WOOD BIOMASS IN SUPPLY CHAIN – EVIDENCE FROM THE FGI STUDIES

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Abstract

Wood is a versatile raw material that can be used in many different ways – from paper and packaging to construction. In addition, wood products can be reused and recycled when their original use becomes obsolete. An important renewable resource is wood biomass, which is mostly derived from forest residues, wood processing residues or construction and municipal waste. These materials can be processed and reused, providing a more environmentally friendly alternative. Although recovery rates are relatively low, environmental awareness is increasing. Companies are investing in optimising technological and logistical processes, while at the same time reducing their environmental impact. These efforts can reduce a company's costs and also reduce environmental waste.

The aim of this paper is to characterise residual wood biomass, its forms, sources and uses, and to identify reverse supply chain and their main challenges.

For the needs of the paper, research was conducted using Focus Group Interviews (FGIs). We carried out three direct structured group interviews using questionnaires with managers from companies dealing with residual wood biomass.

Keywords: biomass, wood, residual wood, reverse supply chain, focus group interview

1. INTRODUCTION

Wood is a universal and renewable resource. It comes from trees that can be grown and replaced by new cuttings. It is known for its strength and durability. Properly processed and maintained, wood can last for many years, making it not only environmentally valuable but also economically viable (Moncada et al. 2016).

Wood has a wide range of applications. It can be used to make furniture, building structures, flooring, doors, windows, paper, packaging and many other products. Its versatility makes it an indispensable raw material in many areas of life (Srinivas & Pandey, 2017; Falk, 2019).

It is a renewable resource, so it can be used without running out of natural resources. However, this does not mean that it is not worth seeking its reuse. Its wise use can contribute to sustainability and environmental goals. Particularly relevant here is residual wood biomass (Nunes et al., 2023).

One of the most important reused wood resources is biomass, which is mostly derived from forest residues, wood processing residues or construction and municipal waste. The biomass materials can be processed and reused, providing an environmentally friendly solution (Daian & Ozarska, 2019; Kawa, 2023).

All waste wood can be recycled therefore the same tree can be used in many different ways (Wang et al., 2016). For example, if one makes a beam out of a tree that's being replaced over time, you can get it back and turn it into wooden cutlery, which, when it's recycled back, can be used later as a base for conifers or gardening tools. However, recovery rates for wood biomass are still relatively low, indicating that there is room for improvement. Nevertheless, there is a growing recognition of the importance of environmental sustainability.

Wood biomass is derived from the organic material found in wood, including trees, branches, bark, sawdust, wood chips, etc. It comes from a variety of sources, including forest residues, wood processing by-products and construction and demolition waste. It offers a solution to the disposal of wood waste, such as forest residues and wood processing. Instead of allowing these materials to decompose or contribute to landfill waste, they can be used as a valuable resource for energy production. It is a renewable energy resource that can be used for a variety of purposes, including the production of heat and electricity (Evans et al., 2010). It is valued as a sustainable alternative to fossil fuels because of its ability to reduce greenhouse gas emissions and promote environmentally friendly use of natural resources (Ciesielczuk, 2016).

Residual wood biomass, like wood and wood-related products, is subject to numerous technological and logistical processes (Rentizelas et al., 2009). We are dealing with a supply chain that is referred to as a reverse supply chain because of the reverse direction of the residual biomass flow (Prahinski & Kocabasoglu, 2006). There are many challenges associated with this, as biomass requires special storage and transport conditions (Burnard et al. 2015; Allen et al. 1998; Tatsiopoulos & Tolis 2003). It is of relatively low value, so processes need to be well planned and efficiently executed.

To date, the reverse supply chain of residual wood biomass is little recognised, particularly on the empirical side. There are many theoretical works and with mathematical models. Practical knowledge is therefore lacking. In particular, there is a lack of answers to the questions:

- For what purpose is residual biomass used (other than for energy purposes)?
- How is the reverse supply chain of residual wood biomass understood?

- What are the key processes and actors in the reverse supply chain of residual wood biomass?
- What are the problems and opportunities in the reverse supply chain of residual wood biomass?

The primary objective of this paper is to provide an in-depth characterization of residual wood biomass, encompassing its various forms, origins, utilization, and the exploration of challenges within the reverse supply chain associated with it.

