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WOOD BY-PRODUCTS AND THEIR USE IN POLAND IN A CONTEXT OF THE DIRECT SURVEY OF WOOD PRODUCERS

Abstract. In recent years, environmental protection has been prioritized, including through a rational use of natural raw materials, waste minimization and maximization of waste reuse. It is of great importance especially in the wood sector where by-products, i.e. non-waste post-production residues from consecutive stages of wood processing in the production of wood materials and products, create an additional market for raw and other materials. Nevertheless, the resources and possible uses of by-products have not been fully defined in practical terms. Therefore, this paper presents the results of a survey carried out by the Wood Technology Institute in 2016 to broaden and validate the knowledge of Polish resources of wood by-products, taking into consideration their sources, types, functional properties and uses. The survey was based on 2015 data and targeted 477 wood companies. It revealed that the volumes and shares of by-products generated in the wood industry were highly diverse. In 2015, the largest amount of wood by-products was generated in the process of plywood and window production while the production of wet-process hardboards and dry-process LDFs generated the smallest volumes of by-products. In turn, the production of wet-process porous fiberboards was a zero-waste process in the companies surveyed.

Keywords: wood by-products, sources of wood by-products, types of wood by-products, uses of wood by-products

INTRODUCTION

In Poland, for many years, wood by-products (i.e. post-production products, non-waste residues from consecutive stages of roundwood processing in the production of wood materials and products) have been a source of raw wood material alternative to forests. By-products become especially important during periodical shortages of raw wood materials. Post-production products, such as pieces, sawdust, chips, wood dust and bark, are mainly used onsite by wood producers for both secondary material processing and energy purposes, and are also an important source of renewable energy for the power sector.

Rational management of wood by-products/post-production wood products is of consequence for the industrial, economic and social development. Renewable natural reserves strengthen long-term ecological,

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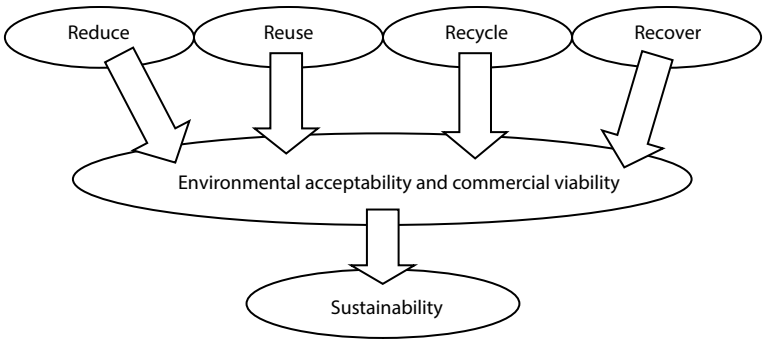

Fig. 1. The concept of "sustainability" based on wood by-products
Source: own elaboration based on Mohanty et al., 2002; Ratajczak et al., 2017.

economic and social balance. Wood by-products create an additional market for raw and other materials, and bring considerable economic and ecological benefits (such as reduction of water, soil and air contamination, and minimization of storage and collection losses). These aspects are conducive to environmental protection and improvement of human life quality – which underpin the idea of sustainable development – and are in line with the new resource consumption approach presented in the circular economy model, i.e. a closed-loop zero-waste economy that assumes waste minimization and making humans less dependent on natural reserves.

Recently, the fact that natural reserves wear thin has become a growing reality, and therefore implementing the concept of cascade use of wood and the 4Rs (Reduce, Reuse, Recycle, Recover) are a major concern for any sector's operation, including the forestry-based sectors (Fig. 1).

The model above presents a situation which, tough simplified and ideal, could be the result of the processing of raw wood material and of related input-output flows (Ratajczak, 2013). During the processing of raw material into wood materials, and then into final goods, wood by-products/post-production wood products are created which are either reused in the technological process or are burnt to recover energy. Specific wood industries/branches generate, and at the same time create demand for, by-product resources. This is an important factor for the direction of flows of wood by-products between industries; note that the flows' intensity is the result of demand and supply created by each industry (Bachorz, 2016; Ratajczak, 2013).

