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Classification of used wood to biomass fuel or solid recycled fuel and cascading use in Finland

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ABSTRACT: VTT has studied cascading use and energy use of used wood. The direct use of wood for energy is relatively much lower, and the use of wood for pulp industry much higher in Finland than in the EU. As Finland exports a significant part of its wood biomass (as pulp, paper and board, timber and plywood), the cascading cycles of wood products take place outside the Finnish borders, e.g. in other EU Member State. This limits the cascading cycles inside Finland. Guidelines has developed for the classification used wood (post-consumer wood) for energy use including implementation of the legislation and standards in Finland. It is necessary to define the impact of possible contaminants on the energy utilisation of used wood. This is helpful for categorisation, as well as for identification and characterisation of the contaminants. The guidelines also include an overall categorisation used wood. In this classification used wood is divided in 4 categories A, B, C and D. Categories A and B are classified under EN ISO 17225-1–Solid biofuel and class C under EN 15359–Solid recovered fuel standard. Fuels falling into category C should be incinerated according to waste incineration legislation. Class D wood is treated by wood preservatives and is hazardous waste.

Keywords: cascading use, quality standards, wood waste, used wood.

1 INTRODUCTION

Cascading use of woody biomass is getting increasing attention in current European discussions on the use of wood in the future bioeconomy. Wood products are typically considered to have lower environmental impacts than equivalent products made out of non-renewable raw materials. Woody biomass is presently used in many different value chains, e.g. as wood-based products and materials, bio-chemicals, and bioenergy, and in many different industrial sectors. Targets for greenhouse gas emission reduction and more resource efficient society are expected to further increase the demand for wood raw material in Europe during the next decades. Woody biomass is, when sustainably grown, a fully renewable resource and a largely recyclable and reusable material. Only a small fraction of wood products cannot be re-used or recovered directly (e.g. hygiene paper). However, as woody biomass is a limited resource, its use and the service life of wood fibres should be optimized [6].

The concept of cascading use has been presented in many studies and reports [6]. Simply put, the cascading use of biomass means that biomass is used (and reused or recycled) at least once or several times as a product before its end-of-life (e.g. energy use or landfill) [6].

The terminology used to describe the material that is derived from wood or wood products, which no longer can be used for their original intended purpose varies according to source (country, writer, point of view). The term used wood [5] that has been adopted by ISO 16599 is unambiguous, and clearly states the origin of the material. In some contexts also recovered wood or recycled wood has been used to describe this material. Additionally, one may come across the terms waste wood or wood waste, but these terms are somewhat problematic as the terms themselves imply that the material should be classified as waste. This is, however, not always the case even when the word waste is used as part of the term. Therefore, this paper will employ the term used wood and leave the categorisation of the material to be based on the findings of this work.

In order to classify the wood waste for energy use, it is important to know the properties of wood waste (used wood). If used wood includes heavy metals more than virgin wood it needs to be burned under waste incineration legislation. The value of used wood products always needs to be considered when making decisions on the costs, efforts and time that can be spent on the analysis of the starting material. In addition to being a raw material for solid biofuel, used wood can also be used for wood-based panels, bedding products for horses, cattle, chicken and domestic animals, as well as landscaping and interior furnishing products.

International standard: Solid biofuels–Fuel specification and classes (EN ISO 17225-1) was published in year 2014 [4]. The EN ISO 17225–1 [4] includes also wood waste (used wood), if it does not contain higher amounts of halogenated organic compounds or heavy metals as a result of treatment with wood preservatives or coating than virgin wood. VTT has published guidelines for used wood for Finnish market already in 2008 [1]. Guidelines were based on EN 14961-1 standard. EN 14961-1 standard was updated into the international standard EN ISO 17225-1 [4], which has superseded EN 14961-1 standard. Also European and Finnish legislation has been updated, so Finnish Association of Energy Industries commissioned together with Bioenergy Association of Finland and Finnish Forest industries Federation a study from VTT to update the guidelines.