To fulfil the objectives of this study, we employed focus group interviews as our research approach. We conducted three separate groups interviews, employing a research scenario, with managers representing companies engaged in the management of residual wood biomass.

2. EMPIRICAL RESEARCH PROCESS

In this article we present the results, which are part of a multi-stage research procedure. In the initial stage of the study, we relied on a literature review. Here, we present the results of a group interview. This stage was qualitative in nature and served as a tool for exploring the research area.

Participants for the study were selected in a purposive way. A prerequisite for taking part in the interview was experience of the wood industry, particularly biomass. Persons working in companies: related to the wood industry, sawmills or involved in handling and recycling were selected. Care was therefore taken to ensure representation of the various actors in the wood industry supply chain. Entities that can be described as typical were selected for the research sample. An attempt was made to differentiate the group in terms of gender, age and positions held. Taking into account the recommendations for the number of participants in a focus group interview (Rabiee, 2004; Krueger & Casey, 2000), the sample size was set at 6 people (additionally, 1 person was always a reserve in case of the absence of another person from the planned group). The structure of the sample in terms of gender, age, position and company focus is shown in Table 1.

Table 1 Characteristics of the study sample

No.	Position	Subject of activity	Age	Gender
Date of interview: 05.07.2022				
1	Manager	Manufacture of scantlings, angle beams, slats, quarter rounds	42	F
2	Assistant manager at a sawmill	Sawmill	36	M
3	Specialist technologist	Sawmill	n.a.	M
4	Junior manager	Sawmill	n.a.	M
5	Senior contractor contact person	Wood processing plant	46	F

No.	Position	Subject of activity	Age	Gender
Date of interview: 05.07.2022				
6	Owner	Production of wooden structures and timber houses	n.a.	M
Date of interview: 06.07.2022				
1	Assistant manager	Structural timber production	n.a.	F
2	Quality control of finished goods	Garden architecture and pellet production	n.a.	F
3	Logistics specialist	Sawmill	32	F
4	Production line assistant manager	Sawmill	46	M
5	Assistant sawmill manager	Sawmill	34	M
6	Manager	Production of wooden structures, elements and houses	41	M
Date of interview: 07.07.2022				
1	Assistant manager for logistics and transport	Production of wooden packaging	26	F
2	Assistant Sawmill Manager	Sawmill	25	M
3	Assistant sawmill manager	Sawmill	26	M
4	Customer service advisor	Production of chairs and frames	25	F
5	n.a.	Processing and production of pellets	35	M
6	Assistant manager	Sawmill	n.a.	M

Source: own studies

A total of three FGIs were scheduled. They were originally planned to take place in different cities, but due to the holiday season and the prevalence of conducting surveys remotely during the pandemic (Willemsen, 2022), interviews were organised on different dates (4,5 and 6 June 2022) with different respondents in an online version. Online FGIs have many advantages, e.g. no need to travel to the interview site, which increases elasticity and reduces travel costs, no need to rent a room and no need for recording equipment. The disadvantages, however, are less interaction between survey participants and fewer opportunities to observe responses.

Interviews were organised by an independent research agency that specialises in carrying out a variety of both qualitative and quantitative research on behalf of companies and academic institutions. They were conducted by a professional moderator.

The research took place on the basis of the research scenario, which was prepared by the research team and submitted to the research agency. The scenario was developed on the basis of literature studies and the experience of the researchers.

The interview took the form of a discussion in which the moderator gave tasks and posed questions according to a set scenario and the participants expressed their opinions on the topics that were covered (Dilshad & Latif, 2013). If there were doubts in the group about the content of the questions, the moderator helped to clarify the context or clarify concepts by giving examples.

The moderator was given the following guidelines before the study began:

- encourage respondents to be active by stressing the importance of the results of this study, their relevance in the context of ongoing research. If the discussion slows down or drifts into other topics, the moderator stimulates the group by asking additional questions and seeing if participants have anything to add that is worth including.
- encourage respondents to express their feelings and opinions – especially if they are evasive (e.g., claiming ignorance or theorising)
- ensure that all respondents have an opportunity to express themselves, and stress that each opinion is important,
- reassure them that the researchers are interested in hearing different voices and exploring different views – especially if confrontational interactions arise between respondents.