Although the management of wood by-products in Poland may be considered rational and compliant with the concept of cascade use of wood and the 4Rs (the market for wood by-products in Poland has already been studied by various scientific institutions, including the Wood Technology Institute), there is still a deficiency of knowledge on their actual resources and applications. Also, there are not enough methods and research tools which would enable assessing the actual supply of, and current demand for, wood by-products (Cichy and Prądzyński, 1999; Ratajczak and Szostak, 1994; Szostak, 1997; Szostak and Ratajczak, 2003).

This paper presents the results of a 2016 survey carried out by the Wood Technology Institute as a part of research on the market for wood by-products/post-production wood products generated in the Polish wood sector (Szostak et al., 2016). The survey was especially important as a way to verify the underpinning assumptions of models for assessing the potential and usability of wood by-products. Also, it provided an opportunity to deepen and validate the knowledge of their sources, types, functional properties and uses. The survey's aim was to depict the actual condition of wood by-products management in wood companies in 2015.

SURVEY METHODOLOGY

The survey of wood producers was a two-stage procedure. The first stage (preparation) included drawing up the questionnaire and selecting the respondents. The questionnaires contained closed and semi-open single- or multiple-choice questions. Aspects covered by the survey include:

- the amount of wood by-products/post-production wood products generated by wood companies,
- the type and structure of wood by-products/post-production wood products generated during the production process of wood materials and products,
- uses of wood by-products/post-production wood products.

The second stage (execution) included data collection and assessment, analysis of the results and drawing conclusions from the survey. The survey covered operators active in the wood sector, i.e. the sawmilling industry (35.6%), furniture industry (35.6%), pulp and paper industry (wood pulp producers, 0.6%), wood-based panel industry (manufacturers of particleboards, OSBs, wet-process and dry-process fiberboards, plywood, veneers and LVL panels, 9.6%), packaging industry (pallet producers, 6.7%), and builders' carpentry and joinery industry (producers of windows and doors, 11.3%), and outside the wood sector: the chemical industry (manufacturers of matches, 0.6%). The survey was based on 2015 data.

The respondents were not selected randomly (non-probability selection[1]) but purposefully, by taking into consideration the features of relevance for this survey. The main sampling criterion was the type of business run by the respondents. The operators were identified based on the Polish Classification of Activities (PKD, 2007); 477 respondents were selected for the survey (based on "Drzewnictwo"[2] and other databanks), following an additional verification through an Internet search query.

The respondents were e-mailed two reminders. After ca. 3 months from the survey delivery date, the response rate was over 13%.

RESULTS OF THE SURVEY

The survey helped broaden the existing knowledge on sources and types of, and the market for, wood by-products created in the Polish wood sector. Also, it allowed the author to assess the volume of wood by-products/post-production wood products generated in wood industries, and to discover their uses.

Volume and types of wood by-products generated in the wood sector

As revealed by the survey, in 2015, the processing of roundwood into sawnwood generated 37% (on average) of by-products/post-production products (in relation to the sawnwood volume; see Table 1). The by-products were mostly pieces (55%); in turn, sawdust and

Table 1. Wood by-products in wood companies surveyed in 2015

Wood by-products	Percentage
In relation to the amount of raw wood material processed into:	
sawnwood	37
wood pulp	14
In relation to wood materials used for the production of:	
furniture	15
other products* (e.g. flooring materials, laminated elements)	26
In relation to the production volume of:	
wood-based panels:	
plywood	80
veneer	40
MDFs	17
LDFs	2
particleboards	25
hardboards	3
porous boards	0
LVL	15
matches	45
wooden windows and doors:	
windows	69
door leaves	22
frames	17
door leaves with frames	19
pallets	43

*Result of further processing of sawnwood in sawmills.
Source: own elaboration based on survey results.

