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POTENTIAL OF POST-CONSUMER RECOVERED WOOD AND POSSIBLE WAYS OF IT USING IN UKRAINE

Wooden products should be designed and made in a way that ensures efficient energy recovery at the end of their life time. This should be done after any other potentials of material recycling are exploited and with a minimal technical effort and environmental impact. Consequently, criteria for the design of wooden products, such as shape or color, have to be extended by criteria for an efficient energy recovery, regarding also aspects of reuse and material recycling of wooden products or its components. The study aims at the development of design criteria for wooden products, which meet the requirements towards sustainable economics in terms of shape, functionality, reuse, recycling and energy recovery after the final use on material level.

This paper gives an overview about the Ukrainian definitions and classification principles for hazardous wastes on the Ukrainian level. Further, it describes the assessment of treated wood waste properties and the classification system of wood wastes applied in the Ukrainian classifier of waste wood. Finally, it presents an overview about the main actives in treated wood wastes, their classification according to the established Ukrainian codification and the problems arising thereof for the Ukrainian impregnation industry.

The most relevant achievements of this research were reached in the following areas of interest: management of recovered wood; amounts of recovered wood; quality aspects of recovered wood; energy generation; market aspects of recovered wood; greenhouse effects of recovered wood; design of wood products.

The most interesting results gained during research are:

- The amount of Recovered Wood in Ukraine (assumption, 2008) is about 2.9 Mio. t/a which corresponds to about 13 % of the annual round wood consumption of 14.3 Mio. t/a and about 43.5 PJ/a (12.1 TWh/a) or 6,7 % of the current annual primary energy consumption in Ukraine of about 181 TWh in 2008 year.
- As 46.7 Mio. Inhabitants (2006) are in the Ukraine, there is an annual specific amount of recovered wood of about 62 kg/capita (*additional potential).
- It is assumed, that about 0.3-0.4 Mio. t/a are CCA treated wood, which are about 10-13 % of the annual amount of recovered wood.

All four groups can be used for energy generation to produce useful energy like heat and electricity in special dedicated combustion plants. For recycling to new wooden products (e.g. wooden based panels) mainly the group 1 and 2 are feasible. Currently in Ukraine the recovered wood is used (Baseline 2008, assumption) for the following management options: 24 % for energy generation, 10 % for recycling and reuse and the rest of 66 % for composting, landfill and unknown options.

These 2.9 Mio. t/a contribute to:

- 15 PJ/a fossil fuel savings because of energy generation;
- 1 Mio. t/a fresh wood savings because of recycling and reuse;
- 1 Mio. t/a CO_2 reduction.

A comparison for different Scenarios for the use of recovered wood for energy generation and recycling is made; in which it is assumed, that each of the Scenarios provides the same amount of useful energy and wooden products. This means for energy generation, if less recovered wood is used an additional amount of fossil fuels is needed. For recycling it means, if less recovered wood is used additional fresh wood from sustainable forest management is needed.

The total CO_2-emissions decrease significantly by an increasing share of recovered wood used for energy generation and vice versa. The additional amount of CO_2-emissions from providing fresh wood is increasing by an increasing share of recovered wood for energy, but the increase is insignificantly or even negligible compared to the achievable CO_2-reduction from substituting fossil fuels for energy generation. The CO_2-emissions of providing fresh wood of Scenario 2 «Energy generation only» are with 0.087 Mio. t/a the lowest and in Scenario 3 «maximum recycling» with 3.076 Mio. t/a the highest. Assuming that Scenario 1 «Energy generation and recycling» with CO_2-emisisons of 1.854

Mio. t/a is most realistic future situation. Compared to the «Baseline 2008» of Ukraine the increase of the share of recovered wood for recycling would increase the CO_2-emissions of about 0.633 Mio. t/a; whereas with an increasing share of recovered wood for energy generation a maximum CO_2-emission reduction of about 2.443 Mio. t/a might be achieved.

Keywords: wood, post-consumer wood, wood preservative agents, post-consumer wood systematization, post-consumer recovered wood coding, recycling, waste management, energy recovery, assignment waste wood, CO_2-emisisons.

Background

Further development of international economic collaboration of Ukraine requires carrying out an energy policy coherent to the policy of leading world countries, first of all European Union. EU countries goal is transition to sustainable development. In energy field they make great efforts to improve energy security, to increase the use of own renewable energy resources, to reduce negative influence of energetics upon environment. For the period till 2010 EU countries plan to raise the share of renewables up from a level of 6 % in 1997 to 14.6 % [9, 17] of the total primary energy consumption. Realization of these plans and achieved big technological progress, particularly in wind energy and biomass utilization, inspire them with more ambitious plans. The positive technical, economic and structural conditions for the use of biomass for energy generation will enable biomass to contribute significantly to this aim.

In 2000 consumption of wood and wood waste in Ukraine for energy production amounted to about 5.8 TWh [9]. According to prognosis consumption of wood and wood waste (Post-consumer Recovered Wood) for energy production will be about 13 TWh in 2030 and may achieve 16.3 TWh/a in 2040. Further development of energy utilization of wood and Recovered Wood can be also expected under reorganization of forestry and intensive development of forestry and examination of the technical potentials of Recovered Wood and wood residues as both secondary raw materials and as energy sources. So, prognosis on energy utilization of wood and Recovered Wood in 2050 may be 25 TWh/a.

In the Kyoto process the European Union has committed to reduce European greenhouse gas (GHG) emissions (CO_2, CH_4, N_2O etc.) by 8 % from 1990 level by the year 2010 [8, 28]. Predicting further development of economy and energetic on the basis of modern and the most effective technologies, experts came to a conclusion about possibility to replace nuclear and fossil fuel (totally or partly depending on a region) by renewable energy sources (RES). For example, scenario worked out for Denmark demonstrates that transition to sustainable energy system will not exceed expenditures necessary for supporting traditional energetic, at least during the nearest 30 years. At the same time emission of CO_2 can be reduced by 70%.

Energy generated from biomass is able to substitute for fossil fuels used for electricity, heat supply and transportation fuel. Biomass will therefore contribute substantially to the reduction of greenhouse gas emissions, mainly CO_2 from fossil fuel combustion. Landfilling of organic material leads to CH_4 emissions, and the GHG potential of CH_4 is 21 times higher than that of CO_2. Therefore, avoiding landfill of biomass can reduce CH_4-emissions from landfill sites. One of the most important sources of biomass – in addition to forestry and energy crops – derives from industrial wood at the end of its life (e.g. demolition wood, timber from building sites and the commercial sector).

Scope of Recovered Wood

There is no common definition available for Recovered Wood in the context it is used in Ukraine. In the Conference of the National University of Forestry and Wood Technology of Ukraine (NUFWT of Ukraine) a preliminary definition that was used was based on the system used in the European Waste Catalogue (EWC). However, in this system, Recovered Wood is not seen as a waste under all circumstances. Indeed, the concept of Recovered Wood specifically recognizes that a large proportion of the potentially available wood being considered under this category is definitely not to be regarded as a 'waste' material. Discussions by NUFWT of Ukraine researchers at several conferences made clear that Recovered Wood is an important raw material for the panel board industry and for energy producers.

In NUFWT of Ukraine the following definition is used for the term Recovered Wood: **«Recovered Wood is demolished solid products biomass (examples: used construction biomass, used pallets biomass) and used products biomass that is going to be used in the same product for another purpose (example: used railway sleepers), generated from used solid wood products». «The term Recovered Wood does not cover biomass in used solid wood products that is going to be used once more in a new setting (example: wooden chair), or biomass in intermediate solid wood products that is going to be used in new solid material products (example: used panel boards)».**

Finally, when estimating the amounts of Recovered Wood in Ukraine the researchers by NUFWT of Ukraine agreed as a working hypothesis, that all quantities of wood biomass coming through the secondary resource management system had to be included. In most cases the secondary resource management system is an integrated part of the waste management system after use in at least one life cycle. Therefore the term used for Recovered Wood in this paper can also be named as «**Post-Consumer Wood**».

Recovered Wood covered by the scope of NUFWT of Ukraine includes all kinds of wooden material that is available at the end of its use as a wooden product («post-consumer» or «post-use» wood). Beside forest residues and energy crops, Recovered Wood is one of the most important renewable sources of biomass and as a renewable raw material and energy carrier. Recovered Wood mainly comprises packaging materials, demolition wood, timber from building sites and fractions of used wood from residential, industrial and commercial activities.