The process of the interviews was documented by means of audio and video recording. The participants' statements were then transcribed on the basis of the recordings. The first analysis of these transcripts made it possible to conclude that the study managed to avoid unfavourable phenomena such as spontaneous conversations between participants (both on topics related and unrelated to the topic of the study), overactivity or complete inactivity of some participants (Olejnik et al., 2022).

The interview consisted of three main parts: an introduction (including participants presenting themselves), a main part (containing tasks and questions – as shown in Table 2), and a conclusion (summarising and thanking participants for participating in the discussion).

At the beginning of each interview, the moderator presented the name of the research project, its purpose and for which institution the study is being conducted and by whom it is funded. She then informed the research participants that they were participating in a focus group interview. She also presented the main principles of this type of research and encouraged participants to express their opinions. She informed the participants about the recording of the study and assured them that the study is confidential. The empirical material collected will be subjected to qualitative analysis excluding the possibility of identifying respondents. The meeting was scheduled to last up to 120 minutes.

The moderator then asked the respondents to briefly introduce themselves, in particular to give their first names, which were needed for their efficient identification during the survey. Once this procedure was completed, the moderator moved on to the first stage of the survey.

The main part of the study was composed using 16 tasks. Some of these tasks were performed individually to encourage each participant's active participation. At the same time, other tasks were carried out by the whole group of participants in order to achieve synergy. All questions were open-ended, giving participants the freedom to express their opinions. In cases where the answers were insufficient from the point

of view of the research being conducted, the moderator provided additional clarifications and questions to elicit more detailed information.

The tasks in the core part of the study were divided into 2 groups: sources and uses of residual wood biomass and reverse supply chain.

Before the moderator asked the first question, she did a warm-up exercise. She asked the respondents to write on their own sheets the associations connected with the keyword "residual biomass" and "residual wood biomass".

The first group of tasks (tasks 5-8) covered '"forms and sources of residual wood biomass", "use of residual biomass", and "use of residual wood biomass". The second group (tasks 9-16) dealt with supply chain, in particular associations with the keyword "reverse supply chain" and the identification of processes, actors, problems and opportunities related to it.

Table 2 Focus group interview scenario

No.	Task	Content of the task presented to respondents	Task type
1.	Associations with the keyword "residual biomass"	Moderator says the words "residual biomass" and asks the respondents to write on their own sheets the associations connected with this keyword.	Individual task
2.	Associations with the keyword "residual biomass"	Moderator asks: • Can the answers be grouped in some way? • Why did you group the associations in such a way? • According to what criteria?	Group task
3.	Associations with the keyword "residual wood biomass"	Moderator says the words "residual wood biomass" and asks the respondents to write on their own sheets the associations connected with this word.	Individual task
4.	Associations with the keyword "residual wood biomass"	Moderator asks: • Can they be grouped in any way? • Why did you group the associations this way? • According to what criteria?	Group task
5.	Forms and sources of residual wood biomass	Moderator asks to write on their own sheets what "forms and sources of residual wood biomass" respondents know.	Individual task
6.	Use of residual biomass	Moderator asks respondents to write on their own sheets what residual biomass are used for (in general, regardless of the source).	Individual task

No.	Task	Content of the task presented to respondents	Task type
7.	Use of residual wood biomass	Moderator asks respondents to think about how and what residual wood biomass are used for.	Individual task
8.	Use of residual wood biomass	Moderator asks respondents if the uses of woody biomass can be categorized. Moderator asks respondents if industries, products, technologies, etc. can be assigned to these uses of woody biomass residues.	Group task
9.	Associations with the keyword "reverse supply chain"	Moderator says the words "Reverse Supply Chain" and asks the respondents to write on their own sheets the associations connected with this word. Why these associations?	Individual task
10.	Associations with the keyword "reverse supply chain"	Moderator asks: • Can they be grouped in some way? • Why did you group these associations in such a way? • According to which criteria?	Group task
11.	Reverse supply chain processes	Moderator asks respondents to consider what reverse supply chain processes are and to write on their own sheets their associations.	Individual task
12.	Reverse supply chain processes	Moderator asks the respondents to identify the most important and the most difficult processes. Moderator asks respondents to indicate the criterion for selecting the most relevant and most difficult processes.	Group task
13.	Actors in the reverse supply chain of residual wood biomass	Moderator asks the respondents to give actors in the reverse supply chain of residual wood biomass.	Individual task
14.	Actors in the reverse supply chain of residual wood biomass	Moderator asks the respondents to indicate the criterion for grouping the entities.	Group task
15.	Problems and opportunities in the reverse supply chain of residual wood biomass	Moderator asks respondents to write on the sheets what problems/challenges and opportunities/possibilities are related to residual wood biomass	Individual task

