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DEVELOPMENT OF SOURCE SEPARATION

Waste plan for the Versowood Oy Otava sawmill

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ABSTRACT

Waste is a global issue and, if handled poorly, can endanger the health of both people and the environment. In accordance with both international agreements and legislation, the generation of waste should be minimized, and recycling should be increased. As defined in the principles of the circular economy, the value of the materials should be preserved, and the materials should be kept in circulation for as long as possible. If the materials can no longer be used as they are, they should be sorted into different types of waste at their place of origin, thus enabling high-quality and efficient material recycling. In the next few years, the waste legislation regarding business activities has also been tightened. Efficiently managed waste management and source separation can also bring financial benefits for the company.

The objective of this thesis was to study the current state of the commissioner's waste management in September of 2023. The research methods used in this thesis were literature review, observations in the commissioner’s property, and interviews with employees and persons responsible for the company’s waste management. In the observations, it was noted that the source separation is not carried out as required by law, and the waste management is not clear and efficient enough for the sorting to be successful. According to the interviews, the employees had different ideas about the state of the commissioner's waste management and the importance of waste sorting. The interviews also revealed that the changes in the waste legislation had not been clarified and thus the waste management did not meet the statutory requirements.

Based on the information received, a waste plan was made for the commissioner to improve and update their waste management. The waste plan included not only the requirements for environmental legislation and their environmental permit but also concrete measures to improve waste management. The final waste plan was drawn up together with the commissioner to meet their needs and wishes.

Keywords: waste management, circular economy, source separation, sorting

CONTENTS

TERMS AND ABBREVIATIONS

Separate collection of waste or **source separation** refers to waste sorting in the location where waste is generated.

Circular economy is a system where the goal is to maintain the value of the material, keep the material in circulation, and to reduce the amount of generated waste.

Waste is substance which has been or is to be discarded, or which its holder is obliged to discard.

Industrial waste refers to production waste generated in the industrial sector.

Municipal waste includes waste that is generated in households and waste that is comparable to household waste.

Energy waste is waste that cannot be used as raw material as such but can be processed into recycled fuel for energy production.

Mixed waste refers to non-recyclable waste from which for example hazardous waste and recyclable materials have been separated.

Biowaste means biodegradable food and kitchen waste.

Hazardous waste is waste that due to its chemical or other properties can cause harm to the environment or human health.

Electronic waste refers to all the electronic devices that are no longer in use and are disposed. All lamps excluding halogen and incandescent lamps should also be sorted as electronic waste.

Plastic packaging refers to plastic used for packaging products or, for example, for attaching pallets. The separate collection of plastic packaging includes plastic packaging placed on the market.

IBC package refers to a large container that can be used to store and transport various liquids.

1 INTRODUCTION

Industry is a significant part of modern society and enables us to produce not only services and products, but also economic growth. However, industrial operators are also known to produce negative impacts on the environment. In recent years, the aim of EU legislation has been to use resources efficiently and to promote the circular economy. The aim is also to improve the efficiency of industrial waste management. (European Environment Agency 2021.)

The forest industry accounts nearly 20 % of the value of Finland's export goods (Metsäteollisuus, n.d.). There are almost 80 industrial sawmills operating in Finland, as well as hundreds of smaller companies. In 2022, nearly 12 million m^3 of sawn timber was produced in Finland, making Finland one of the world's leading producers and exporters of sawn timber. (Sahateollisuus, n.d.) Versowood Oy is a sawn timber producer and processor founded in 1946. In addition to sawn timber, Versowood's products include glulam, wooden packaging, energy products and products related to construction and agriculture. In its production, the company utilizes Finnish spruce and pine. Versowood Oy, which employs approximately 900 people, has 13 units in Finland and one unit in Estonia. (Versowood Group 2023a.)

A sustainability transition refers to the change that is needed to ensure the carrying capacity of the environment. To make the changes for the earth's carrying capacity, actions must be taken in the lives of individuals, in legislation and in business activities. One aim is that companies' operations could be directed towards more sustainable methods of operation. (Hukkinen 2022.) For companies, the global transition towards a circular economy creates opportunities for business and sustainable growth. According to Sitra's circular economy playbook for businesses, companies can get financial benefits from, for example, developing their waste management. So that the company can direct its operations towards the realization of a circular economy, it is recommended that the company commits to their recycling goals and reduces the amount of waste that ends up in landfills or incineration. (Sitra 2022, 94.)

A waste plan can clarify the waste management and sorting of an industry or organization. Therefore, the purpose of this thesis is to create a waste plan for the Otava sawmill based on the information obtained from the observations and interviews. The objective of this waste plan is to support the sawmill's waste management so that source separation can be made more efficient and waste management will be updated to meet the requirements set by the law.

2 THEORETICAL BACKROUND

Waste is a global issue and if the management is inefficiently and weakly organized it may pose a risk to both humankind and the environment. Waste management can be considered to start from waste producers, who can be anyone, an individual, a resident of a community, or, for example, an entire company. Waste management has links to global challenges, not only to climate change and resource security but also to sustainable production and consumption. (United Nations Environment Programme, 2015, 14–19, 182.)

A linear economic system is based on the consumption and discarding of materials and disposal after use. It can also be considered as the opposite of a circular economy where the aim is to minimize the generation of waste, loss, and harmful environmental effects. In a circular economy waste is considered of as raw material for another product. Modern waste treatment aims to either recycle the waste materials or to utilize it in energy production. The previously mentioned processes have replaced landfilling of waste in Finland. (SYKE 2017, 1–2.) Waste incineration allows us to produce energy, but t it doesn’t help us reach the benefits of a circular economy. In the contrary, incinerating waste supports a linear model, allowing society to consume and get rid of waste by incineration processes. (Peart 2016, 58.)

In accordance with the new EU industrial strategy, companies should gradually transition to a sustainable economic system. This transition is also profitable for individual companies, as closed-loop models can increase the profitability of their activities. According to the Circular Economy Action Plan (CEAP) by the EU, circular processes can achieve significant material savings in production

processes and create economic opportunities. The European Commission urges industries to increase their circularity. As a goal to all EU member countries the general goal is to prevent the generation of waste and increase the recycling of materials. (European Commission 2020, 3–7, 14.) In accordance with the sustainable development goals created by the United Nations in 2015, the generation of waste should be significantly reduced by the end of this decade, and therefore recycling and reuse is recommended. As an indicator of achieving the target, the UN proposes monitoring the quantity of recycled materials. (United Nations n.d.)

2.1 Source separation of waste

Waste is generated in many different functions around us, both in households and services as well as in various production facilities, and with the growing population, the importance of solid waste management has increased (Singh & Singh 2015, 1,4). According to the principles of the circular economy, the generation of waste should be prevented, and the value of materials and products should be preserved. When reuse of materials is no longer possible, materials should be used as components or raw materials for new products. (Ellen MacArthur Foundation n.d.) Sorting different types of waste separately is the first step to successful and high-quality recycling, which enables the reuse of materials. The separate collection of waste also prevents contamination of other waste types as well as the environment and communities. (European Environmental Bureau 2020, 1–2.)

In accordance with the EU's circular economy policy, the goal is that by 2025 the recycling rate of municipal waste would rise to at least 55%, and the recycling target for packaging waste is 65%. (European Parliament 2018). However, in a report published by the European Commission in June 2023, it says that even though Finland has achieved a 65% recycling rate for packaging waste, we are unlikely to achieve the set goals for municipal waste recycling. Currently, the municipal waste recycling rate is approximately 40%. In addition to reducing the amount of waste, the Commission proposes to increase the collection and recycling of bio-waste and plastic. With the revised waste legislation, obligations

regarding the separate collection of waste were added to both households and companies. For Finland to reach the recycling goals set by the EU, municipalities and companies must pay special attention to organizing the separate collection required by waste legislation. (Finnish Government 2023.)