One aim of the VTT was to clarify which fractions of used wood can be defined as solid biofuel and which fraction as solid recovered fuel. VTT collected data of used wood from literature, industries and laboratories of used. The new guidelines include information of existing legislation in the European Union, practises and regulations of Finland and Annexes includes examples of different used wood fractions and their classification [2].

2. CASCADING USE OF WOOD PRODUCTS AND ENERGY USE OF USED WOOD

The concept of cascading use has been presented in many studies and reports, but the definitions used in these publications differ. So far there seems to be no full consensus on what is considered as cascading use of wood products. In the commonly cited report by Mantau in 2012 [7], cascade use is defined as the multiple use of wood resources from trees by using residues, recycled (utilization in production) resources or recovered (collected after consumption) resources. Mantau (2012) also presents a concept of cascading factors, which he calculates for the European wood flows. In the calculation of total cascading factor, he takes into account the energy use of recycled wood (used wood in this paper), but also the direct energy use of wood residues. He also points out that cascades do not take place in one single sector, but between several sectors [6].

Furthermore, the EU Forest Strategy (COM (2013)659) states that cascade use fulfils the criteria of resource-efficiency. According to the strategy, under the cascading principle, wood should be used in the following order of priority: wood-based products, extension of their service life, re-use, recycling, bioenergy and disposal. However, the strategy also recognises that in some cases, such as in changing demand or environmental protection, different approaches may be needed. Moreover, it is said in the strategy that the Commission will together with Member States and Stakeholders develop good-practice guidelines for the cascade principle [6].

In the recently accepted ILUC proposal (Outcome of the European Parliament's second reading, April 2015, 8037/15), waste hierarchy and cascading use have been mentioned as one of the criteria that the Member States need to take into account in their reporting to the European Commission (article 22 of RED) on the use of waste and residue raw materials for biofuels and bioliquids [6].

The Finnish forest industry has built optimised wood use cycles over many decades. The direct energy use of streams like black liquor or bark can be considered as reasonable in pulp and paper industry with highly developed facilities and elevated self-sufficiency, and sometimes even a surplus in energy use. Therefore, a strictly defined cascading principle should not be seen as the only option to improve overall efficiency of forest industry. Moreover, the wood use cycle should be considered as a system including the export markets. Some countries are primarily producing the virgin fibre and the other ones are the consumers taking the major liability for cascading and efficient use of the products [6].

The cascading factors in Finland compared to those for EU are presented in Figure 1. It can be seen that the cascading factor for recycling in products (factor D) is significantly lower for Finland than for EU, due to export of products. However, the utilisation of residues in energy is higher in Finland than in EU. Thus the total cascading factor for Finland (1.56) is just slightly lower than for EU (1.57) (when also direct energy use of logging residues is included).

Total use of used wood was almost 4,800 TJ in Finland in 2014. Use of demolition wood is separated and it was almost 1,400 TJ. Used wood is used in 107 plants, and more than 75% is used in plants bigger than 20 MW_{th} (Table I).

Table I. Energy use of used wood and demolition wood in 2014. Source: The Natural Resources Institute Finland, Luke, Esa Ylitalo, June 2015

Output, MW_{th}	Total use of used wood			Total use of demolition wood		
	1,000 solid m^3	GWh (TJ)	%	1,000 solid m^3	GWh (TJ)	%
< 1	4	7 (25.2)	0.5	..	-	
1 – 4.9	74	130 (468)	9.8	..	0	
5 – 19.9	104	184 (662.4)	13.8	..	2 (7.2)	0.5
> 20	586	1,012 (3,643.2)	75.9	..	387 (1,393.2)	99.5
TOTAL	768	1,333 (4,798.8)	100	..	389 (1,400.4)	100