No.	Task	Content of the task presented to respondents	Task type
16.	Problems and opportunities in the reverse supply chain of residual wood biomass	The moderator encourages the respondents to rank the identified problems and opportunities according to their importance/significance.	Group task

Source: own studies

The audio-visual recordings made during the study were the basis for creating the transcription. The process of creating the transcription started with the person responsible for recording the interview, who prepared a first version of it. The transcription was then reviewed by the moderator to verify its accuracy. Appropriate corrections were made where necessary. After these corrections, the transcriptions were handed over to the research team.

The transcriptions were analysed using an inductive approach, following a commonly used method in qualitative research (Thomas, 2003). The analysis process involved reading the transcriptions multiple times and partial coding, which involved assigning short words or phrases to describe specific features of the utterances. After careful analysis of the transcriptions, a set of codes was established based on the content of the utterances and the features found in the literature. The codes were grouped according to different categories, such as the sources of wood biomass and the types of actors in the reverse supply chain identified in the participants' statements.

3. RESULTS

As mentioned, the moderator did a warm-up at the beginning, asking respondents to make associations with the terms “residual biomass” and “residual wood biomass” respectively. Respondents gave a lot of keywords associated with these terms. These were spontaneous responses, so they were often linked to other categories. Associations were often connected to experience and place of work. Below are a few sample statements:

“In my case, it is mainly sawdust, woodchips, such waste materials. Then there's bark, conifer needles and sometimes roots from cuttings. In addition, demolition wood also comes to us, used pallets or contaminated waste. Grass can also be a biomass material, but that's not exactly in my line of work”.

“The 'bio' itself indicates that it is something that should be organic and decompose on its own in nature”.

“If we have to prepare boards to size, there is waste left over that is irregularly shaped. In addition to this, shredded wood, sawdust, offcuts that remain after wood processing”.

"I would add leftover food, as one collects, anything that can ferment. Semi-finished products from animals, from vegetables, from fruit, anything that even causes fermentation and causes gases, creating".

"My associations with this term are: shavings, bark, leaves, straw, low-quality cereals, oilseed cake, animal excrement, municipal waste".

"Briquettes, sawdust, shavings, chips, worked pieces, larger pieces, such remnants which were not suitable for production, beams or similar things, frames from dismantling of windows for example".

The moderator then asked for the responses to be grouped together. This task resulted in the categories shown in Table 3.

In this task, respondents gave a lot of associations related to wood, which they were asked about in the next question. In order to avoid repetition of wood-related answers, only those associations related to „residual wood biomass" are shown in Table 4.

Table 3 Categories and examples of residual biomass

Categories	**Energy**	**Waste**	**Agriculture**	**Food**
Examples	- renewable energy - heat sources - biofuel - biogas production - biodegradation - biology - fermentation and gas formation	- recycling - municipal waste - industrial waste - post-production residues - scrap material	- low-quality cereals - manure - straw - animal excrement - hay - grass - agricultural waste - pomace from oilseed crops	- products from vegetables, fruits - food scraps - potato peelings

Source: own studies

Table 4 Categories and examples of residual wood biomass

Categories	**Wood**	**Reuse**	**Demolition wood**	**Others**
Examples	- sawdust - shavings - bark - woodchips - pieces of wood after processing	- energy source - disposal - recycling - briquette - pellet	- used pallets - doors - old rafters - furniture - windows frames - railroad sleepers	- cellulose - paper - resin - lignin - mulch

	- wood chunks - branches of trees - needles - roots - litter waste - offcuts - shredded wood - leaves - branches - shrubs - brushwood		- old roof trusses - floors - demolition wood	

Source: own studies

The next task was to provide grouping criteria. Respondents grouped biomass according to the following categories:

- by origin: animal and vegetable,
- due to waste: dry and wet,
- due to use: industry and agriculture.

