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The potential of wood residue streams for industrial wood pellet production in the Baltic Countries and Poland

An assessment of the potential of wood residue streams for the production of industrial certified pellets for the Baltic Countries and Poland

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The potential of wood residue streams for industrial wood pellet production in The Baltic Countries and Poland

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Executive summary

Currently most solid biomass in the European Union (EU-27) is made from high grade secondary¹ wood residues, e.g. clean saw dust and wood chips. The demand for solid biomass is expected to keep on growing. However, the potential of high grade secondary wood residues is limited and alternative biomass sources need to be mobilized.

This study, identifies and assesses the potential of low valued residue streams for the Baltic Countries and Poland, that can be used for the production of industrial certified wood pellets. A statistical approach is used on a country level, based on the current production of primary wood and secondary wood products and the amount of tertiary residues. Secondly, the statistical approach is complemented with empirical data from selected industries and regions in each country to identify gaps or errors in the available statistical data and improve the level of detail in the resource assessment. To identify the wood streams and unused residue streams in the Baltic Countries and Poland, a wood balance² has been made of the wood industry. Further, expected future developments in the wood sector were included to assess the long term potential, and two empirical cases show the costs of mobilization. The wood processing industry is divided in the following industries/product types:

- Wood processing industry sector (sawmilling, veneer peeling, pulp and paper production and wood based panel production)
- Other wood industry (furniture production, construction materials, packaging materials and other wood products)
- Post-consumer wood (PCW) includes all sorts of materials which are available at the end of life of wooden products.

Figure 1 shows the resource balance for Poland in 2010. Both processes which produce and use wood residues are identified. Figure 2 presents the residue balance, with the current production and use of wood residues, and shows the technical potential for unused residues in the Baltic Countries and Poland combined, to be 5.2 Mm³, largely consisting of tertiary residues. The results of the wood residue balance shows that secondary residues from the wood processing industry are to a large extent, already used.

¹ Secondary residues are residues which are released by processing of primary wood.

² The wood balance matches the input of wood with the output of primary products and residues and the current use of residues.

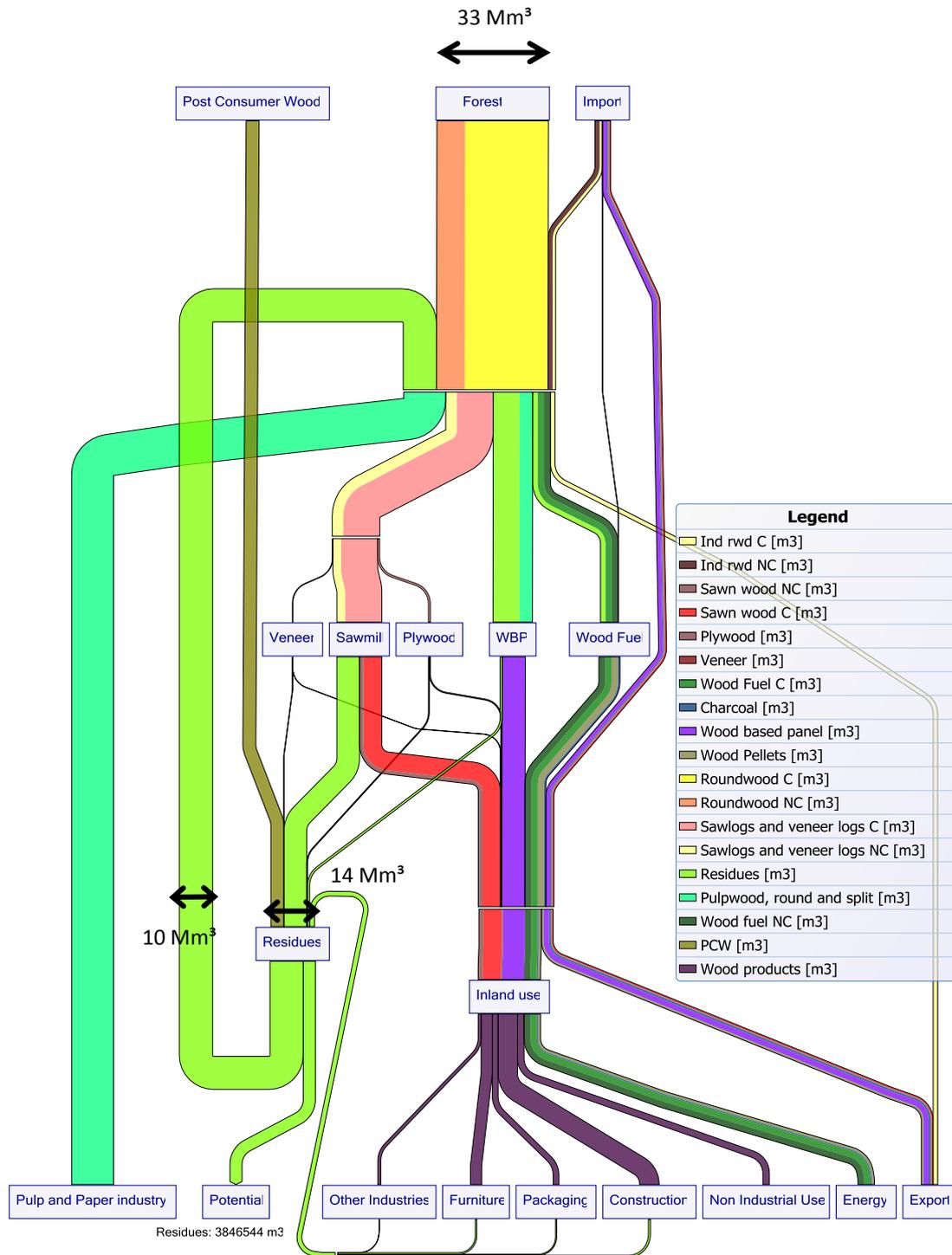


Figure 1 Wood resource balance Poland 2010

On the long term, the wood markets in Poland and the Baltic Countries are expected to grow significantly. However, the growth of the residue potential is not linear due to more efficient processes and different product outputs. Figure 2 also presents the potential for 2030, the potential is estimated to rise 25%, to 5.9Mm³ in 2030.

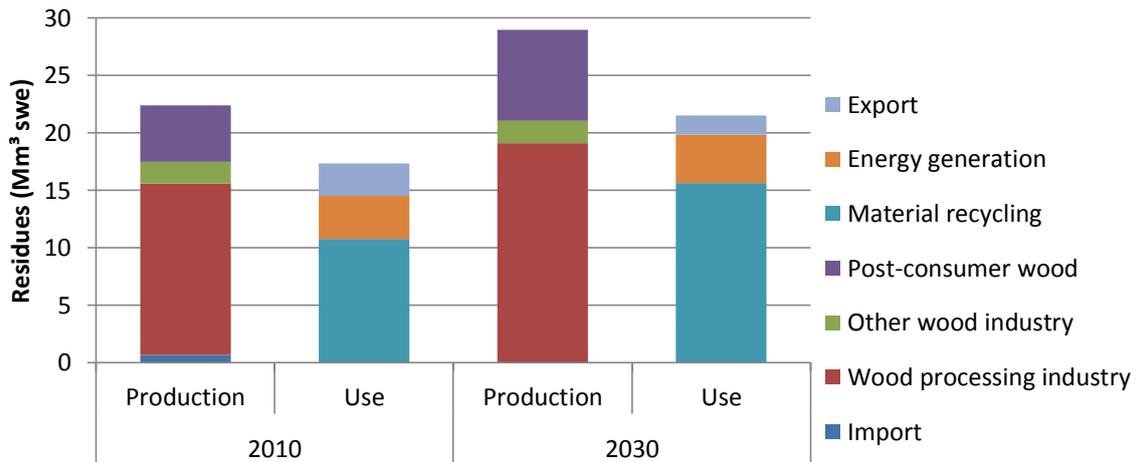


Figure 2 Production and use of residue streams per category in the Baltic Countries and Poland for 2010 and 2030

Figure 3 presents the production and use of residues per country. The largest technical potential of unused wood residues is available in Poland. The potential of tertiary residues in Poland was estimated to be 3.68 Mm³ swe and all secondary residues are already used in this region. In Lithuania, the technical potential is 0.36 Mm³ swe, unused tertiary residues account for 70% of the potential. The technical potential for Latvia is 0.68 Mm³ swe, where unused tertiary residues account for 33%. The potential in Estonia is insignificant, as current residues are to a large extent already used, and large amounts residues (including possible chipped roundwood, sold as residues) are exported. As Estonia is still expected to export large amounts of residues, the potential is expected to remain insignificant in 2030.

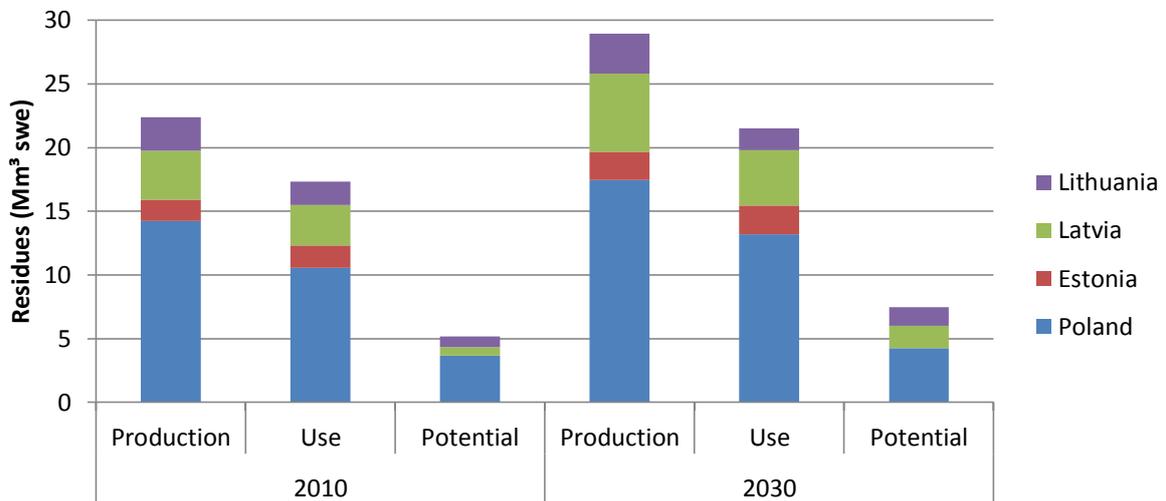


Figure 3 Production and use of residue streams per country in the Baltic Countries and Poland for 2010 and 2030

It can be concluded that at this point, there are not large amounts of unused secondary residues in the Baltic Countries and Poland. Residues are available, but they mainly consist of tertiary residues, which are (at this point) to a large extent not mobilized. However, little information is available on the technical availability and quality of this stream, and it may need extensive treatment before it can be used for wood pellet production.

Foreword

This report presents the results of my master thesis, which I conducted as a final part of the master program Energy Science at Utrecht University, the Netherlands. I would like to thank my examiner, Martin Junginger, from the Copernicus Institute at Utrecht University, for providing supervision and the opportunity to work on this project. Also, thanks go to Pjotr Schade from Everest Energy and Steven Meyers from Fram Renewable Fuels, for their review of my work and the opportunity to contribute to the Inbio project.

Expert interviews were an important part of our research. I am very grateful for the assistance of the hosting institutes, who supported me during a 6 week field trip to Poland (BAPE in Gdansk) and Latvia (Ekodoma in Riga). Therefore I would like to thank Katarzyna Grecka, and Andrzej Szajner from BAPE, and Līga Ozolina from Ekodama. I also thank Andrzej Schlezer, Pjotr Neubauer and Łukasz Mejsner from the Regional Directorate of the Polish State Forest in Gdansk for providing extensive information of the Polish forest, field trips into the forests and providing interpreting assistance during interviews.

Many others were involved, providing useful data and/or information for this project via phone interviews and email. Thank you all.

Last but not least, special thanks go to my daily supervisor Ric Hoefnagels for his critical reflection and support during the project. Ric managed to stimulate my mind, even when the results of the project looked at some point not very promising. Thanks!

Abbreviations and definitions

C	Coniferous wood - softwood
EFISCEN	European Forest Information SCENario model
FAO	Food and Agriculture Organisation of the United Nations
IEA	International Energy Agency
m ³ rwd/m ³ product	Describes the m ³ of roundwood needed to produce one m ³ of product
Mm3	Million cubic meters
Mtoe	Million Tonnes Oil Equivalent
NC	Non-coniferous wood – hardwood
odt	Oven dry tonnes
PCW	Post-Consumer Wood
RR	Recovery Ratio
rwe	Roundwood Equivalent
RS	Residue share
swe	Solid Wood Equivalent
TAC	Total Annual Cuttings
USE	Use, refers to potential that is currently utilized
UNECE	United Nations Economic Commission for Europe
WBP	Wood Based Panel

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1 Introduction

Bioenergy is traditionally a regional form of energy, particularly in developing countries where people still rely on local biomass for their daily energy needs. But there has been a growing interest in modern bioenergy in industrialized countries. In the context of growing concerns on greenhouse gas emissions and energy security, large amounts of bioenergy have been mobilized in the past decade. Bioenergy in the form of biomass, both from European as non-European sources, has increasingly devolved into a commercial form of energy and refined fuels. Bio-based energy for transportation (e.g. bioethanol and biodiesel), electricity production and heating (e.g. wood pellets and briquettes) have become widely available.

At this point, most solid biomass in the European Union (EU-27) is made from high grade secondary³ forestry residues, e.g. clean saw dust and wood chips, and is used for heat production, co-fired in coal fired power plants, medium sized combined heat and power (CHP) plants and small scale stoves). The European Commission (EC) has set ambitious targets in order to increase the use of renewable energy sources up to 20% in 2020 (EC, 2009), where biomass is expected to play an important role.

A growing number of countries claim in their National Renewable Energy Action Plans (NREAP), that they aim to reach these targets by using a large share of bioenergy in their production portfolio (EC, 2011). Therefore, the demand of biomass for heat and electricity production is expected to increase. However, the potential of high grade secondary forestry residues is limited, and alternative biomass sources need to be mobilized. While dedicated wood stocks (e.g. short rotation crops like willow) are expensive and are under debate due to competition with material and land use (Chum, et al., 2011, p. 85), a possibly great potential is still available in unused wooden waste materials.

1.1 Background information

There are a lot of unused (low value) residue streams from woody biomass production, processing and end-of-life scrapping as confirmed by top-down studies. E.g. Mantau (2010) found a total of 169 Mm³ of residues for the EU-27. The use of, amongst others, new advanced cleaning processes makes it possible to utilize these streams. However, it is mostly unknown which residue streams are potentially available, in what quantities and what they are currently used for.

In the state Georgia, United States, the potential of unused residues is already recognised. Three unused waste streams are converted into industrial pellets (on a lab-scale), and test results look promising. The recognition of the availability of unused residue streams in the state Georgia, United States, has led to

³ Secondary residues are residues which are released by processing of primary wood.

the initiation of the Inbio project. In the Inbio project, a cooperation of a biomass trader (Everest Energy, project developer), a certification company (Control Union and US pattern) and Utrecht University (Copernicus Institute) are aiming *to develop a new biomass stream, made from “urban wood” and other waste streams, and create economic, certified industrial wood pellets⁴ for large scale production for co-firing in coal fired power plants*

“Urban wood”⁵ is biomass, not sourced from new roundwood, but made from residue streams. The low value waste streams may not directly be suitable for the production of industrial pellets. Some of the streams might be contaminated (e.g. with sand, plastic or metal), but a new advanced cleaning process, enables the use of these streams. “Low value” refers to the competitiveness with other applications of the waste streams, low value streams are not, or only occasionally used for other applications or put on market below market value.

Possible low value waste streams include secondary residues from making poles for telephone and electricity lines (pole peelings), residues for processing (fines, dust, sawdust), and tertiary residues like disposed wood waste (e.g. disposed shipping pallets), so-called post-consumer wood (PWC).

To develop this new biomass stream, insight is needed into the available potential. Current studies recognise the possible potential of the residue streams (Mantau, 2010), (Vis, et al., 2010) but show little detail of the potentials of these specific streams. Modelling approaches do not account for the widespread possibilities for these sources. Statistic information about the potentials is either unavailable or not specific enough and the quality of the data varies per country. Regions are too large without information on local levels and different sources of residue streams are not specified. According to Vis et al. (2010) statistical data of individual countries and the EU do not match. Furthermore, data on the available potential (and use) of post-consumer (urban waste) wood (PCW) is limited. For residues generated by the processing of wood, conversion efficiencies are the main source of uncertainty. Moreover, the availability of these residue streams could be scattered over a large region, which makes the mobilization difficult and expensive.

1.2 Goal and problem definition

Within the Inbio project, the Copernicus Institute researches the possibility for (global) utilization of low value residue streams. This research focuses specifically on the Baltic Countries and Poland. The goal of this master thesis is *to assess the potential of a selection of low valued residue streams for the Baltic Countries and Poland, that can be used for the production of industrial certified wood pellets.*

⁴Used sources are to be residue streams, not round wood, and usable in industrial equipment for the generation of heat. Certification constraints are not yet clearly formulated in the Inbio project.

⁵ “Urban wood” as defined in the USA, includes various biomass streams; “Urban wood is the portion of the wood stream that can include sawn lumber, pruned branches, stumps, and whole trees from street and park maintenance. The primary constituents of urban wood are used lumber, trim, shipping pallets and trees”. Major sources of “urban wood” waste in the US include the wooden part of municipal solid waste (MSW) and construction and demolition (C&D) waste.

Research questions:

- What is the current wood resource balance⁶ of the Baltic Countries and Poland?
- Which low value woody biomass residue streams exist in the Baltic Countries and Poland, which are not, or only occasionally, used for other applications?
- What is the current technical potential of the existing low value woody biomass streams in the Baltic Countries and Poland, and what is the availability of this potential throughout the year?
- What are the costs of the mobilization of the biomass residues, and transportation of the pelletized biomass from the Baltic Countries and Poland to the Rotterdam harbour?
- What are the expected future developments for the long term (post 2030) technical potential?

This report will first discuss the used methodology and scope of the research. The third chapter, input data, presents the used data as basis for the analyses. Chapter 4 gives an overview of the current wood industry, describing the input output and use of wood and wood residues for each country. Chapter 5 provides more detailed analyses of the potential of wood residues, including future developments and economic availability. Chapter 6 presents an analysis of the sensitivity of the input parameters. In the discussion (chapter 7) the key limitations of the methodology and used input parameters are discussed and the results are compared with other studies. In the conclusion, the research questions are answered and recommendations for further research are presented.

⁶ A wood resource balance describes (and matches) the production, use, imports and exports of all wood streams in a selected region(s)

2 Methodology

This chapter describes the scope, methodology and required parameters to determine the potential of biomass residues in the selected regions.

2.1 Scope

2.1.1 Time

The primary focus of this research is on the current situation of the use and potential of residues in Poland and the Baltic Countries. However, an outlook is also provided for the technical potential of wood residues in 2030, based on the expected developments in the wood industries and the consequences for the production and use of wood residues.

2.1.2 Type of biomass resources

Wood residues can be categorized into three types of residues, based on product lifecycle phase of wood materials: primary forestry residues, secondary wood residues, and tertiary residues. This research solely focuses on secondary and tertiary woody residues that can be used as feedstock for the production of industrialized pellets. Primary forest residues, but also liquid and gaseous biomass (e.g. black liquor) and agricultural products, residues and waste are therefore excluded from the research.

Secondary wood residues are accumulated by two industries: the wood processing industry, and other wood industries. The wood processing industry sector covers the first step of primary wood processing. This includes sawmilling, veneer peeling, plywood production, pulp and paper production and wood based panel production. The wood processing industry uses roundwood, chips from roundwood and residues from processing, and produces finished and semi-finished wood products. The (semi) finished products of the wood processing industry are sawnwood, veneer sheets, plywood, pulp and paper, and all types of wood based panels respectively. Residues include various types of biomass: sawdust, cutter chips, square-cuttings, bark, slabs, lump wood residues and black liquor. The latter is not suitable for the production of wood pellets and is therefore beyond the scope of this research. However, to complete the wood resource balance, the wood consumption of the pulp and paper production is included.

Other wood industry describes the wood industry which further processes the (semi-finished) wood products from the wood processing industry, furniture production, construction materials, packaging materials and other wood products.

Post-consumer wood (PCW) includes all sorts of wooden materials which are available at the end of life of wooden products.

2.1.3 Mobilization

The costs of the mobilization of the biomass residues, and transportation of the pelletized biomass from the Baltic Countries and Poland to the Rotterdam harbour is only rudimentarily included in this research. Earlier research by de Jong et al. (2010) describes in detail what the preferred transportation corridors, costs and environmental consequences are for the transportation of solid biomass to the Rotterdam harbour from the Baltic Countries and Poland.

2.1.4 Region

The focus region of this research includes Poland and the Baltic Countries; Estonia, Latvia, Lithuania in Europe. Secondary wood residues are highly dependent on their parent sectors (forest cultivation and wood processing) and are directly related to the production. The Baltic Countries (Estonia, Latvia and Lithuania) and Poland have a high forest cover, a large wood industry (UNECE and FAO, 2011), and are currently among the biggest wood pellet producers in Europe (Bioenergy International, 2011). Further there is large land availability for bioenergy production (Wit & Faaij, 2008) and growing bioenergy production (Blumberga & Ozolina, 2009) (Erlickyte-Marciukaitiene & Marciukaitis, 2009).

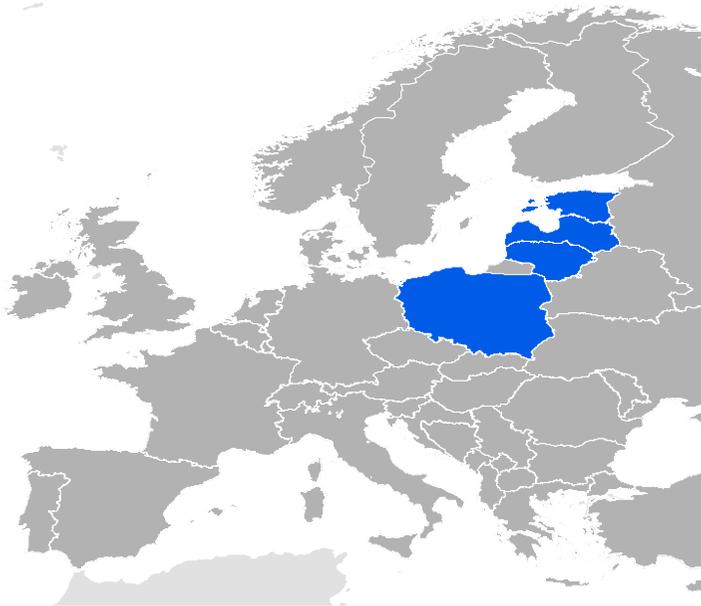


Figure 4 Focus region for wood residues

2.2 Resource assessment methods

Generally, methodologies to assess biomass resources can be divided in resource-focussed and demand-driven approaches. Resource-focussed approaches typically assess the theoretical and technical potential to produce biomass from a given feedstock, taking into account the demand for competitive products.

The statistical method is a resource-focussed approach in order to assess the technical potential of secondary wood residues, based on production data and simple statistical analysis. For this approach, (detailed) information on the wood processing industry is required, such as the conversion efficiency of the different wood industries.

When the statistical approach is combined with location specific information, it is called a spatially explicit method, and presents data on the availability of the resources for a specific location. This makes it possible to take location specific parameters into account that affect the availability of the biomass, such as:

- Consumption of unprocessed wood by the processing units
- Volume of final products in each unit
- Geographic data on location of the units,

The spatially explicit approach applies the data from the statistical method.

Demand driven approaches typically assess the economic potential and competitiveness of the biomass-based energy system compared with conventional energy systems. The cost-supply method is an example of the demand driven approach. The cost supply method assesses the economic potential of secondary wood residues, for a specific location/transportation distance, and compares the costs of secondary wood residues with the costs of alternative fuels.