Waste not only pollutes the environment, but also releases carbon dioxide and methane into the atmosphere, which accelerates climate change. Sorting waste and increasing the recycling rate has a huge impact on carbon dioxide emissions from waste. (European Commission n.d.a) The annual quantity of the collected solid waste globally is 11,2 billion tons and 5 per cent of the global greenhouse gas emissions is caused by the decomposition of the waste's organic share. (United Nations Environment programme n.d.). According to research by TOMRA, sorting mixed waste alone could reduce 0.73 billion tons of CO_2e globally in a year. By improving recycling practices, sorting mixed waste and global residual waste treatment, the annual global emission reduction is estimated to be around 2.76 billion tons CO_2e. (TOMRA 2021.)

2.2 Finnish waste legislation

As a Member State of the European Union, Finland's waste legislation is based on EU legislation (Figure 1), but for some parts, however, Finland's waste legislation is stricter than the requirements set by the EU. (Ministry of the Environment, n.d.a.) EU waste legislation aims to improve waste management, reduce the amount of waste ending up in landfills and support innovation in recycling. The aim of EU legislation is to make the most efficient use of raw materials derived from waste. (European Commission, n.d.b.)

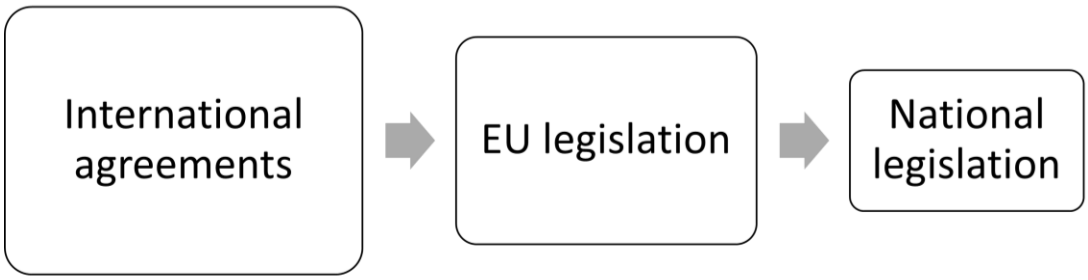

Figure 1. The impact of international agreements and EU legislation to national legislation.

International agreements are an integral part of EU law and international agreements must apply throughout the EU (Figure 1). International agreements constitute both rights and obligations for the contracting parties. (EUR-Lex 2020.) As an example of international actions, the EU is committed to implementing the UN Sustainable Development Goals. The 17 SDGs and 169 sub-goals set out clear targets to be achieved globally by 2030. (European Commission, n.d.c.) Targets and indicators have also been defined for sustainable consumption and production, such as minimising waste (United Nations, n.d).

The Finnish Waste Act defines a waste hierarchy (Figure 2) for the waste treatment. In accordance with the order of priority, waste management must be organized in a way that generation of waste should be prevented. However, if waste is generated, it must be reused or prepared for reuse. If this is not possible, the waste must be recovered as raw material, in practice recycled. If it is not possible to recycle the material, the waste must be utilized as energy. Landfilling of waste is only possible if it would not otherwise be recovered for technical or economic reasons. (Waste Act 646/2011.)

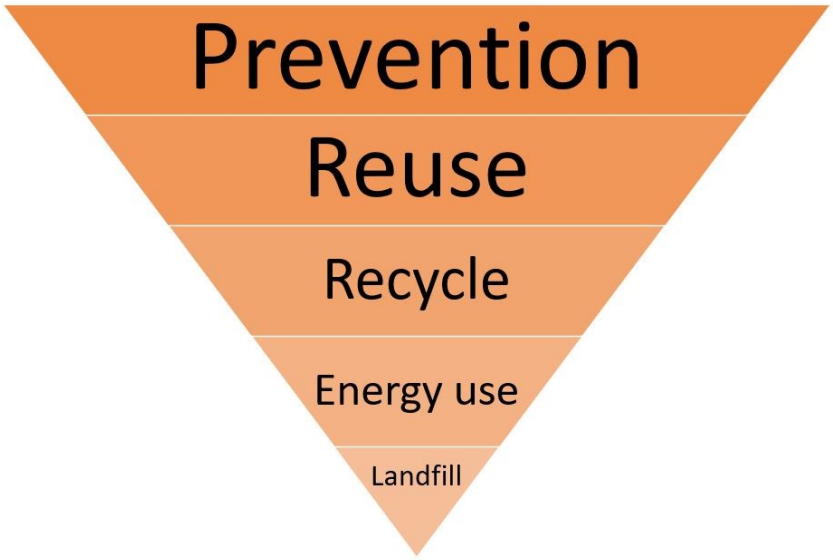

Figure 2. Waste hierarchy as a waste management principle (Waste Act 646/2011)

The Waste Act also defines responsibilities for the producers of products and waste generated from them. In accordance with producer responsibility, those companies that pack, import, or sell their products in Finland, and whose turnover

in the previous year was more than one million euros, are obliged to bear the costs of waste management of the products or their packaging. The goal of producer responsibility is, for example, to prevent the generation of waste, to enhance the reuse or utilization of waste, and to reduce the harm caused by waste to people or the environment. The scope of producer responsibility includes, for instance, packaging, magazines and office papers, and electrical equipment. (Waste Act 646/2011.)

In 2022, the Finnish Ministry of the Environment published the National Waste Plan to 2027. The plan was required by EU Directive 2008/98/EC on waste and includes a national waste management plan as well as a plan to reduce the amount and harmfulness of waste. In the future, the aim is to prevent waste generation in general. Among other things, the vision of the plan presents material-efficient production, high-quality waste management, waste reduction and cooperation between operators in the field to promote high-quality material cycles. The waste plan proposes measures that are binding on state administrative level, but measures are also proposed for other actors as well. These actors may include, for example, companies and industrial production facilities. (Ministry of the Environment 2022a, 11–14.)

2.3 Environmental protection and permit

In accordance with the Environmental Protection Act, the operator has an ‘obligation to be aware’, according to which the operator must be aware of the environmental effects and risks of his operations, and in addition has the obligation to find out the possibilities for reducing the harmful effects of his operations. The operator must organize their activities in a way that pollution of the environment can be prevented, or pollution can be limited to as low a level as possible. (Environmental Protection Act 527/2014.)

Activities that pose a threat of environmental pollution must have an environmental permit. For example, a sawmill producing more than 20,000 m^3 of lumber per year is considered such an activity. (Environmental Protection Act 527/2014.) To be granted an environmental permit, the activity must not cause

significant environmental pollution or a risk thereof. In addition, the granted permit may contain various provisions relating to waste and waste management. Environmental authorities supervise the achievement of environmental protection objectives by monitoring the compliance of environmental permits. If the operator has not fulfilled the obligations set out in the environmental permit, the authority may issue an order to those who are responsible for the operations. (Ministry of the Environment, n.d.b.)