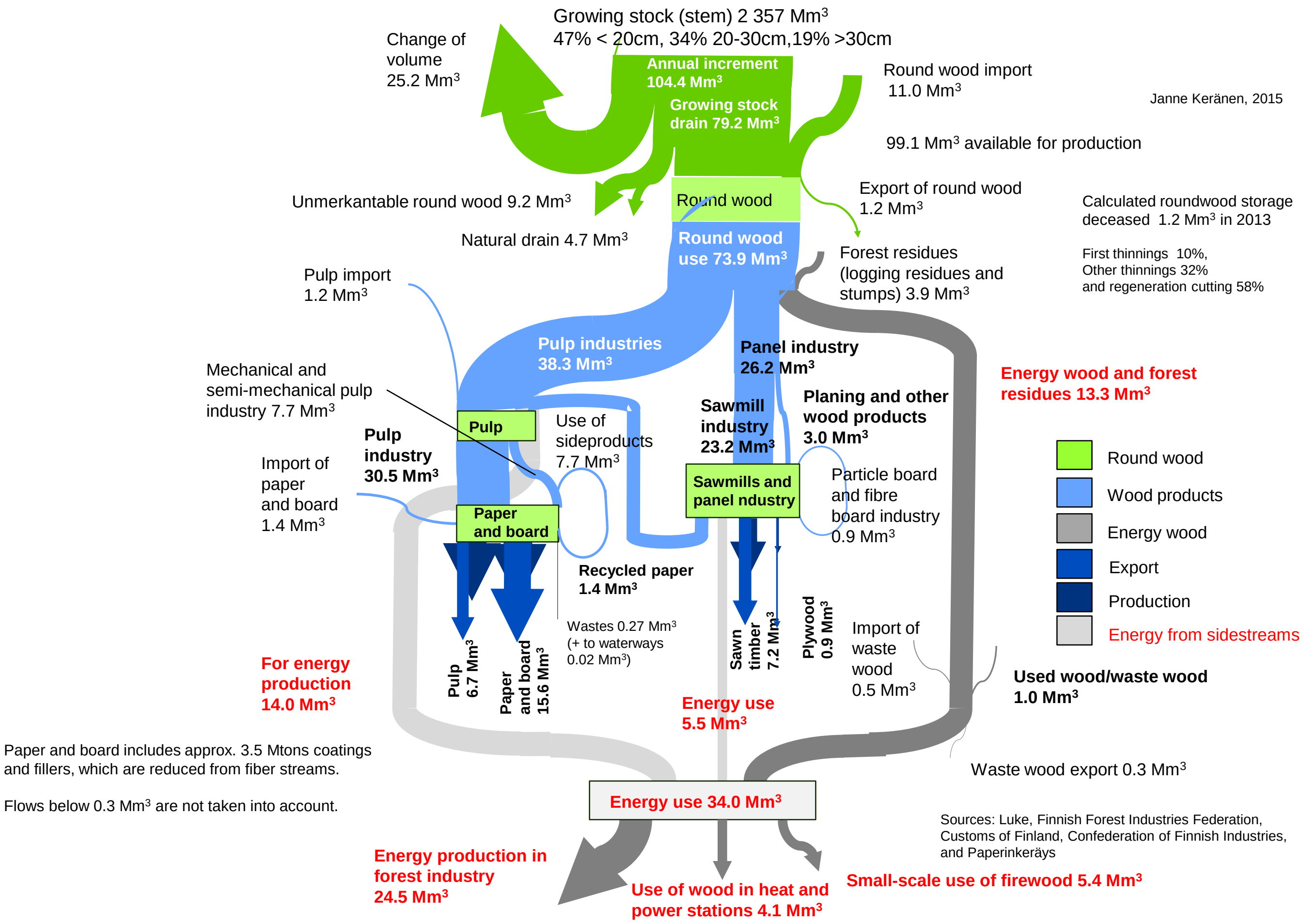

Figure 1. Wood flows in Finland [6].

3. ENVIRONMENTAL EFFECTS OF USED WOOD

It is necessary to define the impact of possible contaminants on the energy utilisation of used wood. This is helpful for categorisation, as well as for identification and characterisation of the contaminants.

For the scope of this paper, the term contamination is defined as the presence of particles, chemicals, and other undesirable substances and objects, i.e. contaminants that are absent in virgin wood or normal industrially produced timber.