[1] The condition for using the non-probability selection is the availability of knowledge of the surveyed population. It may be more useful for research purposes than random models. See: Babbie, 2005; Frankfort-Nachmias and Nachmias, 2001; Kaczmarczyk, 1995; Szreder, 2010 and other authors.

[2] "Drzewnictwo" databank stores data on the forestry sector and is kept by the Wood Industry Economics Department of the Wood Technology Institute in Poznań.

chips dominated (47%) at further stages of sawnwood processing into final products (Table 2). In 2015, in the surveyed wood-based panel companies, most wood by-products were generated during the production of plywood (80% in relation to the production volume) and veneers (40%). The production of other panel types was characterized by a relatively low volume of by-products, most of which were post-production products in the form of pieces which accounted for more than 50% of the total production volume in the case of plywood, MDFs, veneer and hardboard production. The main by-products of LVL panels and particleboards were bark and wood dust, respectively.

Table 2. Types of wood by-products generated in the production process of wood materials and products in wood companies surveyed in 2015

Wood materials and products	Type of wood by-products			
	pieces	sawdust and chips	wood dust	bark
	%			
Sawnwood	55	37	0	8
Final products (of sawnwood processing)	42	47	2	9
Wood-based panels:				
plywood:				
during roundwood processing	66	11	–	23
at further stages of the technological process	69	28	3	–
veneer	70	10	5	15
MDFs	53	–	30	17
particleboards	21	–	79	–
hardboards	100	–	–	–
LVL	30	–	10	60
Matches	73	7	0	20
Wood pulp	–	14	–	86
Wooden windows and doors:				
windows	48	24	28	–
door leaves	48	24	28	–
frames	48	24	28	–
door leaves with frames	51	32	17	–
Pallets:				
during roundwood processing	43	44	–	13
at further stages of the technological process	53	47	–	–
Furniture:				
waste from solid elements	53	35	12	–
waste from elements of wood-based panels	67	17	16	–

Source: own elaboration based on survey results.

According to respondents, in 2015, the percentage of wood by-products in wood pulp production was 14% (in relation to the amount of raw material processed), of which 86% was bark, and 14% sawdust and chips. On the other hand, as regards the production of matches, by-products accounted for 45%, of which 73% were pieces, 20% was bark, and 7% were sawdust and chips.

In this survey, the manufacturers of wooden windows and doors responded that the largest amount of wood by-products was generated during the production of windows (69% in relation to the production volume), whereas door production generated smaller amounts of by-products, accounting for 22% (doors without frames) or 19% (doors with frames). In this industry, pieces were the dominant form (accounting for almost 50% of the total volume) of wood by-products.

According to the survey, in 2015, the average ratio of wood by-products created by pallet producers was 43% (in relation to the pallet production volume); note that ¾ of the wood by-product volume was created during roundwood processing into sawnwood. When it comes to pallet production, most by-products were pieces and sawdust and chips, with some small amounts of bark.

In 2015, the ratio of wood by-products generated by the furniture industry was ca. 15% in relation to wood materials used for furniture production. The responses suggested that almost 2/3 of by-products were generated during the processing of wood-based panel elements. Furniture production is mostly responsible for by-products in the form of pieces (53% of the total amount of solid elements and 67% of the total amount of wood-based panel elements), sawdust (35% and 17%, respectively) and wood dust (12% and 16%, respectively).

Management of wood by-products generated in the wood sector

The results of the survey suggested that in 2015, 62% of by-products generated in the wood sector were intended to be used onsite and 38% were intended for sale (Fig. 2). In both cases, by-products were intended primarily for energy purposes (57% and 90%, respectively).