The Criminal Code has a separate section on damaging the environment. If someone deliberately or through gross negligence preserves, handles, or stores substances in violation of the Chemicals Act and this act may cause environmental pollution, they must be sentenced to a penalty according to the law. Also, if a person neglects their obligation to organize waste management according to the Waste Act or violates the ban on burning waste collected for landfilling or for recycling, they can be sentenced for damaging the environment. (Waste Act 646/2011, Criminal Code 39/1889.)

2.4 Industrial waste and legal requirements

Waste can be classified in several different ways, but typically waste is classified as either municipal waste or production/industrial waste (Waste Act 646/2011). Municipal waste includes waste generated in households and such waste generated from production that can be equated to municipal waste. These wastes are covered by the municipality's waste management. Industrial or production waste refers to the waste that is generated in industry sectors. Sometimes waste from mineral mining and energy production is also considered as industrial waste. Industrial waste is different in each industry and the amounts of waste vary. (Statistics Finland, n.d.)

In 2021, a total of approximately 125 million tonnes of waste was generated in Finland. In industries, the amounts of waste changed in different directions in different industries, but the amount of total waste was growing compared to previous years. (Statistics Finland 2023.) As a result of the revised Waste Act, companies located in urban, service, tourism, and workplace areas are obligated

to sort their waste more precisely than before. From July 2022, these companies must organize separate collection for the waste generated in their operations. The purpose of the legislative amendment is not only to increase reuse and recycling but also to reduce waste generated by these companies. (Ministry of the Environment 2022b.) According to the revised legislation, industrial waste should therefore also be organised according to waste hierarchy.

The corporate and industrial waste management must be organized in accordance with the Waste Act and other regulations. Companies must also sort and store waste according to the instructions, in proper containers. (Government Decree on Waste 978/2021.) Companies are obligated to arrange separate collection for paper, cardboard, glass, metal, plastic and biowaste if it is generated in quantities exceeding certain limit values (Table 1).

Table 1.Waste types and their weekly limit values for obligated waste separate collection. (Government Decree on Waste 978/2021)

Waste type	**Quantity per week (kg)**
Biowaste (other than garden waste) which is not processed in the property	10
Plastic packaging, paper, and cardboard waste	5
Glass waste	2
Metal packages or other metal waste	2

In addition, hazardous waste such as batteries, paints, oils, and solid oily waste must always be collected separately (Suomi.fi 2022). The principle of the Chemicals Act is that, considering the quantity and hazardous nature of chemicals, sufficient care and caution must be followed in operations to prevent environmental and health risks. (Chemicals Act 9.8.2013/599). If chemicals are stored in IBC packages, the packages must be double-jacketed and can also be lifted from above or below with a lifting device attached to the work machine. If the package is single-jacketed, it should be stored on a drainage or protection basin. (Government Decree on the safety requirements for the industrial handling and storage of dangerous chemicals 856/2012.)

Electronic waste must be collected separately in such a way that processing of electronic waste as mixed waste is minimized and the proper processing of separately collected waste is enabled. The collection must be arranged in a way that the electronic waste can later be further processed and recycled. The storage for electronic waste must have an impermeable surface layer equipped with a liquid leakage collection system. In addition, the storage location must have a weather-resistant cover in the appropriate areas. (Government Decree on Waste Electrical and Electronic Equipment 519/2014.)

The waste producer must also ensure that there is unhindered access to the waste collection location, that there are enough covered containers, and that the type of waste to be collected and the contact information of the company responsible for collection are clearly marked on the waste container. The container or its immediate vicinity must also have instructions for the type of waste to be collected. Waste containers must be emptied often enough so that the collected waste fits into the container, and that the container can always be closed. Possible litter caused by waste collection must be cleaned from the environment without delay. (Government Decree on Waste 978/2021.)

Companies can reduce the amount of waste they generate by minimizing raw material and product waste. The generation of waste can be prevented in the design of the company's products, avoiding unnecessary packaging, and by favoring recycled or recyclable packaging materials. Production should be designed in a way that the amount of waste is minimized at all stages of production. (Motiva 2019.) It is also possible to clarify a company's waste management by drawing up waste management instructions for the company, which specify what is done with each waste and who is responsible for the different areas of waste management. (Suomi.fi 2022.)

2.5 Municipal waste regulations

Municipal waste management regulations are issued in accordance with the Waste Act. The regulations describe binding regulations in the area, but also the obligations of the Waste Act and other legislation. Municipal waste management

regulations provide information about waste management and the waste management system in the area. The purpose of waste management regulations is to promote compliance with the priority order of waste management and to prevent harm caused by waste management or waste. The waste management regulations describe how property owners must act in their waste management and how to transport their waste. The municipal waste management regulations apply to properties that are under the municipality's responsibility for organizing waste management. These include, for example, residential and leisure properties as well as properties for service and administrative activities, and other operators that use municipal waste management services. (Municipal waste management regulations of the City of Mikkeli 2023, 1, 16.)

The regulations state that the municipal waste management regulations do not apply for business activities comprehensively. Partially, however, similar requirements have been noted in the Waste Decree, so separate collection and recycling obligations must always be implemented in accordance with the decree. Where applicable, other operators, such as businesses, must also comply with waste management regulations. In that situation, the municipality's waste management regulations fully apply to the waste owner. Operators outside the municipality's responsibility for waste management, for example business operators, are also subject to certain waste management regulations regarding practical arrangements and technical requirements for waste management. Waste management must always be properly separated, handled, and transported in a controlled manner, regardless of whether all waste management regulations apply to the holder of the waste. (Municipal waste management regulations of the City of Mikkeli 2023, 1 ,7–8.)

3 VERSOWOOD OY OTAVA SAWMILL

The Otava sawmill has been operating in its current location since 1891 but passed into the ownership of the Versowood group in 1997. Otava sawmill is located 15 kilometres from Mikkeli by lake Puulavesi and employs 70 people in its production facilities. The production area of the sawmill is approximately 30

hectares, and the production focuses on sawing spruce with an annual production capacity of nearly 300,000 m^3. (Versowood Group 2023b.)

The sawmill process is divided into several different steps (Figure 3). The logs brought to the sawmill area are sorted into different groups according to the type of wood and the size of the log. In the second phase logs are debarked and the resulting bark is stored for further use. After debarking the logs are sawn and sorted according to size into different compartments and dried. After drying, the lumber is sorted and, after packaging, is ready to be delivered to the customer or taken to storage for later transport. (Wallin 2014, 23–25.)

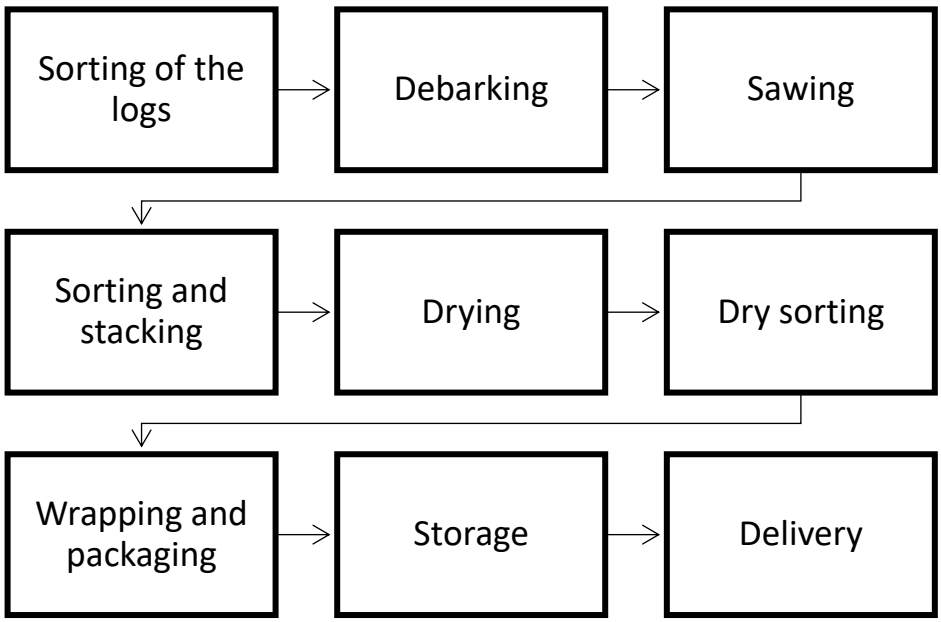

Figure 3. Sawmill process. (GlobalSpec n.d.)

