;
- Strengths and weaknesses of the processes implemented;
- Opportunities and threats of the processed implemented;
- Other quantitative data such as: level of investment, estimated costs and benefits
- Awareness and perception of the effectiveness of policies.

Table 8 Questionnaire structure. Short and Long Versions

Short Version Questionnaire	Long Version Questionnaire
General information 1. Managing waste wood and side-streams 2. Resource efficiency and value chains of wood product industries and side stream utilization 3. Policy impact on businesses, strategy and innovation towards circularity	General information 1. Managing waste wood side-streams 2. Technologies for wood processing of side-streams 3. Resource efficiency and value chains of wood product industries and side stream utilization 4. Side stream utilization: products, markets, competitive ability, sustainability, other business factors 5. Projects involvement

The purpose of the questionnaire was to collect specific information from the stakeholders perspectives in addition to those already obtained with the general analysis of the state of the art. In particular, the output expected is a detailed analysis of the internal and external factors that can influence the processes implemented by the stakeholder involved in different levels of the value chains of side stream utilization and waste management.

It is aimed in the project to collect 10-15 interviews or questionnaires in 1-2 countries in each region in Europe: southern, central, eastern, northern.

4.2 Interview results

In this first step of the analysis the stakeholders at different levels of the value chains from Italy, Germany, Slovenia, Spain and Finland were involved. In particular, the actors involved are: storage and waste disposal platforms, sawmills, panel producers, machine producers of wood chippers, decking and biocomposte granulate producers, wood fiber producers, construction element producers.

The analysis of the questionnaires collected until now highlights some general aspects in the different countries that can be of more relevance in some contexts than others. The analysis will be completed when the full set of interviews and questionnaires from different regions and countries is available to compile the results and conclusions.

Strengths

One of the main strengths to highlight regards the common perception of the efficiency of the value chains of wood waste management, and

the well-functioning networks that involve a large number of active companies and stakeholders. A fundamental aspect is the high degree of resource efficiency in the countries involved in terms of good overall management of raw materials, side streams and all kinds of wastes, the use of renewable raw materials and the use of alternative sources. In some cases, like the Italian one, the recycling rate of wood waste material reaches almost 100%, ensuring a system with no waste material. Modern woodworking mills are also near close loops of material use in their production, but this depends much on the current markets of side streams which differ considerably between the countries (bioenergy, particle and fiber boards, pulp and paper, value-added chemical products, other special uses).

Another main strength that is in favor in the implementation of circular approach is the general positive attitude from society and decision makers for cascading and sustainability: circular economy and sustainability in general are becoming more and more popular and companies that follows these approaches are supported by policies and recognized by institutions. The policies and regulations are rather well known by the companies of the sector (except in Eastern Europe). The general perception of them in environmental terms is positive. Sustainability and climate-smart approach is accepted and promoted among the companies and policy makers.

Weaknesses

One weakness is related to the large share of side streams of the basic production of the companies, the different wood species and dimensions and scattered availability and high transportation costs that make it difficult to manage the different kinds of wood wastes to be recovered. Another negative point is linked to the lack of technical knowledge and practices regarding the phases of wood processing like the management of wood dust or the fumes deriving from drying processes. This varies according to the type, size and technology of the industries, in the supplying and utilizing companies both. Wood-based products are not typically designed to meet an easy recyclability, which limits the attractiveness among the manufacturers and users of subsequent recycled materials and products.

Some processes like cleaning of wood involve substantial investment costs, high energy consumption, and high wear of machinery and consequent maintenance costs. In addition, special treatments are often needed to sort the side stream and waste materials or upgrade their quality. The high expenses have a negative influence on the level of development of the processes, aggravated by the low investment resources available in the companies of this sector.

Lack of uses and markets for side-streams and wastes is a common obstacle for the development of side-stream and waste management sector in the different regions of Europe. Albeit bioenergy sector is generally growing Europe, in some countries like Italy the wood-based wastes are not used for energy production. Instead, some countries are characterized by well-established uses, high level of technology and knowledge in wood-based bioenergy. For example in Germany and Finland there is a good availability of special technologies, whereas in other countries like Spain or Italy there is a need to increase the efforts in developing new technologies for processing of wood waste materials.

Green field construction and demolition produce larger quantities of different wastes, wood-based wastes among others. Generally, the sorting and flowing to recycling is rather easy for the construction companies as long as good sorting instructions are available and the transportation costs to recycling are reasonable. According to the construction companies, the logistical systems or pre-planning of waste management of the construction and demolition sites are not well-developed, and call for more regulation and standards. While the recycling companies or associations, either public or private, are finally responsible for recycling and waste management, the few markets of the waste-based products is are a challenge for them.