For woody biomass, respondents grouped it according to the following categories:

- in terms of calorific value,
- in terms of moisture content of components,
- in terms of conversion to energy,
- in terms of reuse in another form – recycling,
- in terms of processing – form, solid, gas, liquid,
- due to the purpose – returns to the environment e.g., bark and new products are created,
- due to form-permanent, e.g., OSB (oriented strand board) and non-permanent e.g., energy from combustion.

In the next task, respondents were asked by the moderator to identify "forms and sources of residual wood biomass". In this case, the respondents mostly gave quite similar associations as in the previous tasks. In the case of forms of woody biomass, however, this can be summarised as follows:

- shavings,
- woodchips,
- sawdust,
- shavings,
- branches,
- boughs,
- brushwood,
- needles,

- leaves,
- roots/root systems,
- cellulose,
- tree trunks,
- bark.

Moreover, respondents identified the following sources of woody biomass residues:

- tree cutting: forests, orchards,
- sawmills,
- farms – tree pruning, e.g., during reforestation program,
- secondary market: furniture factories, municipal plants (bulky waste), city cleaning plants, pallet processing, demolition of wooden buildings, doors, windows, floors, railroad sleepers.

The last task in this group concerned the purpose of biomass residues. Respondents most often mentioned energy production as the purpose of biomass residues. The following are examples of statements: "Production of fuels for firing in cookers, such as pellets", "Biomass for energy production, as biocarbon for example, bio-oil".

Examples of using biomass to produce building products and paper were often given: "All kinds of boards, some kind of particle board, fibre board, composite boards, decking boards, OSB, in the form of some kind of underlay or soffits".

Other examples include: "For animal husbandry, i.e. those mulches or production of litter for cats, dogs, rabbits, etc."; "Various kinds of bedding, underlay just for flowers, if someone has rabbits or guinea pigs"; “There are more and more attempts to use cheaper resin glue production. I think in Germany they are making T-shirts out of plastic parts and there are also attempts to use textile parts out of wood".

There was also an interesting theme related to the use of waste biomass in art: "As decorative wood and for the renovation of buildings", "using wood as an art form"; "Certainly folk artists make some artwork out of roots," he said. "From such a bigger root you can make a table or some kind of chair, armchair, whatever".

Another area is cosmetics and herbalism: "For example, an oak bark-scented soap". "Pharmacies that specialise more in herbal medicine or something like that, that's where you can often buy just oak bark for infusions too";

Respondents' statements can be organised into the following categories:

- energy production – pellets, biocarbon, bio-oil;
- recycling – production of osb, pallets, particleboard, fiberboard, composite boards, decking;
- pharmaceutical industry – oak bark for infusions, birch bark for soaks;
- chemical industry – industrial alcohols (ethanol), varnishes, impregnants, resin adhesive production;
- construction – wooden nails, carpenter's pegs, for insulating buildings (processed products similar to styrofoam);
- pulp industry – paper;
- food industry – smoking chips, for smoking various meats, ice cream sticks, toothpicks, trays, cups, cutlery, bowls.
- agriculture – for fertilizer, compost, animal bedding;

- horticulture – bark, mulch, garden chips dyed in various colors for gardens;
- landscaping – roots, sculptures, lamp fragments;
- zoology – bedding for hamsters, rabbits, guinea pigs, for terrariums;
- floristry – flower bases, flower compositions;
- tourism – for marking trails;
- automotive industry – dashboards in cars;
- clothing industry – clothes and shoes from wood residues.

As before in this task, respondents gave a lot of associations related to wood, which they were asked about in the next task. For this reason, statements from the next task will be omitted.

In the second group of tasks, the respondents were asked by the moderator to indicate associations with the keyword "reverse supply chain". Most respondents do not deal with logistics on a daily basis, so it is interesting to see how the respondents understood the term reverse supply chain. Intuitively, the respondents understand the term quite well: "In our case it looks like this: there is an order, a salesman is responsible for it, then there is a customer like a wholesaler, then some manufacturer who receives the products and produces a product, for example, a piece of furniture, and then the customer should get it. At this stage, there may be some quality problem, resulting, for example, from the fact that we produced a bad quality board. Then the product comes back to us – such a reversal occurs - and we have to think about whether to dispose of it or recycle it and make the right product again".