Therefore all wood grades from forestry residues including tops, thinnings and branches from forest operations are excluded as they are not in the scope of researchers by NUFWT of Ukraine. Black liqueur from pulp production is also not within the scope of researchers by NUFWT of Ukraine.

Recovered Wood is described by the following origins: saw mill, wood manufacturing industry, particle board industry, pulp and paper industry, construction and demolition activities, residential and commercial sectors, packaging. Where as this research is mainly focusing on Recovered Wood from the wood utilization side, but including market interactions, market effects and future market developments with wood from the wood processing side.

The most important parameters describing Recovered Wood are size, quality properties, condition, heating value, moisture content, content of chlorine, ash, contamination and heavy metals.

Management of Recovered Wood

European wood recycling has grown steadily over the last decade, mainly due to increased consumption by the panel board industry. Millions of tones are still sent to landfill each year as most of the current markets for recycled wood require clean, solid timber. Outlets for other wood waste, including panel products and treated wood waste, are very limited in many countries. Much of the panel board and treated wood waste is currently sent to landfill because there are no other acceptable or practical options. Some interesting projects addressing this problem have recently been completed, such as «UK Waste» and «Resources Action Programmer (WRAP)» by TRADA Technology in UK. The aims of a majority of the reported projects were to identify ways of diverting waste material from landfill via reuse, recycling, composting and energy recovery.

The management of Recovered Wood in general and of related Recovered Wood management systems in particular, can be analyzed in different ways. One appropriate method is by describing the current situation and giving an outlook for the future by covering the following aspects: amounts and qualities of Recovered Wood in relation to the whole wood utilization, related legislation and regulations for handling Recovered Wood, classification of Recovered

Wood recognition of key players and available approaches and tools in the decision-making contexts, and anticipation of future developments in the area.

During the COST E31 [8, 20], examples of existing management systems in Austria, Sweden and United Kingdom were selected and briefly summarized to illustrate diversity of approaches and focuses of interest in management systems (directly dealing with Recovered Wood) in different European countries. Worth mentioning is that in certain countries there are no 'recognizable' management systems at all, so future development and standardization must obviously receive much more professional attention in order to unify European Recovered Wood long term and operational management policies. Legislation acts related to Recovered Wood have been issued by the European Union since the early 1970s through different Directives. Documents assessed in this research cover the period from 1975 to 2000 and give an overview of the legal developments related to Recovered Wood wastes, treatment of hazardous waste and incineration of wastes. It is interesting to note that the term «Recovered Wood waste» is the dominant one although nowadays interpretation of Recovered Wood is more general. No special reports are evident in the European countries related to real life implementation of aforementioned legislative acts and legislation.

Amounts of Recovered Wood

For the first time, an estimation of the amount of Recovered Wood in 20 COST E31 countries was obtained in 2002 year. It also showed that Recovered Wood is an important resource for reuse and recycling, for example in the panel board industry and energy generation (table 1). Sustainable management of this resource for material and energy use may mitigate environmental impacts such as the green house effect. In addition, the availability of this wood resource in the future offers possibilities for emission trade to fulfill the Kyoto protocol.

The average amount of Recovered Wood from the 20 countries listed in table 2 was approximately 65 kilograms per capita. The actual capita fig. for each country is shown in fig. 1. There are large differences between countries; for instance, the Fig. for Hungary is only 3 kg/capita whilst Serbia is 241 kg/capita. In Austria, Germany and the

Netherlands the data are based on research projects. The amount of Recovered Wood in Austria is 96 kg/capita, whilst in Germany it is 72 kg/capita, and in the Netherlands it is 76 kg/capita. All these countries have more Recovered Wood per capita than the average of 65 kg/capita. This may lead to the conclusion that the total amount of Recovered Wood estimated is in the correct order of magnitude.

Table 1. Share of uses of Recovered Wood in COST E31 countries [8, 10, 29]

Country	Reuse	Recycling	Energy Generation	Landfill	Composting	Others, unknown
	Transfer coefficients in percent divided with 100					
Austria	0,05	0,4	0,42	0,02	0,1	0,01
Belgium	0,38	0,28	0,02	0,02	0,1	0,2
Bulgaria	0,01	0,25	0,35	0,05	0	0,34
Croatia	0,05	0,15	0,7	0,05	0,02	0,03
Finland	0	0,48	0,51	0,01	0	0
France	0	0,71	0,14	0,15	0	0
Germany	0	0,152	0,691	0,002	0,008	0,147
Greece	0	0	0	0	0	1
Hungary	0,05	0,1	0,2	0,5	0,1	0,05
Ireland	0,08	0,66	0,01	0,08	0,02	0,15
Italy	0,07	0,572	0,347	0,011	0	0
Netherlands	0	0,6044	0,3672	0	0	0,02794
Norway	0	0,05	0,7	0,02	0,07	0,17
Poland	0,11	0,03	0,02	0,01	0	0,83
Portugal	0	0,12	0,01	0,02	0	0,85
Serbia	0,01	0,05	0,24	0,3	0	0,4
Slovenia	0,05	0,025	0,67	0,23	0,025	0
Spain	0	0,8	0,05	0,09	0,05	0,01
Sweden	0,025	0,025	0,9	0,025	0,025	0
United King	0	0,16	0,28	0,22	0,11	0,23

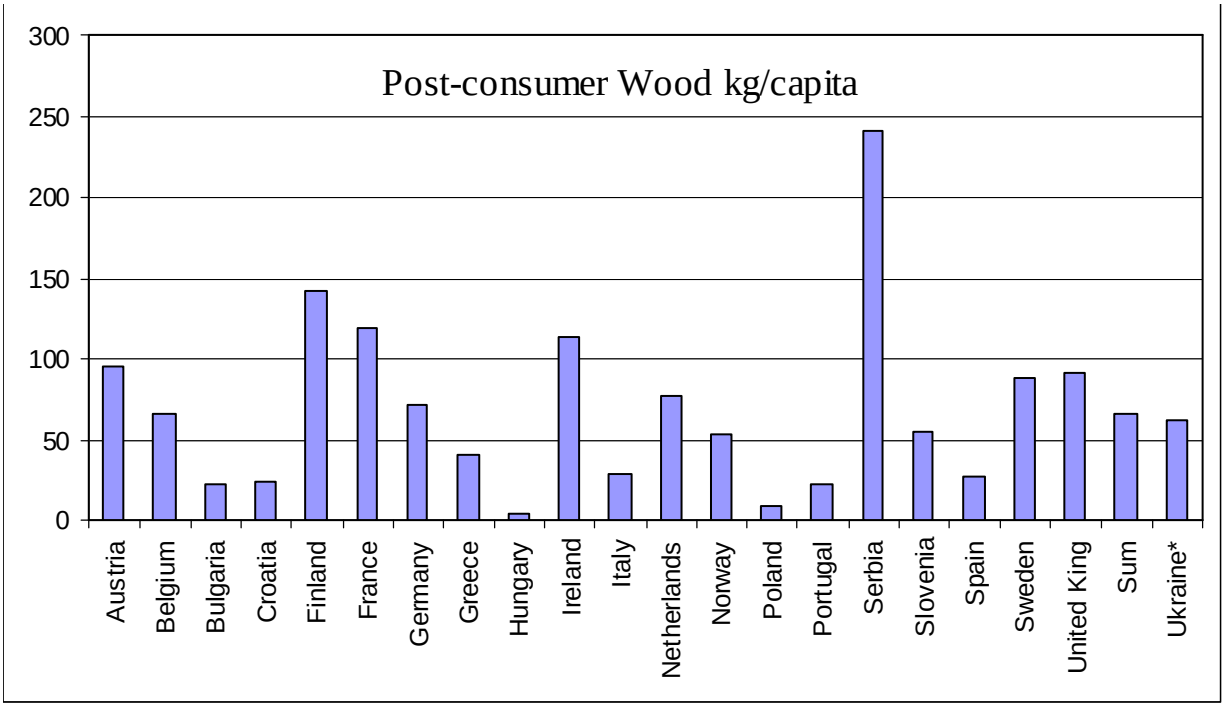

Fig. 1. Amounts of Recovered Wood per Capita in the 20 countries (actual) and in the Ukraine* (potential)

Table 2 includes the data provided with questionnaires and the assessed amounts of «post consumer wood». Because of different definitions of Recovered Wood in the various member countries the statistical data are different and very often including forestry residues or residues from wood processing.