Many wood product companies (and federations) view the fluctuating market, low prices and few uses and customers of their side-streams as a big problem. More demand and innovations and investments among potential users have been proposed, but expected to be done by the users in the first hand. Potential companies need proof-of-concepts about the profitability of the investments, this evidence is lacking in many cases. It is a clear weakness that the innovation and product development system is slow, and the public financing systems work with a varied intensity and financial basis.

Steady and long-perspective policies in the public policies of regulation and subsidies are also stressed by both the supplying and processing companies. This regards both the status of different raw materials, acceptable uses and relevant EU laws and directives their national interpretation. Clear and balanced approach to bioenergy vs. cascading is wanted by the companies and federations.

Opportunities

The main opportunities for this sector regard the possibility to extend the markets to new end of life options and new customers: bio-refineries, composite products, plastics and coal replacing products, modern implementation of bioenergy, new ways of composting, soil and water purification, landscaping, etc. Wood fiber producers have an expanding market potential and a possibility to extend the target markets in terms of export. In material

procurement it is possible to implement practices like shared procurement, delivery and use of different woods, including forest energy. The fact is that in some countries the wastes are not used for energy production – this is an aspect that should be implemented.

Generally, the recyclability of wood-based materials and products, including construction products, should be upgraded and the on-site sorting should be developed to raise the attractiveness among the potential users. Demonstrations, pilots and proofs-of-concepts have shown to be efficient ways to promote novel business models and products, so they evidently work also in side-stream and recycling business. This should include also the development of criteria and methods of LCA.

With regards to the lack of knowledges and skills, the companies should focus and invest on professional training for experts in the different areas, to improve the capacities that are not well-developed. The system and product certifications are central in this context: these kinds of practices can be helpful to increase positive perceptions between producers and customers. This has been observed in the participation in projects on recycling and sustainability that can support the transition from typical linear economy approaches to the circular ones.

Regarding policy measures, appreciating the local preferences about wood utilizations and recycling and increasing consumer knowledge and behavior about side-streams products should be major opportunities to support the business. Recommendations or requirements for the public acquisitions and investments of governmental and municipality organizations could be used to promote products made of recycled materials and convince the markets in private and consumer sector, the green building initiatives policies being a good reference. Full implementation of the Triple Helix innovation and development system in regional and national work could be a way to accelerate the knowledge development and sharing, collaboration between the stakeholders and product and market development.

Threats

There are many difficulties that the companies involved to side stream supply and utilization and wood waste management have to face. First of all, in some regions the presence of competition on some side streams between the different uses and companies increase the raw material costs, although in some regions the lack of demand and uses is still obvious. In both cases, these are aggravated by the high costs of transportation due to the long distances between all the phases of the value chains.

Second threat can be the lack of collaboration among companies and policy makers, and poor reliability of companies on certain systems that are inevitable for the society but crucial for the business and profitability in the sector (accessibility to raw materials, build-up of costs). As it has been underlined before, the sector is well aware of the policies and regulations. It was observed that the compliance with the EU and national regulation may lead to higher costs for companies, customers and final users, and is often technologically demanding. These aspects are linked with the complex administrative-environmental management that may limit the operations of the companies and distance the companies from the purpose.

Some threats are associated to the profitability of the operations and the role of final users. With regard to the first point, the market is characterized by low market price and unprofitability of wood-based electricity, in particular. There is a common perception that recycled wood is just for heating energy, so the biggest challenge in the sector is to convince customers that recycled wood has similar quality as new wood if it is properly selected and processed and the product is relevant. The role of the customers is crucial and the evidence is similar in all countries.

References

Alakangas E, Hurskainen M, Laatikainen-Luntama J, Korhonen J (2016) Properties of fuels used in Finland (In Finnish). VTT Technology 258, 229 p. + Appendices.

Antikainen R, Dalhammar C, Hildén M, Judl J, Jääskeläinen T, Kautto P, Koskela S, Kuisma M, Lazarevic D, Mäenpää I, Ovaska JP, Peck P, Rodhe H, Temmes A, Thidell Å (2017) Renewal of forest based manufacturing towards a sustainable circular bioeconomy. Reports of the Finnish Environment Institute 13/2017.

Axtell RL, Andrews CJ, Small MJ (2002) Agent-based modeling and industrial ecology. Journal of Industrial Ecology 5(4): 1-13. Available at: https://doi.org/10.1162/10881980160084006

Cabeza, D. (2012). *Logística inversa en la gestión de la cadena de suministro*. Marge books.

Cazzaniga NE, Jonsson R, Palermo D, Camia A (2019). Sankey diagrams of woody biomass flows in the EU-28. EC Joint Research Centre, Publications Office of the European Union, Luxembourg. Online at: https://doi.org/10.2760/227292, JRC115777.