Some respondents pointed to the changing role of the actor in the supply chain: "This is the change from seller to buyer". „Selling in a direction other than what is established"; "As a customer, I buy wood which I then process into furniture. A by-product of this processing is, for example, offcuts and chips. I can collect this residue and sell it, for example, to a wood supplier, who can then turn the chips into pellets for heating".

Other respondents pointed to a change in process: "Re-using something that has already been used once, to go back to the first process"; "For example a furniture company sells chips to another company that produces particle board, and each of these companies produces something from wood and processes it."; "For example, a customer who orders something may in the meantime be a supplier to that person from whom he ordered it. He or she has some waste or unnecessary stuff that he or she can pass it back to that supplier to use for his or her needs"; "This can be called recycling of wood material, returning these wood chips to be milled again and again to create wood panels, or just turning some waste that will not be suitable for further restoration, and turning this into fuel material".

In the next task, respondents were required to identify reverse supply chain processes. The moderator asked the respondents to identify the most important processes and to indicate the criterion for selecting those processes.

In all three interviews, respondents cited different processes. In order to make their presentation more readable, they were divided into the following processes that take place in the reverse supply chain.

Selecting and sorting

"There must be a specific selection of this biomass and then this can go to a specific recipient. This selection of what kind of waste it is and the appropriate grouping and distribution to the right recipients."

"With us, it's sorting and seasoning so that this biomass material doesn't decompose, so that it doesn't become soggy. Then it's resale."

"If we have shavings and sawdust left over, we have to make a selection as soon as possible, because this is material that is subject to decay and cannot always lie for a long time."

"If the wood comes to us at the sawmill, it should not have any additional elements, such as nails. Sometimes there is contamination, so each log simply passes through a metal detector so as not to damage the process line."

Storage

"We have to have a receiver for it who will come and collect it more quickly, because sometimes it's more profitable to burn it than to send it on, because it can't lie in the damp, you need a proper warehouse for it".

"The storage time is also important, so that these products, these wastes are simply stored as short as possible, so that they reach the place of collection as soon as possible".

"You have to have the right conditions for storage so that this waste doesn't lose its quality".

"It can't be stored for too long, so that some processes don't start that will destroy the waste".

"Such a place must meet certain conditions. Certainly, it should be a dry and airy place."

"It is also very important to ventilate the biomass residue, and for ventilating you need a place, but this must be provided, it can't be that we dump it somewhere and it just lies there."

Quality control

Another process mentioned by respondents is quality control: "Longer stored any wood, wood waste, is of lower quality. They begin to spoil, rot, mold, fungi appear. The freshest waste is the best. There is an important quality control, we try to keep up to date".

Transport

"We have to have proper transport, that is, with a tarpaulin for the chips, it can't catch moisture, also we look for transport with a truck with a tarpaulin".

"We have to have special containers to transport or store it, and if we have some tree trimmings left, some branches there, then we need a truck that has some kind of shredder for those branches, so we can store it in a warehouse".

"Transportation plays the most expensive role. We have to think about whether it is profitable to transport it somewhere, whether it is profitable for us to burn it at our place or to dry this wood".

Costs are also highlighted by other respondents: “You have to look for contractors simply as close as possible (...) because then we save on transportation costs”.

"The dimensions of the waste are important, because with some, the transport and logistics costs can exceed that saving on reusing the waste".

"So that it is close, because then we save on transport costs. Then we also reduce the risk of the goods getting mouldy before we get them to the recipient".

Disposal

“If the product is not suitable for sawdust, or is rotten, it is burned.’

“Everything is collected, especially since for the winter, you can always reheat the hall”.

In the next task, respondents were asked to answer the question which actors are involved in the reverse supply chain of woody biomass residues.

Respondents identified types of actors according to their role in the reverse supply chain:

- commodity producer/sawmills,
- recycling/ecological/eco companies,
- transport and logistics companies,
- municipal waste collection companies – furniture,
- urban land reclamation companies,
- distributors of finished wood biomass products.