For this thesis, the environmental permit granted to the Otava sawmill in 2005, as well as the inspection memoranda from 2019 and 2022 are used. Some of the information in the original environmental permit is already out of date, such as the efficiency of the thermal power plant and the amount of production capacity, but for example the burning of oil waste mentioned in the environmental permit is no longer done in the sawmill's thermal power plant according to later documents.

To grant the environmental permit, the authority has set permit regulations regarding waste. The environmental permit states that valid municipal waste

management regulations and their sorting obligations must be followed in the company’s waste management. In addition, the waste generated in the operation must be stored in such a way that it does not cause a risk of environmental pollution or littering the environment. (Environmental Permit of Versowood Otava 2005.) Versowood Group also has their own environmental policy, according to which the waste management operates in accordance with the principles of the circular economy, and chemicals are handled carefully. In the group's operations, the aim is to prevent harmful environmental effects caused by any operations. According to Versowood's Environmental Alphabet, the group aims to favour the utilization of waste and reduce the amount of mixed waste. (Versowood Group n.d.)

4 MATERIAL AND METHODS

4.1 Establishing the current waste management practices

In this thesis the methods used were literature review, observations, and interviews. The purpose of the literature review was to study waste management requirements for companies, Finnish waste management legislation and the importance of waste sorting for the promotion of the circular economy. For this thesis, both international agreements and Finnish waste legislation had to be studied, alongside with municipal waste management regulations. In the thesis, it was also important to get background information about the commissioner and the principles of the modern sawmill industry so that it was possible to form a waste plan suitable for the company. Information about the commissioner was collected from the company's website and from reports and other materials received from the company's employees. In addition to the company's own reports, basic information about the commissioner's waste management was obtained from waste service providers and the waste authorities of the city of Mikkeli. (Figure 4.)

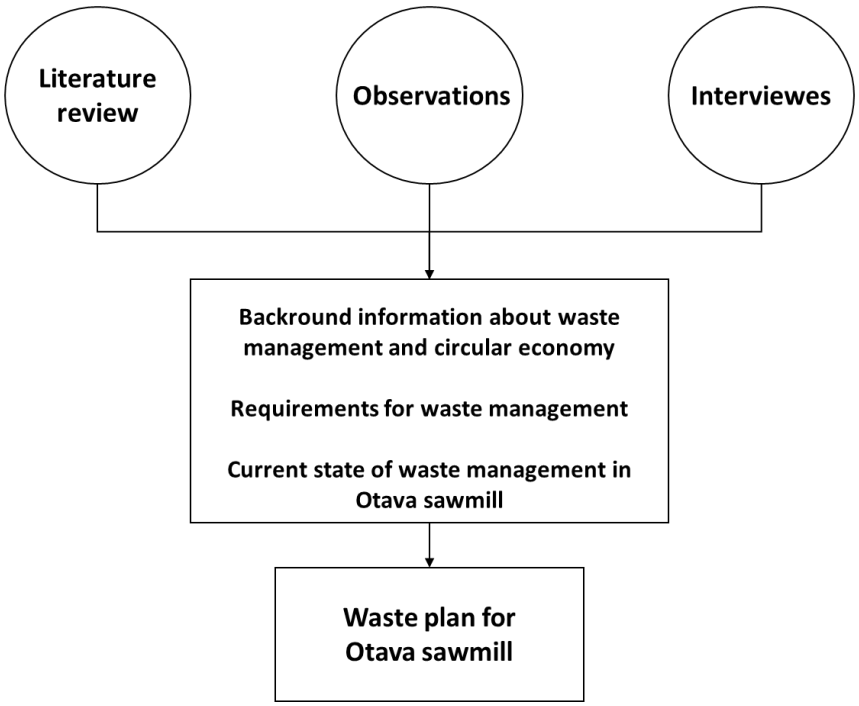

Figure 4. Methods used for this thesis and the waste plan.

4.1.1 Observations

With observation, it is possible to verify how the things told by people or the information in documents are implemented in practice (Paalumäki & Vähämäki 2020, 127). The advantage of observation can be that the researcher has direct access to natural environments and that the researcher receives immediate and direct information about the studied activity (Hirsjärvi et al. 1996, 213–124). Since the aim was to study the implementation of waste management and its functionality, observation was chosen as one of the research methods for this thesis.

Before the observations, the area and the basic functions of the sawmill were studied, so that it was easier to understand the needs related to waste management. A simplified version of the map of the sawmill area (Appendix 1) was made and attached to the observation template (Appendix 2). During the observation tours the most important functions of the sawmill and the locations of the area's waste containers were marked on the map. Each waste container was numbered on the map according to the order of observation, and the observations were recorded on the observation template in the place

corresponding to the number. During the observation rounds, attention was paid to the number of waste containers, possible markings, condition, colour, or other characteristics. In addition, the contents of the waste containers were visually assessed. The purpose of this was to find out if the contents of the waste container correspond to its purpose. The location of the containers was also noted considering the sawmill's functions and logistics.

During the observation tours, photographs were taken of the waste containers and areas around them and attached to the observation notes. Observations were carried out on three different days, and on the first day the sawmill manager as well as the persons responsible for the operations of the various units participated. Observations were carried out both in the outside areas of the sawmill, near the production lines and in the staff's break rooms. The observations were carried out in September 2023. Several different observation visits ensured that the changes in the sawmill environment could be considered in observations and abnormal situations could also be recorded. During the observation rounds, notes were taken from a total of 15 waste collection points, 10 of which were located outside the sawmill. Inside the sawmill, observations were carried out at 6 different waste points, which were located both in the staff break rooms and near the production lines. In addition, observations were carried out at a waste sorting station located in the sawmill yard, where the collection of electronic waste, hazardous waste, and solid oily waste is centralised.

When analysing the results of the observations, similarities from different observation points were traced and noted. The results were also divided into different groups according to their features. From the observation results, in addition to the number of waste points, the number of observed waste containers was calculated, as well as the quantity of those waste containers that were marked or had instructions for sorting attached to them. The number of containers with and without lids, as well as the uses and quantities of waste containers of different colours were also calculated, and the data compiled into figures and tables.

4.1.2 Interviews

The current state of waste management at the Versowood Oy Otava sawmill was also studied by conducting open interviews with employees and sawmill management. In interviews, the purpose is to find out the person's perceptions, thoughts, and experiences about the subject to be studied (Hirsjärvi & Hurme 2022, 41). In the interviews conducted for the thesis, the focus of the questions was not only to find out the basic information about the sawmill's waste management (responsible persons, places where waste is generated, etc.), but also the interviewees' own experience of the functionality of the waste management and the importance of sorting. The interviewees were not given an actual list of questions, but in all interviews the theme was the functionality of the sawmill's waste management and its possible challenges or obstacles to sorting. The interviews were carried out verbally during observation tours. The results of the interviews were written as notes alongside the summary of the interviews (Appendix 3), and the results were divided into thematic groups for analysis. When analysing the results of the interviews, the purpose was to find both similarities and differences in the answers.