Currently in these 20 countries the recovered wood is used for the following management options: 34 % for energy generation, 38 % for recycling and reuse and the rest of 28 % for composting, landfill and unknown options.

Table 2. Amounts of Recovered Wood and use of Recovered Wood in the different countries [8, 18, 25, 28, 29]

Country	Reuse	Recycling	Energy	Landfill	Composting	Others, unknown	Total
	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]	[t/a]
Austria	38,750	310,000	325,500	15,500	77,500	7,750	775,000
Belgium	259,540	191,240	13,660	13,660	68,300	136,600	683,000
Bulgaria	1,633	40,825	57,155	8,165	-	55,522	163,300
Croatia	5,052	15,155	70,723	5,052	2,021	3,031	101,034
Finland	-	360,624	383,163	-7,513	-	-	751,300
France	-	5,041,000	994,000	1,065,000	-	-	7,100,000
Germany	-	906,224	4,119,742	11,924	47,696	876,414	5,962,000
Greece	-	-	-	-	-	450,000	450,000
Hungary	1,600	3,200	6,400	16,000	3,200	1,600	32,000
Ireland	38,552	318,053	4,819	38,552	9,638	72,285	481,898
Italy	112,841	922,070	559,368	17,732			1,612,011
Netherlands		755,525	459,000			34,925	1,249,450
Norway	-	12,300	172,200	4,920	17,220	41,820	248,460
Poland	34,100	9,300	6,200	3,100	257,300	-	310,000
Portugal		28,320	2,360	4,720		200,600	236,000
Serbia	18,100	90,500	434,400	543,000		724,000	1,810,000
Slovenia	5,375	2,688	72,025	24,725	2,688	-	107,500
Spain	-	960,000	60,000	108,000	60,000	12,000	1,200,000
Sweden	19,600	19,600	705,600	19,600	19,600	-	784,000
United King	-	885,760	1,550,080	1,217,920	608,960	1,273,280	5,536,000
Sum	**535,142**	**10,872,383**	**9,996,395**	**3,125,083**	**916,822**	**4,1147,127**	**29,592,953**
t/(c*a)	**0,0012**	**0,0239**	**0,0220**	**0,0069**	**0,0020**	**0,0091**	**0,0651**

Quality Aspects of Post-Consumer Wood (PCW)

Waste wood must be assigned to one of four of the following waste wood categories depending on the level of pollution:

- **Waste wood category** PCW I**:**

Waste wood in its natural state or only mechanically worked which, during use, was at most insignificantly contaminated with substances harmful to wood;

- **Waste wood category** PCW II**:**

Bonded, painted, coated, lacquered or otherwise treated waste wood with no halogenated organic compounds in the coating and no wood preservatives;

- **Waste wood category** PCW III**:**

Waste wood with halogenated organic compounds in the coating, with no wood preservatives;

- **Waste wood category** PCW IV**:**

Waste wood treated with wood preservatives, such as railway sleepers, telephone masts, hop poles, vine poles as well as other waste wood which, due to its contamina-

tion, cannot be assigned to waste wood categories PCW I, PCW II or PCW III, with the exception of waste wood containing PCBs.

In Germany utilization and disposal of this wood is regulated by the Waste Wood Directive – «Ordinance on the Management of Waste Wood», which is put into force, March 2003 [26]. In accordance with this decree, wood is classified in the following categories: A I, A II, A III, A IV. Waste wood which constitutes waste wood containing PCBs within the meaning of the PCB/PCT Waste Ordinance [PCB/PCT-Abfallverordnung] and is to be disposed of in accordance with the provisions of this Ordinance, in particular insulating board and sound insulating board treated with agents containing polychlorinated biphenyls. Table 3 shows that the market volume consists of A I / A II as well as A III / A IV respectively one half each. The categories A II and A III respectively have a share of about one third of the total volume. Waste wood containing PCBs has got a share of about 0,1 %.

Table 3. Categories by waste wood ordinance in Germany and Ukraine

Category		PCW («Altholz») in Germany [7, 15]				PCW in Ukraine*)	
		2003		2006		2008	
Germany [8]	Ukraine [5]	[Mio. t]	[%]	[Mio. t]	[%]	[Mio. t]	[%]
Altholz I	PCW I	1,112	17,0	1,085	18,2	0,493	17,0
Altholz II	PCW II	2,265	34,7	1,979	33,2	1,032	35,6
Altholz III	PCW III	2,050	31,4	1,795	30,1	0,885	30,5
Altholz IV	PCW IV	1,094	16,7	1,097	18,4	0,484	16,7
Waste wood containing PCB		0,010	0,1	0,006	0,1	0,006	0,2
Total		6,531	100,0	5,962	100,0	2,900	100,0

) PCW in Ukraine – Potential amount of post-consumer wood (PCW) in Ukraine

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.

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 AI to A IV are then allocated to the individual substance recycling paths; energy recovery is governed by the provisions of the Federal Emission Control Act and the statutory ordinances issued on the basis thereof. Waste wood containing PCBs is classified, as a «special category» if it's PCB content is more than 50 mg/kg [8]. Waste wood containing PCBs must be disposed of in accordance with the PCB/PCT Waste Ordinance – only thermal treatment procedures come into question.

Implications for the Ukraine Industry

The assignment of waste wood to category A IV can pose difficulties to the wood industry. Waste timber can be contaminated to different extents with paint, lacquer, coatings and wood preservatives. Some active ingredients can represent a particular risk potential. Among these are pentachlorophenol, lindane, permethrin, dichlorodiphenyl-threechloretan (DDT), polychlorinated biphenyls (PCB), polychlorinated terphenyls (PCT), polybrominated biphenyls (PBB), polyvinilcloruro (PVC), and oils that are produced by fractions of coal tar (benzopyren) and compounds which contain benzo(a)pyren and other superficially active hydrocarbons (SAH) and others chemical elements (arsenic, boron, cadmium, copper, mercury, lead, titanium, fluorine, chlorine, chromium, zinc and others [8, 23, 24, 27, 30) and their compounds, as well as creosotes (table 4).

Table 4. Kind of wood preservatives and estimated quantity of wood waste from different origin [27, 30]

Assortment	Impurity*) (possible)	Retention	Estimated quantity (*1.000 to/a)	
			Germany	Ukraine**)
Sleepers	Creosote, CCB[1]	45 kg/m^3-175 kg/m^3 ndi	ca. 60 – 85	ca. 15 – 20
Poles	CCB, CCF, CCA creosote, $HgCl_2$	6-12 kg/m^3 ca. 90 kg/m^3 0,6-1,0 kg/m^3	ca. 15 – 25	ca. 4 – 6
Landscaping	CCB, CCF Cu-HDO-salts creosote tar oil derivates/ formulations LOSP	6-8 kg/m^3 3-4 kg/m^3 ca. 80 kg/m^3 250-400 g/m^3 ndi	ca. 220	ca. 55
Hop-poles	CCB, CCF, CCA creosote $HgCl_2$	ca. 6-8 kg/m^3 ca. 90 kg/m^3 ca. 0.4-0.8 kg/m^3	present stock (pcs): 150000 – 270000	present stock (pcs): 35000 – 65000
Vineyard posts	CCA, CCF CCB creosote $HgCl_2$ CFA	5-6 kg/m^3 ca. 10 kg/m^3 50-100 kg/m^3 ca. 0.6-1.0 kg/m^3 5-6 kg/m^3	ca. 9 – 14	ca. 2 – 3
Wood from demolition of buildings, building sites	all WPs except creosote, chloronaphthaline and $HgCl_2$; coatings, varnishes, impurities etc.	no specification	ca. 500 – 2000	ca. 200 – 470
Wood for packaging/ palettes	rarely	-:-	ca 470 – 970	ca 115 – 235
Cable drums	CCB, CCF, CC	6-8 kg/m^3	ca. 31 – 45	ca. 9 – 11
Furniture	varnishes, glues, coatings	unknown	ca. 2500	ca. 1600
Industry residues[2]	rarely, known if applied	no specification	ca. 8100	ca. 900
Total treated			**1300 – 3400**	**400 – 800**
Untreated			**10600**	**2500**
Grand total			**11900 – 13900**	**2900 – 3300**

*) – CCA – wood preservative containing Cu (copper), Cr (chrome) and As (arsenic) compounds; CCB – wood preservative containing Cu, Cr and B (boric acid) compounds; CCF – wood preservative containing Cu, Cr and F (fluorine) compounds; CC – wood preservative containing Cu and Cr compounds; CFA – wood preservative containing Cu, F and As compounds; Cu-HDO – wood preservative containing N-cyclohexyl-N-nitrosohydroxyl amine copper.