According to the survey, in 2015, sawnwood producers used ¼ of wood by-products/post-production wood products for their own purposes, and sold the remaining three quarters (Table 3). They declared that by-products in the form of pieces (88% of the by-product volume intended for the company's own production purposes) were the main by-products used for direct material processing (17% of by-products used onsite) while sawdust and chips (78% of the volume of by-products intended for onsite energy use) were the primary materials used for the company's own energy purposes (83% of by-products used for the company's own purposes). 53% of marketable by-products generated in the sawmilling industry were by-products used for energy purposes (sawdust and chips prevailed in this group, with a share of 52%) while 45% of by-products sold were intended for production purposes (65% of them were by-products in the

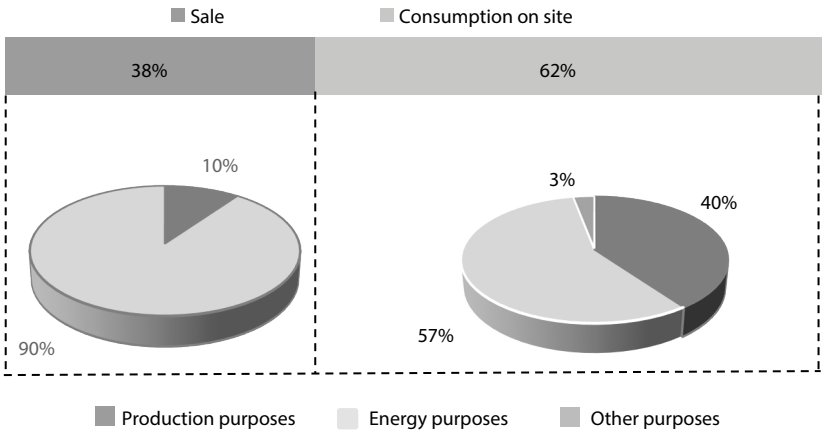

Fig. 2. Management of wood by-products generated in wood companies surveyed in 2015
Source: based on survey results.

Table 3. Uses of wood by-products generated in wood companies surveyed in 2015 (%)

Wood materials and products	Wood by-products used for:						
	onsite use			sale			
	total	production	energy	total	production	energy	other1
Sawnwood	27	17	83	73	45	53	2
Wood-based panels	60	3	97	40	58	37	5
Wood pulp	100	0	100	0	0	0	0
Matches	100	0	100	0	0	0	0
Wooden windows and doors	49	0	100	51	7	93	0
Pallets	49	38	62	51	58	40	2
Furniture	48	13	87	52	31	61	8

[1]E.g.: agriculture, horticulture, tanning, wooden accessories etc.
Source: based on survey results.

form of pieces). The share of by-products intended for other purposes (e.g. agriculture or horticulture) was 2%.

The group of consumers of by-products sold for energy purposes was dominated by individual consumers (52%; e.g. households), while corporate customers accounted for 48% (e.g. schools, hospitals, field boiler houses, CHP plants) (Fig. 3).

According to respondents, wood by-products generated in the wood-based panel industry in 2015 were primarily used for their companies' own purposes (60% of the total amount of wood by-products in the wood-based panel industry), mostly for energy purposes (97%, including 43% of by-products in the form of pieces). The ratio of by-products sold by the respondents was