Respondents also listed the types of companies by industry:

- furniture industry,
- chemical industry,
- paper industry,
- construction industry,
- horticultural companies,
- agriculture.

The further task was to identify problems or challenges in the reverse supply chain for woody biomass residues. Among the most frequently mentioned problems were those related to increasing costs – both of raw materials, energy and labour: “A lot of processes are based on electricity, machines, balers, crushers, shellers, it's all on electricity, today practically nothing is produced by hand anymore on a larger scale. Many companies may struggle to make their operations profitable”; "The problem is the rising costs of transporting and supplying the material in question”; "The challenge is proper logistics to reduce transport and storage costs, optimise stock management, minimise excess waste and optimise fuel consumption during transport"; "The human factor has still been an issue for some time. There are no people to work with, particularly in the male construction type industry"; „The biggest challenge is probably to ensure that the chain is uninterrupted, from the cutting of the tree, by all recipients. So that the wood doesn't lie around and spoil. Here, so that these stages between one recipient and another are very short”; "Environmental protection can also be a challenge. It is known that they are tightening a lot of standards all the time

regarding emissions of various gases. Technological processes, such as composting, must not have a negative impact on the environment".

Opinions of respondents can be identified as the following problems and challenges:

- processing – high electricity costs, all machines run on electricity which contributes to low profitability;
- maintenance of timber stocks in Poland;
- economic instability – price increases, inflation;
- purchase of new equipment – issue of investment in plant and equipment.
- environmental protection – tightening of environmental standards;
- taxes and law – problems related to taxes, social security;
- lack of human resources – lack of people to work in sawmills on machinery;
- access to timber, blockades, high tariffs, inability to import timber from Ukraine, Belarus and Russia;
- limits on felling;
- storage – expensive and risky due to possible loss of wood properties.

Respondents in the same task were also asked to identify opportunities and possibilities related to residual wood biomass. They found it difficult in the context of the current economic and social situation. However, they pointed to several issues: „As an energy source, biomass will increase its market share. Given the energy crisis we're having now, limited access to coal, limited access to gas, it seems to me that this is just the way to go in terms of an energy source"; "The chances are, looking at what the European Union is doing in terms of ecology, that maybe the residual wood biomass industry will get more attention and maybe there will be subsidies to make it work more efficiently, just as farmers have, etc."; "Emphasis on making people aware of the fact that wood is better for us than many other things, i.e. plastic, coal, gas, and can be used in an easier way, in a more environmentally friendly way"; „Perhaps one day we will be able to make clothing from this woody biomass, why not, eco clothing".

Grouping the contributions, the following opportunities related to residual wood biomass can be identified:

- increasing the share of energy production,
- the possibility to process wood more than once,
- green products – educating the public that wood products are green,
- strengthening of environmental policy by the EU and creating new opportunities for products made from wood biomass,
- new markets after the end of the war – after the end of the war in Ukraine, an opportunity could be new markets, the reconstruction of Ukraine.

4. CONCLUSIONS

Our research has shown that the concept of waste biomass is very broad and can be looked at in different ways. One that has a very high potential is residual wood biomass. The paper characterises residual wood biomass, its forms, sources and uses,

and identification of reverse supply chain processes and the main challenges associated with it.

In this paper, the results presented are an integral part of a multi-stage research process. Focus group interviews were used as part of the research conducted. As the qualitative research was the first stage of the study, hence the interview was treated as a tool for exploring the research field. The findings from the discussion will help us to formulate hypotheses that will be further verified in the second stage of the research, using a quantitative approach. Moreover, these findings played an important role in the development of the research tool, the interview questionnaire.

We are aware of the limitations of research using the FGI method. Firstly, the group of participants in a group interview is not representative of the general population, which limits the possibility of general conclusions. Secondly, the results of an FGI have a subjective character, as it depends on the perception of the participants. Thirdly, respondents may express their opinions while being influenced by the opinions of others, which may not reflect their true beliefs.

Despite these limitations, FGIs are a research method that is used to discover new phenomena, but also to explore opinions on known issues. In addition, their results are used, as mentioned, to prepare studies using the quantitative method.

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