**) – Potential additional amount of post-consumer wood (PCW) in Ukraine

1 – Private railways in some cases may use chromium containing salts (only pine).

2 – Industry residues are solid wood cut-offs, chips, shavings, dust, bark; Ndi – No definite information available

Post-Consumer Wood (PCW) – Recovered Wood might be is classified according to its special characteristics, mainly described by treated, untreated, contaminated and hazardous fractions, in four different categories (groups):

- PCW-I (Group 1) – «Untreated recovered wood»: wooden packaging material, building and demolition wood wooden bulky rubbish of residential waste fraction;
- PCW-II (Group 2) – «Treated recovered wood»: treated building and demolition wood, wooden bulky rubbish of residential waste fraction;
- PCW-III (Group 3) – «Contaminated recovered wood»: transmission poles, railway sleepers;
- PCW-IV (Group 4) – «Hazardous recovered wood»: piles and poles salt impregnated, chemical treated wood waste (CCA and CCB).

Mantau and Bilitewski [16] have disclosed a total amount of waste wood and wood in waste of about 11.2 Mio. tons (air-dry). This amount is derived from data of the statistical Federal Office and the administrative offices which were lifted up in the context of the waste statistics.

These amounts of wood waste emerge in different areas of private businesses and public communes. According to the authors the «wood is collected separately in some cases, however, mainly it is a component of waste mixtures. A part of the wood is sorted and utilized or disposed afterwards. The pre-dominant part is removed or utilized directly without an inter-step of sorting» (Mantau and Bilitewski 2005). Primarily the wood in the mixing waste is distributed directly for disposal. About 5.6 Mio. tons are disposed, either landfill or thermal.

The utilization of waste wood happens mainly for material or energetic use. Furthermore, an import of about 0.9 Mio. tons and an export of post-consumer wood of about 0.7 Mio. tons were calculated. In Germany, about 6.5 Mio. tons are utilized (table 5). This amount subsumes the waste wood which can be defined as post-consumer wood and the imported volume.

Table 5. Origin of post-consumer wood in Germany [7, 16, 19]

Origin	2001		2003		2006	
	[Mio. t]	[%]	[Mio. t]	[%]	[Mio. t]	[%]
Commerce (package)	0,812	13,6	1,369	21,0	1,271	21,3
Construction waste	1,881	31,4	1,742	26,7	1,629	27,4
Wood-processing industry	0,855	14,2	0,912	14,0	0,884	14,8
Municipal waste	1,758	29,4	1,353	20,7	1,237	20,8
Import	0,222	3,8	0,632	9,7	0,585	9,8
Other	0,455	7,6	0,523	8,0	0,356	5,9
SUM	**5,983**	**100,0**	**6,531**	**100,0**	**5,962**	**100,0**
Disposed, either landfill or thermal	4,383		4,679		5,938	
AMOUNT	**9,600**		**11,200**		**11,900**	

The following table 6 displays an overview of the origins of post-consumer wood, which will be relevant only for potential sustainable post-consumer wood supply.The waste wood shall be assigned to the waste wood categories permitted for the intended recovery path by means of visual checks and sorting. If it is suspected that the waste wood has been creosoted, the waste wood must be assigned to category A IV. When assigning waste wood to a category, the type and origin of the waste wood shall be taken into consideration in accordance with table 7 as an assumption of a general rule. Assignment to another waste wood category is permitted in particularly justified exceptional cases. It must be documented in the facility log-book and the reasons for this

must be given. Interfering substances must be removed. If it is not possible to assign the waste wood definitively to a particular waste wood category, it must be assigned to a higher category.

Table 6. Potential sustainable of post-consumer wood (PCW) in Ukraine

Origin	Post-consumer recovered wood					
	potential additional amount in Germany		potential amount in Ukraine [1-3]			
	2005 [10]		2008		2009	
	[Mio. t]	[%]	[Mio. t]	[%]	[Mio. t]	[%]
Commerce (package)	0,286	15,71	0,258	8,90	0,225	8,65
Construction waste	0,595	32,67	0,658	22,69	0,457	17,58
Wood-processing industry	0,245	13,45	0,184	6,34	0,105	4,04
Municipal waste	0,483	26,52	0,395	13,62	0,335	12,88
Other	0,212	11,64	0,364	12,55	0,243	9,35
SUM PCW*)			**1,859**	**64,10**	**1,365**	**52,50**
TDW PCW**)			1,041	35,90	1,235	47,50
TOTAL	**1,821**	**100,00**	**2,900**	**100,00**	**2,600**	**100,00**
Uses of wooden resours (UWR) [2]			14,300		10,500	

*) PCW = UWR × 13%/100%;
**) PCW = Tough domestic waste (TDW) × 1%/100%

Overview of management options

In fig. 2 the possible options for management of recovered wood are shown, mainly recycling to new wooden products or energy generation for heat and/or electricity. Of course for all different groups of recovered wood, a special processing e.g. sorting, chipping, separation of metals has to take place.

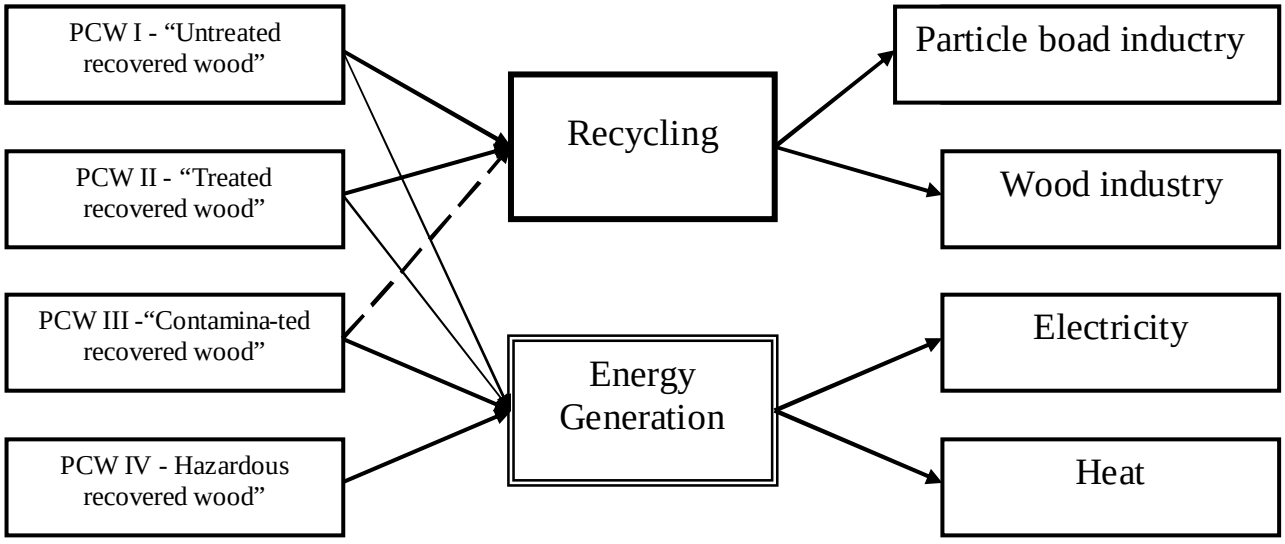

Fig. 2. Management options of recovered wood

All four groups are very suitable to be used for energy generation (e.g. heat, or cogeneration of heat and electricity), even each of the groups needs special combustion technology, whereas group 4 will mainly be co-fired in MSW incineration plants. Untreated wood (group 1) is best suitable to recycling but also bigger fractions of treated recovered wood (group 2) might be recycled. According to current market situation the price of recovered wood in group 1 and 2 determines, if it is used for recycling or energy generation. The exact amounts of recovered wood used for energy generation and

recycling are not known in Ukraine. Therefore it is necessary to define different Scenarios for the use of the recovered wood. For all different management options a specific processing of recovered wood is necessary to reach a high input quality as biofuel for energy generation or secondary raw material for wooden based products, e.g. chipping, metal separation.