From an environmental point of view, the risks of used wood combustion are air pollution from flue gases or leaching of hazardous substances from ash after disposal. Operation failure, normally appearing as boiler deposit formation or corrosion, is a technical issue that also needs to be considered. Mechanically, problems in fuel conveyors may occur due to glass, fittings, and various fastening systems that are attached to used wood products. Another important aspect to be accounted for is issues related to occupational health. It is mainly dust that causes problems, especially if hazardous contaminants are present. Regardless of what the negative impact of contaminants is, whether it is technical, environmental, or health related, the characterisation of used wood including the contaminants within it is of utmost importance. Characterisation will provide necessary information for decision making and planning of activities. When the material is adequately characterised, it should then be possible to plan appropriate sorting and quality assurance procedures. Some contaminants, like plastic, metals, concrete, gypsum, and glass, is possible and quite easy to remove mechanically. Others are more or less permanently attached to the wood, for instance paint, varnishes, coatings, preservative, glues, etc., and are thus practically impossible to separate from the wood material.

Used wood contamination can be divided into two categories: "chemical" and "mechanical". Chemical contamination is more or less permanently adhered to the wood and thus nearly impossible to separate from the wood material, whereas mechanical contaminants are possible to remove from the wood by sorting or work up. Methods for detecting contaminants are necessary for establishing and improving product quality. Moreover, characterisation of used wood is the basis of risk assessment of products made thereof.

Normally, the following parameters of used wood are screened: "Heavy metals": arsenic, cadmium, chromium, copper, mercury, nickel, lead, thallium, zinc, Polycyclic aromatic hydrocarbons (PAHs), e.g. napthalin, anthracene, benzo[a]pyrene, halogens like chlorine, bromine and fluorine, Pentachlorophenol (PCP) and lindane, Polychlorinated biphenyl (PCB) and Volatile organic compounds (VOCs)

Heavy metal contaminants, originating from paints and preservatives, need to be considered in the production and utilisation of solid biofuels from used wood.

Another important issue is to control the nature and amount of pollutants formed during used wood combustion. The behaviour of used (recovered) wood as a fuel is in principle similar to that of clean wood. Used wood is often quite dry (usually < 20w-%), thus the net calorific value can be higher than for common fresh wood fuels (e.g. bark). Used wood fuels may, however, have a higher content of contaminants, which may accelerate the formation of deposits in the boiler as well as corrosion. Further, the composition of ash can be affected.

This is normally not a problem in large scale combustion plants with efficient flue gas cleaning, but combustion of this material in the single ovens of private houses should be discouraged. Ashes, on the other hand, contain the residues of the burnt wood. Consequently, there is the possibility of high concentrations of heavy metals, and unburned or oxidised pollutants. Environmental risks related to used wood combustion in large scale plants are related to ash recycling as fertiliser.

Although used wood is included in the list of wastes, it should be kept in mind that it should not always necessarily be regarded or treated as waste. Used wood or used wood products may enter another life cycle, especially through material recycling and reuse but also when the material is utilised as energy.

Their classification is not relevant to this paper concerning residual and used wood from industrial and municipal (post-society) sources. Figure 2 describes solid biofuels derived from the by-products and residues of the wood processing industry, as well as post-society used wood. Part of the woody material under the heading "used wood" (class 1.3 according to EN ISO 17225-1) can justifiably be classified as biomass. Due to the absence of international clear guidelines and definitions, the classification of used wood into either waste or biomass remains debatable in the case of certain fractions of wood residues and wastes. [1]

Deposit formation is related to the fuel and ash composition. Solid biofuels and recovered fuels are high in calcium and alkali metals. In addition, recovered fuels tend to have relatively high chlorine contents. The result of this is accelerated deposit formation in the boiler. In fuels, reactive calcium and alkali metals are either organically bound or they may occur as carbonates or salts. During combustion these react and form oxides, sulphates or chlorides. Especially chloride salts have low melting points. Therefore, it is generally acknowledged that chlorine induces ash deposition. Chips made from clean used wood and used construction wood, as well as pallets, can from a combustion point of view be regarded equivalent to wood chips. Demolition wood, containing painted wood, board residues and other non-woody construction materials, may, on the other hand, contain for instance lead. Lead is known to cause problems in combustion. The level of boiler deposits from combustion of contaminated demolition wood is similar to that of recovered fuels in general.