Typical parameters to include are:

- Price of residues at facilities
- Price of alternative fuels
- Transportation distance
- Technical potential secondary residues (from e.g. statistical method)

To estimate the technical potential of unused residues, the statistical approach is used on a country level, based on the current production of primary wood and secondary wood products and amount of organic waste products. Secondly, the statistical approach is complemented with empirical data from selected industries and regions in each country to identify gaps or errors in the available statistical data and improve the level of detail in the resource assessment.

2.3 Statistical method

International timber production and trade statistics (e.g. UNECE/FAO/Eurostat) publish best internationally available data on wood removals, trade and production. Statistical data on the output of the wood processing industry is available and these statistics are bound to international definitions and classifications of commodities. Nevertheless, trade statistics do not cover the trade of wood residues and waste recovery streams. In the past, abundance of wood resources resulted in low demand for wood residues and are therefore also not included in the statistics. However, markets have changed and the wood residue streams have become an essential part of the total wood resources. Nevertheless, the statistical data available still does not include these wood residue streams or only in aggregated product categories.

Therefore, a wood balance has been made of the wood industry to identify the wood streams in the Baltic Countries and Poland based on statistical data combined with literature data and empirical data. The wood balance matches the input of wood with the output of primary products and residues and the current use of residues. In this way, the potential of unused residues can be determined (Vis, et al., 2010) (Mantau, 2010).

The available statistical information describes the total roundwood production, production of (semi) finished wood products, imports and exports in a certain country. However, to assess the residue production, the amount of input material has to be assessed first. Further, the statistical information may not be complete. It is therefore vital to check the sum of the production with the total roundwood resources.

In order to calculate the roundwood input and output of the different production steps in the wood industry, recovery ratios (RR) are used. A recovery ratio describes the number of units roundwood needed per unit of product produced. The recovery ratio is different for every product, factory, and country. Therefore, country and product specific information is used if available. If not available, data from neighbouring countries are used, according to the UNECE Country groupings with similar forest product sectors (Appendix A), or European averages.

The wood processing industry is divided in the following industries/product types:

- Wood processing industry sector (sawmilling, veneer peeling, pulp and paper production and wood based panel production)
- Other wood industry (furniture production, construction materials, packaging materials and other wood products)
- Post-consumer wood (PCW) includes all sorts of materials which are available at the end of life of wooden products.

2.3.1 Wood processing industry

2.3.1.1 Sawnwood residues

In the sawmilling industry, sawmills process sawlogs into beams and planks: so called sawnwood. This process uses round logs, where the output is (mostly) rectangular, and generates wooden residues. Following Vis et al. (2010), the production of residues from sawnwood processing, follows from the residue share and recovery ratio (RR).

In order to verify the statistic production volumes, all the product and semi-finished products are balanced with the total annual cuttings. The total amount of annual cuttings (TAC) is derived from the production volume using the recovery ratio (RR):

$$TAC_{\text{sawnwood},y} = P_{\text{sawnwood},y} / RR_{\text{sawmills},y} \text{ (Equation 1)}$$

Residues from sawnwood (R_{sawnwood}) follow from the residue share (RS), and the volume input, the total annual cuttings (TAC_{sawnwood}) per species (y):

$$R_{\text{sawnwood},y} = RS_{\text{sawmill},y} * TAC_{\text{sawnwood},y} \text{ (Equation 2)}$$

Part of the generated residues in sawmills are used internally, for process heat, and are therefore not part of the current potential. The residue share (RS) is therefore corrected by the internal use (I):

$$RS_{\text{sawmill},y} = 1 / RR_{\text{sawmill},y} - I_{\text{sawmill}} \text{ (Equation 3)}$$

2.3.1.2 Residues from wood based panel industries

The wood based panel industry can be split up in two categories: 1) plywood and veneer, made from roundwood, and 2) other wood based panels like MDF, OSB, hardboard and particle boards, made from wood chips and particles.

The total annual cuttings for plywood and veneer are derived from the production volume using the recovery ratio per species:

$$TAC_{\text{product } x,y} = P_{\text{product } x,y} / RR_{\text{product } x,y} \text{ (Equation 4)}$$

Residues follow from the residue share, and the volume input, the total annual cuttings per species:

$$R_{\text{product } x,y} = RS_{\text{product } x,y} * TAC_{\text{product } x,y} \text{ (Equation 5)}$$

Typical residues from sawmilling are sawdust, slabs and square cuttings.

$$RS_{\text{product } x,y} = 1 / RR_{\text{product } x,y} - I_{\text{product } x} \text{ (Equation 6)}$$

The method applied is similar for all product groups in the wood based panel industries. However, input material may consist of both roundwood and wood residues from other processes (e.g. sawmills, wood based panel production and post-consumer wood). To determine the use of wood residues, share of input materials (IS) is used, describing the share of residues in the input material.

$$R_{x, \text{input}} = IS * TAC_x \text{ (Equation 7)}$$

2.3.1.3 Residues from pulp and paper industries

Residues from the pulp and paper industry consist mainly of black liquor, which is primarily used internally for heat production. Since black liquor is not suitable for wood pellet production, it is outside the scope of this research. However, the pulp and paper industry can be a major user of wood resources, and in principle also use industrial wood residues. To complete the wood resource balance, in input of wood determined using: $TAC_{\text{product } x,y} = P_{\text{product } x,y} / RR_{\text{product } x,y}$ (Equation 4).

2.3.2 Other industrial wood residues

The wood processing industry produces (semi) finished wood products from roundwood. Further processing of (semi) finished wood products (e.g. sawn wood and wood-based panels), in the other wood industry, also accumulates wood residues. The processing of semi-finished and finished wood products delivers mainly residues like dust, shavings, trimmings, rejections or cuttings. Following (Mantau & Bilitewski, 2010), the theoretical potential of these residues can be determined based on residue share (RS) of the sector and the total wood product input (PI) per sector x:

$$R_x = RS_x * PI_x \text{ (Equation 8)}$$

The other wood industry is therefore divided into four sectors: construction, furniture, packaging and other industries.

However, statistical data on the wood product input is not recorded. An estimate can be made, using the expansion factor (EF) for wood consumption and the turnover of the sector (x):

$$PI_x = \text{Turnover}_x * EF_x \text{ (Equation 9)}$$

2.3.3 Postconsumer wood

Postconsumer wood (PCW) includes all kinds of wooden material that is available at the end of its use as a wooden product. Postconsumer wood mainly comprises of packaging materials, demolition wood, timber from building sites and fraction of used wood from residential, industrial and commercial activities.

In EUWood (Mantau, 2010) , PCW potentials are given for all European countries. Further, the Cost Action E31 project (Merl, et al., 2007), give the amounts of recovered wood in Europe based on an expert survey. Local studies, like Ratajczak (2004) and Dauge et al. (2007) give more detail about the local circumstances and potential sources of the recovered wood.

Further, Eurostat provides information about the packaging waste composition, including wooden packaging waste in 2008 (Eurostat, 2010). It is not possible to use other statistics on wood waste from Eurostat, because they are aggregated with secondary residues and biomass resulting double counting (Eurostat, 2011).

2.3.4 Conversion

In the wood resource balance, quantities are expressed in roundwood equivalents and solid wood equivalents. A roundwood equivalent calculates the input of roundwood needed for a (semi) finished product. For example, in order to produce a table, different processes are included in the production (sawmilling, panel production etc), and add up to the amount of roundwood needed for the production (Figure 5)

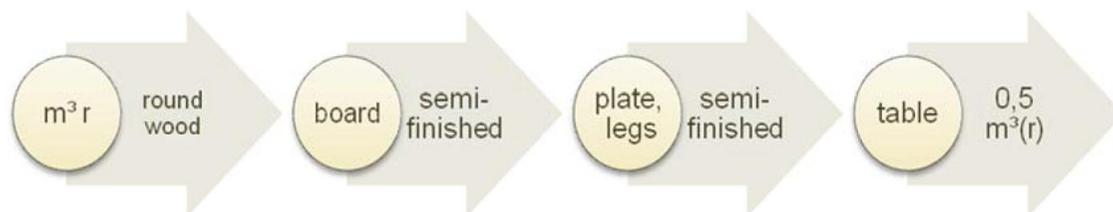


Figure 5 Roundwood equivalent (Mantau, 2010)

When calculating the amount of residues this is incorrect: to produce one m³ of residues, one would need three m³ of roundwood. Therefore, solid wood equivalent is used, describing the amount of wood that is transferred from one sector to another (Figure 6)

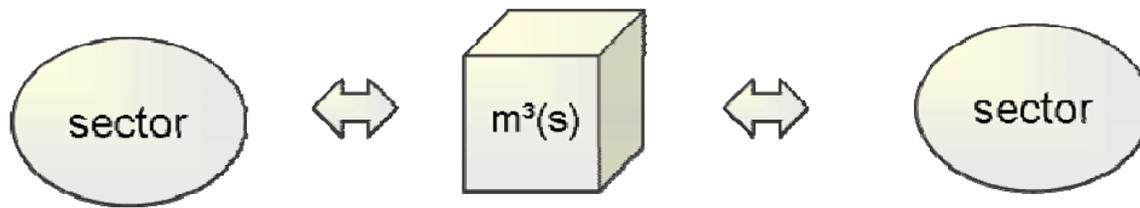


Figure 6 Solid wood equivalents

2.4 Empirical data gathering

Residues from wood processing are in principle a low value wood resource. In the past, general abundance of wood resources resulted in low demand for wood residues and the wood residues were therefore also not included in the statistics. In the last decade, the rising wood pellet market, and the change of resource in the wood based panel industry has changed this. Even nowadays, few or no statistics are available, and are aggregated for the whole industry. Volumes may change depending on different factors (as described above). Therefore, groundtruthing of existing statistics and estimates is necessary to increase the reliability of the research. This section describes the methodology used during the empirical research, which consisted of three main stages: the stakeholder analysis, the field trip and the questionnaire.

2.4.1 Stakeholder analyses

The availability of wood residues is highly dependent on the presence of the respective parent sector. This means that areas with high activities in the wood sector will automatically have a high residue generation. Furthermore, smaller wood processing companies tend to source their wood locally, typically within a 50 km radius, indicating that regions with high afforestation would have a high residue production.

Various sources (Bioenergy international pelletmap, Pellet@tlas country reports, local wood producing industry association, chamber of commerce, alibaba, sawmilldatabase.com) provide information on the location of wood the wood processing industry and the other wood industry. All the known stakeholders are therefore visualised in a map of the country.

2.4.2 Field trip and Interviews

For the resource assessment of low-value biomass streams in the Baltic Countries and Poland a site visit has been conducted to Poland and Latvia. The aim of the visit was to meet with umbrella organizations and stakeholders for data and information on the top-down assessment of biomass resources and to interview companies in wood processing industry sectors in the supply regions. Company interviews were initialized, aiming to:

- Verify the used parameters in the resource balance

- Verify the statistical input data
- Gain insight in future developments
- Identify barriers in the use of residues for industrial wood pellet production

2.4.3 Questionnaire

An important tool for empirical research is the questionnaire. Sending out a questionnaire is a one-time opportunity to acquire data from the stakeholders. The questionnaire should be complete enough to acquire all necessary data, but at the same time short enough to enhance cooperation. Hence, the questions are reduced to the essential aspects, so that respondents can relate to the questions in their daily routine.

The main aim of the questionnaire was to assess possible suppliers of wood residues and acquire bottom up data to match the top down assessment. To maximise the return of completed surveys, the following was done:

- Questionnaire was made online, such that anyone can access and open the questionnaire
- The length of the questionnaire was restricted to 6 questions, of which three were closed.
- Associations and corporations were contacted as much as possible to spread the questionnaire, and to exude confidence
- Partially completed questionnaires were accepted
- This final report was offered as an incentive for fulfilling the questionnaire.
- Finally, the questionnaire was translated to Polish, as many Polish entrepreneurs do not speak (sufficient) English to answer the questions.

Because some companies may have more production locations in multiple countries, the questionnaire clearly states to only answer for a single location.

The complete questionnaire is attached in Appendix B and Appendix C. A list of approached companies and other stakeholder is attached in Appendix D.

2.5 Costs of mobilization

This section presents the used methodology to determine the costs of mobilization of the residues, pelletization and transportation to Rotterdam. A cost supply method is used to assess the economic potential of secondary forestry residues, for a specific location/transportation distance. The costs of mobilization consist of four parts: feedstock costs, (costs of) transportation to the pellet plant, pelletization and the transportation to the destination.

Feedstock costs are acquired during the empirical research (section 2.4). The techno-economic parameters for the costs of pelletization are derived from the Swedish framework conditions in Thek and Obernberger (2004) as shown in (Hoefnagels, et al., 2011). The data is corrected for energy requirements (Europe's energy portal, 2012), inflation (Chemical Engineering, 2012) and labour costs (Eurostat, 2010).

Transportation costs are determined by the used transportation corridor and mode (e.g. truck transportation, rail transportation and sea shipping). The costs of transportation are assessed based on Jong, de et al. (2010), where an extensive analysis presents the costs of transportation from the Baltic Countries and Poland to the Rotterdam Harbour. The data is corrected for the fuel costs.

2.6 Future developments

The future potential of biomass residues depends mainly on the development of key determining factors. These include:

- Increase of roundwood production
- Changes in input material for production
- Optimization of production processes
- Optimization of internal use of residues for process heat
- Optimization of waste management

This section describes the changes in the methodology for the future developments in the production and used of residues in the Baltic Countries and Poland. The key determining factors shown above effect the wood processing industry and the production and use of PCW.

2.6.1 Future development in the wood processing industry

Secondary wood residue volumes grow with production. An increase in the production of roundwood from forest will, depending on the demand, increase the production of wood products. As the production of residues is dependent on the parent industry, this would lead to an increased residue production. Therefore, the expected growth in the primary wood industry gives an indication of the expected growth in the wood residue production.

Apart from primary wood products (roundwood), part of the wood industry (partly) uses wood residues or deliberately chipped primary wood as input material for their production. Western European wood based panel producers for example, already use a higher share of wood residues and PCW as input materials (Benthem van, et al., 2007). It is expected that producers in Poland and the Baltic Countries will shift more towards new input materials for the production of wood products. This could lead to a shift where more clean residues are available for biomass production. This research describes a full market overview, where production and use of residues are described separately. The potential of PCW is therefore already included in the production, and the total potential of residues would not change when clean residues are exchanged for PCW in the wood based panel industry.

The efficiency of the wood processing industry differs per country. The efficiency is dependent on the used technology and the quality of the input material. Western European countries generally have higher efficiencies, RR's, and use a different (mostly higher) share of residues in the input material. Similar development is expected in the Baltic Countries and Poland, where old machines will gradually be replaced by modern technology. For the future

developments, it is expected that the efficiency of the different industries will shift towards Western European standards. This would lead to a decrease in the production of wood residues.

The wood processing industry generally uses part of the generated residues to provide process heat. Boilers and processes were in general designed to eliminate/use the residues which, at that stage, had no destination. However, with the demand for woody biomass still increasing, the market value of these residues increases as well. Optimization of internal use of residues for process heat may therefore increase the potential of residues on the market. Future developments include more efficient boilers, and or a change of input materials, for example, by using bark and PCW instead of clean residues.

2.6.2 Future development of post-consumer wood

The EU Landfill directive 1999 introduces strict legislation and targets in the reduction of landfilling. As an example, figure 7 shows the development of the potential of PCW in Europe for the next decades. The total potential (POT) of PCW is increasing, but the share of disposed (DIS) wood is never zero, because there will always be a certain share of wood in the waste which is not recoverable, and therefore remains 5%.

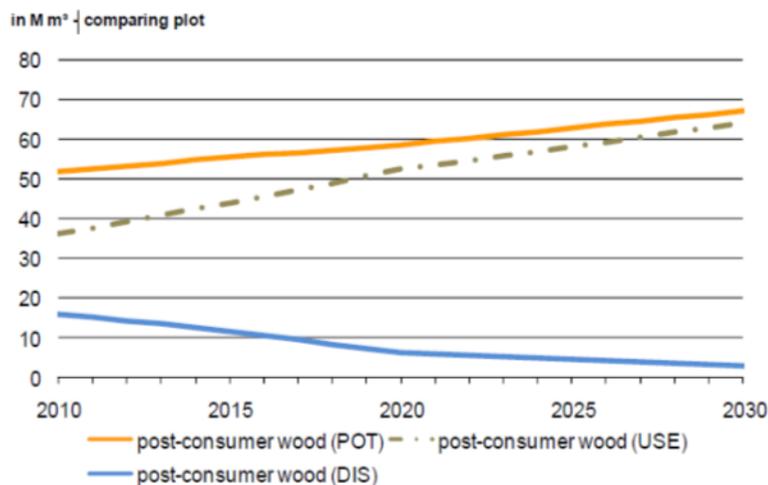


Figure 7 Future potential and use of PCW in Europe (Mantau, 2010)

In EUWood (Mantau, 2010), PCW potentials are given for all European countries for 2030, these are extrapolated based on current and future net use of sawnwood and the current potential of post-consumer wood. Further, Ratajczak (2004) provides an estimated growth of 9% for 2002-2015, based on empirical research.

3 Input data

This chapter presents the input data, used in the statistical method to create the wood resource balance as described in chapter 2. The input data is divided in the following industries/product types and data sources:

- Statistical data sources (general country statistics)
- Wood processing industry sector (sawmilling, veneer peeling, pulp and paper production and wood based panel production)
- Other wood industry (furniture production, construction materials, packaging materials and other wood products)
- Post-consumer wood (PCW) includes all sorts of materials which are available at the end of life of wooden products.
- Future developments in the wood industry

For each of the categories above, the input data is presented for Poland, and the Baltic Countries (Estonia, Latvia and Lithuania).

3.1 Statistical data sources

The basis for of the wood resource balance is the roundwood removals and the total production of wood products. FaoStat publishes yearly statistics on roundwood removals for countries and the production (m³/yr of tonnes/yr of finished products) of the wood products. Figure 8 presents the different categories of wood and wood products from FaoStat. The FaoStat statistics on wood products are used to determine the total annual cuttings and generated residues per wood product. In the wood resource balance, this is matched with the industrial roundwood removals.

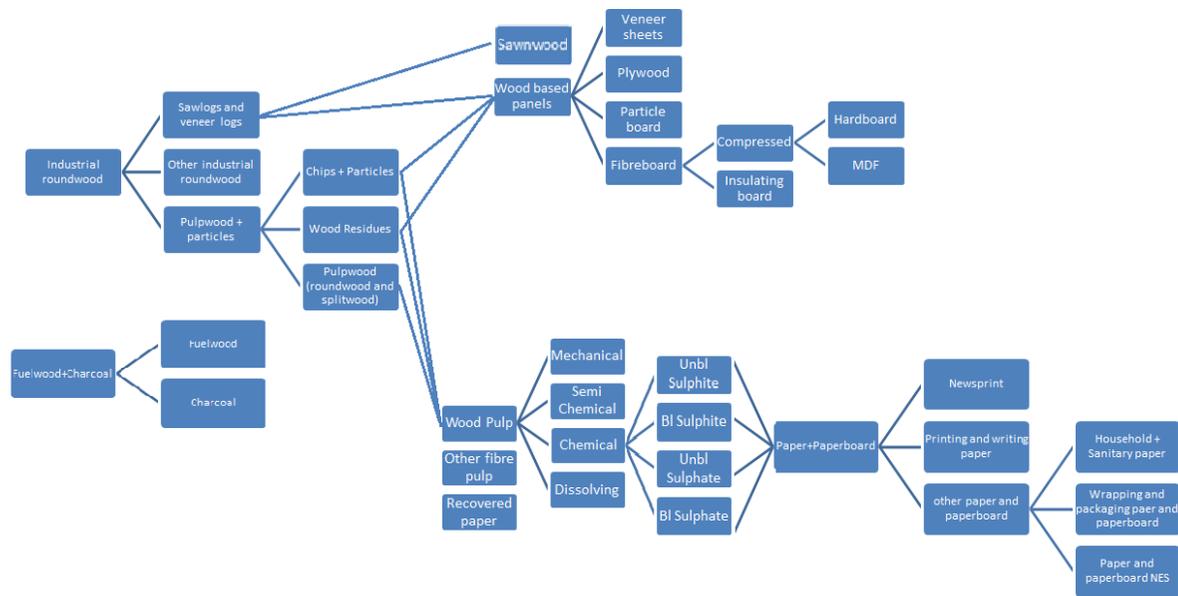


Figure 8 Wood streams in Faostat

Different input data has different units. Table 1 presents the used conversion factors for fresh wood.

Table 1 Wood conversion factors (Mantau, 2010)

From/to	Mm ³	Modt	PJ	Mtoe
Mm³	1	0.5	8.72	0.21
Modt	2	1	18.18	0.44
PJ	0.11	0.055	1	0.024
Mtoe	4.76	2.26	41.87	1

PCW has a lower moisture content than freshwood. An average volume to weight ratio of 1.67 is used.

3.2 Wood processing industry

The wood processing industry includes: sawmilling, wood based panel production, veneer peeling, and pulp and paper production.

3.2.1 Sawnwood

The figure below gives the number of sawmills per volume of output in Poland. Although the share of large sawmills is relatively small, the largest volume is produced by large sawmills.

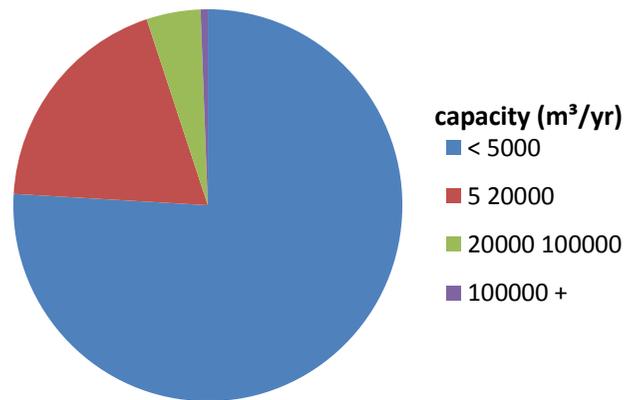


Figure 9 Number of sawmills per capacity in Poland in 2010, total 9000 business enterprises. (Acker, 2008)

Figure 10 presents the product outputs from sawnwood, veneer and plywood production. About 50% of the roundwood input is processed into product.

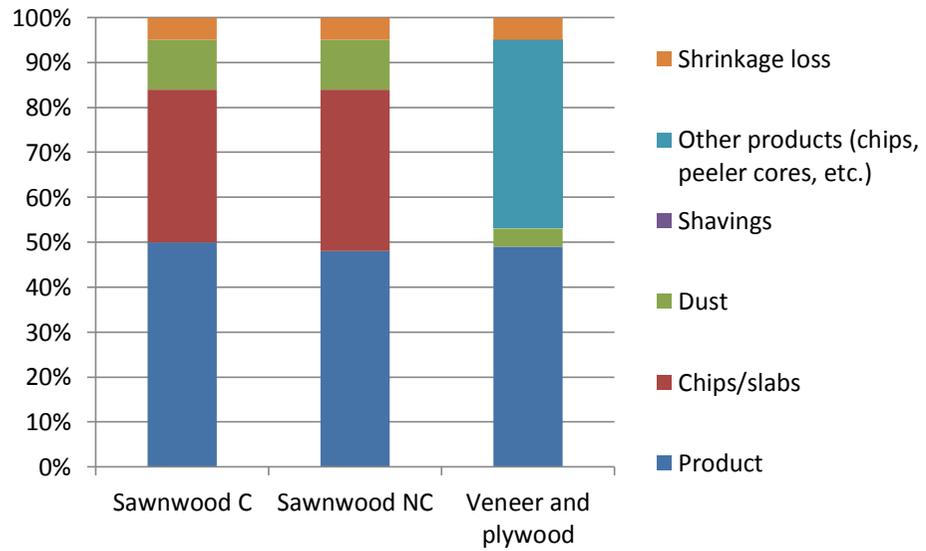


Figure 10 Average residue share and residue assortments from primary processing industry (Fonseca, 2010)

However, the recovery ratio (RR) is highly dependent on the used technology and quality of the wood: the more imperfections, the higher the recovery ratio. Therefore, the recovery ratio differs per country. Figure 11 presents the recovery ratio per country.