Table 7. Usual assignment of the common types of waste wood in Ukraine [4-6, 8]

№	Common types of post-consumer wood (PCW)			Usual assignment	Waste code	
	group	kind	varieties		Europe [8]	Ukraine
1	Wood waste from woodworking and machining		Waste, cuttings, shavings from solid wood in its natural state	PCW-I	03 01 05	2000.2.2 2000.3.1
			Waste, cuttings, shavings from derived timber products and other treated wood (with no harmful contaminants)	PCW-II	03 01 05	2000.2.2 2000.3.1
2	Packaging	Palettes	Palettes made from solid wood such as: Europalettes, industrial palettes made from solid wood	PCW-I	15 01 03	7710.3.1.06
			Palettes made from derived timber products	PCW-II	15 01 03	7710.3.1.06
			Other palettes with composite materials	PCW-III	15 01 03	7710.3.1.06
		Boxes	Transport cases, crates made from solid wood	PCW-I	15 01 03	6000.3.1.04
			Transport cases made from derived timber products	PCW-II	15 01 03	6000.3.1.04
			Boxes for fruit, vegetables and ornamental plants as well as similar boxes made from solid wood	PCW-I	15 01 03	7710.3.1.06
			Ammunition boxes	PCW-IV	15 01 10*	7730.3.2.01
		Cable reels	made from solid wood (made before 1989)	PCW-IV	15 01 10*	7730.3.2.01
			made from solid wood (made after 1989)	PCW-I	15 01 03	7710.3.1.06
3	Waste wood from the construction industry	Waste wood from building sites	Solid wood in its natural state	PCW-I	17 02 01	4510.1.3.06
			Derived timber products, barked wood, treated solid wood (with no harmful contaminants)	PCW-II	17 02 01	4510.1.3.06
		Waste wood from tearing down and sorting out	Boards, false ceilings, planks from interior works (with no harmful contaminants)	PCW-II	17 02 01	4510.1.3.06
			Door leaves and frames (with no harmful contaminants)	PCW-II	17 02 01	4510.1.3.06
			Profile boards for the fitting out of rooms, ceiling panels, ornamental beams etc. (with no harmful contaminants)	PCW-II	17 02 01	4510.1.3.06
		Waste wood from demolition and restoration work	Heat and sound insulating board treated with agents containing polychlorinated biphenyls	Disposal	17 06 03*	4510.3.2.01
			Chipboard used in construction	PCW-II	17 02 01	4510.1.3.06
			Wood used in construction for load-bearing elements	PCW-IV	17 02 04*	4510.1.3.06
			Timber framework and rafters	PCW-IV	17 02 04*	4510.1.3.06
			Windows, window posts, outer doors	PCW-IV	17 02 04*	4510.1.3.06
			Impregnated wood used in external structures	PCW-IV	17 02 04*	4510.1.3.06
		Other	Wood from construction and demolition work containing harmful contaminants	PCW-IV	17 02 04*	4510.3.2.01
4	Impregnated waste wood used in external structures	Different	Railway sleepers	PCW-IV	17 02 04*	4510.3.2.01
			Telephone masts	PCW-IV	17 02 04*	4510.3.2.01
			Various wood used in horticulture and landscaping, impregnated garden furniture	PCW-IV	17 02 04*	4510.3.2.01
			Various wood used in agriculture	PCW-IV	17 02 04*	4510.1.3.06
5	Furniture	Different setting	Furniture, solid wood in its natural state	PCW-I	20 01 38	7710.3.1.10
			Furniture, with no halogenated organic compounds in the coating	PCW-II	20 01 38	7710.3.1.10
			Furniture, with halogenated organic compounds in the coating	PCW-III	20 01 38	7710.3.1.10
6	Waste wood from bulky refuse (mixed)			PCW-III	20 01 37	7730.3.1.03
7	Waste wood from industrial use (e.g. industrial flooring, cooling towers)			PCW-IV	17 02 04*	4510.3.1.01
8	Waste wood from hydraulic engineering			PCW-IV	17 02 04*	4510.3.1.01
9	Waste wood from dismantled vessels and goods waggons			PCW-IV	17 02 04*	4510.3.1.01
10	Waste wood from damaged structures (e.g. burnt wood)			PCW-IV	17 02 04*	4590.3.1.01
11	Fine fraction from the processing of waste wood to make derived timber products			PCW-IV	19 12 06*	2000.3.2.01

Re-use/recycling

The waste wood categories AI 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 Emission Control Act [26] and with regard to emissions are subject to the Seventeenth Ordinance on the Implementation of the Federal Emission Control Act (cf. table 8) 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 (cf table 9), including relevant sampling and analysis provisions, for the wood chips produced for use as raw materials for the manufacture of derived timber products (cf table 7). 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.

Table 8. Methods for the substance recycling of waste wood [21]

Recovery method	Permissible waste wood categories				Special requirements
	AI	AII	AIII	AIV	
Processing of waste wood to wood chips for the manufacture of derived timber products	Yes	Yes	(Yes)		The processing of waste wood from category A III is only permissible if varnishes and coatings have been largely removed by pre-treatment or will be largely removed during processing
Production of synthetic gas for further chemical use	Yes	Yes	Yes	Yes	Recycling is only permitted in installations licensed for this purpose under Article 4 of the Federal Emission Control Act
Manufacture of active carbon/industrial charcoal	Yes	Yes	Yes	Yes	Recycling is only permitted in installations licensed for this purpose under Article 4 of the Federal Emission Control Act

Table 9. Limit values for wood chips used in the manufacture of derived timber products; creosoted creosoted waste wood must be eliminated [8, 11, 21]

№	Element/compound	Concentration (milligrams per kilogram dry mass)
1	Arsenic	2
2	Lead	30
3	Cadmium	2
4	Chromium	30
5	Copper	20
6	Mercury	0,4
7	Chlorine	600
8	Fluorine	100
9	PCP	3
10	Polychlorinated biphenyls	5

Possible Scenarios for future management options

In table 10 the description of three Scenarios for the use of the annual estimated amount of 2.9 Mio. t recovered wood in Ukraine 2008 is shown. The difference of these three Scenarios is the share of recovered wood used for energy generation and recy-

cling. Scenario 1 «Energy generation and recycling» seems to reflect current situation the best, whereas Scenario 2 «Energy generation only» reflects total use of recovered wood for energy and Scenario 3 «Maximum recycling» tends to use as much as possible of the recovered wood for recycling. With a heating value of 15 GJ/t of recovered wood the current amount of 2.9 Mio. t is equal to an energy amount of about 43.5 PJ/a (12.1 TWh/a; Terra – 1×10^{12}), which is about 6.7 % of the current annual primary energy consumption in Ukraine of about 181 TWh in 2008 year.

Using the assumption shown in table 11 the amount of useful energy produced as well as the additional needed amount of fresh wood and fossil fuels is calculated. A comparison of the three Scenarios is made, where it is assumed, that each of the Scenarios provides the same amount of useful energy and wooden based products. This means for energy generation, if less recovered wood is used an additional amount of fossil fuels is needed. For recycling it means, if less recovered wood is used additional fresh wood is needed.

Table 10. Definition of three Scenarios for management of recovered wood in relation to «Baseline 2008» in Ukraine

Scenarios	Energy generation	Recycling	Other uses *)	Share for energy generation
	[Mio. t/a]			[%]
Baseline 2006 (20 COST E31 countries)	10.00	11.40	8.20	34 %
Baseline 2008 of Ukraine (assumption)	0.70	0.29	1.91	24 %
Scenario 1: Recycling and energy generation **)	1.45	1.45	-	50 %
Scenario 2: Energy generation only	2.90	-	-	100 %
Scenario 3: Maximum recycling ***)	0.58	2.32	-	20 %

*) other uses: landfill, composting, others;
**) assumption: 50% recycling and 50% energy generation;
***) assumption: 20% not suitable for recycling.