CER catalogue available at http://www.ccrifiuti.it/doc/cer.pdf

CONAI (2017). Packaging recovery in Italy: THE CONAI SYSTEM. Available at: http://www.conai.org/wp-content/uploads/2014/09/The-CONAI-System -2017.pdf

Dammer, L., et al. (2016). Mapping study on Cascading use of wood products. Technical Report. WWF and Mondi.

DEFRA (2008). Waste Wood as a Biomass Fuel. Market Information Report. Available at: https://www.forestresearch.gov.uk/documents/2078/DEFRA_Waste_wood_as_a_biomass_fuel_2008.pdf

Department for Environment Food & Rural Affairs (2012) Wood Waste Landfill Restrictions in England

Department for Environment Food & Rural Affairs (2013). Wood Waste Landfill Restrictions in England: Call for Evidence.

Ecocerved, Camera di Commercio di Fermo. *Manuale per un comportamento corretto nella classificazione dei rifiuti speciali.* Ottobre 2012.

Egger, Environment & Sustainability. Sustainable construction and healthy living with Egger wood-based materials. Available at:

https://www.egger.com/get_download/f72c39df-c869-4b04-ad9e-4bfe17492c9b/Brochure_Environment_Sustainability.pdf

European Commission (2018) Updated Bioeconomy Strategy: A Sustainable Bioeconomy for Europe: Strengthening the Connection between Economy, Society and the Environment. Publications Office of the European Union, Brussels.

Federal Ministry for the Environment, Natura Conservation and Nuclear Safety (2011). Closed-loop waste management.

Garcia, C.A., Hora, G. State-of-the-art of waste wood supply chain in Germany and selected European countries. Waste Management (2017).

German Law Archive. https://germanlawarchive.iuscomp.org/?p=303

Hassan MK., Villa A., Kuittinen S., Jänis J., Pappinen A (2018) An assessment of side-stream generation from Finnish forest industry. Journal of Material Cycles and Waste Management, pp. 1-16.

Koskisen Grou. https://www.koskisen.com/

Kunttu J, Hurmekoski E, Heräjärvi H, Hujala T, Leskinen P (2019) Preferable utilisation patterns of wood product industries' by-products in Finland. Forest Policy and Economics 2019-101946. Available at: https://doi.org/10.1016/j.for.pol.2019.101946

Ley 22/2011, de 28 de julio, de residuos y suelos contaminados. Available at: http://smartleges.com/es/biblioteca-de-leyes/ley-22-2011-de-28-de-julio-de-residuos-y-suelos-contaminados/2014780

Mantau U (2015) Wood flow analysis: quantification of resource potentials, cascades and carbon effects. Biomass and Bioenergy, 79 (2015), pp. 28-38.

Metsa Group. https://www.metsagroup.com/en/Pages/default.aspx

Ministerio de agricultura, alimentación y medio ambiente. (2012) DIseño metodologico para la clasificación de productos recuperables de los residuos de madera, orientado a potenciar enfoques de gestión, producción y consumo más sostenibile. Madrid. [Available at: https://www.miteco.gob.es/images/es/Informe%20residuos%20madera_29112010_para%20editar_tcm30-193004.pdf]

Nelles, M., Gruenes, J., & Morscheck, G. (2016). Waste management in Germany-development to a sustainable circular economy?. *Procedia Environmental Sciences*, *35*, 6-14.

Pantsar M, Herlevi K, Järvinen L, Laita S (2016) Leading the cycle: Finnish road map to a circular economy 2016 – 2025. SITRA Studies

121. Available at: https://media.sitra.fi/2017/02/28142644/Selvityksia121.pdf

Pirhonen I, Heräjärvi H, Saukkola P, Räty T, Verkasalo E (2011) Recycling of wood products. Final report of the preliminary research project funded by Finnish Wood Research Ltd (In Finnish). Working Papers of the Finnish Forest Research Institute 191. 66 p.

Rilegno (2018). Rapporto 2018 Progetti, Innovazioni, Prospettive.

Rilegno. http://www.rilegno.org/

Sathre R, Gustavsson L (2009) Process-based analysis of added value in forest product industries. Forest policy and economics, 11(1), pp. 65-75.

Verkasalo E, Kurppa S, Korpinen R, Leppälä J, Muhonen T, Kurttila M, Katajajuuri JM (2019) UBES New biorefinery ecosystems with benefits from scales: results and recommendations of development project (In Finnish). Natural Resources and Bioeconomy Studies. Natural Resources Institute Finland (Luke). Manuscript.

Wood Recyclers Association. The Voice of the Waste Wood Industry. https://woodrecyclers.org/

WRAP (2007): Development of methods and sampling protocols for measuring contaminants in recycled wood for use in the panelboard sector.

WRAP (2012). The business Case for the Wood Waste Collection Hubs.

Ylitalo E (2019) Official statistics of Finland: forest industry wood utilization, Natural Resources Institute (In Finnish). Available at: http://stat.luke.fi/metsäteollisuuden-puunkäyttö/