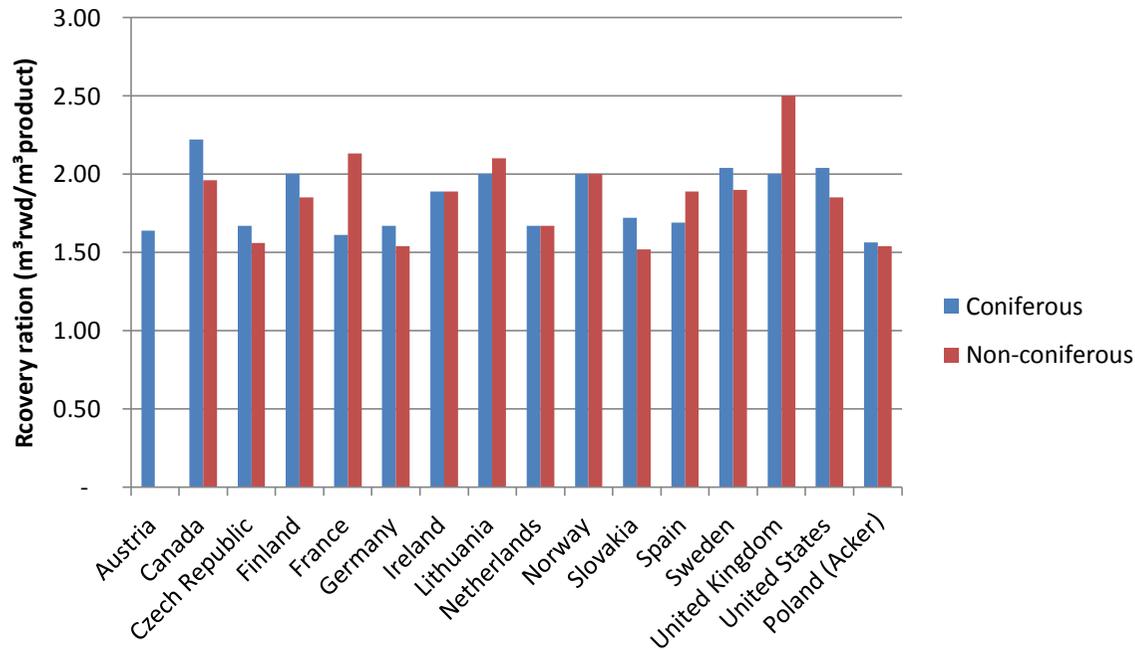


Figure 11 Recovery ratio per country for sawmilling (Fonseca, 2010) (Acker, 2008)

Table 2 below presents the selected recovery ratio for sawnwood production. Poland uses relatively old and inefficient wood processing technologies such as second hand machines imported from Germany. Also the quality of wood logs in Poland is heavily skewed to lower quality logs (Wegrzyn, 2011). The efficiency of the sawmill industry is therefore smaller than Western European countries. The recovery ratios of Acker (2008) are therefore not used. Instead, the recovery ratios of Lithuania are used for all four countries.

Table 2 Recovery ratio used sawnwood (m³rwd/m³product)

	(Fonseca 2010) Lithuania	(Acker, 2008) Poland (avg 2000-2005)
Sawnwood (C)	2.0	1.56
Sawnwood (NC)	2.1	1.54

3.2.2 Wood based panels

The production of wood based panels is more efficient than the production of sawnwood, as the input material consists of residues or deliberately chipped roundwood. Table 3 presents the recovery ratio for board production.

Table 3 Recovery ratio and residue share wood based panel production (m³rwd/m³product)

Source	(Mantau 2010)	(Fonseca 2010) Average	(Fonseca 2010) Lithuania	(Acker 2008) Poland	(Mantau 2010)
Product	Recovery ratio				Residue share
Particle board	1.48	1.51	1.57	1.6	3.94%
OSB	1.47	1.63		1.85	9.80%
MDF	1.8	1.68		2.2	9.61%
Hardboard		2.03			11.61%
Insulation board		0.83			4.75%

For Poland, country specific recovery ratios are used from Acker (2008). For hardboard and insulation board this was however not available, so the average values from Fonseca (2010) are used. For the Baltic Countries, the country specific recovery ratios for Lithuania are used, and complemented with the average values of Fonseca (2010). For the accumulated residues during production, the residue share from Mantau (2010) is used.

Wood based panel producers are a main user of residues in their production. According to Acker (2008) medium density fibreboard (MDF) production in Poland uses 80% raw forestry material. The remaining 20% is covered by industrial wood residues. For oriented strand board (OSB) production, 100% forestry raw materials are used.

Figure 12 shows the input material shares for particle board production. Poland, Estonia and Lithuania are not separately specified. For the Baltic Countries, the Latvian data from is used (Riet, 2005). For Poland, country specific information from Acker (2008) is used, stating that only residues are used in the production of particle boards (Table 4).

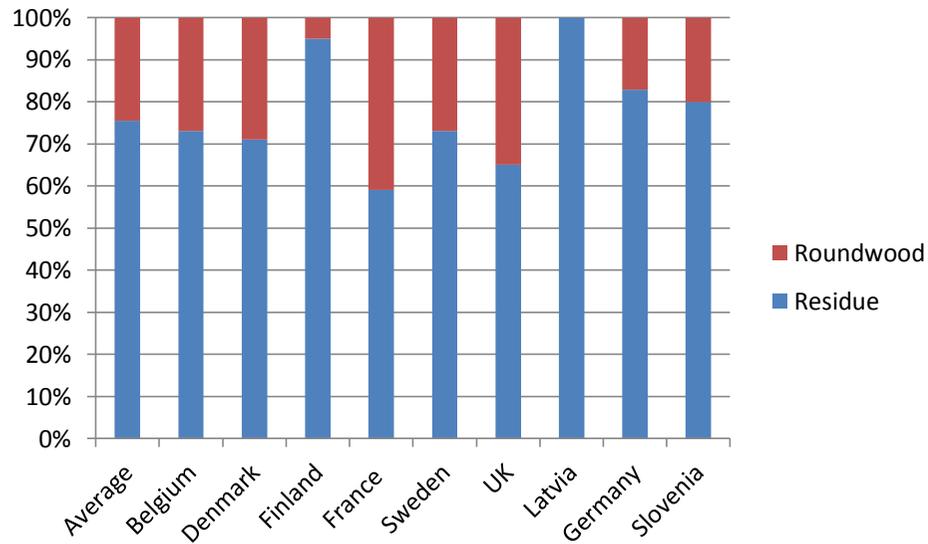


Figure 12 Input source raw material particle board production for selected countries (Riet, 2005)

Table 4 gives an overview of the used input shares for the calculations.

Table 4 Residue share input materials

Residue share input material	Poland	Estonia	Latvia	Lithuania
Particle Board	100%	100%	100%	100%
Hardboard	0%	0%	0%	0%
MDF	20%	20%	20%	20%
Insulating Board	0%	0%	0%	0%

3.2.3 Veneer and plywood

Veneer and plywood is made from (mostly non coniferous) roundwood, by peeling or slicing. Table 5 shows the recovery ratio for veneer and plywood production

Table 5 Recovery ratio for veneer and plywood production (m³rwd/m³product)

Source: Product:	Recovery ratio		
	(Mantau 2010)	(Fonseca 2010)	(Acker 2008) Poland
Plywood Total	1.85		
Veneer Total	1.735		
Plywood & Veneer total		1.87	
Plywood C		2.12	2.5
Plywood NC		2.31	2.2
Veneer C		1.92	
Veneer NC		2.55	
Plywood & Veneer C		2.02	
Plywood & Veneer NC		2.29	

In Poland: 85% of the produced veneers and 82% produced plywood is made from non-coniferous wood (Acker, 2008). Table 5 shows country specific information for plywood production in Poland, for veneer the European average value from Mantau (2010) is used. Production in the Baltic Countries more efficient, RR are based on the European averages (Mantau, 2010).

3.2.4 Pulp and paper

Although residues from pulp and paper production are not included in this research, the pulp and paper production uses part of the available wood resources. The use of wood is therefore included in the wood resource balance. Table 6 presents the used recovery ratio for pulp and paper production. No country specific information is available, and the recovery ratio is therefore based on the European average.

Table 6 Recovery ratio for pulp and paper products (Fonseca, 2010)

Pulp products	m ³ rwd/Mt
Semi-chemical	2.67

Chemical	4.49
Chemical Bleached	4.63
Chemical Unbleached	4.55
Newsprint	2.8
Uncoated mechanical	3.5
Coated paper	3.5
Sanitary and household paper	3.25
Packaging materials	3.25
Case materials	3.25
Folding boxboards	3.25
Wrapping paper	3.25
Other paper mainly for packaging	3.25
Other paper and paperboard	3.25

3.3 Other industrial wood residues

Other wood industry processes the (semi) finished wood product for furniture production, construction materials, packaging materials and other wood products. Statistics on the use of wood for these sectors are not available. Therefore, monetary data from Eurostat is combined with expansion factors to determine the use of wood products in these sectors.

Appendix A presents the turnover of the different industries in 2008. Expansion factors

table 7) are based on a study by Mantau & Bilitewski (2010) on the German situation. Combining this with the turnovers in the sectors given by Eurostat, gives the consumption of wood products by industry.

Table 7 Expansion factors wood consumption (Mantau & Bilitewski, 2010)

	Consumption (m ³ /100,000€)	Nace sector code
Construction	262.2	DD203
Furniture industry	43.3	DN361
Packaging industry	266.1	DD204
Other	115.7	DD2051

To determine the residues, accumulated during production, the residue shares of Mantau & Bilitewski (2010) are used, based on a detailed study on the residues of these sectors of the German situation. The residue shares are presented in table 8.

Table 8 Residue share of wood per sector (Mantau & Bilitewski, 2010)

Residue share per sector	
Construction	0.10
Packaging	0.18
Other	0.10
Furniture	0.13

3.4 Post-consumer wood

The potential amount of post-consumer wood (PCW) is based on existing studies. EUWood (Mantau, 2010), is used for the basic PCW potentials per country. The potential of PCW per country, and the share of material that is currently used, is presented in table 9.

Table 9 Potentials and share of different uses of post-consumer wood (Mantau, 2010);

	PCW [m ³ swe]	Share of different uses of post-consumer wood		
		Recovered for raw material	Used for energy	Not used
Poland	4,113,210	0.04	0.01	0.95

Estonia	195,390	0.15	0.10	0.75
Latvia	265,530	0.10	0.05	0.85
Lithuania	337,340	0.15	0.10	0.75

A local case study from Ratajczak (2004) provides more detail about the local circumstances in Poland. This study shows the potential of PCW in Poland for 2002 and 2015 (

table 10) and gives a detailed insight in the origin of the potential supply of PCW in 2002 (figure 13).

Table 10 Potential supply and application of PCW in Poland (Ratajczak, 2004)

m³ swe	2002	2015
Wood-based panels	1,850,000	1,744,000
Power Generation	3,100,000	3,706,000
Total	5,000,000	5,450,000

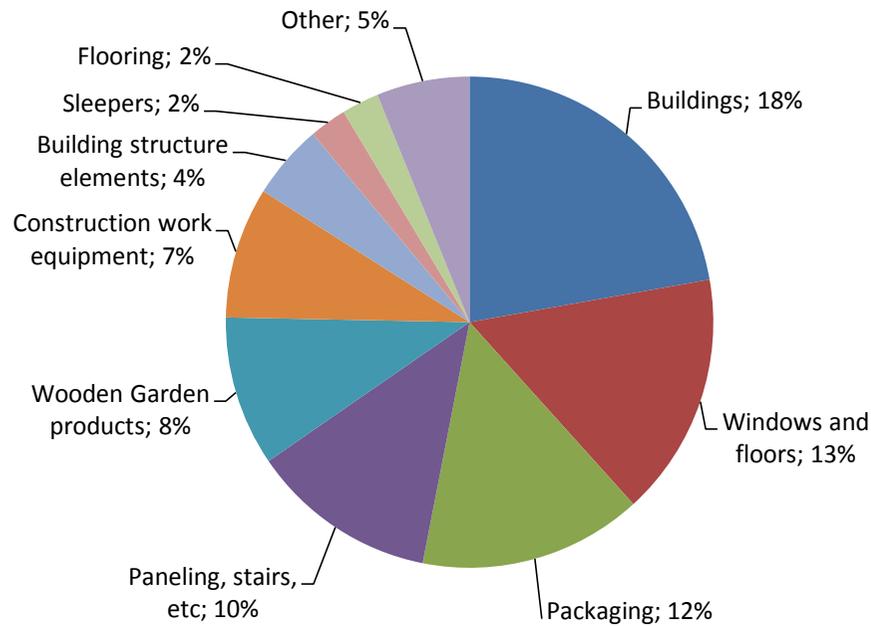


Figure 13 Supply of PCW in Poland, 2002 (Ratajczak, 2004)

Other studies, Cost Action E31 project (Merl, et al., 2007), and the Polish Biomass chamber of commerce (Sencyszyn, 2010), give the amounts of recovered wood in Europe based on an expert survey. Further, Eurostat provides information about the packaging waste composition, including wooden packaging waste in 2008 (Eurostat, 2010). This data is presented in table 11.

Table 11 PCW wood potential Poland

m ³ swe	Merl 2007	Eurostat wood packaging waste 2008	Polish Biomass Chamber of Commerce 2004
Recycling	72,478	140,419	
Energy	10,354	391,314	
Unknown/Not recovered	429,691	594,203	2,505,000

Others		12,410	
Total	512,523	1,138,345	2,505,000

3.5 Costs of mobilization

Table 12 presents the cost parameters for pelletization, based on Thek and Obernberger (2004), updated for 2011.

Table 12 Costs parameters for pelletization

Parameter	Unit	Pelletization
Scale	t/h	3
Load Factor		0.7
Capital	M€	3
	€/t ¹	15
O&M (fixed)	€/t	4
Labour	€/t	19
Other costs	€/t	0.6
Electricity	MJ/t	533
Heat	MJ/t	2,649

¹ Lifetime = 20 years, Discount rate 7%

Country specific parameters for fuel costs are presented in table 13.

Table 13 Fuel costs for Poland and Latvia in 2012

€/MJ	Poland	Latvia	Source
Electricity	0.0276	0.0263	Europe's Energy Portal (2012)
Diesel	0.0367	0.0343	Europe's Energy Portal (2012)
Natural Gas	0.0099	0.0092	Europe's Energy Portal (2012)
IFO 380	0.0109		Bunkerindex (2012)

Labour costs differ significantly per country. Table 14 presents the labour costs for the relevant countries (Eurostat, 2010). Germany and the Netherlands are included as an example for the difference with labour costs in Eastern Europe. As can be seen in table 14, labour costs are much lower in Eastern Europe. Therefore, it will be assumed that for road transport transportation companies will use in the transportation of biomass the truck drivers from the producing countries.

Table 14 Labour costs (euro/hour) for several countries (Eurostat, 2010)

Country	Labour costs (€/hour)
Poland	7.94
Latvia	5.35
Estonia	7.59
Lithuania	6.41
Germany	27.54
Netherlands	29.49

3.6 Future developments

This section presents the input data for the estimated future developments in the production and use of wood residues for 2030.

3.6.1 Wood processing industry

Future developments are based on the developments in the forest sector, and wood industry. Appendix A presents the expected growth in both the forest sector and the wood industry, according to the UNECE and FOA (2011). Further, the recovery ratios are expected to be at the level of current Western European standards, presented by Fonseca (2010).

3.6.2 PCW

For the future developments of PCW, future trends are provided in the EU Landfill directive (EC, 1999). The directive was set up “to prevent or reduce as far as possible negative effects on the environment from the landfilling of waste, by introducing stringent technical requirements for waste and landfills”. A shift to more waste recycling and incineration is expected, lowering the amount of wood ending up in landfills.

The potential amount of post-consumer wood (PCW) is based on existing studies. EUWood (Mantau, 2010), is used for the basic PCW potentials per country in 2030. The potential of PCW per country is presented in table 9.

Table 15 Potentials and share of different uses of post-consumer wood (Mantau, 2010)

PCW [m ³ swe]	2010	2030
Poland	4,113,210	6,700,000
Estonia	195,390	300,000
Latvia	265,530	400,000
Lithuania	337,340	500,000

4 Wood industry input, output and use

This section describes the wood industry in the three Baltic Countries and Poland. First a complete resource balance gives a summary of all the wood flows in the region. The balance is build using the statistical approach, describes in section 2.3. Per country, the input, output and use of wood is described for the following industries/product types:

- Wood industry sector (sawmilling, veneer peeling, pulp and paper production and wood based panel production)
- Other wood industry (furniture production, construction materials, packaging materials and other wood products)
- Post-consumer wood (PCW) includes all sorts of materials which are available at the end of life of wooden products.
- “Wood pellet market” describes the current wood pellet market and their material use

The geographical overview of stakeholders shows where the wood industry is located within the selected region. It identifies possible “hot spots” over the different wood industries.

4.1 Poland

Figure 14 below presents the current wood flows in Poland. The total roundwood production in Poland was just over 33 Mm³ in 2010. The main roundwood products are coniferous pulpwood (11.5 Mm³) and coniferous sawnwood (10.8 Mm³). 4% of the roundwood is directly exported, the total import accounts for 7% of the total roundwood production. In Poland, 90% of the forests are state owned, by the Polish State Forest. Wood is brought to the market via an auction system. After World War Two, the forest cover of Poland was about 20%. In the last 60 years this has gradually been increasing until now, when the forestation of Poland is 29%, the increment of the Polish forests is still high.

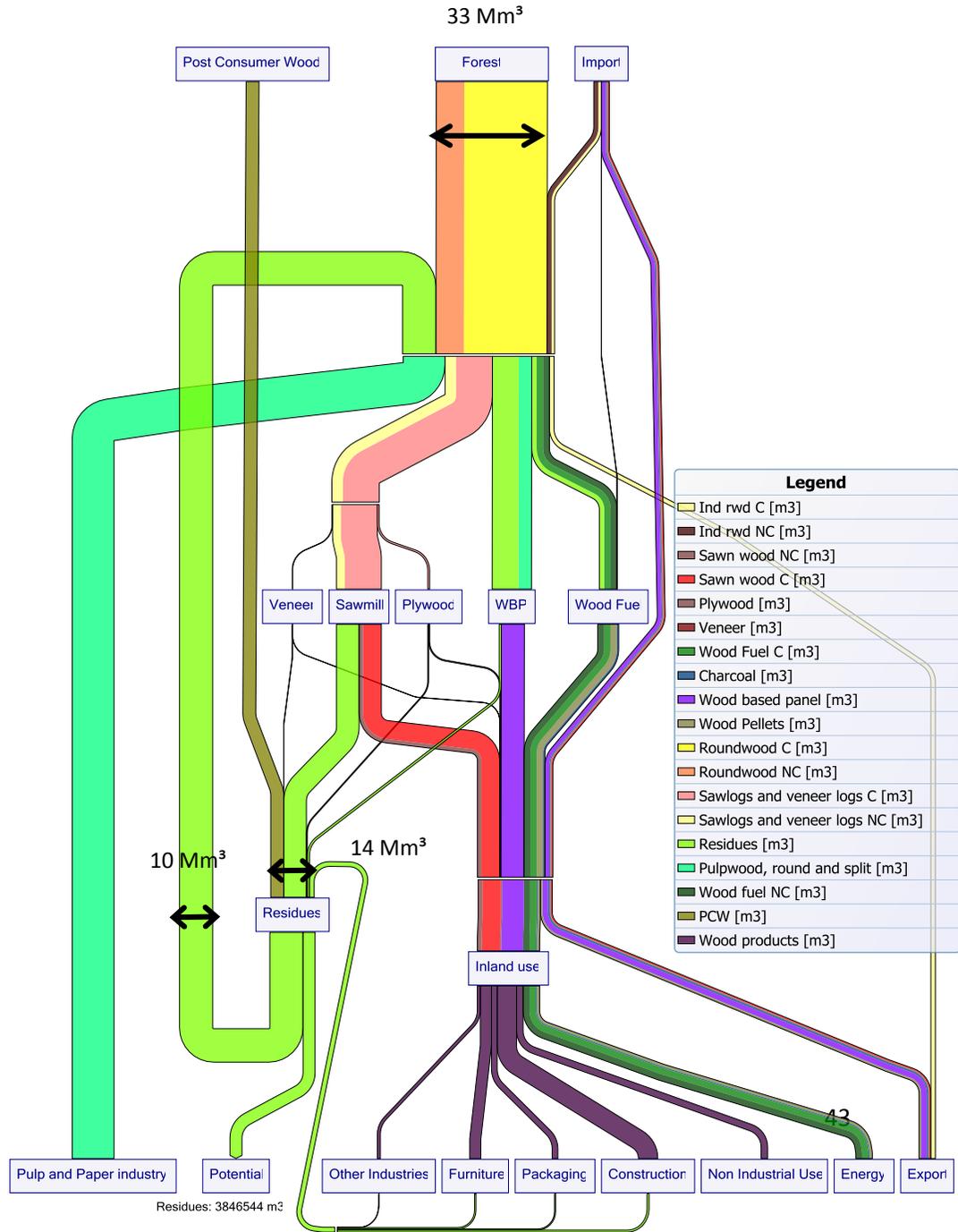


Figure 14 Wood flows in Poland (Eurostat 2010, Faostat 2010 and own calculations)

4.1.1 Geographical overview of stakeholders

Figure 16 presents a geographical overview of the wood industry in Poland. Production of nearly all products is highly scattered over the country. Larger wood pellet plants appear to be located in the South or Mid- and North West.

Figure 15 shows the forest area in Poland. The primary wood industry is mainly located in highly forested areas, as are most sawmills. Although the larger sawmills are situated in the North, near the ports, more sawmills (in number of business enterprises) are actually located in the southwest part of Poland. (Acker, 2008). Large-scale veneer production is only situated in the East and West of the country. Large-scale plywood production is situated in the North, where beeches grow on the wet soils of the lake district.