Table 11. Assumption used for comparison of the three Scenarios [12-14, 22]

Assumption value	Unit
Heating value of recovered wood	15 GJ/t (4.167 MWh/t)
Average energy efficiency for heat	60 %
Average energy efficiency for electricity	20 %
Share of recovered wood used for combined heat and power production	20 %
Fibre losses during recycling	10 %
Additional fossil energy for recycling	0.0035 TJ/t (0.972 MWh/t)
Higher efficiencies for fossil fuels	10-13 %
Heating value of fossil fuels	17 GJ/t (4.72 MWh/t)
CO_2-emissions of fossil fuel combustion (oil)	78 t/TJ (280.8 t/GWh)
CO_2-emissions of fresh wood supply	0.030 t/t

Results from Scenarios

For the three Scenarios in table 10 the amount of useful energy – split up in heat and electricity – and the additional demand for fresh wood is shown (fig. 3) . Scenario 2 «Energy generation only» produces the highest amount of useful energy (27.8 PJ/a) but also needs the biggest amount of fresh wood (2 Mio. t/a). Whereas Scenario 3 «Maximum recycling» provides the lowest amount of useful energy (5.5 PJ/a) but needs no additional fresh wood. Scenario 1 «Energy generation and recycling», as a realistic

average of Scenario 2 and 3 produces an average amounts of useful energy (13.9 PJ/a) and needs about 0.8 Mio. t/a fresh wooden material from sustainable forestry.

In the following considerations the results from the Scenarios are more generalized by relating the results to the share of recovered wood that is used for energy generation. For Scenario 1 «Energy generation and recycling» the share is 50 %, for Scenario 2 «Energy generation only» 100 % and for Scenario 3 «Maximum recycling» only 20 %.

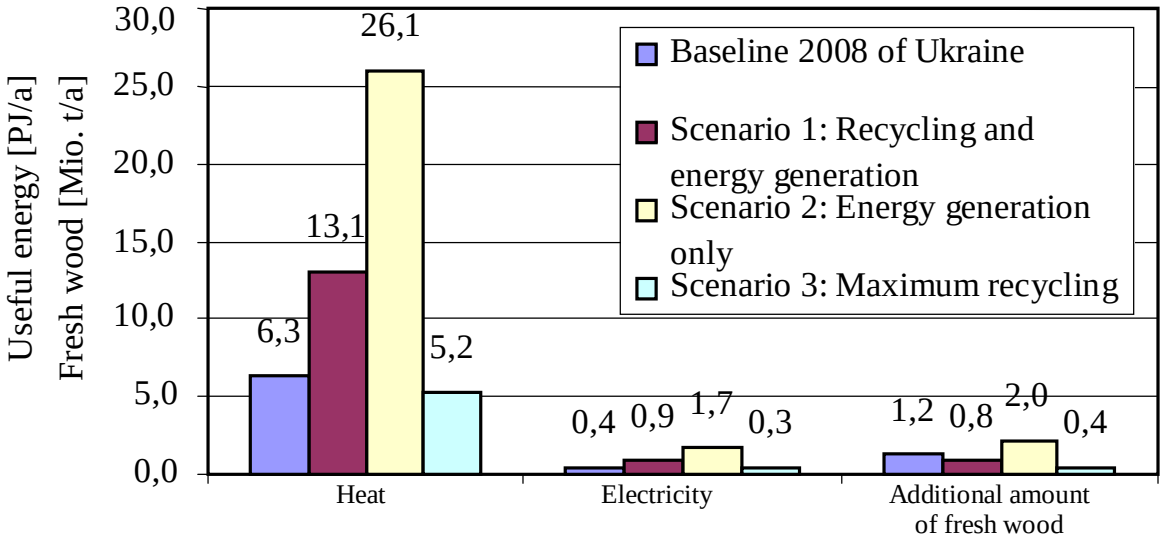

Fig. 3. Useful energy and additional amount of fresh wood in the 3 Scenarios

In fig. 4 the additional amount of fossil fuels needed for energy and for recycling and the additional amount of fresh wood need is shown. Increasing the amount of recovered wood used for energy generation the amount of fossil fuels is reduced and in the same way the additional amount of fresh wood is increased. Scenario 3 «Maximum recycling» has no additional need of fresh wood but the highest need of additional fossil fuels of about 39.4 PJ/a, whereas Scenario 2 «Energy generation only» has the highest need of fresh wood of about 2 Mio. t/a but no additional need of fossil fuels. Scenario 1 «Recycling and energy generation» has an additional demand of about 0.8 Mio. t/a of fresh wood and an additional amount of fossil fuels of about 24.7 PJ/a.

In addition as the emissions of greenhouse gases (focus on CO_2-emisisons) are most relevant for current and future decisions in fig. 5 the CO_2-emissions related to the additional use of fossil fuels and for supplying fresh wood from sustainable forestry are calculated [28]. The total CO_2-emissions decrease significantly by an increasing share of recovered wood used for energy generation and vice versa. The additional amount of CO_2-emissions from providing fresh wood is increasing by an increasing share of recovered wood for energy, but the increase is insignificantly or even negligible compared to the achievable CO_2-reduction from substituting fossil fuels for energy generation. The CO_2-emissions of providing fresh wood of Scenario 2 «Energy generation only» are with 0.087 Mio. t/a the lowest and in Scenario 3 «maximum recycling» with 3.076 Mio. t/a the highest. Assuming that Scenario 1 «Energy generation and recycling» with CO_2-emisisons of 1.854 Mio. t/a is most realistic future situation. Compared to the «Baseline 2008» of Ukraine the increase of the share of recovered wood for recycling would increase the CO_2-emissions of about 0.633 Mio. t/a; whereas with an increasing share of recovered wood for energy generation a maximum CO_2-emission reduction of about 2.443 Mio. t/a might be achieved.

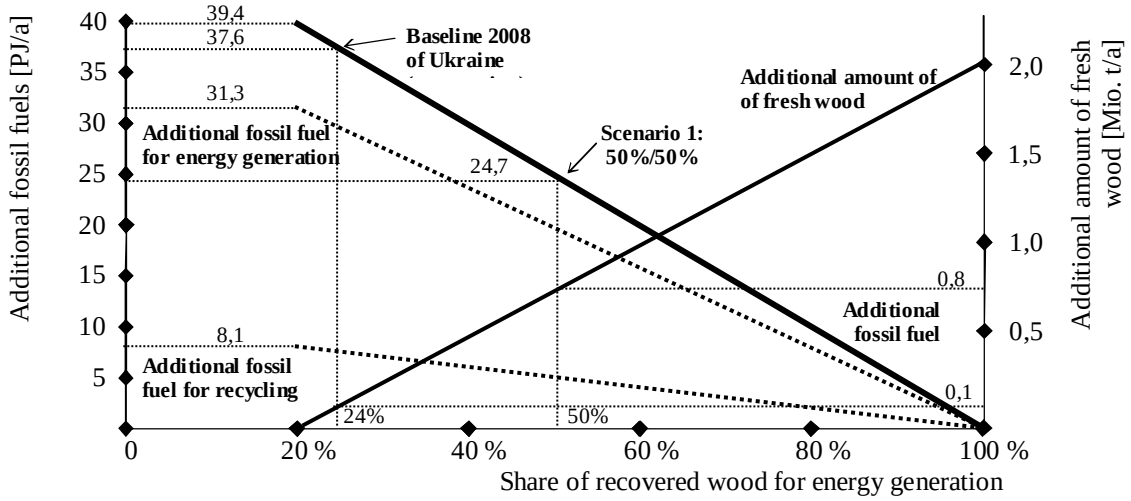

Fig. 4. Additional fossil fuels and amount of fresh wood in relation to the share of recovered wood used for energy generation instead of recycling in Ukraine