4.2 Compiling the waste plan

To compile the waste plan for Versowood Otava sawmill, information obtained from the literature review, observations and interviews was combined. The commissioner's wish was to have a written waste plan that, with minor changes, could be used by both employees and the sawmill management. The commissioner's wish was to have a concise, written document that would include sorting instructions for the types of waste generated at the sawmill. When planning the content of the waste plan, an attempt was made to consider both the wishes and needs of the commissioner, as well as the requirements set by law for the company's waste management.

5 RESULTS

5.1 Literature review

The literature review revealed that waste sorting is one of the key parts of a circular economy. The waste legislation has thoroughly defined the national goals for sorting both municipal and industrial waste.

Table 2. Legal and environmental permit requirements for the generated waste types.

Waste type	Requirements set by the company's environmental permit	Legal requirements for the waste type
Mixed waste	Source segregation, written guidance for waste sorting and training for the entire personnel	Generation of waste should be prevented. If it is generated, should be handled according to waste hierarchy. (Waste Act 17.6.2011/646, 8 §)
Energy waste	Not mentioned	According to waste hierarchy waste that cannot be recycled, can be utilized in energy production. (Waste Act 17.6.2011/646, 8 §).
Biowaste	Not mentioned	If the weight of generated biowaste in the property exceeds 10 kg per week, it must be separately collected. (Government Decree on Waste 978/2021,21 §).
Cardboard, paper, plastic	Not mentioned	If the weight of generated cardboard, paper or plastic packages in the property exceeds 10 kg per week, it must be separately collected. (Government Decree on Waste 978/2021,21 §).
Metal	Not mentioned	If the weight of generated metal packages or other metal waste in the property exceeds 2 kg per week, it must be separately collected. (Government Decree on Waste 978/2021,21 §)
Wood waste	Can be crushed and incinerated in the sawmill's thermal power plant.	Wood material that is not harmful to the environment or health can be used in energy production. If the wood material contains preservatives or other added chemicals, the wood

		material can be considered as a by-product. Wood that is dirty or contains other materials is classified as waste. (The Ministry of the Environment 2014, 13.)
Hazardous waste	Should be collected separately, each hazardous waste type to their own container. Must be stored in a warehouse intended for hazardous waste in a covered space with impermeable floor. Must not be stored in the property for more than one year.	Container for the hazardous waste must be impermeable and resealable. The container also must withstand the load caused by use, transfer, and storage. If the operation causes more than 100 tons of waste in a year, generated hazardous waste, and requires environmental permit, the producer of the waste must keep records of the generated waste. (Government Decree on Waste 978/2021, 8 § and 33 §).
IBC packages	Not mentioned	If IBC or other containers intended for liquid chemicals are stored outside, they must be placed on an impermeable surface that is surrounded by a boarder to prevent possible leaks. If containers contain chemicals that are dangerous for the environment, they must not be stored near sewers. Government Decree on the safety requirements for the industrial handling and storage of dangerous chemicals 856/2012, 29 § and 52 §.

The implementation of the commissioner's waste management is guided by both national legislation and regional waste management regulations, but also the requirements set by the company's environmental permit (Table 2). These regulations specify both the basic elements of organizing companies' waste management, but also various obligations regarding waste quantities.

Table 3. The commissioner's waste quantities from the year 2022.

Waste company 1	Waste type	Amount of waste (tons)
	Mixed waste	4
	Energy waste	14

Waste company 2

Waste type	Amount of waste (tons)
Metal scrap	181 386
Other waste	20 960

Waste company 3

Waste type	Amount of waste (tons)
Reused as material	818940
Disposed	4

The commissioner’s waste management is divided between three companies, either due to price, simplicity, or the company's special expertise. In this thesis, the companies are separated by numbers. The combined amount of all waste from all three different waste management companies for 2022 (Table 3) is approximately 1 021 tons. Different companies report the types of waste in their waste reports in slightly different ways. If the quantities of clearly reused or recycled waste are combined, the total quantity of materials is approximately 1,000 tons. Therefore, the amount of other waste remains as 21 tons.

5.2 Observations and interviews

During the observation rounds, observations were made from a total of 33 waste containers in 15 different waste collection points. Because the observed waste collection points were of different sizes, some locations had only 1 container and some had several for different purposes. In the sawmill area there were also different kind waste containers such as large bulk waste containers and front loader containers.

The most significant observation at all observation locations was that there were no appropriate containers or no containers at all for different types of waste to be sorted. Of all containers that were observed 17 were meant for mixed waste or the markings were lacking, and the container was used for collecting mixed waste. Four of the containers were meant for incinerable wood waste and both solid oily waste and metal had three different containers. Hazardous, cardboard, and electronic waste had only one container each. There were no containers for collecting biowaste, paper and glass in the observed locations. (Figure 5) Based on interviews and observations, the paper waste generated in the offices is sorted into either mixed or energy waste or collected separately and taken to a

thermal power plant to be incinerated. According to interviews, glass waste is not produced from any of the operations in the sawmill area.

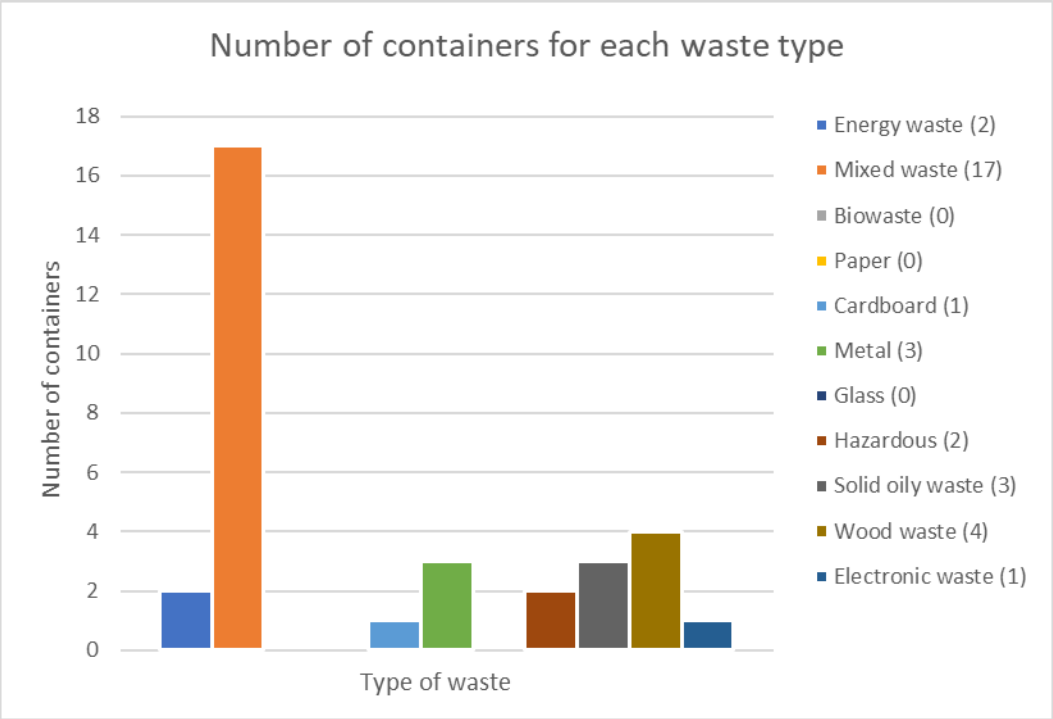

Figure 5. Number of containers for each waste type in the observed locations.