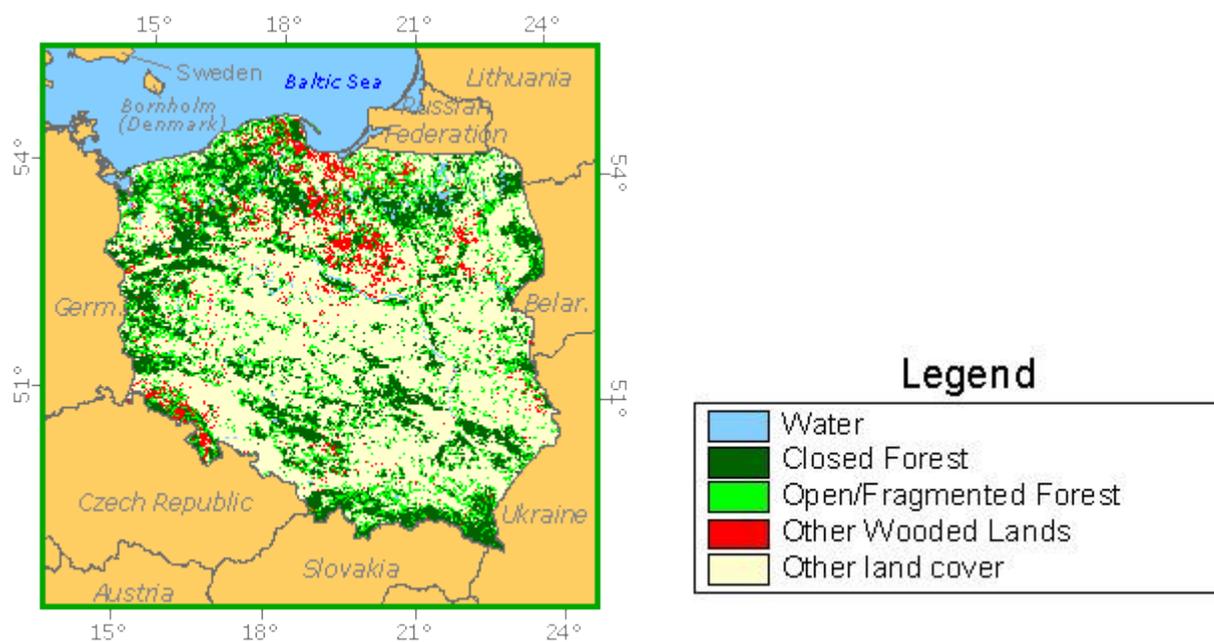


Figure 15 Forested areas in Poland (FAO Forestry Department, 2001)

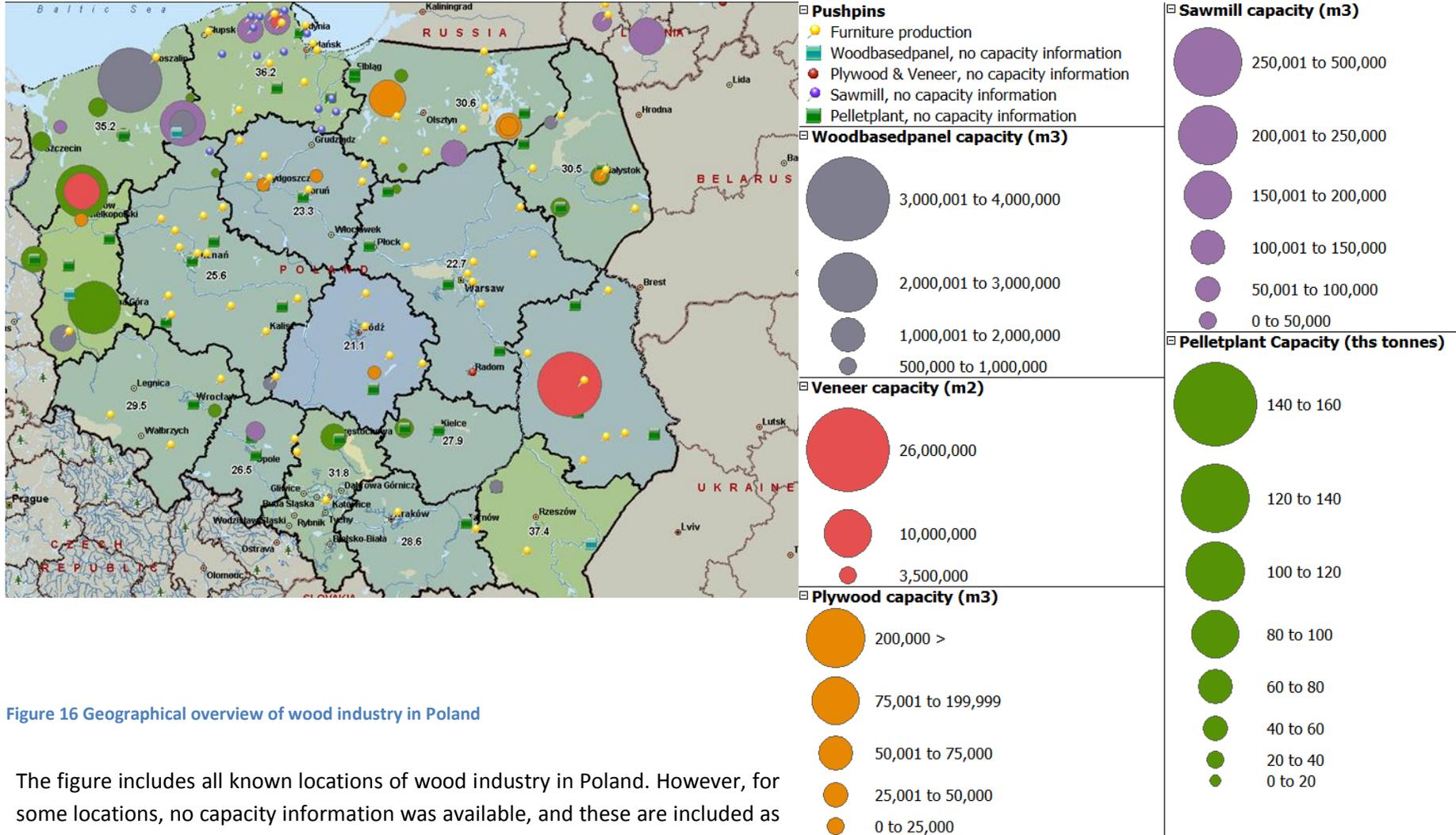


Figure 16 Geographical overview of wood industry in Poland

The figure includes all known locations of wood industry in Poland. However, for some locations, no capacity information was available, and these are included as a small bullet or square. Also note that the picture may not be complete, as (large amounts) of smaller business entities are not included.

4.1.2 Wood processing industry

The production of secondary residues from the wood processing industry (saw mills and veneer mills) depends largely on the quality of the wood logs. Lower quality logs are categorised as pulplogs or fuel wood. The State Forest district of Gdansk revealed that the quality distribution of the wood is heavily skewed to lower quality logs. It indicates that due to the lower quality of sawlogs and veneer logs, the residue share in sawmills and veneer mills is relatively high compared to European standards.

4.1.2.1 Sawnwood production

Poland has a very large sawmill industry, processing over 8.6 Mm³ roundwood, into 4.2 Mm³ swe of sawnwood in 2012. The majority of the wood is processed in few large sawmills. The remainder is scattered over more than 9000 sawmilling plants over the country (table 16). As the State Forest owns 90% of the forests in Poland, the wood processing industry is depending on the State forest to release wood on the market. Due to a policy for high increment of the forest, the amount of wood released to the market is low, and the wood processing industry in Poland currently suffers a lack of wood. The average utilization rate of contacted sawmills is less than 60% of their maximum capacity.

Table 16 Capacities of sawmills in Poland (Acker, 2008)

Number of sawmills	Share	Volume of round timber (m ³ /yr)	
6840	76%	<	5000
1710	19%	5	20,000
405	4.6%	20,000	100,000
54	.6%	100,000	+
9000			

According to the Polish State Forest District Gdansk (Wegrzyn, 2011), there is currently no wood material wasted, or at least not in large quantities. Clean residues from the wood processing industry are sorted and sold to the board industry. Bark is sold as garden material. Square cuttings from smaller sawmills are sold for domestic use.

There is a large market for clean sawmill residues. Large sawmills cooperate with neighbouring pellet plants, which convert the produced sawdust and chips into wood pellets. Smaller sawmills sell their residues to wood based panel producers (e.g. Kronospan). Residue prices vary, and are currently 10-12 €/m³ (nov 2011, 60 km from the Gdynia harbour) (Szymerkowski, 2011). Roundwood prices for coniferous sawlogs are currently around 60 €/m³. Residues for wood based panel production are sorted to size in containers. Square cuttings are sold as firewood to the local domestic market. It is stressed by the stakeholders that this domestic market is very important in Poland. Many households are dependent on cheap heating fuels from both forestry residues and residues from sawmills. Clean sawdust is used to fuel the dryers, and these account for approximately 10% of the total residue production. (Szymerkowski, 2011)

Based on the information above, and the input data from other Faostat statistics, the total residue production from Polish sawmills is 7.2 Mm³ swe.

4.1.2.2 Plywood and veneer production

There are 30 veneer producers in Poland. Veneers are produced by sawmills as well as by producers of wood-based panels, 85% of the veneer and 82% of the plywood is produced from non-coniferous wood (Acker, 2008).

The recovery factor for veneer production is high, 1.74 m³rwd/m³product. However, the total production of veneer sheets in Poland is 73,000 m³, making the total annual cuttings needed for this production 127.000 m³, a small part of the total wood industry. The residue production of veneer mills in Poland in 2010 was therefore relatively small: 55.000 m³ swe.

The production of plywood in Poland in 2010 was 0.32 Mm³. For that, 0.7 Mm³ of input material was needed, resulting in a residue production of 0.4 Mm³ swe.

4.1.2.3 Wood based panel production

The total production of wood based panels in Poland was 7.3 Mm³ in 2010. For this production, 12.5 Mm³ of input material is used. The wood based panel industry is one of the main users of clean wood residues in Poland, with 8.4 Mm³ of residue input for production.

4.1.3 Other wood industry

Other wood industry includes all further processing of (semi) finished wood products, like wood based panels and veneer sheets for furniture production, and wooden beams in construction. The Polish furniture industry, whose growth rates were usually above the 10% level, is now facing difficulties. With a decrease of 2.2% in the furniture industry, Polish furniture producers try to be more competitive in the export markets and in their domestic market where imports account for 85% of the local consumption (UEANET, 2008).

Using expansion factors (Mantau, 2010), and the statistical data from Eurostat (2011), the total wood products consumption of the sectors is determined, and shown in the figure below. The amount of other industrial residues is determined by combining the wood consumption of the other wood industry, and the residue share per sector (table 8). The potential of other industrial residues is 1.5 Mm³ swe.

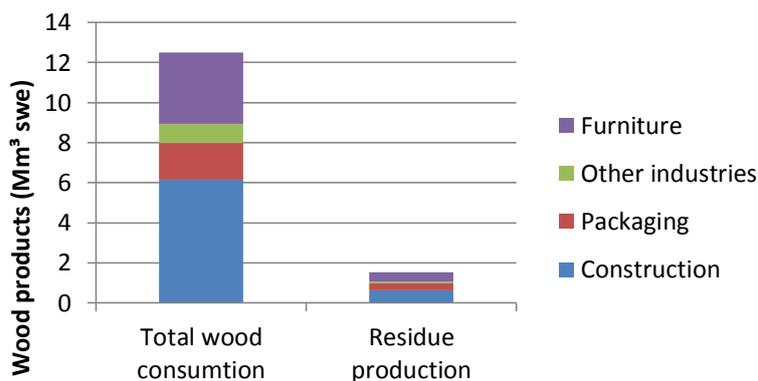


Figure 17 Wood consumption other wood industries in Poland by sector

4.1.4 Post-consumer wood

The potential of PCW has been assessed by different studies using different approaches resulting in a large range in the total potential between these studies.

Figure 17 shows the current use and possible potential of these different studies. The Cost E-31 project (Merl, et al., 2007) assessed a potential of (only) 518,000 m³ swe, where the origin and destination of 83% is unknown. They seem to base their estimation on the potential supply from packaging materials, as assessed by (Ratajczak, 2004). However, according to Eurostat (2008), the current supply of used packaging materials is 1.1 Mm³ swe, of which 0.54 Mm³ swe is already used today. The Polish biomass chamber of commerce assessed the total potential supply to be 40 kg/capita annually, this equals 2.5 Mm³ swe of PCW for Poland (Sencyszyn, 2010). The Wood Technology Institute in Poznan (Ratajczak, 2004) estimated double this, 5 Mm³ swe potential of PCW in 2002, based on an extensive case study. In EUwood, Mantau (2010) estimated the potential of PCW to be 4.1 Mm³ swe in Poland, of which 95% is not used.

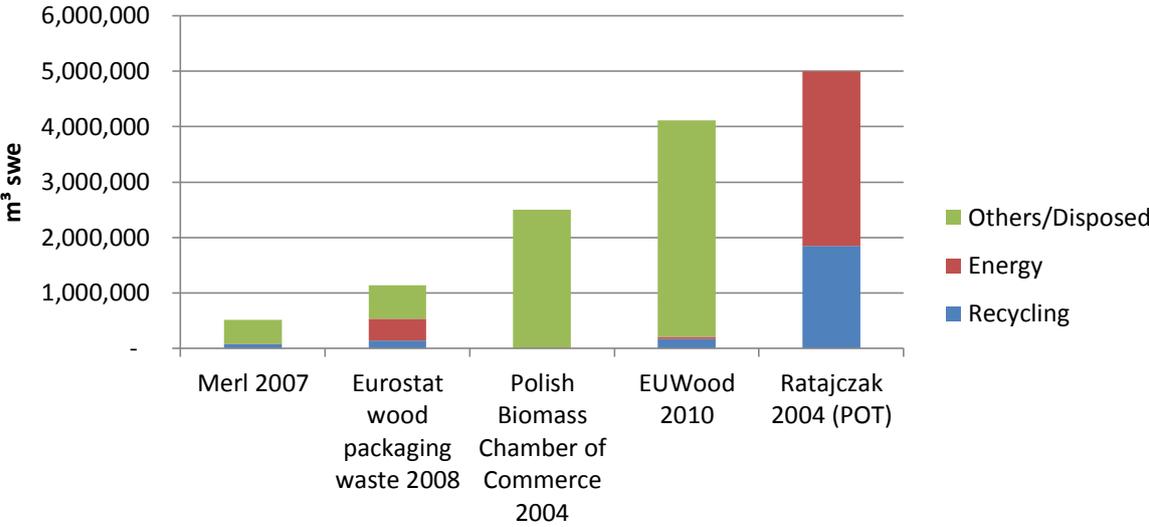


Figure 18 Availability of PCW in Poland

All studies above show a potential in PCW in Poland, as PCW is now hardly used. Information about the quality, level of contamination and possibility for mobilization is lacking. In Ratajczak (2004) it is stated that currently no PCW is recycled on large-scale. EUwood (Mantau, 2010) assumed this to be about 5%. Figure 19 shows the potential source of PCW in Poland. Large amounts of used furniture, demolished wooden buildings, window and door frames, and used packaging materials can potentially be reused or recycled.

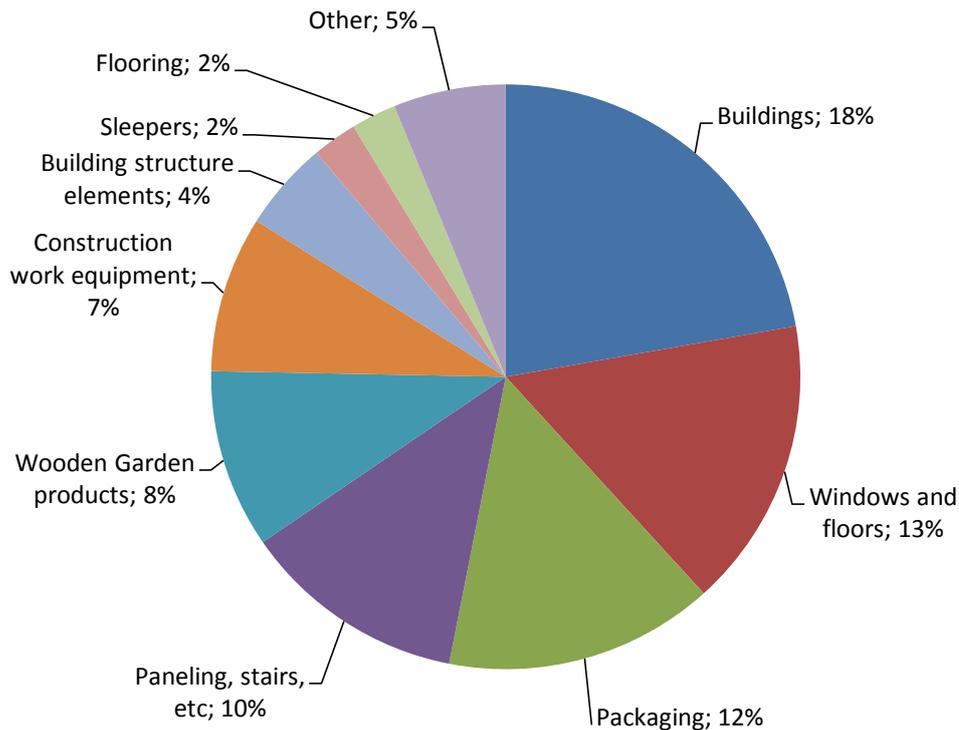


Figure 19 Source of PCW in Poland 2002 (Ratajczak, 2004)

Ratajczak (2004) assumes 37% of the potential PCW to be suited for material recycling. The remaining 3,1 Mm³ swe of PCW is only suited for energy production.

Potentially 20% of the roundwood supply can therefore be substituted by PCW. The potential of PCW in Poland used for this study is 4.1 Mm³ swe (Mantau, 2010).

4.1.5 Wood Pellet market

Wood pellet production in Poland started in 2003. Pellets were mainly exported, but also used for both individual house heating and for industrial purposes, like co-firing in coal fired power plants and municipal heating systems. In 2009, 300.000 ton (44%) of the produced pellets where exported, 80,000 ton (12%) were used for individual household heating and 150,000 ton (22%) were co-fired. (Wach & Bastian, 2010)

The Polish wood pellet market is not very well organized. The pellet producers compete heavily with each other in the struggle for customers, which results in keeping the company information (production capacities and total production) confidential. There is no producers association for pellet producers, and no detailed statistical information is available.

The majority of the wood pellet producers are small: 66% of the producers have a capacity of 30,000 ton/yr of less. Smaller producers typically purchase input materials close to their facility (Burczy, et al., 2010).

Table 17 Wood pellet producers Poland for 2010. Source: Own calculation and (Burczy, et al., 2010), (Bioenergy International, 2011)

Plant size	Number of producers	Capacity utilization
Small (<30,000 ton/yr)	46	76%
Medium (30,000-70,000 ton/yr)	8	66%
Large (>70,000 ton/yr)	4	33%

Recent changes in the national regulations started promoting the use of agricultural biomass (e.g. energy crops, agricultural residues and residues from food processing), increasing the interest in mixed biomass pellets. Power plants exceeding outputs of 5 MWe, need to ensure a growing agricultural biomass share up to 100% in 2015. Plants above 20 MWe are obliged to use 60% agricultural biomass in 2017.

Only four wood pellet producers have capacities exceeding 70,000 ton/yr. These larger producers show very low capacity utilization. Two of them are identified to use clean wood residues from saw milling. The third large producer prepared its own input material (Burczy, et al., 2010).

The total clean residues available in Poland, is 2.28 Mm³ swe. The total installed capacity for wood pellets in Poland is 971,000 tonnes. Assuming an average utilisation of 71% (Cocchi, et al., 2011), the total wood input is 1.6 Mm³ swe, 5% of the total wood production in Poland.

4.2 Estonia

Figure 20 presents the resource balance for Estonia in 2010, based on statistical data from FAOSTAT (2011) and Eurostat (2011). The total roundwood production in Estonia was 7.6 Mm³ in 2010. The main roundwood product is coniferous sawnwood (2.7 Mm³). The amount of wood for paper production is very low, four percent of the total roundwood. The wood processing industry (sawmills, plywood and wood based panels) in Estonia yearly processes 2.9 Mm³ of wood. Pulp and paper industry in Estonia consumes about 0.5 Mm³ swe. A large share (30 percent) of the roundwood is directly exported, the total import accounts for four percent of the total roundwood production. Post-consumer wood streams in Estonia are with about 0.2 Mm³ swe relatively small compared to the other examined countries in this research.

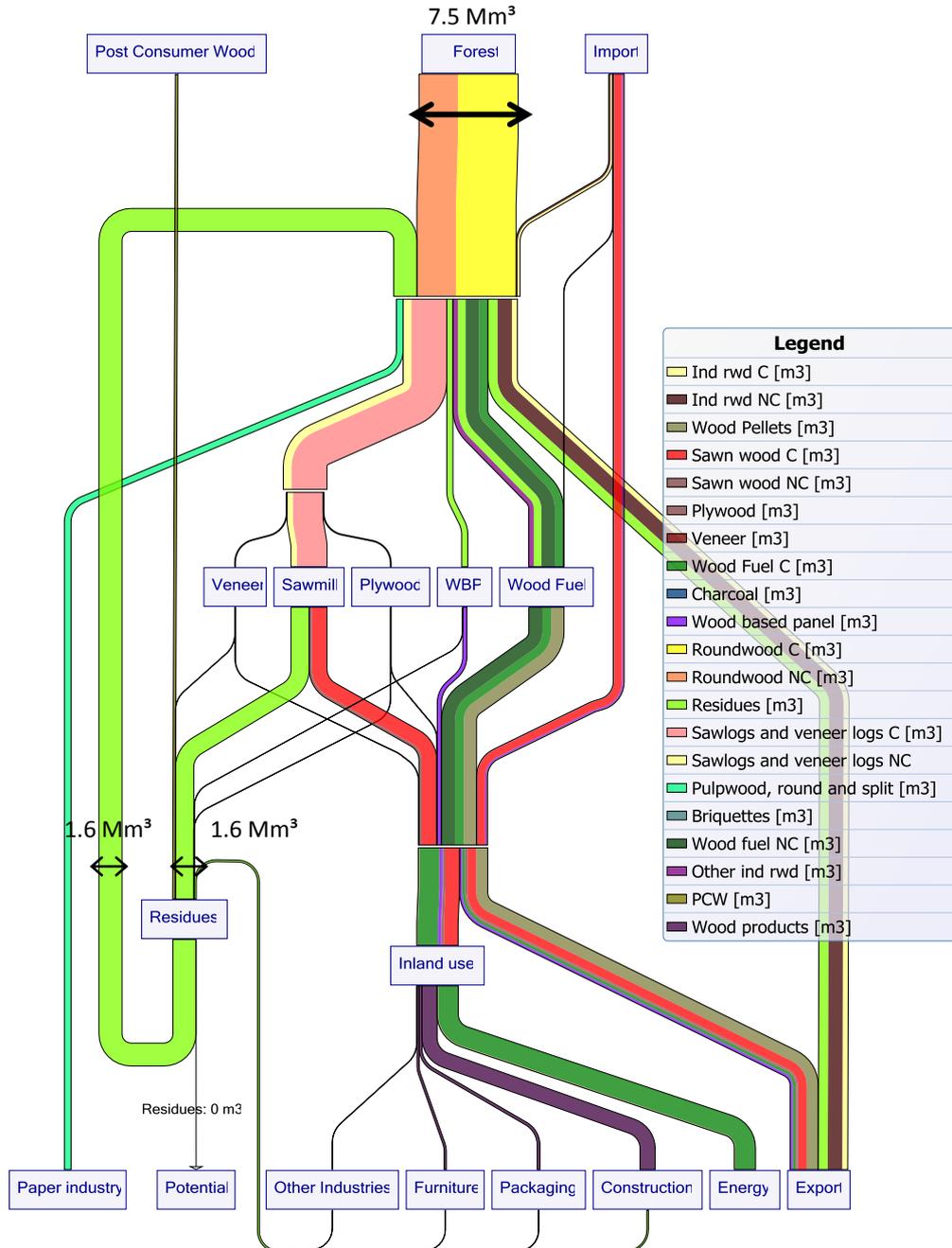


Figure 20 Wood flows Estonia

4.2.1 Geographical stakeholder overview

The Estonian forest cover is 50%, figure 21, shows dense forests in the middle and East of the country. Sawmills are located in the centre and East of the Country. The known wood based panel producer is located in the North East of the country, the plywood producer in the South East, and veneer producer in the capital.

Pellet producers are focussed in the capital, Talinn, as a centre of logistics and trade, and further located in the densely forested areas. Furniture production is mainly located near the ports and the border with neighbouring countries.