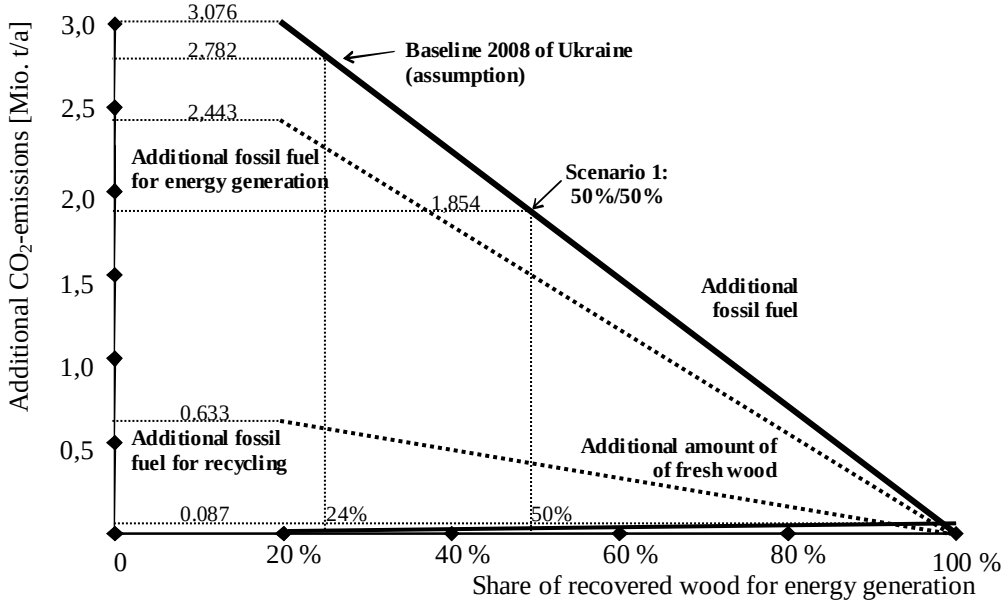

Fig. 5. Additional CO_2-emissions in relation to the share of recovered wood used for energy generation instead of recycling in Ukraine

Conclusions

Recovered wood might be classified according to its special characteristics, mainly described by treated, untreated, contaminated and hazardous fractions, in four different categories:

- category PCW I: «Untreated recovered wood»: wooden packaging material, building and demolition wood wooden bulky rubbish of residential waste fraction;
- category PCW II: «Treated recovered wood»: treated building and demolition wood, wooden bulky rubbish of residential waste fraction;
- category PCW III: «Contaminated recovered wood»: transmission poles, railway sleepers;
- category PCW IV: «Hazardous recovered wood»: piles and poles salt impregnated, chemical treated wood waste (CCA and CCB).

The annual amount of recovered wood in Ukraine is about 3.3 Mio. t/a (potential additional amount, 2008). An increase in future is expected strongly related to economic growth and further market introduction of wooden products.

The amount of Recovered Wood in Ukraine (assumption, 2008) is about 2.9 Mio. t/a which corresponds to about 13 % of the annual round wood consumption of 14.3 Mio. t/a and about 43.5 PJ/a (12,1 TWh/a) or 6.7 % of the current annual primary energy consumption in Ukraine of about 181 TWh in 2008 year. As 46.7 Mio. Inhabitants (2006) are in the Ukraine, there is an annual specific amount of recovered wood of about 62 kg/capita (*additional potential). It is assumed, that about 0.3-0.4 Mio. t/a are CCA treated wood, which are about 10-13 % of the annual amount of recovered wood.

All four groups can be used for energy generation to produce useful energy like heat and electricity in special dedicated combustion plants. For recycling to new wooden products (e.g. wooden based panels) mainly the group 1 and 2 are feasible. Currently in Ukraine the recovered wood is used (Baseline 2008, assumption) for the following management options: 24 % for energy generation, 10 % for recycling and reuse and the rest of 66 % for composting, landfill and unknown options.

These 2.9 Mio. t/a contribute to:

- 15 PJ/a fossil fuel savings because of energy generation;
- 1 Mio. t/a fresh wood savings because of recycling and reuse;
- 1 Mio. t/a CO_2 reduction.

A comparison for different Scenarios for the use of recovered wood for energy generation and recycling is made; in which it is assumed, that each of the Scenarios provides the same amount of useful energy and wooden products. This means for energy generation, if less recovered wood is used an additional amount of fossil fuels is needed. For recycling it means, if less recovered wood is used additional fresh wood from sustainable forest management is needed.

The total CO_2-emissions decrease significantly by an increasing share of recovered wood used for energy generation and vice versa. The additional amount of CO_2-emissions from providing fresh wood is increasing by an increasing share of recovered wood for energy, but the increase is insignificantly or even negligible compared to the achievable CO_2-reduction from substituting fossil fuels for energy generation. The CO_2-emissions of providing fresh wood of Scenario 2 «Energy generation only» are with 0.087 Mio. t/a the lowest and in Scenario 3 «maximum recycling» with 3.076 Mio. t/a the highest. Assuming that Scenario 1 «Energy generation and recycling» with CO_2-emisisons of 1.854 Mio. t/a is most realistic future situation. Compared to the «Baseline 2008» of Ukraine the increase of the share of recovered wood for recycling would increase the CO_2-emissions of about 0.633 Mio. t/a; whereas with an increasing share of recovered wood for energy generation a maximum CO_2-emission reduction of about 2.443 Mio. t/a might be achieved.

Benefits for the Ukraine

The following benefits will be create from this research:

- establish a Ukrainian forum for the management of recovered wood;
- give a comprehensive overview of the different management options for recovered wood;
- give an overview on available data and stimulate new data acquisition on the different Recovered Wood assortments in Ukraine;
- expand the relevant data base;
- provide strategic information for various stakeholders;
- provide information to mobilize additional biomass as a sustainable energy source;
- advance the methodology for environmental, technical and economical evaluation of different Recovered Wood treatment options;
- develop tools for the comparison of different management options for recovered wood;
- initiate possible common proposals to European Community framework programs.

Objectives of Ukraine

The main objective is the improvement of the management of Recovered Wood towards a higher common technical, economic and environmental standard by focusing on the following general items:

- analysis of management approaches for Recovered Wood in Ukraine;
- examine potentials of Recovered Wood as secondary raw material and energy source;
- improvement of databases on technical, economic, environmental and statistical information;
- identify promising approaches for implementation of advanced systems for the management of Recovered Wood.

To advance the management of Recovered Wood significantly on a European level, Ukraine aims to take into account in particular the following specific issues:

- further enhancement of the integration of the management systems for recovered wood;
- examination of the technical potentials of Recovered Wood and wood residues as both secondary raw materials and as energy sources;
- improvement of the quality of the Ukrainian databases on the technical, economical and statistical information for Recovered Wood and its potential;
- analysis of all different managing approaches for Recovered Wood in Ukraine to establish a reliable basis for strategic decisions;
- broadening of the knowledge basis and improvement of assessment procedures to advance the common understanding and to promote the development of appropriate wood recovery systems at the European level to optimize the use of wood resources;
- further development of methodologies including the analysis of different Recovered Wood management systems to achieve an integrated, common description of the Recovered Wood management sector in Ukraine;
- enhancement of the systems for the collection of technical, economic and statistical data concerning the different recovered management systems, and on the quantities and qualities of Recovered Wood;
- improvement of the methods to monitor the implementation of new systems for the management of Recovered Wood to avoid landfilling and through the supply of sustainable energy;
- expansion of the knowledge base on current Recovered Wood management as well as the available qualities and quantities of Recovered wood to support the technical development of further possibilities to use Recovered Wood in (new) materials and products.

Scientific Innovation and Relevance in Ukraine

The scientific innovation and relevance is reflected by the following topics that appear:

- development of new methods including guidelines for the management of Recovered Wood;
- improvement of the methods to evaluate existing and possible new treatment options for wood recovery
- improvement of the methods to generate energy from recovered wood;
- development of a common method for technical, economic and environmental comparison of different Recovered Wood treatment options;
- improvement of the methods to assess the use of Recovered Wood in (new) materials and products;
- investigation of possibilities to increase the use of wood recovered as a secondary material;
- development of methods to improve the data collection concerning the (regional) amount of recovered Wood taking into consideration the different collection systems and treatments applied to wood recovery.

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Потенціал вживаної деревини та шляхи її використання в Україні

Обґрунтовано, що вироби з деревини потрібно проектувати та виготовляти так, щоб у кінці їх життєвого циклу гарантувати ефективне використання для одержання енергії. Це також потрібно робити з метою одержання потенційної сировини для подальшого перероблення з мінімальними технічними затратами і впливом на довкілля. Тому критерії для проектування виробів з деревини, такі як, наприклад, колір або форма, також були б визначальними аспектами для багатократного використання та матеріального перероблення виробів з деревини або їх компонентів. Даний аналіз і наступні дослідження повинні бути направлені у розвиток критеріїв проектування виробів з деревини, які б відповідали економічним вимогам, термінам роботи, функціональним розмірам, багатократному використанню в разі перероблення їх, як вторинної сировини та одержання енергії після завершального використання на матеріальному рівні.