There are a great number of non-wood components, such as plastics and metals that add to the contamination level of used wood.

It is suggested that by careful and selective demolition, as well as sorting of the resulting wood waste most non-wood compounds can successfully be separated from the actual wood. Analyses on sorted fractions indicate that the used wood contains approximately 1% non-wood compounds, mainly plastic and metal compounds, glass, dirt, concrete, bricks and gypsum. Even if the proportion of non-wood components seems relatively small, the effect of incinerating large amounts of unsorted used wood will inevitably cause problems. For example, metal objects of zinc, brass and aluminium, may plug primary air openings. High chlorine levels, with related corrosion issues, are indicative of the presence of PVC residues in the fuel.[1]

3. CLASSIFICATION OF USED WOOD TO BIOMASS AND SRF

In Finland, classes A, B, C and D for used wood and industrial wood residues and by-products were proposed for the Ministry of Environment and industrial associations first time in 2008. The classification into these four classes is elucidated by examples with real used wood cases presented in the Guidelines.

Categories A and B are classified under EN ISO 17225-1–Solid biofuel standard [4] and class C under EN 15359–Solid recovered fuels [3]. Fuels falling into category C are solid recoved fuels (SRF) and should be incinerated according to the Finnish Waste Incineration Act (151/2013). Class D wood is treated by wood preservatives and is hazardous waste.

This classification is in accordance with the classification in the European Waste List. Flow chart in Figure 3