According to interviews and observations there is no plastic collection at the sawmill; instead, the plastic is sorted into either mixed or energy waste, and occasionally it ends up in the wood waste container. At the sawmill production, some amount of plastic waste is generated in different parts of the production facilities from packaging materials. However, at the downstream end of production, in dry sorting, plastic waste is generated from the plastic straps used for stacking the boards, as well as from the plastic hoods intended to protect the boards. The plastic hood placed on the board piles ends up as waste if the plastic breaks or is otherwise unusable. The interviewees had different understandings about whether the plastic they produce is packaging plastic or not. Some interviewees were interested in the possibilities of sorting plastic in their production facilities, some were in the understanding that it is convenient to sort plastic as energy waste.

Of all the 33 containers observed in the sawmill area, 12 had some kind of markings for which type of waste the container in question is intended for, and only two containers had instructions on what kind of waste should and should not be put in the container. Also, only two of the 15 observed waste points had waste containers with a marking on the contents of the container, as well as instructions for sorting. Seven waste collection points had only containers that did not have any kind of markings attached to them, or the marking were so unclear that it was not possible to know which kind of waste the containers were intended for. Waste point 15 had only IBC packages and therefore is not included in these calculations. (Figure 6.)

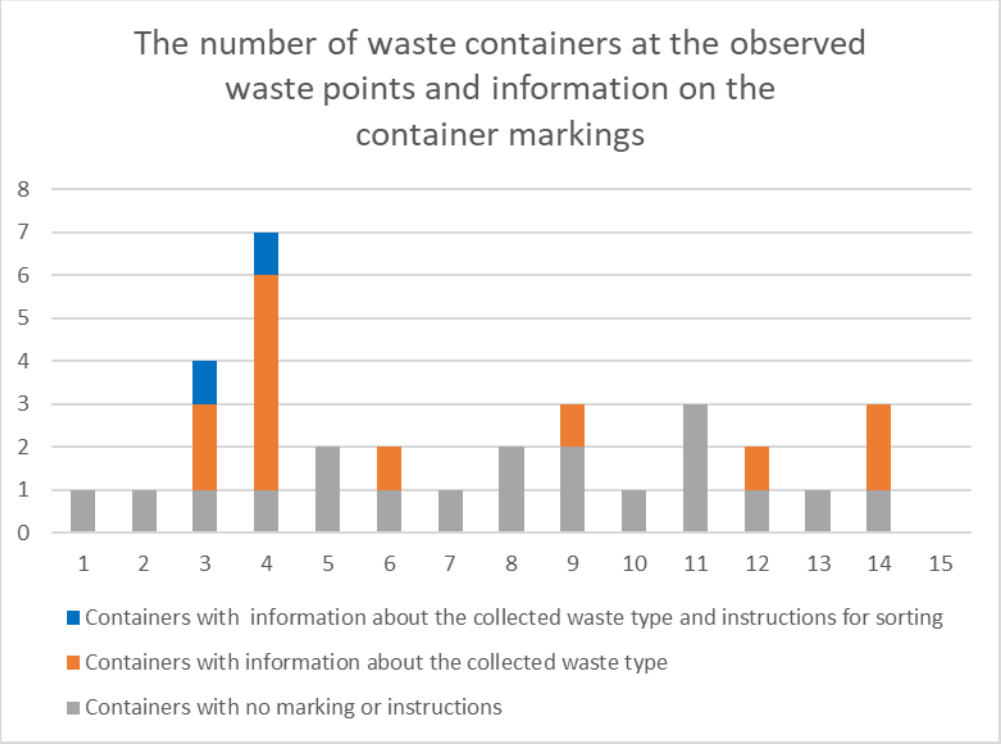

Figure 6. The number of the waste containers at the observed waste points and information on the container markings.

Waste containers with and without lids were found in both the outdoor and indoor spaces. Of all 33 containers 16 were uncovered and 16 covered or partially covered. Outside the sawmill area 45 % of the containers were covered and 55 % uncovered. Inside the sawmill, in production facilities and staff break rooms, 60 % of the containers were covered and 40 % uncovered. Waste point that had only IBC packages is not included in these calculations. (Figure 7.) When analysing

the results, it should be noted that some of the waste containers in the outdoor areas were large containers, where the waste is placed with a bucket loader or other machinery and the need for lidless container is therefore justified. However, the interviewees said that on windy days waste from the containers in the outdoor areas may spread around the sawmill area along with the wind.

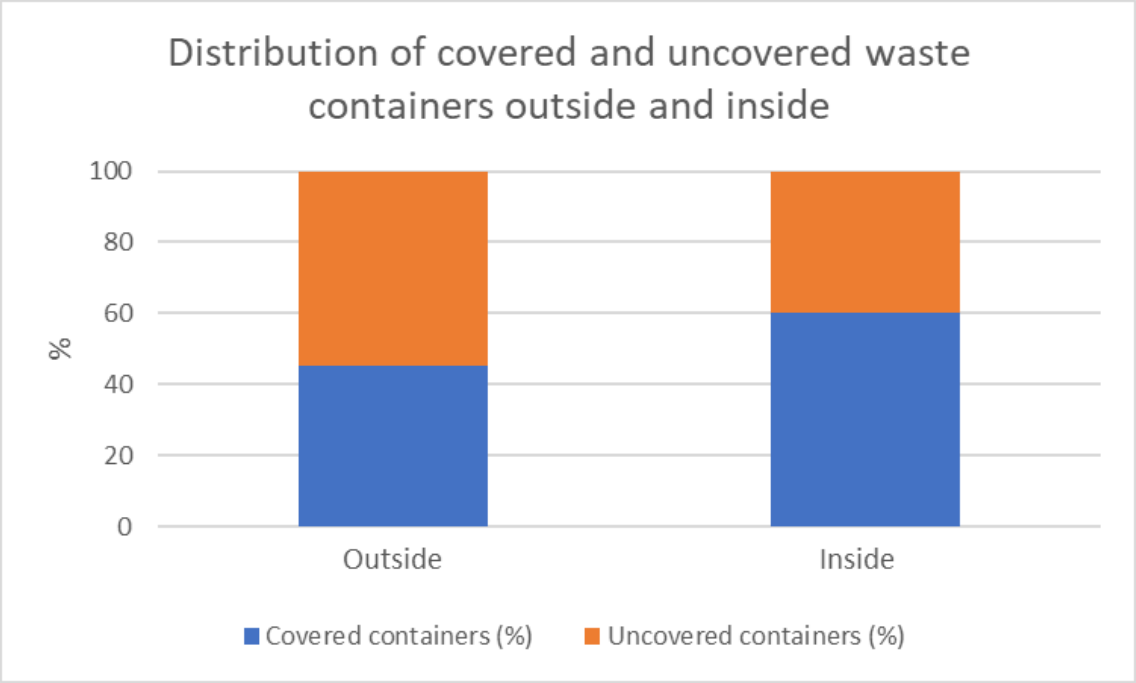

Figure 7. Distrubution of covered and uncovered waste containers outside and inside the sawmill.

Table 4. The colors of waste containers and the waste types they contained.