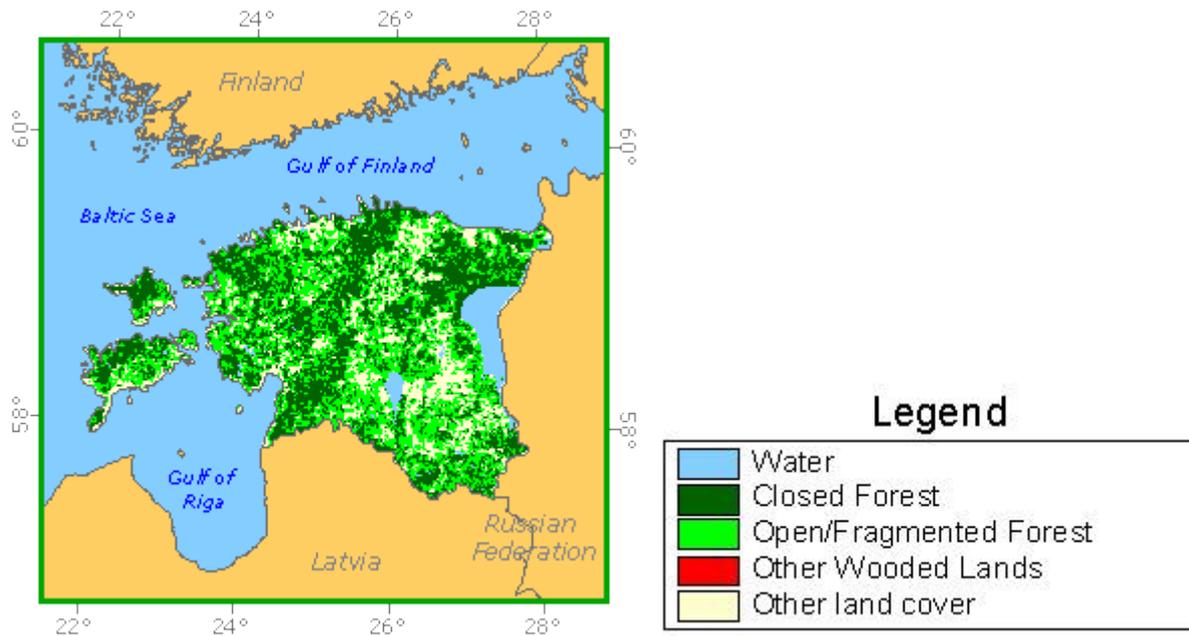


Figure 21 Forests in Estonia (FAO Forestry Department, 2001)

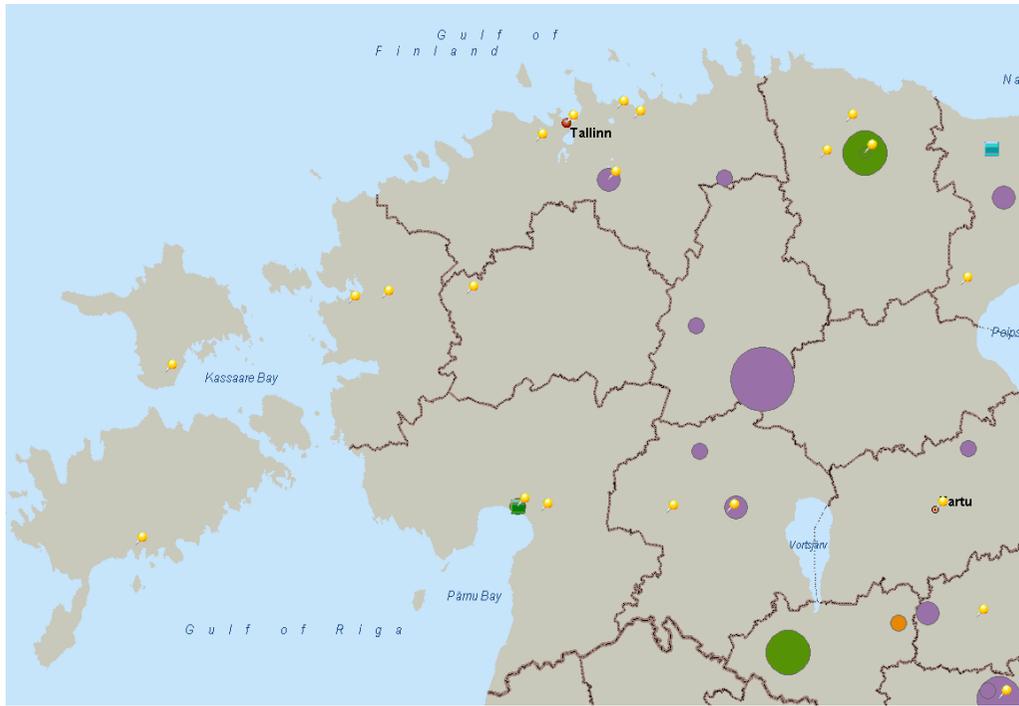
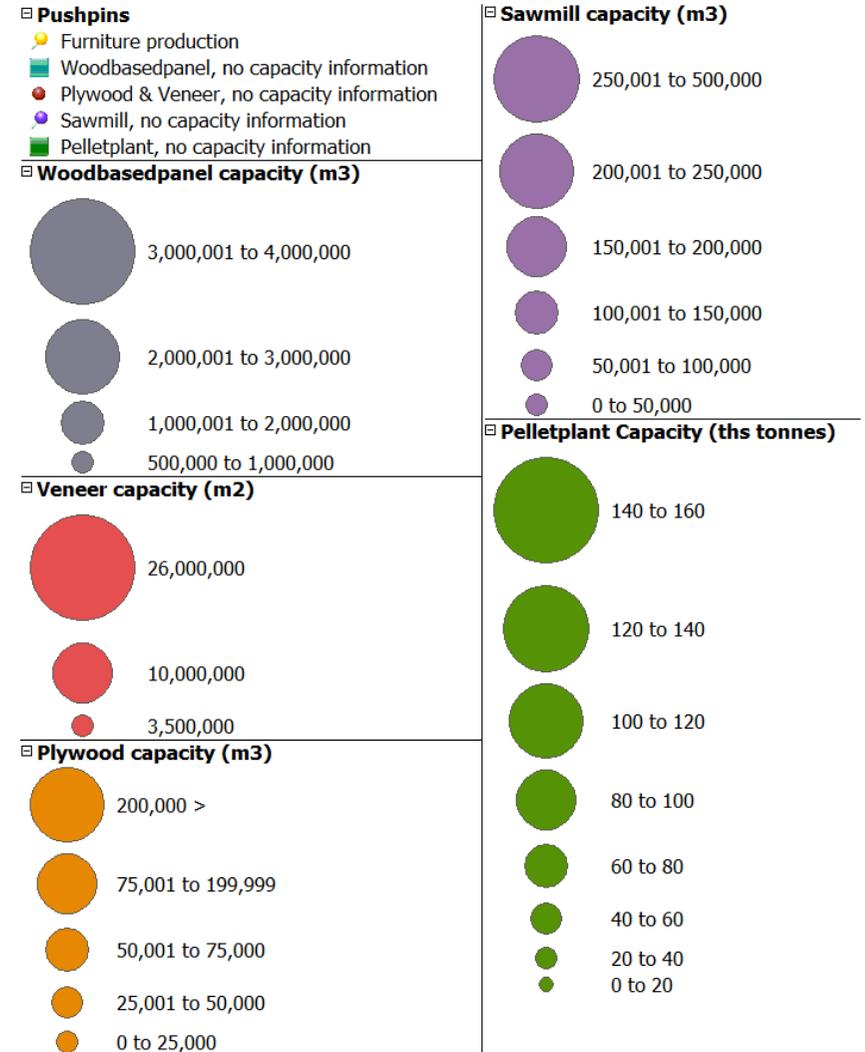


Figure 22 Wood industry in Estonia

The figure includes all known locations of wood industry in Estonia . However, for some locations, no capacity information was available. These are included as a small bullet or square. Also note that a the picture may not be complete, as (large amounts) of smaller business entities are not included.



4.2.2 Wood processing industry

The wood processing industry (sawmills, plywood) in Estonia yearly processes 2.9 Mm³ of wood.

4.2.2.1 Sawnwood production

Total production of sawnwood was 1.4 Mm³ in 2010, from mainly coniferous roundwood. 59% Of the products is exported. Residue production is 1.18 Mm³ swe.

4.2.2.2 Veneer and plywood production

Veneer and plywood production in Estonia is small with two plywood producers using 0.14 Mm³ of roundwood and producing 33,000 m³ and 35,000 m³ of veneer sheets and plywood respectively. The veneer and plywood industry accounts for two percent of the total roundwood consumption in Estonia. Residue production from veneer and plywood comes to 24,000 m³ in 2010

4.2.2.3 Wood based panel production

The wood based panel industry consists of 1 producer, processing 0.47 Mm³ of wood in 2010, into 0.32 Mm³ of wood based panels. In 2010, combined they consumed 0.44 Mm³ of clean residues for the particle board production.

4.2.3 Other wood industry

The Estonian furniture industry had atrociously negative results in 2008, as it suffered from the economic crisis. (UEANET, 2008)

Figure 23 shows the wood consumption and residue production of the other wood industry in Estonia for 2010. The total wood use of the other wood industries was 1.56 Mm³ in 2008. The total generated residues were 0.18 Mm³ swe. The internal use of the furniture industry was 21,908 m³ swe.

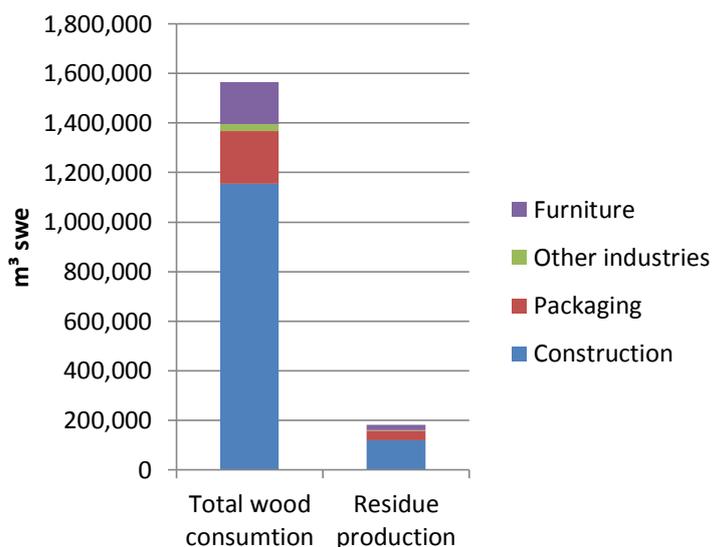


Figure 23 Total wood consumption and residue production from other wood industry in Estonia

4.2.4 Post-consumer wood

Post-consumer wood streams in Estonia are relatively small compared to the other examined countries in this research.

Figure 24 shows that in 2008, a total of 7,804 m³ of wooden packaging waste was generated. A small fraction (5%) of the generated waste is recovered and used for energy production. Waste recycled for new materials is only 1% of the total waste generated. 14% is currently not recovered from other waste streams. The remaining 80% of the wooden packaging waste is otherwise used, or unknown.

According to Mantau (2010), the total potential of post-consumer wood in Estonia is about 0.2 Mm³ in 2009. 75% of this potential is currently not used, 15% is recycled for materials and 10% used for energy production (figure 24). This potential is much larger than the total wooden packaging waste, which is only 4% of the total potential.

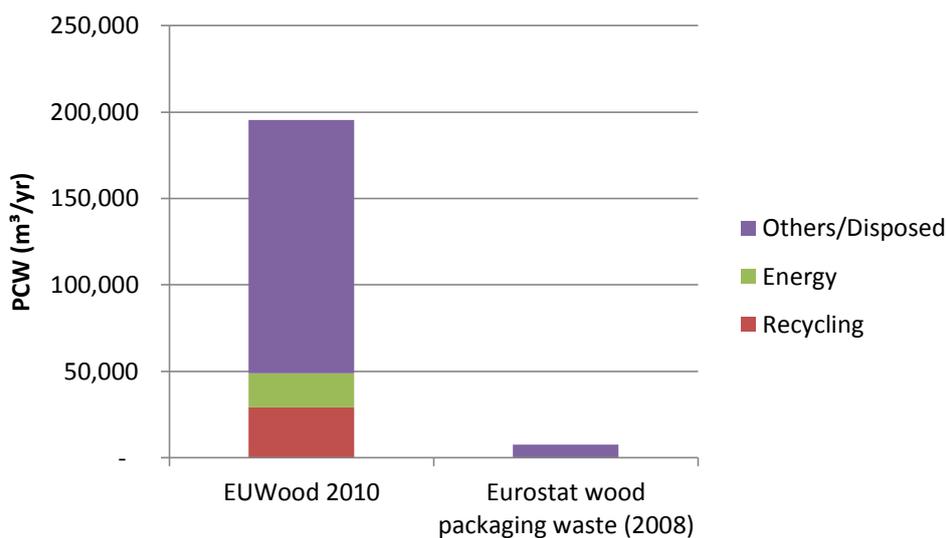


Figure 24 Post consumer wood in Estonia

4.2.5 Wood pellet market

Estonia has three large, and a total of 6, wood pellet producers, with a combined total installed capacity of wood pellets and briquettes of 417,000 tonnes (Bioenergy International, 2011). However, the Estonian statistical agency (Statistics Estonia) states the total production to be 427,000 tonnes in 2010, indicating that capacity utilization to be over 100%. Similar to Latvia, 40% of the wood pellets is produced from roundwood. For the production of wood pellets, 0.9 Mm³ swe of wood residues are used. A vast amount of the produced wood pellets, 92%, is exported (Statistics Estonia, 2010). Internal use of biomass as energy source is gaining popularity. Today, 16.5% of the Total Primary Energy Supply (TPES) is woody biomass (Ellul, 2012).

Wood fuel accounts for 23% (1.7 Mm³ rwe) of the total production and is mainly used as firewood.

4.3 Latvia

Figure 25 presents the current wood flows in Latvia. The total roundwood production in Latvia was just over 13 Mm³ in 2010. The main roundwood products are sawlogs (7.5 Mm³), and pulplogs (3.1 Mm³). The amount of wood for paper production is very low, there is only one paper production plant in Latvia. A large share (42%) of the wood is exported, wood exports consist mainly of wood chips and particles for Scandinavian paper industry and fuel wood. The total import accounts for 3% of the total roundwood production.

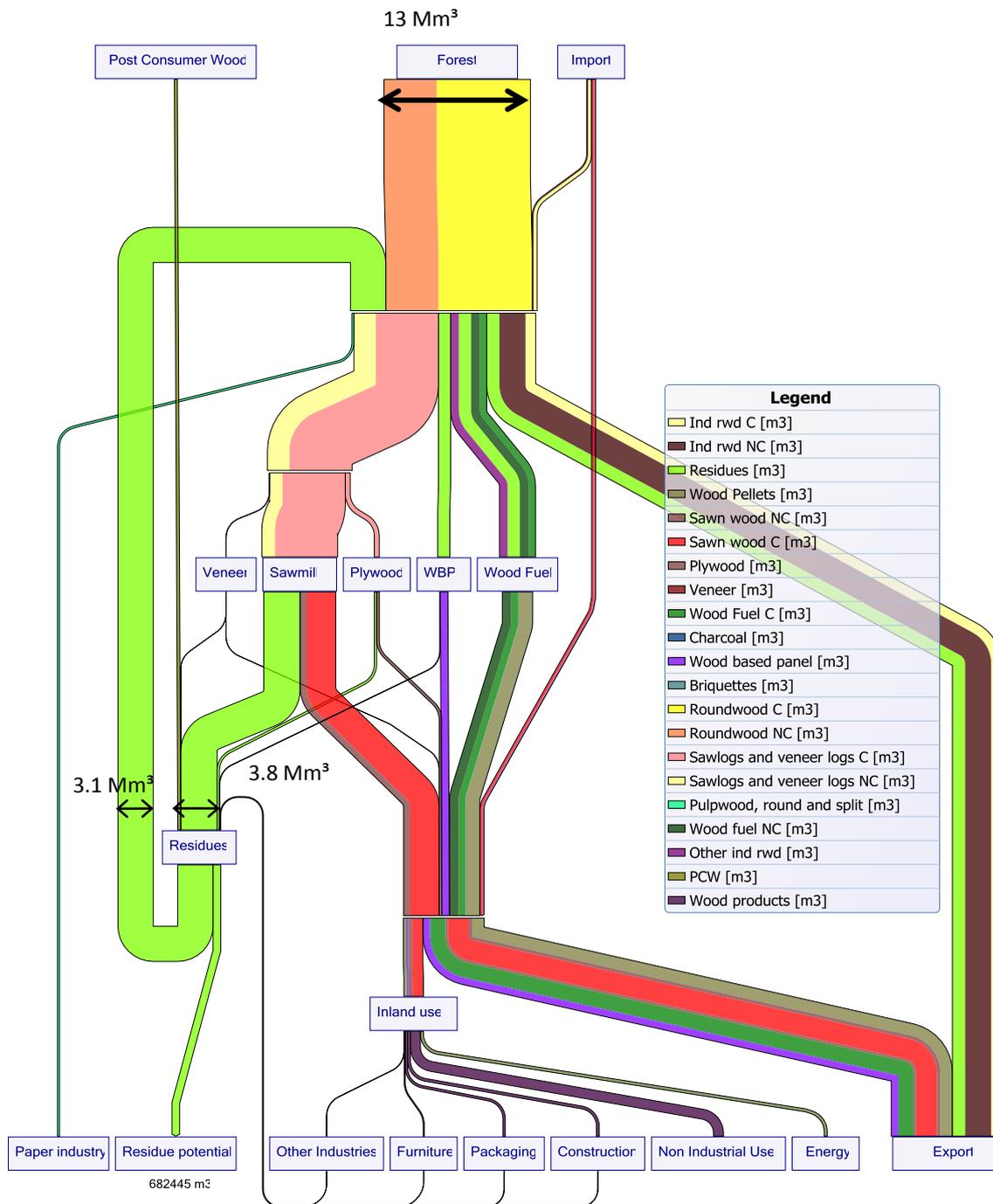


Figure 25 Wood flows Latvia

4.3.1 Geographical overview of stakeholders

The forest cover in Latvia is very high, over 55% (figure 26), which is part of the reason why the wood processing industry is Latvia's largest industrial sector. Figure 27 shows the wood industry in Latvia, basic wood industry is scattered over the country. Among the larger cities with harbour (Riga, Ventspils, Liepaje), the wood industry density increases. The only plywood producer is located in Riga. Wood based panel production is concentrated in Riga, although one HDF producer is situated more inland (Aizkraukle).

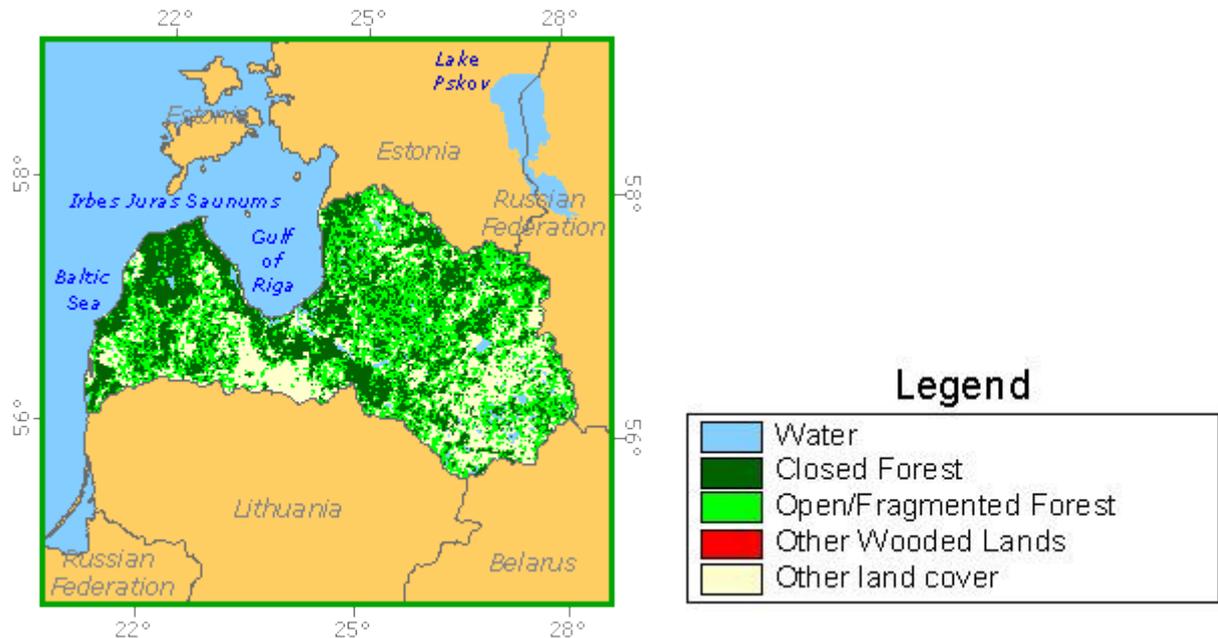


Figure 26 Forest areas in Latvia (FAO Forestry Department, 2001)

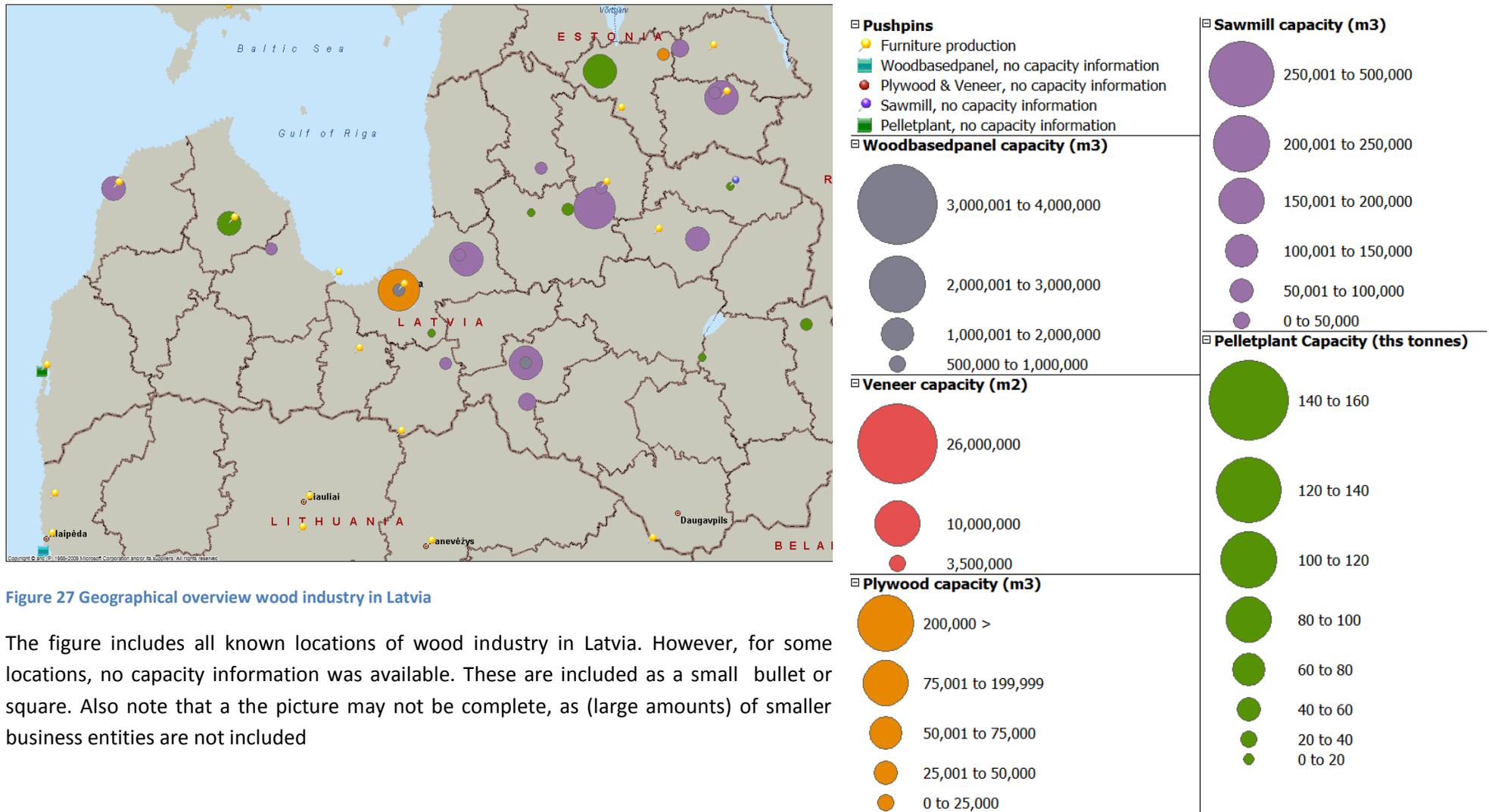


Figure 27 Geographical overview wood industry in Latvia

The figure includes all known locations of wood industry in Latvia. However, for some locations, no capacity information was available. These are included as a small bullet or square. Also note that a the picture may not be complete, as (large amounts) of smaller business entities are not included

4.3.2 Wood processing industry

The wood processing industry (sawmills, plywood) in Latvia processes 7.5 Mm³ of wood yearly.