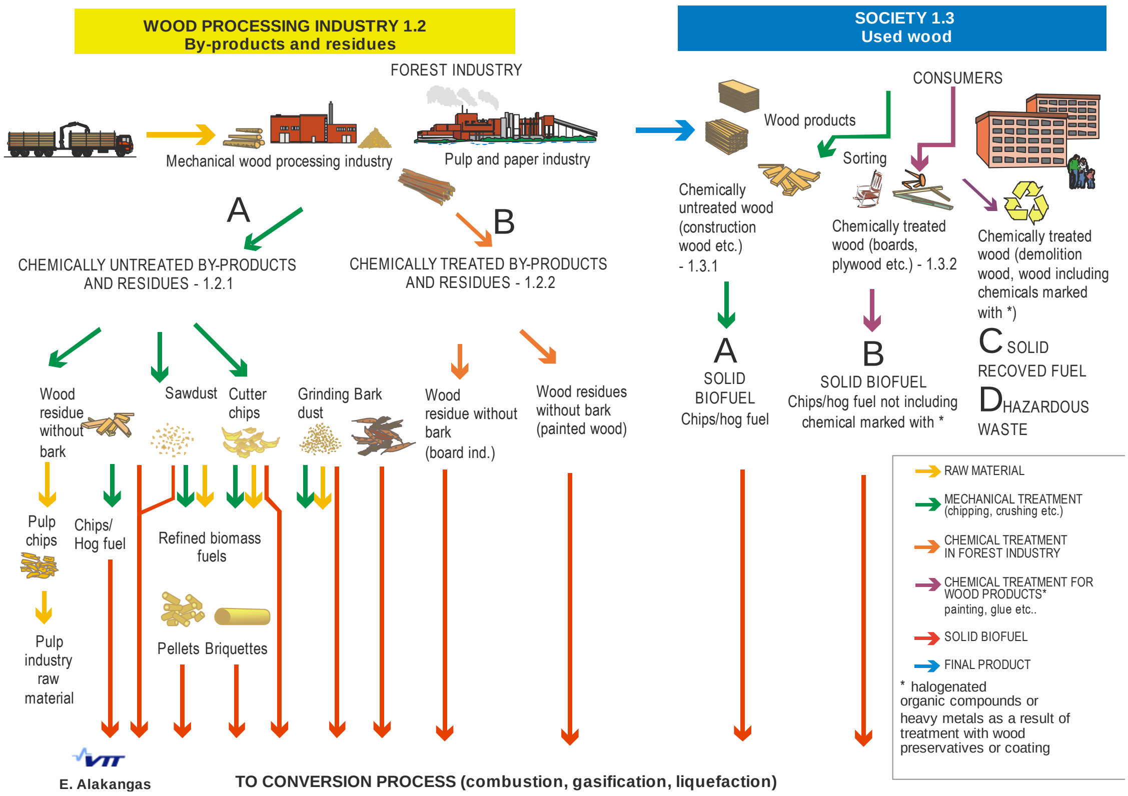

Figure 2. Classification of the industrial by-products and residues and used wood to A, B, C and D classes [2].

clarifies how different used wood classes can be determined.

The first version on the classification was published in Finland in 2008, and EN 14961-1 standard was applied. Many companies started to apply classification in their used wood business and also several environmental permissions include reference to Guidelines [1].

New guidelines were updated in 2014 and also some threshold values of heavy metals were checked [Table II]. Threshold values for class B wood were based on virgin wood values except for arsenic (As). In Finland most of the plants firing used wood are multifuel plants combusting peat or coal with biomass fuels. Peat and coal have higher arsenic values (0.5 – 14 mg/kg dry) than virgin wood (4 mg/kg dry). Threshold value for arsenic was agreed 10 mg/kg dry based average of multicombustion plants fuels. Separate limit values of Cr, Cu and As concentrations was replaced by sum content for class B. In the new classification guidelines the sum of As+Cu+Cr has been reduced to 70 mg/kg dry (earlier 74 mg/kg dry). The value of 74 mg/kg on dry basis was based on the virgin wood values of bark [Table II]. Also information of new Emission Trading legislation were added, especially how to calculate or analysis CO_2 factor for fossil part of the used wood. Also instructions to correct sampling and fuel analysis were added.

The Ministry of the Environment approved the guidelines together with industrial associations in the end of October 2014. The Ministry requested that

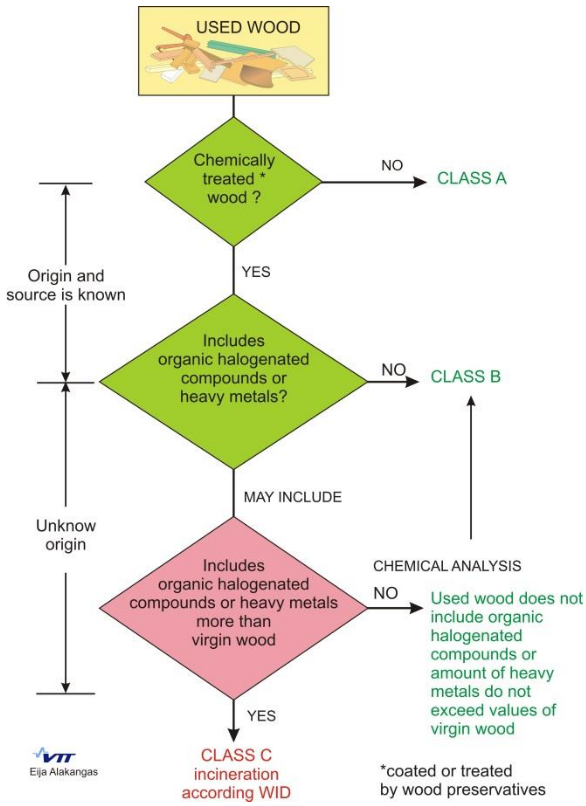

Figure 3. Flow chart how to determinate different used wood categories

combustion of used wood (class B) should be limited for bigger plants. Primarily, class B wood should be burned in plants with output more than 20 MW_{th} and then they are under Emission Trading Scheme (601/2012) and CO_2 factor for fossil part of the fuel (e.g. glue) should be stated. Secondarily, used wood can be used only in new plants, which have output more than 5 MW_{th}, because these plants are under small-plant combustion legislation (750/2013).