Дано детальний огляд та ґрунтовний аналіз про визначення, потенціал та принципи класифікації вживаної деревини на українському рівні. Крім того, зроблено оцінку властивостей і систему класифікації відходів вживаної деревини, яка узгоджуються з українським Класифікатором відходів. А також наведено детальний огляд про походження та об'єми вживаної деревини, її класифікацію згідно встановленого українського кодування та проблеми, які виникають в Україні у лісохімічній промисловості, зокрема, у просочуванні деревини.

Найважливіші досягнення цих досліджень полягали у таких сферах діяльності: майбутнє управління вживаною деревиною, кількість вживаної деревини, якісні аспекти вживаної деревини, виготовлення енергії, можливі ринки вживаної деревини, викиди газів від вживаної деревини, походження виробів з деревини.

За даним дослідженням одержано наступні розрахункові результати:

- кількість вживаної деревини в Україні (припущення, 2008) складає близько 2,9 млн. т/рік, яка приблизно становить 13 % річного споживання деревини (14,3 млн. т/рік) та 1 % від твердих побутових відходів (1 млрд. т/рік), що рівнозначно одержанню близько 43,5 ПДж/рік (12,1 ТВт/рік) або 6,7 % поточного річного первинного енергоспоживання в Україні, яке у 2008 р. становило 181 ТВт/рік.

- потенційна кількість вживаної деревини на кожного мешканця України з 46,7 млн. чол. (2006) становить близько 62 кг.
- встановлено, що близько 0,3-0,4 млн. т/рік складає забруднена деревина категорії IV, а це близько 10–13 % всієї річної потенційної кількості вживаної деревини.

Встановлено, що всі чотири категорії вживаної деревини можуть бути використані для виготовлення енергії – тепла та електрики, у спеціальних спалювальних заводах. Для перероблення для виготовлення нових виробів (наприклад, ДСП) та подальшого використання придатна вживана деревина 1 та 2 категорій. Сьогодні вживана деревина в Україні за об'ємами 2008 р. (припущення) може використовуватись за такими напрямами: виробництво енергії 24 %; перероблення і багатократне використання – 10 %; решта 66 % – невідомий вибір.

Розраховано, що ці 2,9 млн. т/рік вживаної деревини можуть зробити наступний внесок:

- зберегти 15 ПДж/рік від спалювання кам'яного вугілля для виготовлення енергії;
- зберегти 1 млн. т/рік свіжої деревини завдяки переробленню та багатократному використанню;
- скоротити на 1 млн. т/рік викиди CO_2.

Прийнято, що порівняння різних Сценаріїв з використання вживаної деревини, зроблених для виробництва енергії та перероблення, базуються на такі ж (однаковій) кількості енергії та дерев'яної продукції для кожного із Сценаріїв. Якщо для виробництва енергії використано менше вживаної деревини, то буде задіяна додаткова кількість кам'яного вугілля. А якщо для перероблення буде спожито її також менше, то буде використана додаткова кількість свіжої деревини, яка б підтримала деревообробну промисловість.

Розраховано, що найменше викидів CO_2 одержується тільки тоді, коли вся вживана деревина буде використана для виробництва енергії, а якщо ні, то викиди CO_2 збільшуються. Додаткова кількість викидів CO_2 з'являється (пропорційно зростає), якщо частину вживаної деревини, яка використовується для виробництва енергії, замінювати свіжою деревиною, але це збільшення є малим або навіть незначним порівняно з викидами CO_2, одержаними від спалювання (заміни деревини) кам'яного вугілля для виробництва енергії.

Викиди CO_2 є найменшими для Сценарію 2 (виробництво тільки енергії) і становлять 0,087 млн. т/рік, оскільки залежать від використання свіжої деревини, і є найбільшими для Сценарію 3 (максимальна переробка) – 3,076 млн. т/рік. Можливо припустити, що за паритетних умов Сценарію 1 (50 % виробництво енергії та 50 % переробка) викиди CO_2 будуть становити 1,854 млн. т/рік, як найбільш реалістична картина у майбутньому. У порівнянні з «Базовим 2008 р.» для України збільшення частки вживаної деревини для перероблення викиди CO_2 збільшаться до 0,633 млн. т/рік, тоді як збільшення частки вживаної деревини для виробництва енергії, зумовило б максимальне скорочення викидів CO_2 на 2,443 млн. т/рік.

Вигоди для України

Матеріали даного дослідження можуть бути основою таких вигод:

- запровадження всеукраїнського форуму для управління вживаною деревиною;
- надання всебічного огляду різного вибору управління для вживаної деревини;
- створення короткого огляду за існуючими даними та збирання нової інформації про вживану деревину за різними категоріями;
- створення (розширення) доцільної бази даних;
- забезпечення стратегічною інформацією місця збирання для забезпечення правильного сортування;
- розповсюдження відповідної інформації, яка б допомогла мобілізувати додаткову біомасу, як реальне джерело енергії;
- розповсюдження методології для екологічної, технічної та економічної оцінки вживаної деревини з метою вибору її правильного перероблення;
- розроблення способів та інструментів щодо порівняння різних можливостей вибору управління вживаною деревиною;
- ініціювання створення загальних пропозицій до програми, яка є в структурі Європейського Співтовариства.

Завдання для України

Основне завдання – удосконалення управління вживаною деревиною на всіх рівнях, яке повинно базуватись на загальних технічних, економічних і екологічних стандартах, зосереджуючись на наступних моментах:

- аналіз управління вживаною деревиною;
- розрахунок потенціалу вживаної деревини, як вторинного сировинного матеріалу і джерела енергії;
- удосконалення баз даних про технічну, економічну, екологічну і статистичну інформацію;
- впровадження нових підходів управління вживаною деревиною з врахуванням вже існуючих схем.

Щоб просувати управління вживаною деревиною на високому Європейському рівні, Україна повинна звернути увагу на наступні особливі питання:

- подальше збільшення інтеграції керуючих систем для вживаної деревини;
- експертиза технічного потенціалу вживаної деревини, як вторинного сировинного матеріалу, так і як джерела енергії;
- удосконалення якості українських баз даних про вживану деревину і її потенціалу на основі технічної, економічної і статистичної інформації;
- аналіз всіх різних керівних підходів для вживаної деревини в Україні, щоб встановити надійну основу для стратегічних рішень;
- розширення основних знань і удосконалення процедур оцінки, щоб удосконалювати загальне розуміння та прискорювати розвиток відповідних систем відновлення на Європейському рівні, щоб оптимізувати використання лісових ресурсів;
- подальший розвиток методологій, включаючи аналіз різних систем управління вживаною деревиною, щоб досягти об'єднаної, загальної схеми управління вживаною деревиною в Україні;
- удосконалення системи збору технічних, економічних і статистичних даних про величину та якість вживаної деревини з різних адміністративних систем управління;
- удосконалення методів, щоб контролювати виконання нових систем управління вживаною деревиною, уникаючи звалищ, але роблячи постачання для виробництва енергії;
- розширення бази знань як на теперішньому управлінні вживаною деревиною, так і на доступних якостях і об’ємах вживаної деревини, виходячи із технічних можливостей щодо використання її у нових матеріалах і виробах.

Наукова новизна та доцільність в Україні

Наукова новизна та доцільність повинна відображатись у наступних темах:

- розвиток нових методів, включаючи директиви для управління вживаною деревиною;
- удосконалення методів визначення існуючої кількості і можливо нових способів поводження із вживаною деревиною;
- удосконалення методів щодо одержання енергії із вживаної деревини;
- розвиток загального методу щодо поводження з різною вживаною деревиною для технічного, економічного і екологічного порівняння;
- удосконалення методів оцінки використання вживаної деревини для нових матеріалів і продукції;
- дослідження можливостей збільшення використання вживаної деревини, як вторинного матеріалу;
- розвиток методів удосконалення регіонального збору щодо даних про кількість вживаної деревини для різних систем збору і поводження із вживаною деревиною.

Ключові слова: деревина, вживана деревина, речовини захисту деревини, систематизація вживаної деревини, кодування вживаної деревини, повторне використання, управління відходами, одержання енергії, поводження із відходами з деревини, викиди CO_2.