4.3.2.1 Sawnwood production

The total sawnwood production in Latvia for 2010 was 3.4 Mm³. For this, 6.8 Mm³ of roundwood was used, resulting in residue production of 3.2 Mm³. *Larger* sawmills have their own chipper, to produce wood-chips from their residues. Clean residues (from debarked logs) are mostly sold to the pulp and paper industry in Scandinavia, whereas lower quality residues (cuttings with bark and sawdust) are chipped and sold for energy and to the pellet industry. Some of the larger sawmills are connected to a neighbouring pellet plant.

Residues from smaller sawmills are mainly sold on the local market for direct heating purposes. There is an increasing demand of residues for small scale district heating systems, and for domestic use. Clean, high value residues are still sold to local pellet plants (Vīgants, 2011). Prices of residues are around 8-10 €/m³ bulk (nov-2011, 6 km from the Ventspils harbour). Residues for wood based panels and pulp and paper are sorted and thus a bit more expensive. Currently, the market for residues is a bit lower, as roundwood prices are low (like pulplogs and firewood), at some point even lower than the residues. (Timbers, 2011)

4.3.2.2 Veneer and plywood production

There is only one big plywood manufacturer in Latvia: *Latvia fineries*. Chips from the production are supplied to the particleboard industry. Investments have been done recently to allow the use of their own residues for process heat. Although there are a lot of residues (estimated 0.2 Mm³ swe), this still does not cover their demand for heat, and the company buys extra chips to supply them. (Fineries, 2011)

4.3.2.3 Wood based panel production

The total production of wood based panels in 2010 for Latvia was 682 Mm³. Only particle boards are produced, and the vast majority (86%) is exported. The total wood input was 1 Mm³ of residues in 2010. During production, the produced residues (estimated 40,000 m³ swe) do not leave the factory, part of the process residues are used for other products, the other part is used for internal heating (Kronospan, 2011).

4.3.3 Other wood industry

The other wood processing industry is very scattered into small manufactures. The Latvian furniture industry collapsed in 2008, companies suffer to avoid bankruptcy (UEANET, 2008). All contacted furniture producers use their own residues for process heat, and very few sell the remaining to a nearby district heat system. Some furniture manufactures indicate that they actually have to pay for their wood waste, but these streams are contaminated with glue and paint.

Using expansion factors (Mantau, 2010) and the statistical data from Eurostat (2011), the total wood products consumption of the sectors is determined, and shown in the figure below. The total production of other industrial residues in Latvia is 80,000 m³.

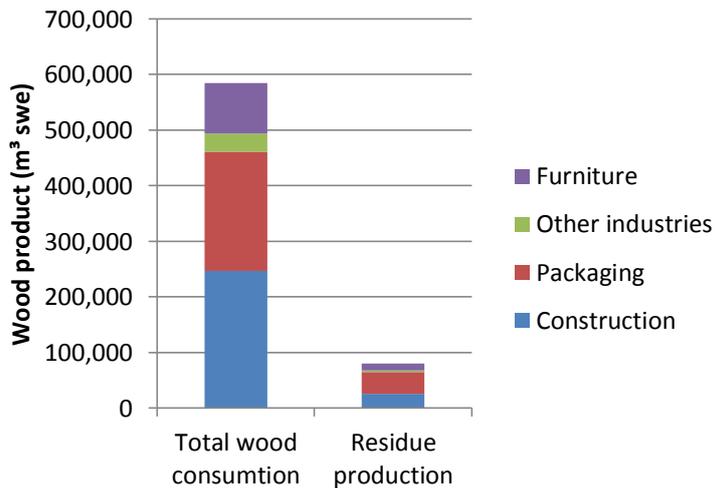


Figure 28 Wood consumption and residue production of other wood industries in Latvia

4.3.4 Post-consumer wood

Domestic wood waste is at this point not separately collected. The Latvian trade market of other materials than wood products is small, wood waste from scrapped packaging materials (for example scrapped shipping pallets) is only in very small amounts available. During the field trip, three companies are identified, recycling packaging pallets. Scrapped pellets are reproduced into wood chips and sold to pellet plants.

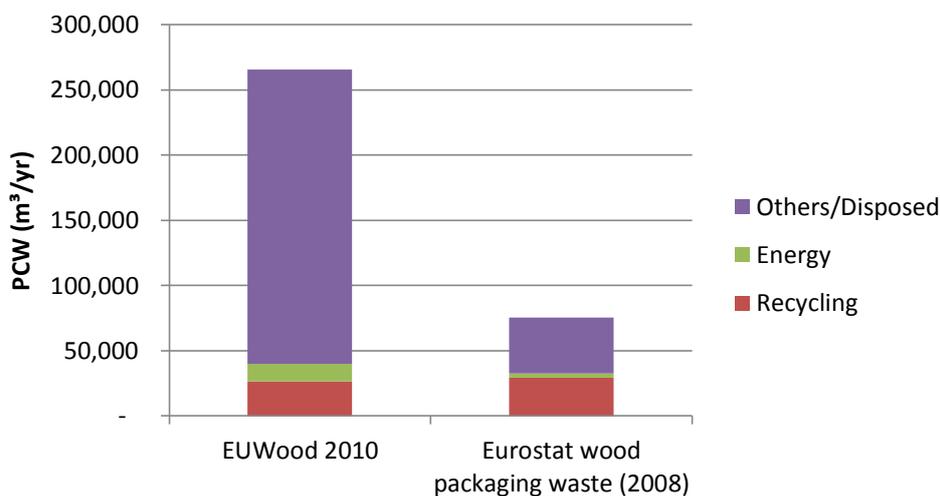


Figure 29 Post consumer wood in Latvia (Mantau, 2010) (Eurostat, 2010)

Figure 29 shows the total available PCW in 2007, assessed by EUWood (Mantau, 2010), to be roughly 0.27 Mm³ swe in Latvia. However, the current use of PCW is only 5% for raw material and energy use. Eurostat statistics on packaging waste show a production of 45.000 tonnes wooden packaging waste annually, or about 75.000 m³ (Eurostat, 2010). The total potential of both studies differ significantly. It is clear that a large part of the current used post-consumer wood consist of packaging waste. However, a large share of this stream is still unused.

4.3.5 Wood pellet market

The current pellet production volume in Latvia is about 800.000 tons/yr. The total wood input is 1.8 Mm³ swe, which is 14% of the total wood production in Latvia. The residue market is saturated, and about 40% of the raw material used to produce these wood pellets is roundwood (Grīnbergs, 2011).

This indicates that the price ceiling for the residue market is either already reached, or will be reached soon. The price will then be the same as the price of roundwood (pulplogs and firewood). One big pellet producer and three smaller producers went bankrupt last year in Latvia.

4.4 Lithuania

Figure 30 presents the current wood flows in Lithuania. The total roundwood production in Lithuania was just under 7.1 Mm³ in 2010. The main roundwood products are coniferous sawlogs (2.3 Mm³), non-coniferous sawlogs (1.4 Mm³) and wood fuel (1.3 Mm³). There is very little pulp and paper production (about 0.37 Mm³). 19% of the roundwood is directly exported, the total import accounts for 5% percent of the total roundwood production.

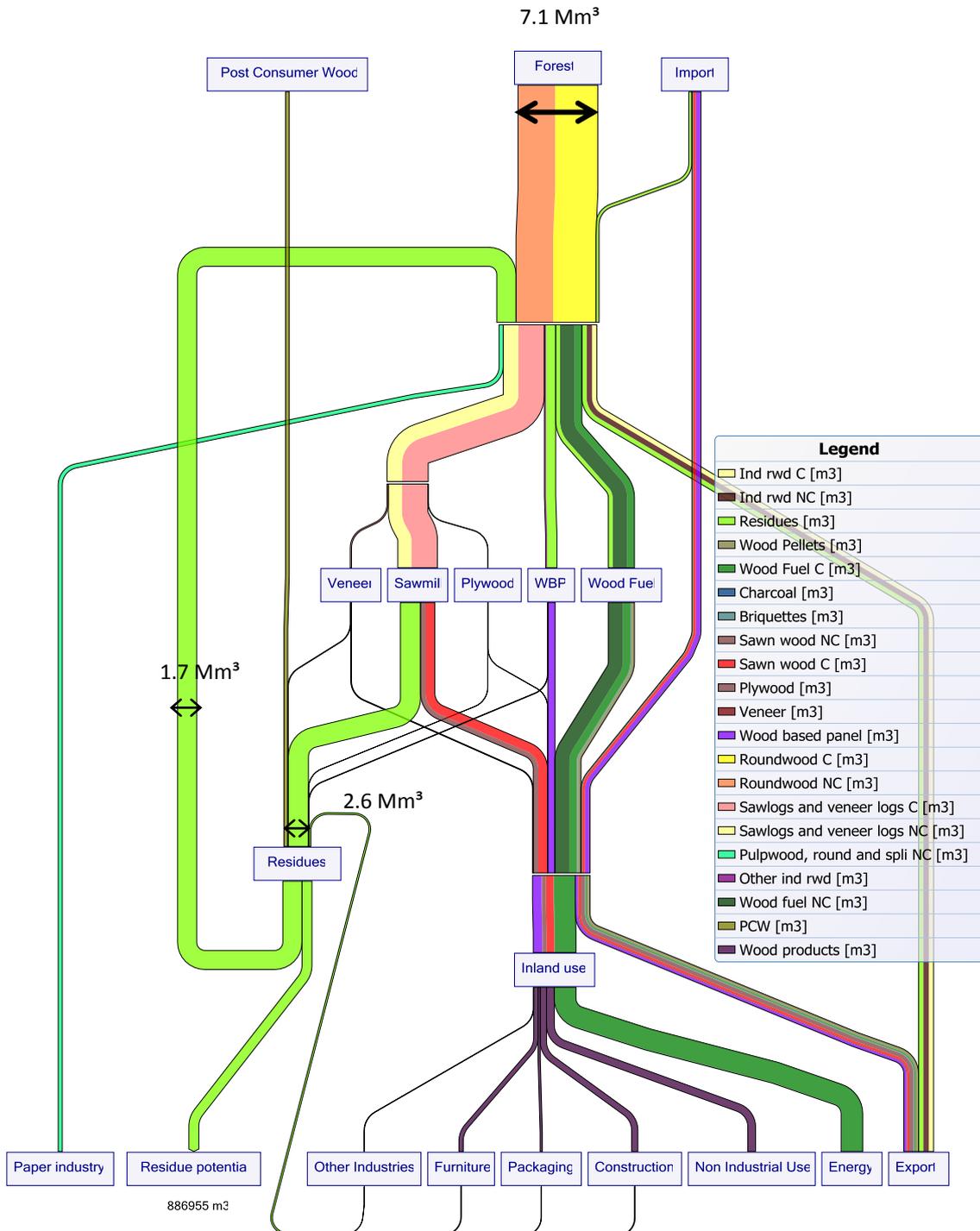


Figure 30 Wood flows Lithuania

4.4.1 Geographical stakeholder overview

The Lithuanian forest cover is 32.7%, with the large forest mainly situated in the East of the country (figure 23). Dominant species are pine, spruce and birch (Acker, 2008). This region is also the main location for the wood industry. Most wood industry is concentrated around the cities; especially Vilnius and Kleipeda are prime locations. Wood based panel production is concentrated in “Giriū Bizonas” and “Klaipėdos mediena” (Acker, 2008) . Figure 32 shows the only plywood manufacturer in Vilnius. The furniture industry is, despite a hotspot in Vilnius, more scattered among the country.

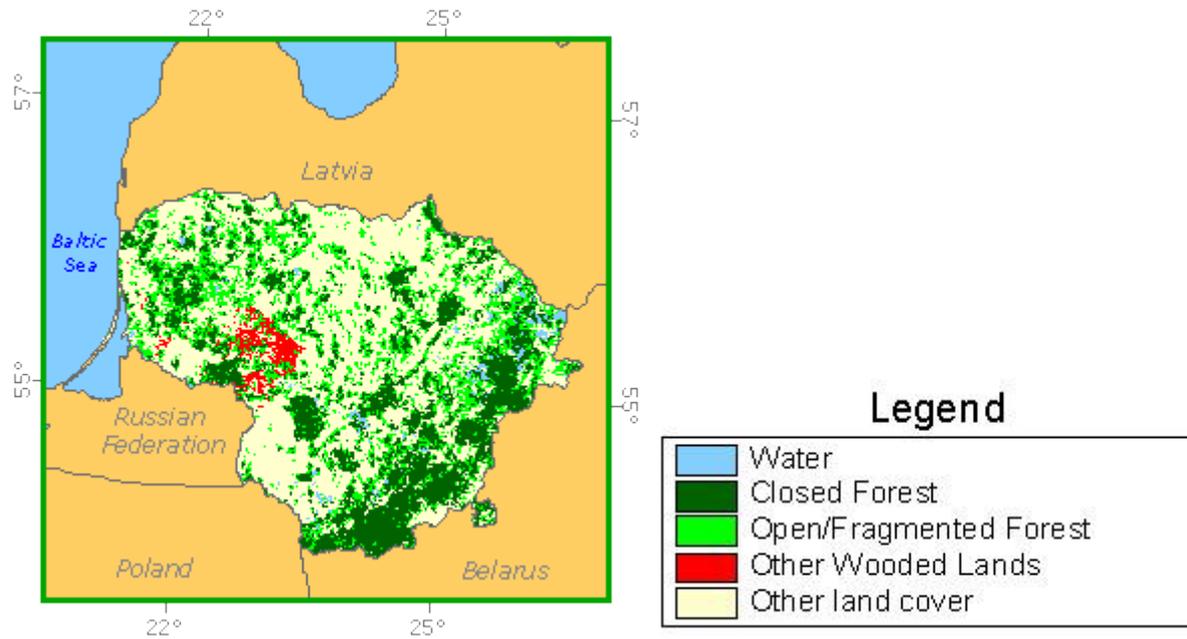


Figure 31 Forests in Lithuania (FAO Forestry Department, 2001)

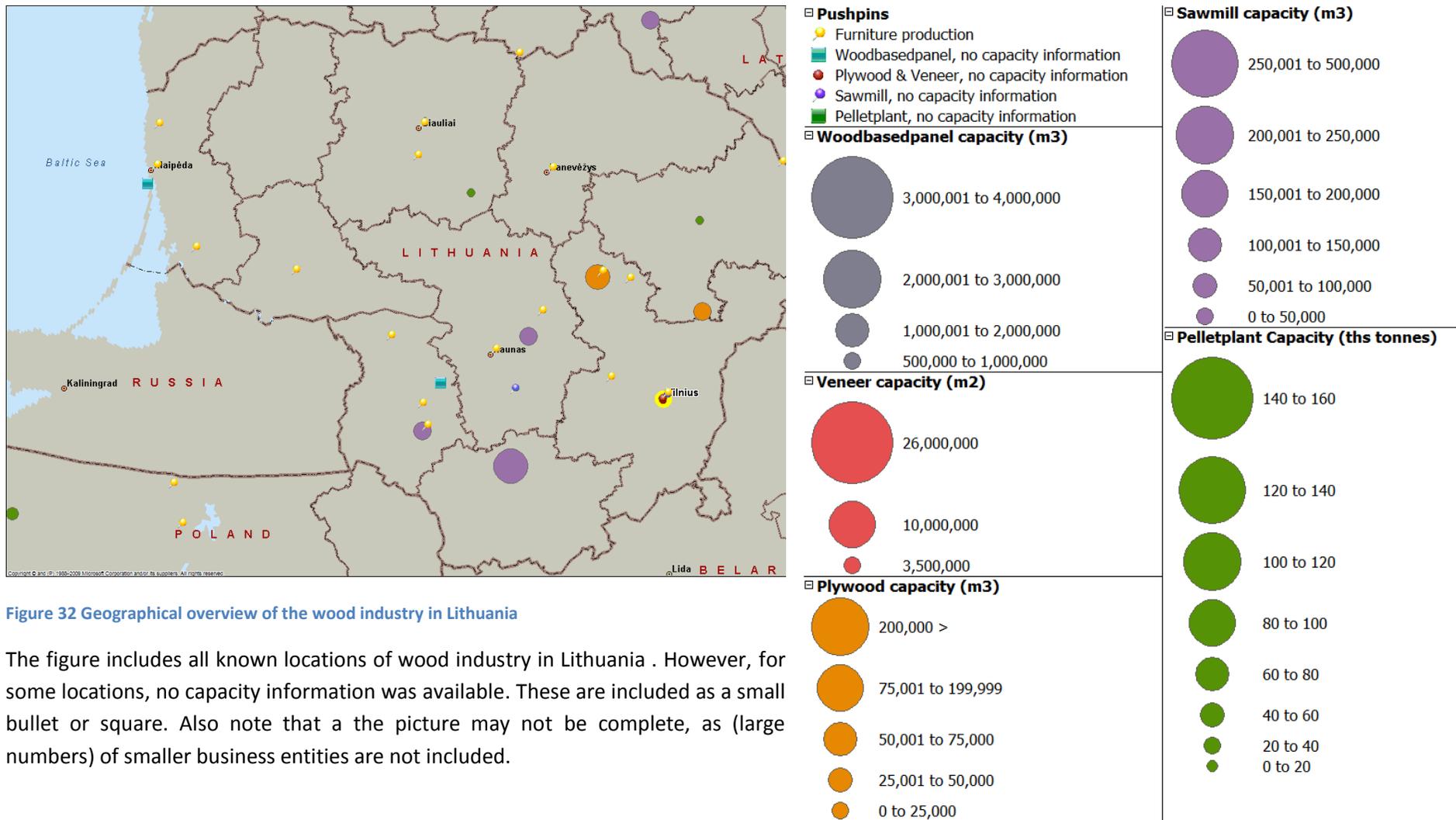


Figure 32 Geographical overview of the wood industry in Lithuania

The figure includes all known locations of wood industry in Lithuania . However, for some locations, no capacity information was available. These are included as a small bullet or square. Also note that a the picture may not be complete, as (large numbers) of smaller business entities are not included.

4.4.2 Wood processing industry

The wood processing industry in Lithuania processed 3.7 Mm³ of roundwood in 2010 (52% of the total roundwood removals from the forest).

4.4.2.1 Sawnwood production

The sawmill industry in Lithuania produced 1.7 Mm³ of sawnwood in 2010, from 2.5 Mm³ of roundwood. Sawdust and small pieces are sold to the particleboard industry, and chips are historically sold to the pulp and paper industry. However, due to competition in prices and low accessibility, waste materials are now also sold for energy purposes (Acker, 2008). Residue production from sawnwood production was 1.7 Mm³ swe in 2010.

4.4.2.2 Veneer and plywood production

Veneer and plywood production in Lithuania is small. But with one plywood producer situated in Klaipeda, and a new production site of Latvias Fineries was recently opened in Ukmerge, it almost doubled its production. The veneer and plywood industry accounts for 2% (0.15 Mm³) of the total roundwood consumption in Lithuania, producing 67,000 m³ and 14,000 m³ of veneer sheets and plywood respectively. The residue production from veneer and plywood production was 65,000 m³ in 2010.

4.4.2.3 Wood based panel production

The wood based panel industry consists of three producers, processing 1 Mm³ of wood in 2010, into 634,000 m³ swe of wood based panels. In 2010, combined they consumed 0.87 Mm³ swe of clean residues and 0.14 Mm³ of roundwood for the production of wood based panels.

4.4.3 Other wood industry

The other wood processing industry is very scattered into small manufactures. The furniture industry in Lithuania saw a surprising rise in the production value of 16% in 2008, while neighbouring countries suffered large losses (UEANET, 2008). Figure 33 presents the total wood consumption and residue production of the other wood industry. The total wood consumption of the other wood industry was about 1.2 Mm³ swe of wood products in 2010. This accumulated about 0.15 Mm³ swe of residues.

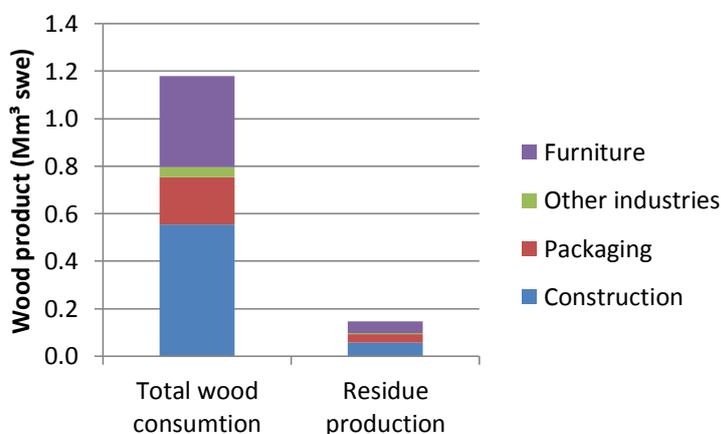


Figure 33 Total wood consumption and residue production of the other wood industry in Lithuania

4.4.4 Post-consumer wood

Post-consumer wood is hitherto hardly used in Lithuania. Figure 34 shows the potential of post-consumer wood assessed by Mantau (2010) for 2007, and the composition of wooden packaging waste in 2008 where 73% of the wooden packaging waste is currently not recovered.

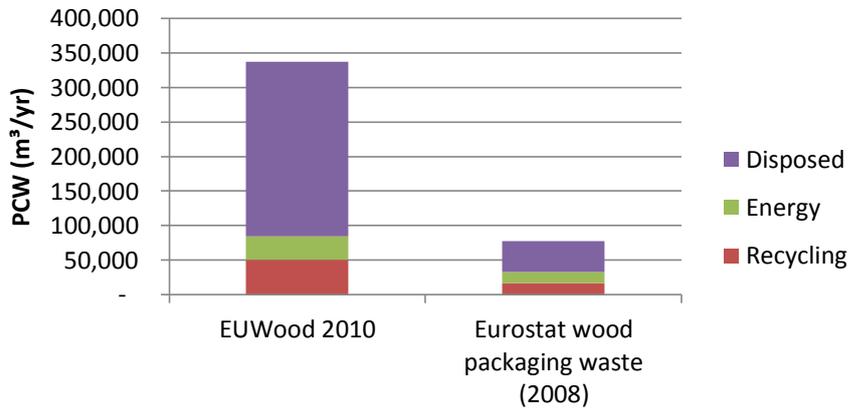


Figure 34 PCW in Lithuania

This shows a potential of 0.34 Mm³ of PCW, while currently only 10% of this is currently used. Part of this is packaging waste. Compared to the Eurostat statistics on wooden packaging waste, a large part is unknown and disposed.

4.4.5 Wood pellet market

There are four main wood pellet producers in Lithuania, with a combined capacity of 140,000 t/yr (Bioenergy International, 2011), located in the East of the country. Total wood pellet production in Lithuania in 2008 was 125,000 tonnes. However, production fell down 80,500 tonnes in 2010 (Cocchi, et al., 2011). The vast majority (95%) of the wood pellets are exported. Briquettes production was 65,200 m³, of which 80% is exported (Regina Erlickytė-Marciukaitienė, 2009).

In Lithuania, 8% of total primary energy supply is from wood (Killmann, 2007). Fuel wood is a large share of total roundwood production (36%). 3.9 Mm³ of fuel wood is sold as firewood, with an average price in 2010 of 22.0 €/m³. Panel production capacity is growing, and competing for the same energy source (Glazko, 2010). More and more boilers and combined heat and power plants (CHP) are installed (currently 257 MW excluding domestic houses). Figure 35 presents an overview energy production from wood and wood waste in Lithuania (excluding domestic houses).