Class A (Virgin wood, only mechanically treated)

- Chemically untreated by-products or residues from forest and wood processing industry and segregated wood from parks, gardens, roadside management etc. (EN ISO 17225-1 Classes 1.2.1 and 1.1.7)
- Chemically untreated used wood (EN ISO 17225-1 Class 1.3.1)
- Proof of the origin and source: In industry description of the production process. Quality management system or similar, in which the separation of the wood waste is described.
- Fuel specification according to EN ISO 17225-1 [4]
- No Finnish Waste Incineration Act (151/2013) to be applied
- No chemical impurities allowed (no B class wood allowed)
- Can be used in all kind of biomass plants

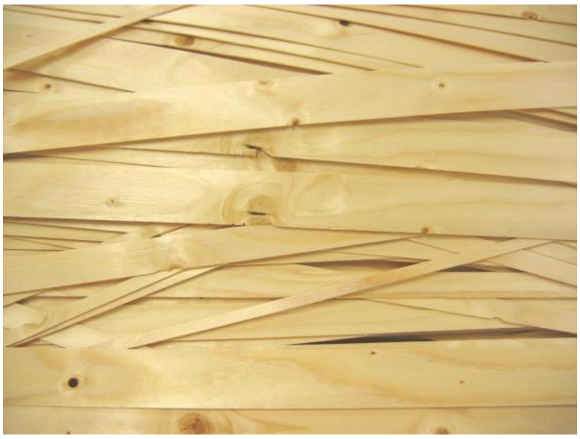

Figure 4. Example of class A wood, ply. VTT

Class B (Coated, lacquered or otherwise chemically treated and coating does not contain halogenated organic compounds (for example PVC) and preservatives, no demolition wood)

- Chemically treated by-products and residues from forest and wood processing industry and (EN ISO 17225-1 Class 1.2.2)
- Chemically treated used wood (EN ISO 17225-1 Class 1.3.2) excluding demolition wood.
- Proof of the origin and source: In industry description of the production process. Quality management system or similar, in which the separation of the wood waste is described.
- Fuel specification according to EN ISO 17225-1
- Maximum 2 w-% of mechanical contaminants (other than class A or B wood) are allowed, such as attached cement or nails, and the annual averages of chlorine and heavy metal contents may not exceed the threshold values of virgin wood (Table II).
- Primarily, class B wood should be burned in plants with output more than 20 MW_{th} and then they are under Emission Trading Scheme (601/2012) and CO_2 factor for fossil part of the fuel (e.g. glue) should be stated. Secondarily, used wood can be used only in new plants, which have output more than 5 MW_{th}, because these plants are under small-plant combustion legislation (750/2013).

If there is a reason to suspect contaminants in class B wood fuel, it has to be re-classified into class C or analyse the chlorine and heavy metal contents of the raw material for exclusion of contaminants (threshold values according to virgin wood, Table II).

Figure 5. Example of class B wood, a pallet. Photo VTT

Class C (Halogenated organic compounds for example PVC in the coating)

- Option 1: Separated as waste, for which the standards of the Waste Incineration Act (151/2013) applies, and the fuel properties are specified according to EN 15359 [3].
- Option 2: Certified with analyses that the level of contaminants does not exceed the given threshold values for chlorine and heavy metals (Table II), after which the wood can be considered as class B wood (biomass fuel; EN ISO 17225-11, class 1.3.2; Waste Incineration Act does not apply).
- Note: Demolition wood belongs to this class (class C; Waste Incineration Decree applies), if it is not possible to prove with quality management system or property specifications, that demolition wood is not chemically treated (e.g. house frames, building timber).