Blue	Gray	Red	Green	Orange	White
Energy waste Electronic waste Mixed waste	Mixed waste Hazardous waste Cardboard	Mixed waste Solid oily waste	Mixed waste Metal scrap	Metal scrap Incineratable material	Mixed waste

Several waste containers of different sizes and colours were found at the observation points (Figure 8). There were a total of six different colours of waste

containers in different places of the sawmill area, which were used for various purposes. All the waste containers, except for the orange ones, had mixed waste as one type of waste. Blue containers were also used to collect energy and electronic waste. In addition to the collection of mixed waste, grey containers were also used for hazardous waste and cardboard. Red waste containers were also used to collect solid oily waste, and green containers were, in addition to mixed waste, also used to collect metal waste. White containers were used only for the collection of mixed waste. The orange waste containers were the only ones that were not actually intended for mixed waste collection. There were two kinds of orange containers in the area for collecting both metal and incinerable waste. (Table 4.)

Figure 8. One of the waste collection points in the sawmill yard area. In the picture on the left, an orange container for scrap metal, a lighter orange for incinerable wood waste, blue for energy waste and grey for mixed waste.

The interviewees said that there are only one type of containers in the staff break rooms, into which all the waste is sorted. During the observation rounds, it was found that in addition to bio-waste, cardboard and plastic packaging also ends up in the mixed waste container (Figure 9).

Figure 9. The contents of a mixed waste container from one of the staff break rooms.

In the sawmill area, outside the central warehouse, there is the property's only cardboard collection point. The interviewees said that the cardboard press was placed near the central warehouse because of the packaging cardboard produced there. The cardboard waste generated elsewhere is sorted, either into mixed or energy waste, or to the wood waste container. Some of the interviewees did not see it as problematic that the waste ended up in a thermal power plant to be incinerated. According to the interviewees, the thermal power plant's combustion temperature is high enough so that the waste sorted there would burn efficiently. Some of the interviewees also stated that the mass that ends up in thermal power plant, be it wood material or for example cardboard or paper, would be useful as a source of energy needed for the operation of the sawmill's drying facilities.

The thermal energy output of the thermal power plant connected to the sawmill is a vital part of the production line. The interviewees saw it as a good thing that wood waste could be burned in the sawmill’s power plant. Some of the interviewees said that plastic or other waste should not end up to the power plant furnace, but some did not find it problematic due to the high incineration

temperature. There were large containers in the yard area, which were intended for the collection of wood waste generated in the production. The containers were not marked, but according to the sawmill's instructions, only wood waste can be placed in them. Among these wood waste (broken boards and other wood to be disposed) that were going to be incinerated in the sawmill's thermal power plant, there was also a lot of other material, such as cardboard, plastic and, for example, old floor brushes.

One of the observation locations was a waste sorting station, where several different containers were placed for the collection of various waste types (Figure 10). Some of the containers were placed outside the building, some inside the building located two steps up. There were several different containers for some types of waste, which were placed in different parts of the building. Most of the containers at the waste sorting station were containers without lids. Some of the containers were very full of waste, such as electronics, and some of the waste was left on the floor of the building (Figure 11).

Figure 10. Waste collection station located in the sawmill yard.

Figure 11. Waste collection point and different waste containers.

At different stages of production, some waste is generated from aerosol packaging (oils, dyes etc.). However, there were no collection containers for these in the production facilities. The only actual collection container for aerosol waste was found at the waste sorting station. There were instructions on the doors of storage cabinets containing aerosol cans and other chemicals, urging to put the empty chemical cans in the waste, but the instructions do not specify which waste container. When visually assessing the waste containers, it was noted that aerosol packages had ended up also in mixed and energy waste containers (Figure 12). The interviewees said that the paper instructions are the sawmill's own, and not distributed by the group to all Versowood sawmills. The interviewees also said that Versowood Group have not given instructions on keeping record of the waste that is generated in the sawmill. The company that receives commissioner’s electric and hazardous waste said that they do not have separate instructions for their customer companies regarding the storage of the

waste in question, but the laws regarding storage and the city's waste management regulations should be obeyed.

Figure 12. The contents of one of the energy waste containers located in the sawmill yard.

Large orange containers are mainly used for scrap metal. By visually assessing waste containers in the sawmill area, very little metal scrap had ended up in other containers. However, quite a lot of other waste material was also found from the scrap metal containers, such as wood and mixed waste (Figure 13). When interviewing the representative of the company responsible for the further processing of the scrap metals, a separate fee is not currently charged for the mixed waste found among the scrap, but improper sorting slows down the company's work.

Figure 13. Metal scrap container in the sawmill yard.

At the beginning of the production line, empty and half-full IBC packages were stored in the outdoor area. One of the tanks was completely open and contained, in addition to rainwater and chemicals, supposably an oil-soaking mat. The tanks were placed in an asphalted yard area either directly on the ground or on top of wooden pallets. Similar, empty IBC packages were also stored in front of the waste collection station (Figure 10). The recycling and storing possibilities for IBC packaging in the sawmill area have been discussed, but the implementation is still in progress.

Some of the interviewees were under the impression that the sawmill generates very little waste. Some thought they would like sorting to be made more efficient, some felt that sorting at the sawmill was inconvenient. In the interviews conducted during the observation rounds, the employees said that the environmental inspections carried out by the authority had found deficiencies and suggested corrections, but that changes had not necessarily been made. The interviewees said that there had been no consequences for not making the suggested corrections. Looking at the latest memorandum of the environmental inspection, no demands for corrections were revealed.

5.3 Waste plan for Versowood Oy Otava sawmill

Based on the literature review, observations and interviews, a waste plan (Appendix 4) was created for the sawmill. The purpose of the waste plan was to clarify the sawmill's waste management and gather information about the legal requirements. Since the idea was to use the waste plan possibly in other Versowood sawmills with only minor changes, the plan needed to be simple, updatable, and easily modifiable.

After cover page and introduction, a table was added to the waste plan in which the types of waste to be collected were separated and color-coded as required by the current instructions given by their waste management companies. In addition, at the commissioner's request, sorting instructions for different types of waste were added to the table, here the current guidelines for sorting of waste management companies were used as sources. Since not all waste types are yet separately collected in the sawmill, information of the waste companies could not be filled for those waste types. Persons responsible for the sawmill’s waste management will add missing information after contracts with the waste companies have been made. The persons responsible for the sawmill's waste management and their tasks for the success of the sorting were included in the plan. Legislation governing the company's waste management was also made at the end of the waste plan. Legislation that was added to the waste plan was also used as references in this thesis.

One of the significant parts of the waste plan is the map of the sawmill area, on which the new locations of the waste collection points were planned. The plan was made together with the production engineer of the sawmill, whose expertise was used when planning the optimal locations for the waste collection points in terms of production operations. The map attached to this thesis is to be forwarded by the group to a graphic designer, who will implement the visual appearance of the map to match Versowood's other materials.

The waste plan was presented to the persons responsible for the sawmill's waste management and supplemented according to their needs and wishes. Based on

the information obtained from this thesis and the waste plan, sawmill supervisors and unit managers will implement waste management-related activities. The implementation will be integrated to a Lean project that started in the sawmill earlier this autumn. The visual appearance of the waste plan will be modified so that it is in line with other materials used in Versowood. After necessary changes in the sawmill waste management the actual waste plan is to be presented to the employees and to instruct them in carrying out the sorting.