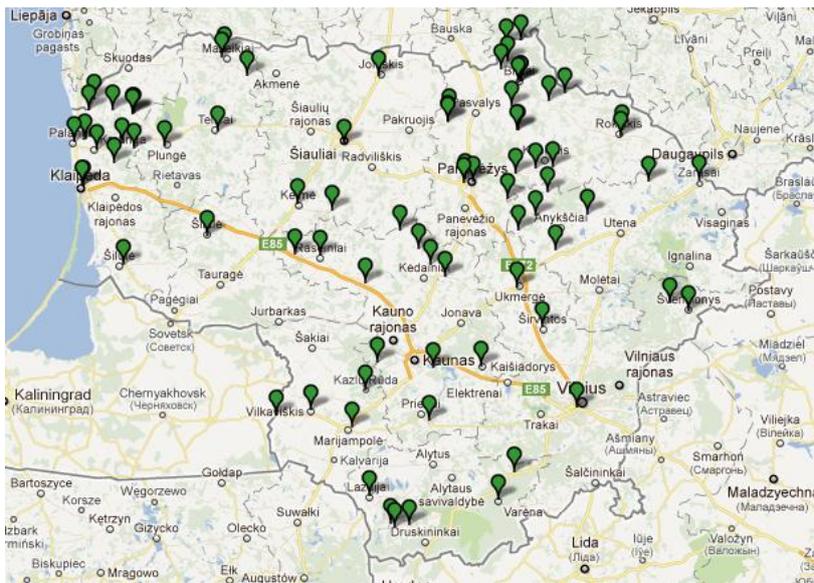


Figure 35 Energy production from wood and waste wood in Lithuania (Valstybės įmonė Energetikos agentūra (Lithuanian Energy agency), 2012)

5 Potential of wood residues and economic availability

5.1 Wood residue sources and potential

In the previous chapter, the input and output of the wood industry is described. This section presents the total estimated production of wood residues from wood processing industries in year 2010 and the total use of these products. The described potential is the difference between the production and use of residues. These residue balances are based on the data from the wood balance, described in chapter 4.

5.1.1 Poland

Figure 36 shows the production and use of residues from different sectors in Poland. Large amounts of residues are available from primary and secondary processing industry and post-consumer wood.

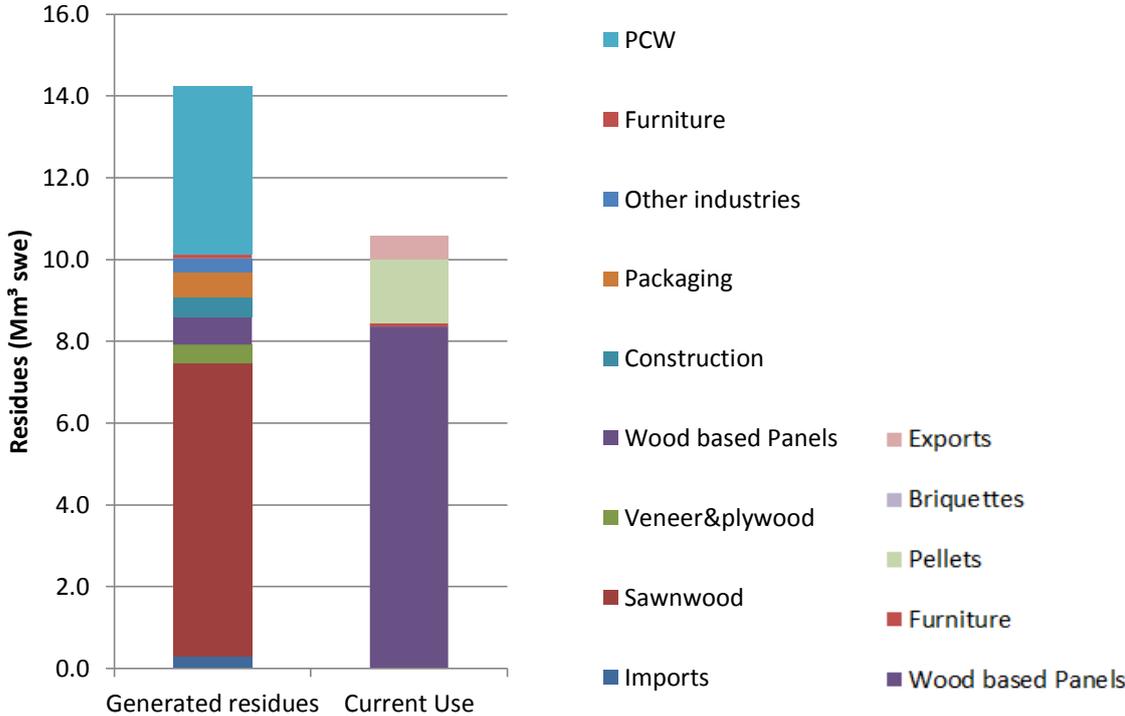


Figure 36 Residue production in Poland per sector

Currently, the wood based panel industry is the main user of wood residues. Current wood pellet production utilizes all the clean residues remaining residues from sawnwood and veneer production. The residues generated by the other wood industry are already partly utilized. The remaining PCW exceeds the current use of wood residues in the Polish wood and energy industry. The remaining potential for wood residues is 3.7 Mm³ swe. However, because PCW is only slightly used at this point, about 37% of this potential is estimated to be suitable for wood based panel production. This would free clean residues for the production of wood pellets. The remaining PCW is suitable for energy production but there is no information about contamination of these streams and the technical potential for mobilizing the streams.

5.1.2 Estonia

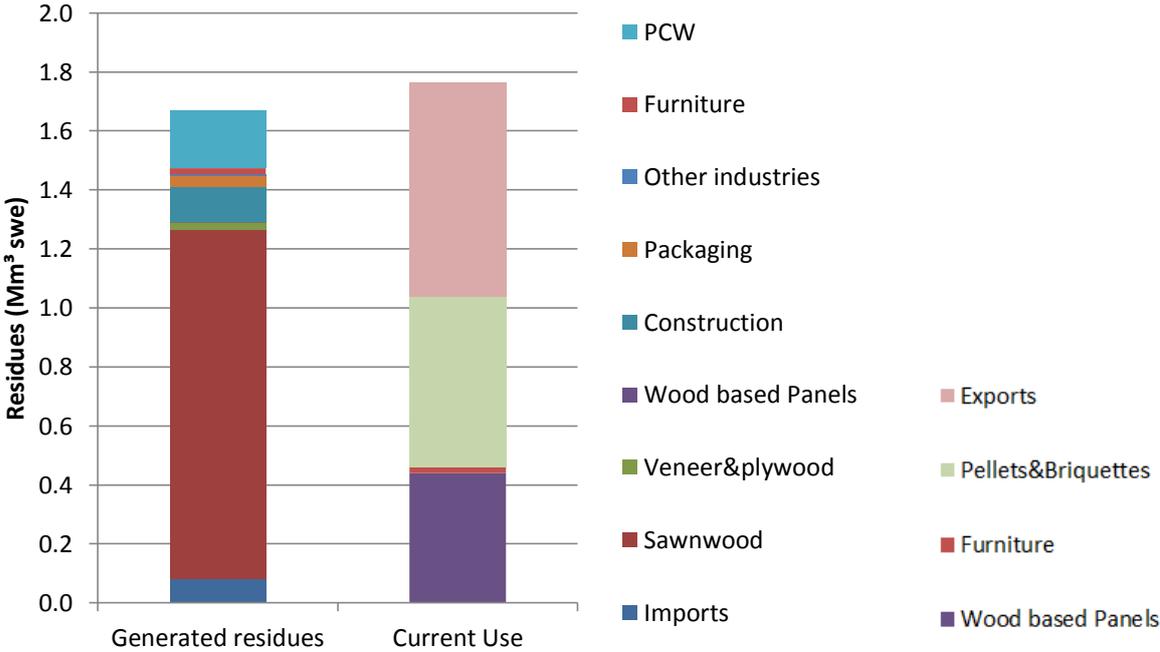


Figure 37 Estonian wood residue production and use

Total residue production in Estonia comes to nearly 1.7 Mm³ swe. 78% of these residues are produced by sawmills. Veneer and plywood production is very small, as is their residue production. Large amounts of wood residues (0.73 Mm³ swe) are exported. This export possibly includes chipped roundwood, sold as residues, as the total use of residues exceeds the current use of residues. The remaining potential is insignificant, as the estimated use of residues already exceeds the current production. Without the export, the unused residues potential would be about 0.63 Mm³ swe.

5.1.3 Latvia

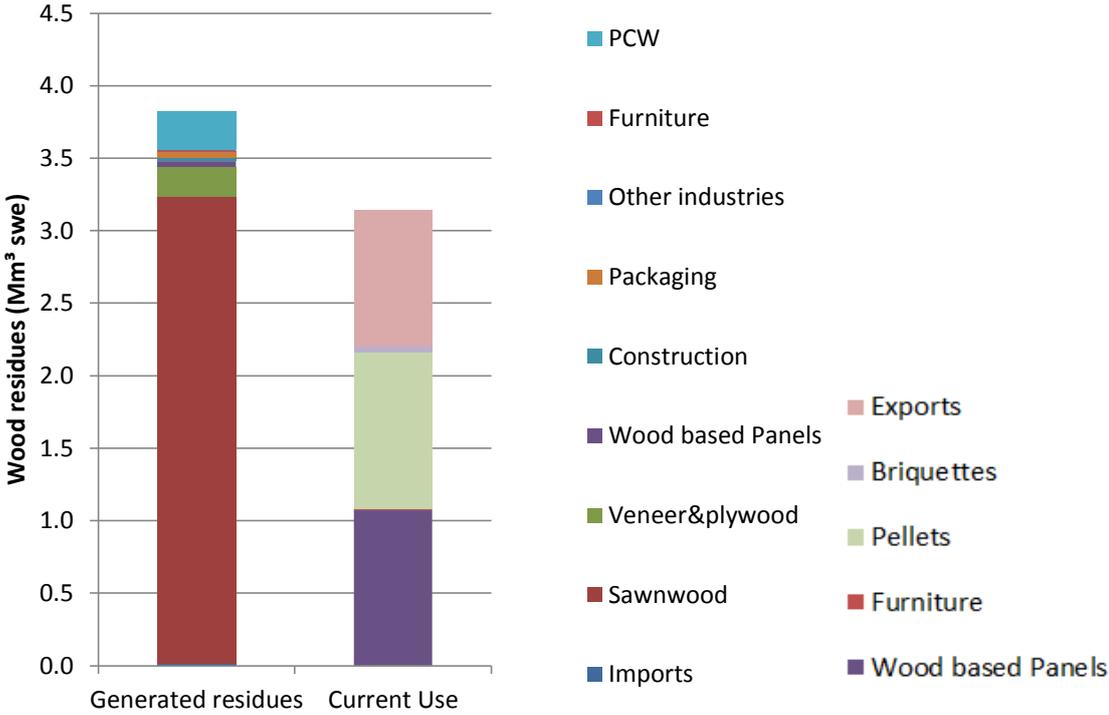


Figure 38 Residue production in Latvia per sector

The Latvian wood processing industry is relatively efficient. The main source of residues are sawmills. Large amounts of clean residues are exported, which results in a lack of residues on the current market, pellet producers are already using roundwood as raw material for their pellets, and have thoroughly researched their market.

Wood based panel production is still the primary use of wood residues, however, the pellet industry is still rising. Furthermore, the increasing use of wood waste for domestic heating will even further decrease the potential of residues for pellet production. Heating boilers have lower quality requirements and users are willing to pay a much higher price than pellet producers, since local heating is a bare necessity in winter.

The remaining potential is about 0.68 Mm³ swe, mainly from other wood industry and post-consumer wood.

5.1.4 Lithuania

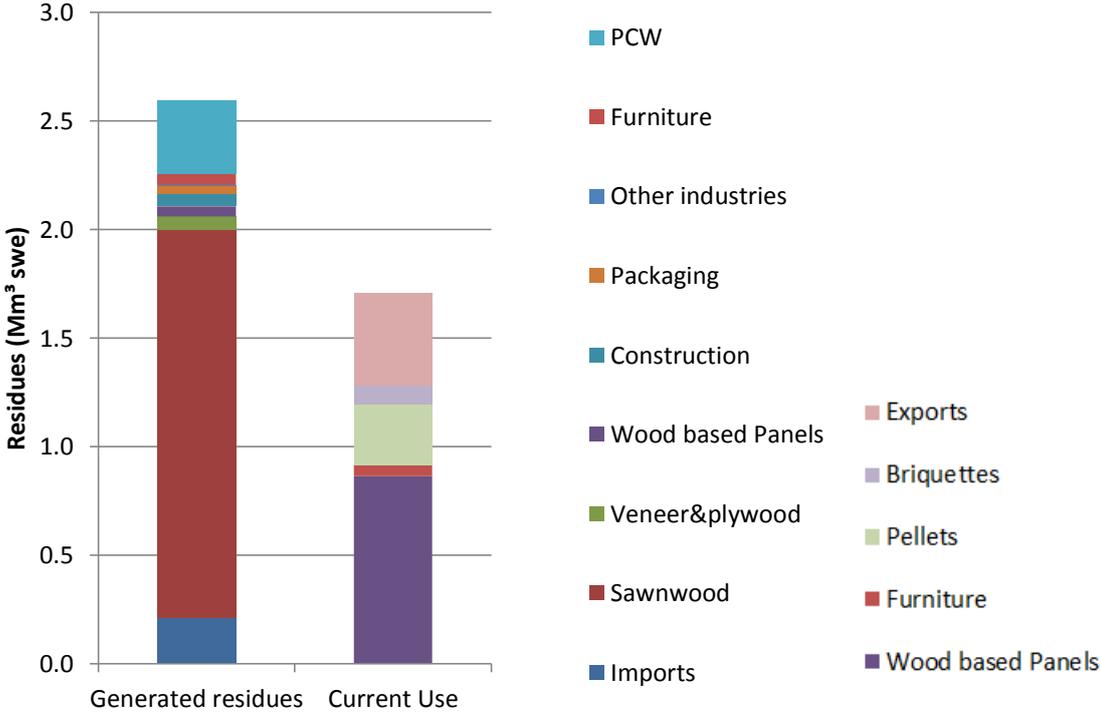


Figure 39 Lithuania wood residue production per sector

The Lithuanian wood processing industry is very diverse. Sawmills create nearly 1.9 Mm³ swe of residues, enough to cover the demand from material and energy production. The wood based panel industry is still a large consumer of wood residues, and vast amounts (over 0.56 Mm³ swe) are exported to Scandinavian grounds for paper production. Residues from furniture production are used internally; pellet producers compete for the remaining chips. The remaining potential for unused residues is about 0.82 Mm³ swe, mainly from other wood industry and post-consumer wood.

5.2 Future trends

This section shows how the results of the analysis may change in the future, based on the expected changes in the forest sector.

In the future, the wood industries are assumed to be more efficient, consuming less input per product output. Recovery factors, for example are assumed to rise up to current Western European (Germany) wood processing countries. For the wood pellet industry, it is assumed that the capacity utilisation will grow to 90%.

5.2.1 Future developments Poland

Polish residue production rises to 22.4 Mm³, due to a strong increase in the sawnwood production. However, the WBP industry shows a similar growth, resulting in a high consumption of wood residues. PCW is assumed to grow to 5.4 Mm³ in 2015 and 6.7 Mm³ in 2030 (figure 40), resulting in a potential of 4.3 Mm³.

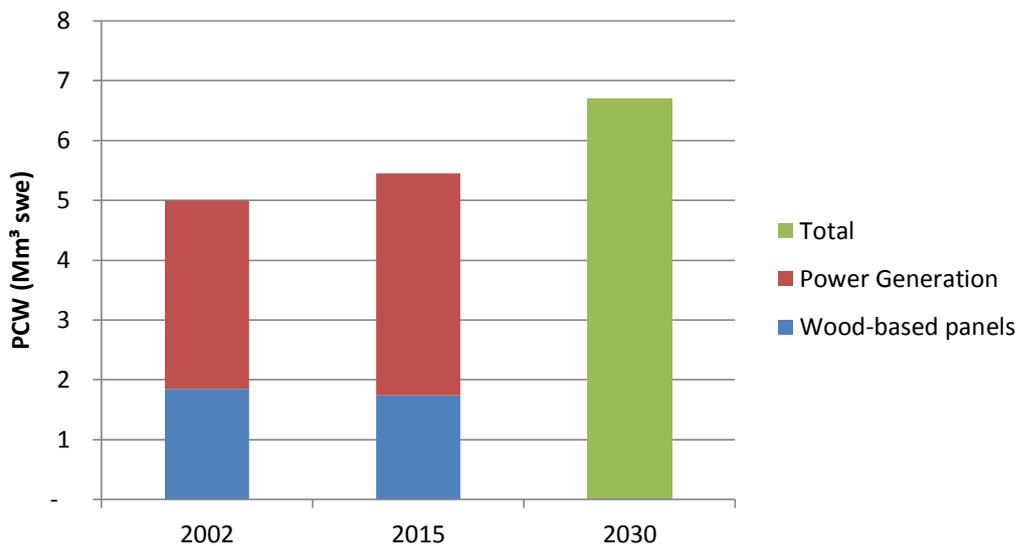


Figure 40 Potential supply of PCW in Poland for 2002 and 2015 (Ratajczak, 2004) and 2030 (Mantau, 2010)

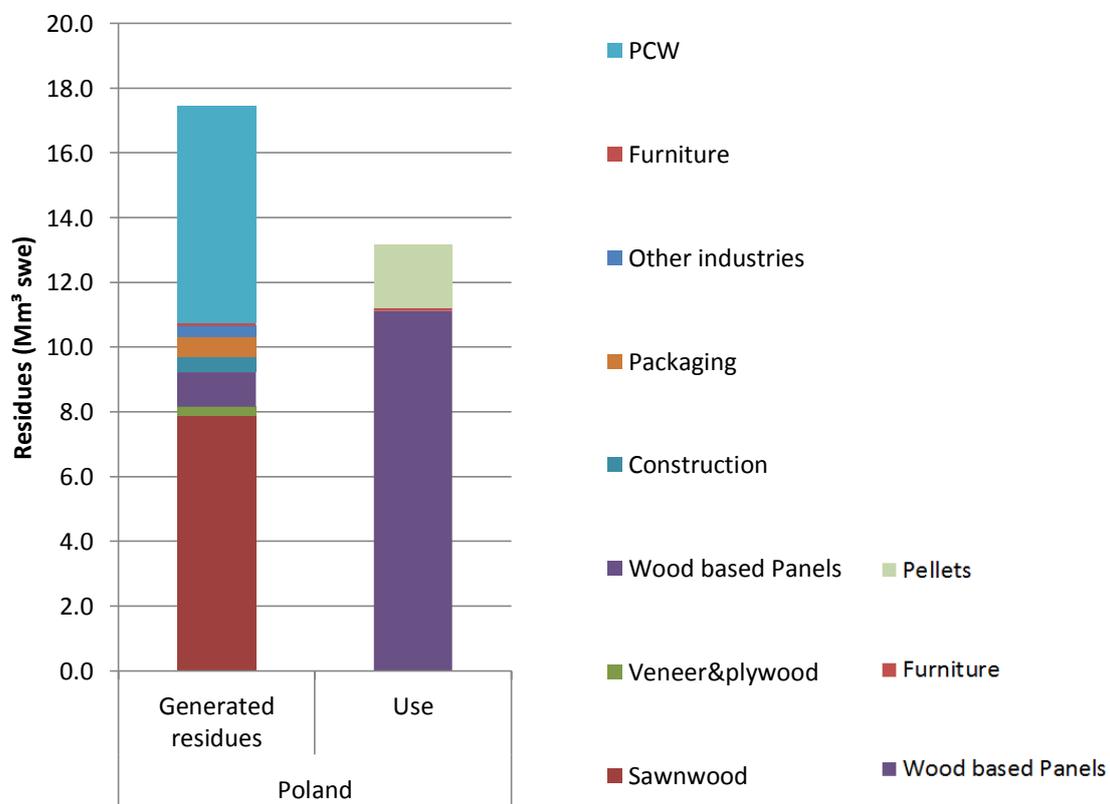


Figure 41 Wood residue potential in Poland for 2030.

5.2.2 Estonia

While the current Estonian market suffers a lack of residues, roundwood removals are assumed to rise by 30% in 2030, compared to current levels. However, the industry barely takes advantage: large amounts of wood residues are still exported. The potential therefore remains insignificant.

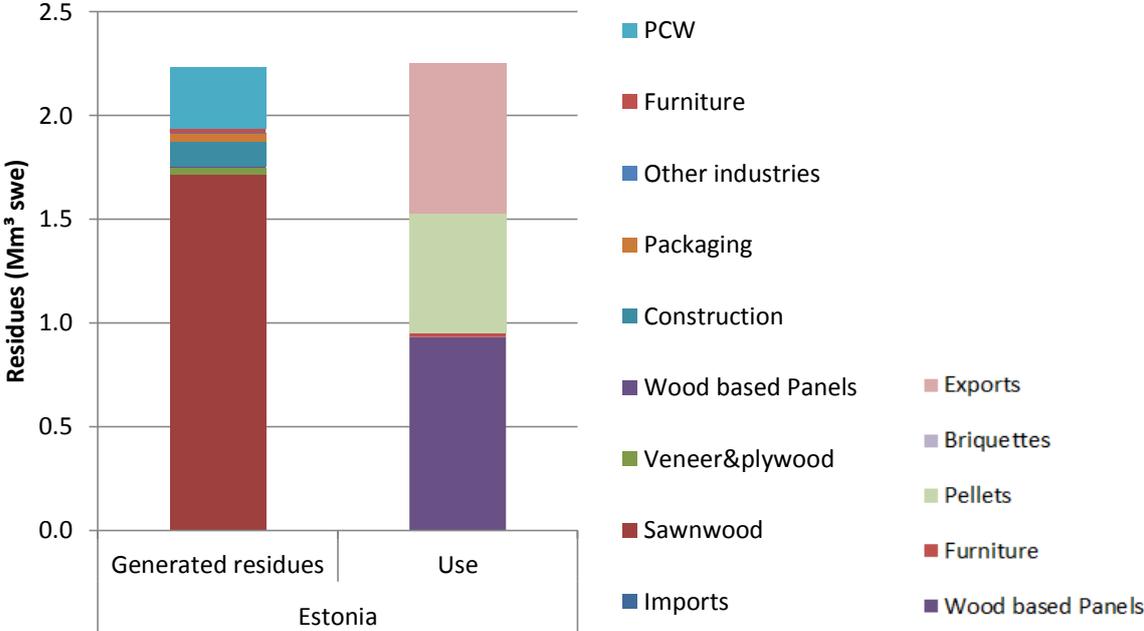


Figure 42 Wood residues in Estonia for 2030

5.2.3 Latvia

Latvian total annual cuttings are proposed to increase by 7.6%, but due to lower exports, the total wood on the Latvian market will increase by 52%. Sawnwood production follows by increasing with 40%, and WBP production is expected to mature, and grow with nearly 100%. This results in a rising residue production up to 6 Mm³, and a potential supply of 1.8 Mm³ of wood residues.