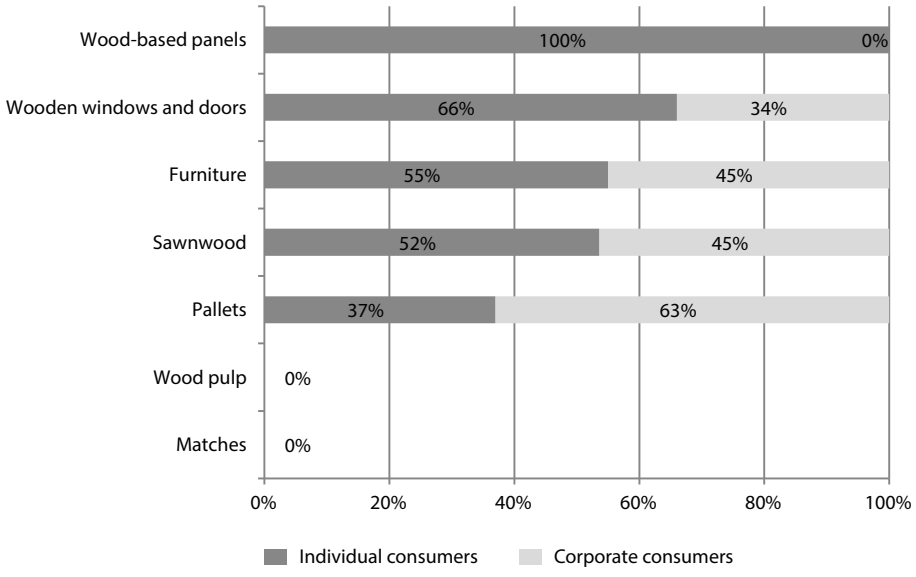

Fig. 3. Shares of consumers of wood by-products sold for energy purposes and generated in wood companies surveyed in 2015
Source: own elaboration based on the survey results.

approximately 40%, of which 58% was intended for production purposes. Those were mainly by-products in the form of pieces (60% of by-products sold for production purposes) and wood dust (33%). Also, 37% of by-products sold were intended for energy purposes (mostly by-products in the form of pieces and bark, with a share of 69% and 31%, respectively). Wood-based panel by-products sold for energy purposes were purchased by individual consumers only.

According to the survey, wood pulp and match manufacturers used their own by-products/post-production products solely for their own energy purposes. In the case of wood pulp producers, 85% of those by-products were bark; in the case of match producers, 73% were by-products in the form of pieces.

Wooden window and door manufacturers covered by this study used wood by-products generated in 2015 primarily for energy purposes: 100% of the volume used onsite (49% of the total amount of wood by-products) and 93% of the volume sold (51%). For their own energy purposes, the companies mostly used sawdust and chips (65%). By-products sold for energy purposes were those in the form of pieces (48%) and sawdust and chips (44%). According to respondents, 66% of window and door by-products sold for energy purposes were purchased by individual consumers, and 34% by corporate consumers.

On the other hand, pallet producers surveyed declared that in 2015 by-products generated during pallet production were used for their companies' own purposes (49% of the total volume) or sold (51%). If used for the company's own purposes, by-products were mainly used for energy purposes (62%) as sawdust and chips (67%). Marketed wood by-products were primarily intended for production purposes (58%) and were sold in the form of pieces (55%) or as sawdust and chips (45%). By-products sold for energy purposes (40%), mainly in the form of sawdust and chips (78%), were primarily purchased by corporate customers (63%).

According to the survey, wood by-products generated in furniture companies in 2015 were sold (52% of the total volume) or used for the company's own purposes (48%). In both cases, energy purposes prevailed; 87% of by-products used for the company's own energy purposes were used onsite; 61% of by-products sold were used for energy purposes. The materials were mostly wood by-products in the form of pieces or sawdust and chips (ca. 40% each). By-products intended for energy purposes were sold to individual consumers (55%) and corporate customers (45%).

CONCLUSIONS

Having in mind the lack of complete, consistent and reliable data on the market for by-products/post-production products generated in the Polish wood sector, the survey contributed to narrowing that cognitive gap, and to broadening and validating the knowledge on the sources, types and uses of by-products concerned.

The generation of wood by-products is closely connected to the production process of wood materials and products; however, quantities of by-products generated largely vary from one wood industry to another. In 2015, the following was reported by the companies surveyed:

- the largest quantities of by-products resulted from the production of windows (69% in relation to the production volume), plywood (80%), and veneers (40%),
- the smallest quantities of by-products resulted from the production of dry-process LDFs (2% in relation to the production volume) and wet-process hardboards (3%),
- the production of wet-process porous fiberboards was a zero-waste process.