Table II. Threshold values for B class used wood in Finland

					Class A		Class B		Class C
	Property		**Threshold value¹, dry basis**	**Virgin wood, which is reference to threshold value**	**Normative**	**Informative**	**Normative**	**Informative**	**Threshold values to be check to be classified as B Class**
	Sulphur	S	≤ 0,2 w–%	bark, broadleaf		X	X		X
	Nitrogen	N	≤ 0,9 w–%	bark, broadleaf		X	X		X
	Potassium	K	≤ 5 000 mg/kg	bark, broadleaf				X	
	Sodium	Na	≤ 2 000 mg/kg	bark, coniferous				X	
	Chlorine	Cl	≤ 0.1 w–%			X	X		X
”Heavy metals”	Σ Arsenic + Chromium+ Copper	As+ Cr+ Cu	≤ 70 mg/kg²	bark, coniferous Σ 74 mg/kg			X		X
	Cadmium	Cd	≤ 1 mg/kg	bark, coniferous			X		X
	Mercury	Hg	≤ 0.1 mg/kg	bark, coniferous			X		X
	Lead	Pb	≤ 50 mg/kg	bark, coniferous			X		X
	Zink	Zn	≤ 200 mg/kg	bark, coniferous			X		X

[1] Threshold values are applied only for Cl, N, S and heavy metals. K and Na are recommended values for evaluation of combustion behaviour.

[3] As-value may not be higher than 10 mg/kg (±30% accuracy of the measurement) for class B wood. Note: 1 000 mg/kg equals to 0.1 w–%. Normative properties are mandatory and informative are voluntary.

Figure 6. Example of class C wood, demolition wood. Photo VTT.

Class D (Preservative-treated wood)

- Railway sleepers
- Transmission and telephone line poles

Class D wood is hazardous waste

Figure 7. Example of class D wood. Photo, VTT.

5. CONCLUSIONS

Finnish wood flows differ significantly from the average European wood flows presented by Mantau in 2012 [7]. Firstly, the direct use of wood for energy is relatively much lower, and the use of wood for pulp industry much higher in Finland than in the EU. Secondarily, as Finland exports a significant part of its wood biomass (as pulp, paper and board, timber and plywood), the cascading cycles of wood products take place outside the Finnish borders, e.g. in other EU

Member State. This limits the cascading cycles inside Finland. In addition, the figures show that the energy use of wood industry side streams is very significant in Finland. If the direct energy use of forest residues was not counted as cascading use, the cascading cycles in Finland would be even more limited [6].

Classes A, B, C and D for used wood and industrial wood residues and by-products were proposed in the guidelines and agreed by industrial associations and the Ministry of the Environment. The classification into these four classes is elucidated by examples with real used wood cases presented in the guidelines [2].

Wood categories A and B are specified according to EN ISO 17225-1–Solid biofuel standard [4] and class C under EN 15359–Solid recovered fuels standard [3]. Class A wood can be burned in all kind of biomass plants and class B wood primarily in plants with output more than 20 MW_{th} and secondly also in new plants with output more than 5 MW_{th}, which can fulfil more demanding emission regulations based on Small-scale combustion plant Act (750/2013). Fuels falling into category C should be incinerated according Waste Incineration Act (151/2013). Class D wood is treated by wood preservatives and is hazardous waste.

6. REFERENCES

[1] Alakangas, E. & Wiik, C:2008. Käytöstä poistetun puun luokittelu ja hyvien käytäntöjen kuvaus [Classification of used wood and description of best practices], VTT report VTT-R-04989-08, 54 p.+ app. 26 p. (In Finnish)

[2] Alakangas, E. 2014, Käytöstä poistetun puun luokittelu soveltaminen käytäntöön [Classification of used wood and implementation into practise], VTT-M-01931, 29 p.+ app. 22 p. (In Finnish)

[3] EN 15359:2011 – Solid recovered fuels. Quality management systems. Particular requirements for their applications to the production of solid recovered fuels.

[4] EN ISO 17225-1:2014. Solid biofuels – Fuel Specification and classes, Part 1 – General requirements.

[5] EN ISO 16559:2014. Solid biofuels – Terminology, definitions and descriptions

[6] Koponen, K., Sokka, L. & Keränen, J. 2015, Cascading use of woody biomass, VTT Research Report: VTT-R-03979-15, 20015, 25 p.

[7] http://www.vtt.fi/inf/julkaisut/muut/2015/VTT-R-03979-15.pdf

[8] Mantau, U. 2012. Wood flows in Europe (EU27). Project report. Commissioned by Confederation of European Paper Industries (CEPI) and European Confederation of Woodworking Industries (CEI-Bois).