6 DISCUSSION

The methods used in the thesis gave a wide understanding of the current state of company's waste management. The observations gave a realistic information of the successes and challenges of waste management and the interviews yielded information about the employees' own experiences, opinions, and perceptions. Since the interviews were carried out in an open and unstructured manner, not all interviewees were asked the same questions. During the interviews, however, it became clear that not all persons responsible for the company's waste management had up-to-date information on the laws and requirements affecting the organization of companies' waste management.

The commissioner's need was the clarification of the company's waste management and finding ways to reduce the amount of mixed waste. Based on the observations and interviews, it can be concluded that a large amount of mixed waste is generated largely because waste is not sorted as they should be. Significant amount of material which could still have value as recyclable components, seems to end up in mixed waste. Sawmill area was also completely missing the collection of bio-waste, which presumably, in a sawmill with about 70 employees, will be generated in the amount specified as the limit value for sorting in the revised waste law. However, when evaluating the reliability of the results, it is good to note that in this study the composition of the waste was assessed visually. The more precise composition of the waste and the share of different types of waste in mixed and energy waste were not clarified in more detail.

In accordance with Article 33 of the Waste Decree, the waste producer must keep record of the waste generated in the operation (Government Decree on Waste 978/2021). Although some self-monitoring had been done at the sawmill, according to the interviewees, there had not been more detailed instructions for this from the Versowood Group. It is possible that more detailed guidelines for waste management, its requirements and related documentation, would support the proper waste sorting at the sawmill. Since different waste types are handled by several companies, it is also very important to have the information combined by the sawmill so that record of the waste management and quantities can be presented to the authority if necessary.

Pursuant to Article 18 of the Waste Act, the burning of waste from normal activities in Finland's water area and economic zone is prohibited (Waste Act 646/2011). However, part of the waste generated at the sawmill ended up in the container intended for incinerable waste. The interviewees had different ideas about the problem of burning waste at the power plant, and it is possible that the interviewees did not know that burning waste is prohibited by law and an activity against the environmental permit. With clear instructions and staff training, it would be possible to make the sorting more efficient so that no other material besides wood waste would end up at the thermal power plant.

Plastic recycling possibilities had already been investigated in the company before, and some of the interviewees were interested in sorting the plastic generated in production. At the moment, the responsibility of the producer of plastic packaging only applies to the packaging that has been put on the market, so the waste caused by the company's packaging does not belong to the separate collection of plastic packaging. (Sumi Oy n.d.) However, at different stages of production, other packaging plastics are also produced, which are covered by producer responsibility for plastic packaging and could thus be sorted. The collection of packaging waste is also supported by the Producer Responsibility Act, according to which the producer of the packaging bears the costs of waste management. Waste sorting and separate collection can therefore also be financially profitable for the company because no transport or waste

treatment fees are charged for emptying the packaging waste container, unlike the collection of energy or mixed waste.

Because of the low waste station fees, it may be reasonable for the companies to take the surplus materials to a waste station rather than sort them. However, possible new national or EU-level requirements and legislation may impose obligations regarding recycling or the use of materials, in which case the demand for recycled materials may also increase and the economic benefits of sorting may be highlighted. (Helo et al. 2021, 17.) It is possible that one of the reasons for the insufficient sorting at the sawmill is that the fees for mixed waste have been moderate so far, and sorting has not seemed economically profitable. Apart from the fact that waste management and sorting should be handled as required by law, the economic aspect is also a good motivator for sorting, as the price of companies' waste processing also might affect the willingness to sort. The circular economy can not only improve the company's efficiency, but also achieve financial savings (Sorasahi & Sinervo 2019).

According to EU’s Circular Economy Action Plan (CEAP), separate collection of waste is a requirement for high-quality recycling. To achieve this, the European Commission intends to propose a harmonization of the separate waste collection system. For example, the purpose is to create common colours for waste containers, harmonized symbols, and information campaigns to facilitate consumer participation. (European Commission 2020, 15.) For this reason, it is justified that the appearance and symbols of the waste containers are unified also in the Otava sawmill, and it is recommended that information concerning waste management and source separation will be given for the employees to achieve efficient sorting.

In the operations of the forest industry, sustainability is at the centre of the entire production chain, and new sustainability commitments were last made in November 2022. Well-managed sustainability and environmental issues are a competitive factor for the industry in question. (Metsäteollisuus 2022a.) In the interim report on sustainability commitments from 2022, it is stated that in the

forest industry, production side streams are effectively utilized in own processes or in industrial symbioses, which has made it possible to minimize the amount of landfill waste. (Metsäteollisuus 2022b.) Based on the interviews, however, challenges have also been identified at other Versowood sawmills and production facilities in the large amount of mixed waste and the inefficiency of waste sorting. For this reason, the waste plan designed for Versowood Otava sawmill was made in such a form that, with small changes, it would be possible to implement in other Versowood branches as well. If waste sorting were made more efficient at all branches in Finland, this would not only promote the fulfilment of sustainability commitments, but also provide financial benefits for the entire Versowood Group.

A study conducted in a Finnish office environment revealed that waste handling and sorting practices are mainly formed by three factors: the physical facilities for sorting, the staff's knowledge of sorting, and routines and attitudes. An example of routines and attitudes affecting the waste sorting willingness, is when a person justifies their lack of sorting by the belief that there not so much waste generating in the property. Therefore, to change the practices, it would be necessary not only to improve the recycling infrastructure, but also to increase the competence and knowledge of the personnel, and to develop the attitudes and atmosphere. (Penttinen 2023, 2–5) To change behaviour, it is crucial to identify the factors that slow down or even prevent the change, so that it is possible to intervene them. The causes of behaviour are often complex and multidimensional, and this is why a deeper understanding of them is important. (Pudas 2023, 8.) When considering the atmosphere of the sawmill's attitude towards waste sorting and legal requirements, it is possible that the attitudes might inhibit the success of waste sorting. Therefore, by motivating employees and sharing information, waste sorting would more likely be successful.

When evaluating the reliability of the results, it is good to note that the observations were carried out by one person during only one month. More frequent observations would increase the reliability of the study and give a more realistic idea of the current state of the waste management in Otava sawmill. Observations at different times during the year would also give even more

reliable results. If more people were to participate in the observations, attention could be paid to different things and increase the information obtained.

The observations may have been influenced by the fact that there was an extension of the thermal power plant building in the sawmill area during the research. Temporary waste pallets had been placed for the waste generated from this activity. When making observations, an attempt was made to consider the influence of the construction site was when analysing the research results. However, appropriate containers and instructions should have been arranged for waste generated from construction, which would have enabled sorting also in special situations.

7 CONCLUSIONS

In recent years, waste legislation has been updated and the requirements for companies have also tightened. It is likely that the requirements concerning waste management will be tightened even more in the future, but it is possible that incentives will also be made for companies to update and improve the efficiency of their waste management. It is important for companies to clarify the status of their own waste management so that they are also prepared for future requirements and changes.

The state of the sawmill's waste management could be studied more in the future. To obtain accurate information on the contents of different waste containers, a more detailed waste survey could be carried out, specifying the types, composition, and quantities of the generated waste. This would also provide the company with accurate information on which types of waste they must sort as required by law. The clarity of the sawmill's waste management and the success of sorting would probably also be supported by guidance and accurate requirements from Versowood Group. In the future, it would be interesting to find out how the changes made in waste management have affected the success of sorting and the amounts of waste generated.

Based on observations and interviews, it was concluded that the company's waste management needs to be clarified, but the attitude towards compliance with legal requirements also needs to be developed. The attitudes of sawmill employees regarding sorting would also be a good research topic for the future.

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