According to the survey, in 2015, wood by-products generated in the Polish wood sector were mostly by-products in the form of pieces; this type of by-products accounted for more than 50% of all types of by-products generated. Sawdust and chips were also important, with a share ranging from 7% (production of matches) to 47% of the total volume of by-products generated (production of final products in the sawmilling industry, and production of pallets). On the other hand, wood dust amounted to a significant percentage of by-products generated in the production of particleboards (79%) while bark was an important by-product in the production of wood pulp (86%) and LVL panels (60%).

Wood by-products were mainly used onsite. In 2015, the companies surveyed used 62% of by-products for their own purposes (38% was sold). Whether used onsite or sold, by-products were primarily used for energy purposes (57% and 90%, respectively).

The survey revealed that wood by-products in the form of pieces were mainly used for own production purposes while sawdust and chips were primarily used for own energy purposes. According to respondents,

as much as 100% of wood by-products in the form of pieces was used onsite for secondary material processing (production of furniture and wood-based panels); up to 78% of sawdust and chips were used for energy purposes (sawnwood producers).

The respondents indicated that wood by-products in the form of pieces were mainly sold for production and energy purposes. The respondents sold primarily wood by-products in the form of pieces or as sawdust and chips. In 2015, producers of wooden windows and doors sold 100% of their total by-product volume for material processing. For furniture manufacturers, that ratio was 78%. The highest percentage of wood by-products in the form of pieces sold for energy purposes originated from the production of wood-based panels (69%). In turn, the highest percentage of sawdust and chips sold for that purpose originated from pallet production (78%).

As revealed by the survey, the demand for wood by-products from individual consumers (households) was relatively higher. In 2015, wood-based panel producers and wooden windows and doors producers sold the largest amount of by-products to consumers (100% and 66%, respectively). In turn, corporate customers (hospitals, schools, CHP plants etc.) purchased a share ranging from 34% to 63% of by-products sold. In this case, by-products were supplied primarily by pallet producers (63% of by-products sold by those producers) and sawnwood manufacturers (48%).

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DRZEWNE PRODUKTY UBOCZNE I ICH ZAGOSPODAROWANIE W POLSCE – W ŚWIETLE BADANIA BEZPOŚREDNIEGO PRODUCENTÓW DRZEWNYCH

Abstrakt. W ostatnich latach priorytetem staje się ochrona środowiska naturalnego, w tym racjonalne wykorzystanie surowców naturalnych, minimalizacja powstających odpadów i maksymalizacja ich wtórnego zagospodarowania. Ma to duże znaczenie zwłaszcza w sektorze drzewnym, gdzie produkty uboczne, tj. pozostałości poprodukcyjne (niebędące odpadami) z kolejnych faz przerobu drewna w procesie produkcji materiałów i wyrobów drzewnych, kreują dodatkowy rynek surowcowo-materiałowy. Jednak w praktyce ich zasoby oraz kierunki zagospodarowania nie są nadal w pełni określone. W artykule przedstawiono wyniki badania ankietowego, przeprowadzonego w Instytucie Technologii Drewna w 2016 roku, którego celem było poszerzenie i zweryfikowanie wiedzy o zasobach drzewnych produktów ubocznych w Polsce, z uwzględnieniem miejsc ich powstawania, rodzajów i cech użytkowych oraz kierunków zagospodarowania. Badanie dotyczyło 2015 roku i skierowane było do 477 firm z sektora drzewnego. Wykazało, że wolumen i struktura produktów ubocznych powstających w branżach drzewnych były bardzo zróżnicowane. W 2015 roku najwięcej powstało ich przy produkcji sklejki oraz okien. Najmniej – w produkcji płyt pilśniowych mokroformowanych twardych i suchoformowanych LDF. Natomiast w badanych firmach produkcja płyt pilśniowych mokroformowanych porowatych była bezodpadowa.

Słowa kluczowe: drzewne produkty uboczne, miejsca powstawania drzewnych produktów ubocznych, rodzaje drzewnych produktów ubocznych, kierunki zagospodarowania drzewnych produktów ubocznych