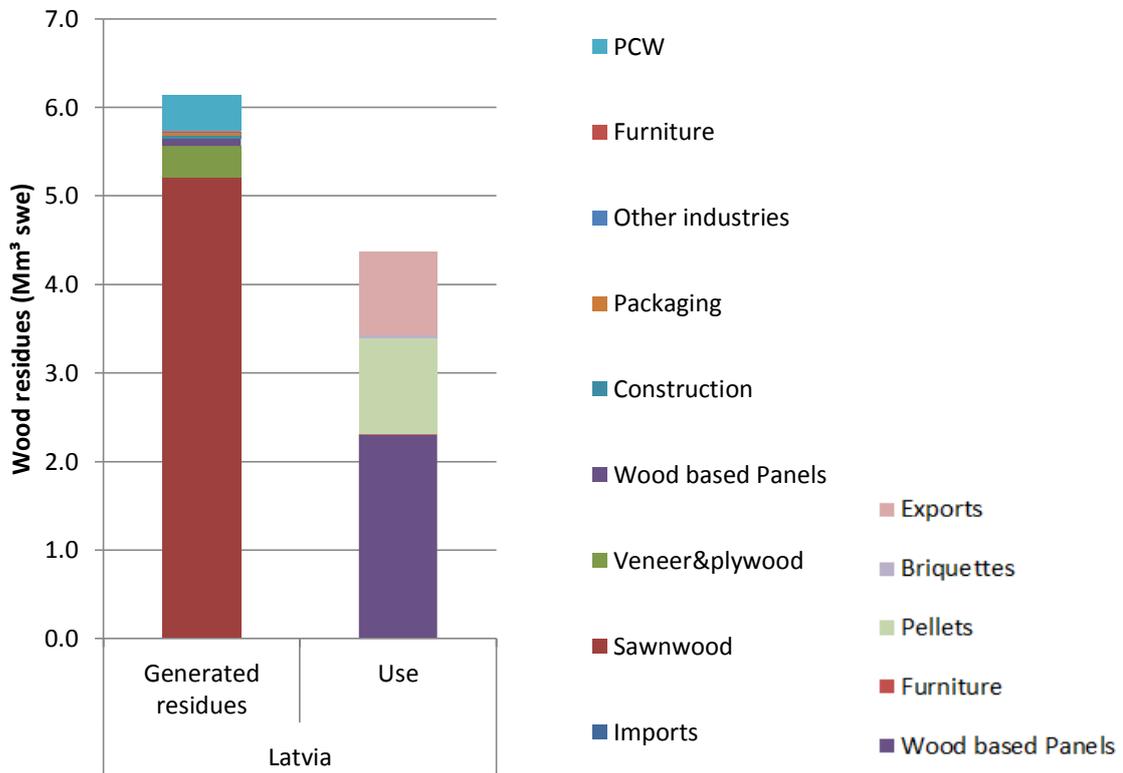


Figure 43 Wood residues in Latvia for 2030

5.2.4 Lithuania

In Lithuania, the wood market rises by 10%, to 9 Mm³ of roundwood removals in 2030. The sawmills take advantage by producing 20% more sawnwood. Particle board industry increases slightly (0.5Mm³), remaining the main user of residues. The potential increases to 1.4 Mm³ of wood residues in 2030.

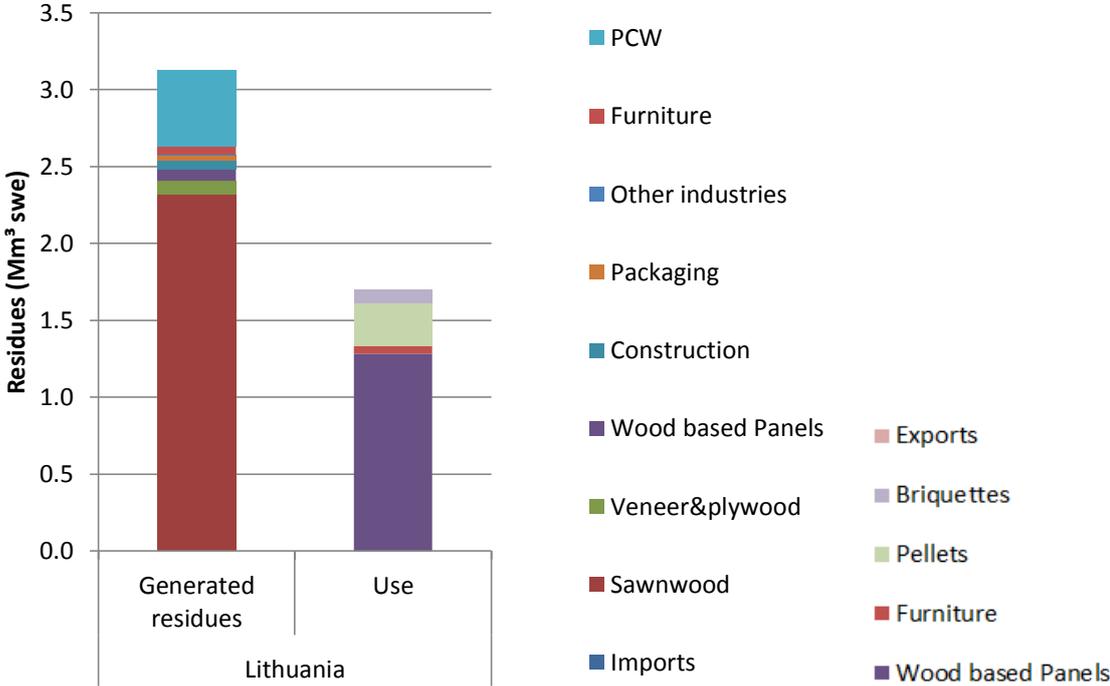


Figure 44 Wood residues in Lithuania for 2030

5.3 Economic availability

The available data, both in literature and empirical data gathered for this research, was not sufficient to assess the economic potential of the available residues streams. This would require more differentiated feedstock costs and spatial explicit data on the availability of the residue streams. However, two sawmills did share their residue costs. In Poland (Gdansk) sawmill residues are sold for 10-12 €/m³, and in Latvia (Ventpils) for 8-10 €/m³ (nov. 2011). Figure 45 provides an indication of the costs of wood pellets, transported to Rotterdam based on this feedstock. Transportation and stevedoring accounts for about 20% of the total costs, the feedstock costs accounts for about 35% of the total costs. The largest costs are pelletization, with 45% of the total costs.

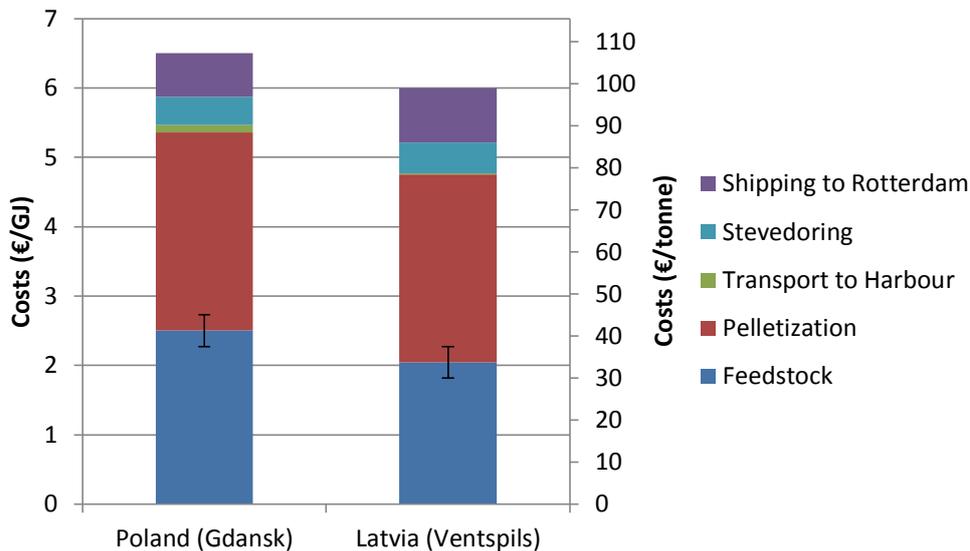


Figure 45 Pellet costs in Rotterdam

Figure 53 shows prices of wood pellets made from sawmill residues, transported to the Rotterdam harbour, of 107 €/tonne and 99 €/tonne for Gdansk and Ventpils respectively. This is well below the wood pellet price on the APX Endex of September 2011, 125.7 €/tonne according to Cocchi et al. (2011). Note that these sawmills represent ideal locations, at a short distance to a sea harbour. Further, these prices represents the costs of pellets in Rotterdam, and do not include profits.

6 Sensitivity analysis

This chapter describes the sensitivity of the input parameters and input data on the potential of woods residue. Of the four countries in the research, Poland has the largest wood sector. Therefore, this section only presents the results of the sensitivity analyses for Poland. The following parameters are included:

- Input materials (IM)
- Recovery ratios (RR)
- Expansion factors (EF)
- Residue share (RS)
- Post-Consumer Wood

The results of the sensitivity analyses for Poland are shown in figure 46, together with the used scenarios. The Y-axis represents the baseline scenario, the current potential of 3.7 Mm³ swe from figure 36. The table 18 (next to the figure) presents the baseline, low and high scenario for the sensitivity analyses.

6.1.1 Input materials

Clean wood residues are mainly used for wood based panel (WBP) production, as the production of WBP uses a large share of the generated clean residues, a different share of residues has large influences on the production. The share of residues used as input material differs significantly across Europe, ranging between 60 and 100%. For the production of MDF, we used the residue share factor of Poland to be similar in the Baltic States, 20% (Acker, 2008). If MDF would be produced from primary wood only, 23% more residues would become available in Poland. For the production of particle board, country specific input parameters were available for Poland and Latvia, both stating that 100% of the input material were wood residues. For Lithuania and Estonia, we assumed that the feedstock use is similar to Poland and Latvia. However, European average share of wood residues in particle board is 59%. This would accumulate an additional 3 Mm³ (84%) of residues, as main uses decreases. To simulate a possible scenario, where the demand for wood energy drives up energy prices, so that the particle board industry changes to other sources (e.g. roundwood or PCW), the input material parameter is also varied between 0 and 100% (effect is shown by the error bars in figure 48). If all particle board production would switch to another input material, this would theoretically free 7.5 Mm³ of clean wood residues on the market. If all MDF material would be made completely from residues, the potential would drop dramatically, to nearly zero.

6.1.2 Recovery ratios

The recovery ratio (RR) describes the number of units roundwood needed per unit of product produced. Because particle board production is large in Poland, the total supply potential of wood residues is also sensitive to the RR of particle board production. For the lower and upper bounds of the sensitivity cases, we assumed the worst and best practice in Europe. The lower (more efficient production) would lead to an increase 2 Mm³ (50%) of potential residues, because fewer residues are generated. The higher RR would lead to a 2 Mm³ decrease of the potential, the less efficient process consumes more residues. The RR of sawnwood has the reverse effect. A more efficient production process will immediately restrain the accumulated residues. The lower limit is set by the most efficient literature value. The country specific value for Poland by (Acker, 2008) is considered too optimistic, as it would represent the most efficient wood industry (see section 3.2.1), and is therefore

used as sensitivity range. This would lead to 1.6 Mm³ (44%) less sawnwood residues on the market, making the potential supply of clean residues unable to cover the current use of residues by the WBP and wood pellet production. The upper limit is set to the European worst case, resulting in 0.2 Mm³ of extra potential.

The future scenario assumes that, for 2030, the efficiency of the wood industry will improve to Western European standards (more efficient wood industry equals lower recovery ratios, low-case in the sensitivity analyses). This results in fewer residues being produced in (for example) sawmills, but also fewer residues being consumed in the production of wood based panels. The result of this combination is discussed in section 5.2.

6.1.3 Post-consumer wood

PCW is an important part of the potential supply of residues. However, the estimates on the availability of this material for Poland vary from 2.5 Mm³ to 5 Mm³ swe. The used potential of 4.1 Mm³ thus immediately leads to a key uncertainty in the potential. The share of used PCW has no influence on the technical potential, as the analysis includes both residue production and use, clean residues can be substituted for PCW without changing the total potential.

6.1.4 Expansion factors and residue shares

The residue production of the other wood industry is calculated based on the monetary turnover of the sector, an expansion factor and the residue share. Both are varied 20%. Because the total contribution of the other wood industry is relatively small, the largest sensitivity on the residue share (construction) is 0.56 Mm³ swe, or 16%, when the construction sector gets more efficient. Packaging shows a variation of 13%. The expansion factors do not show a large variation in the sensitivity analysis.

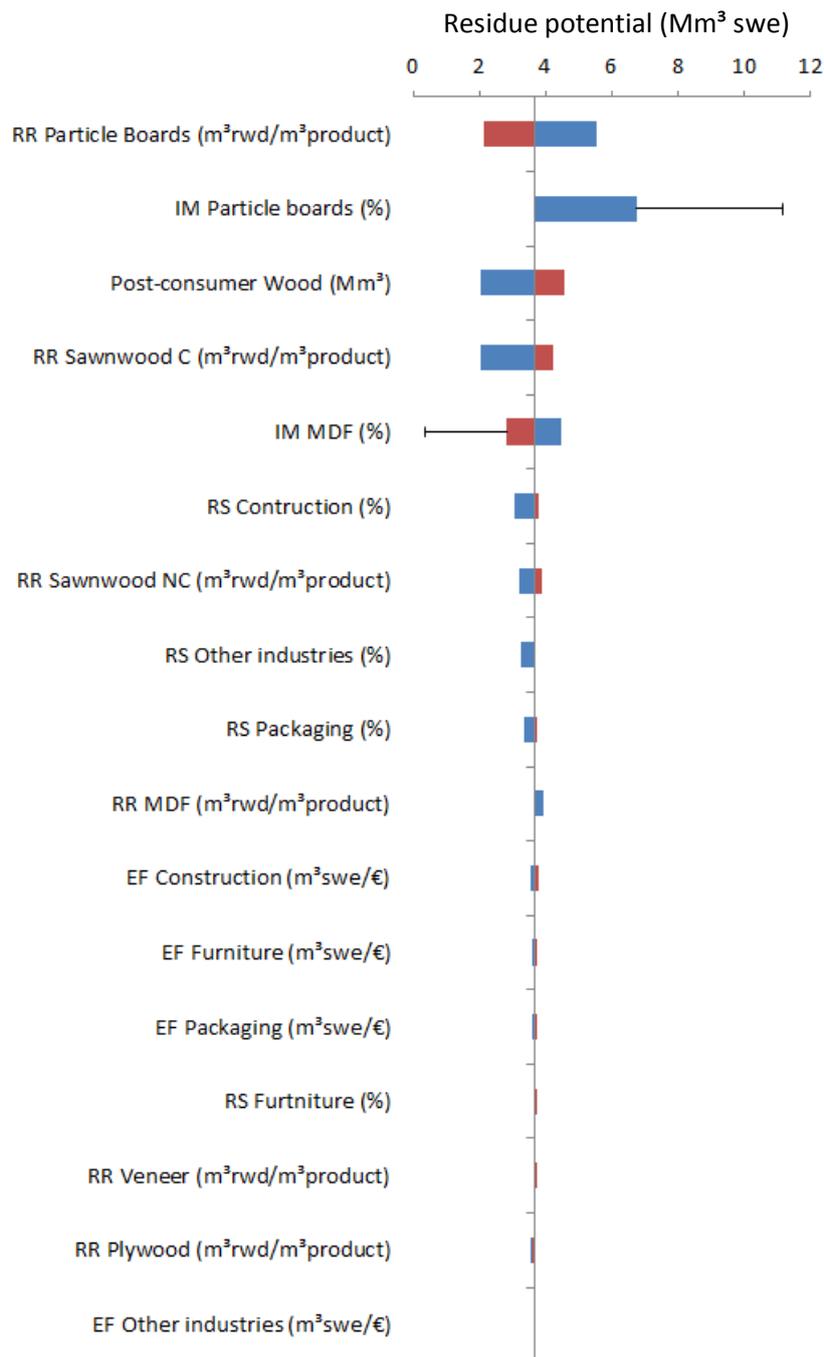


Figure 46 Results sensitivity analyses for Poland

	Base	Low	High
RR Particle Boards (m ³ rwd/m ³ product)	1.60	1.20	1.93
IM Particle boards (%)	1.00	0.59	1.00
Post-consumer Wood (Mm ³)	4,1	2,5	5,0
RR Sawnwood C (m ³ rwd/m ³ product)	2.00	1.56	2.22
IM MDF (%)	0.20	0.00	40.0
RS Construction (%)	0.10	0.08	0.12
RR Sawnwood NC (m ³ rwd/m ³ product)	2.10	1.54	2.50
RS Other industries (%)	0.10	0.08	0.12
RS Packaging (%)	0.18	0.15	0.22
RR MDF (m ³ rwd/m ³ product)	2.20	1.45	2.20
EF Construction (m ³ swe/€)	262	210	315
EF Furniture (m ³ swe/€)	43	35	52
EF Packaging (m ³ swe/€)	266	213	319
RS Furniture (%)	0.13	0.10	0.16
RR Veneer (m ³ rwd/m ³ product)	1.74	1.74	2.55
RR Plywood (m ³ rwd/m ³ product)	1.87	1.84	2.02
EF Other industries (m ³ swe/€)	116	93	139

Table 18 Sensitivity scenarios

7 Discussion

In this study, the current supply and use of wood residues and waste wood is assessed for Poland, Estonia, Latvia and Lithuania. Using a residue balance, the available potential of wood residues for the production of industrial pellets is estimated. Therefore, statistical data was combined with regional specific data from literature and empirical data. This section describes the key limitations of the methodology and the input parameters used, and compares the results to other studies.

7.1 Methodology

The methodology used in this study is mainly based on the statistical approach as described in the best practices handbook of biomass resource assessments of the BEE project (Vis, et al., 2010). This is an approach which makes it possible to make a wood resource balance, using available statistical information, covering all input and output of wood materials and residues.

Statistical data is used from both national and international sources, and combined with product and regional specific parameters and data that are not recorded in the statistics or only published in aggregated categories. To assess the potential availability of unused residues from the wood processing industry, a wood resource balance with generated wood residues and the currently used residues was made. This approach is based on the wood resource balance tool created for the EUWood study (Mantau, 2010). The wood resource balance approach can serve as a tool to identify unused residues that are not reported in statistics.

One of the key limitations of this approach is, however, that if one of the wood streams is not identified, this results in an imbalance. This could lead to an overestimate or underestimate of the potential, depending on residue sources or used streams are not included, respectively. Part of the required data and input parameters were not available for the selected region in this study and had to be extrapolated from other data sources. Furthermore, the used factors to extrapolate data require product and location specific figures, but are only available on country and product group aggregated levels. To address the gap in data availability to develop the wood residue balances, a field trip to Poland and Latvia was organized. The aim of this field trip was to assess the limitations of the statistical approach by comparing the results of the statistical approach to empirical cases. However, during the field trip it became clear that it was infeasible to get insight in the wood processing sectors due to significant barriers in language and market structure and limited data resources available at stakeholders. These barriers are further explained in section 7.4.

7.2 Input data

This section describes the uncertainty of the input data and impact on the uncertainty range of the results in more detail. To assess the volume of industrial wood residues requires detailed sector specific statistical data. The main sources used in this study were the national statistical offices, Faostat for physical production data and Eurostat for economic data. Although the data quality of these statistical sources is sufficient in most cases, there are key limitations. The statistical information on sawnwood production in Poland by the Polish Statistical Office is incomplete, according to the Wood Technology Institute (WTI) in Poznan (Ratajczak & Herbec, 2011). This is addressed by balancing the trade and sold volume of sawnwood. Statistical data shows that large amounts residues are exported in the Baltic Countries. For Estonia, the registered export is so large, that current residue use exceeds the total production. Exported trade flows, registered as wood residues are therefore likely to include chipped roundwood, sold as residues.

To extrapolate the statistical data into a complete wood balance, parameters were based on literature values and figures. Country specific parameters are used as much as possible, like data from Acker (2008) and Fonseca (2010). If not available, data from similar countries is used, according to the “UNECE Country groupings with similar forest product sectors” (Appendix A). However, in some cases the required data was not available, and values from nearby countries or European averages had to be used.

The share of used input materials for the wood based panels was identified as one of the most sensitive parameters in the analysis. For MDF, there is a possible threat when more residues are being used in the production than assumed. As particleboard is assumed to be made completely from residues, a different share of input materials would lead to extra potential residues. However, the used figures are country specific, and are in the range of other countries in the region.

Since sawnwood and wood based panels are the largest product groups, changes in their recovery ratio are significant for the potential. Moreover, sawmilling is one of the main producers of residues, and particle board production a main user of residues. The country specific recovery ratios for Poland based on Acker (2008) are most probably incorrect, as it is highly unlikely that Poland is the most efficient sawmilling country in the world. If Acker (2008) were correct, 1.6 Mm³ (44%) less sawnwood residues would be produced, making the supply of clean residues unable to cover the current use of residues by the WBP and wood pellet production. The recovery ratio for particle board production showed sensitive for changes as well, but there are only a few large producers, and country specific parameters are used. The base value is 1.6 m³rwd/m³product, a country specific value based on Acker (2008), that is in range with the Lithuanian value of 1,57 m³rwd/m³product (Fonseca, 2010).

Similar to the EUwood study (Mantau & Bilitewski, 2010) the parameters for the other wood industry were based on the German wood industry (expansion factors and residue share). More general input parameters result in a higher uncertainty of the output data. However, the total contribution of the other wood industry to the potential of unused wood residues is small. Therefore, uncertainties in the expansion factors and residue shares have little impact on the output.

Post-consumer wood (PCW) is a main part of the potential wood residues, especially in Poland. There are only few studies, and a lot of both quantitative and qualitative information is missing. The availability of PCW has a large influence on the total available potential wood residues.

7.3 Results

Figure 47 compares the current gross production of wood residues in Poland, to the EUWood study (Mantau, 2010) and the Polish National Renewable Energy Action Plan (NREAP). Note that this figure presents the gross production of residues, the use of residues for energy and materials should be deducted to display the potential of unused residues. The current production of residues of this study (Inbio) is significantly higher than found in other studies. Note that the NREAP shows the amount of residues that is expected to be mobilized for energy purposes in 2006, whereas this study and EUWood show the gross potential production of all residues for 2010. This explains why the reported data in the NREAP, does not include residues from other wood industries and very little PCW, as they are currently hardly used. The difference between EUWood and this study in the residues production from the wood processing industry can be explained by the corrected sawnwood production figures. The reported trade in sawnwood is too low, and results in an imbalance in the wood resource balance.

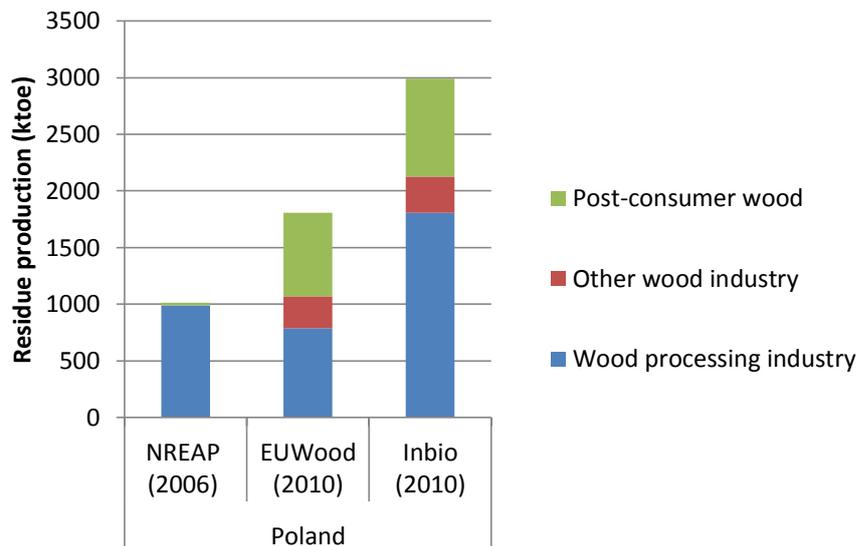


Figure 47 Current production of wood residues in Poland, comparison with other studies

Figure 48 compares the current production of residues in the Baltic Countries, with the NREAP and EUWood (A1 scenario) (Mantau, 2010). Residues from the wood processing industry are in range with the other studies. There is a clear decrease of the residues from other wood Industry compared to EUWood. EUWood based their assessment on the wood industry in 2007, whereas this study is based on 2010 data. After 2007, the furniture industry suffered especially from the financial crisis (JEANET, 2008) resulting in lower production and less residues.

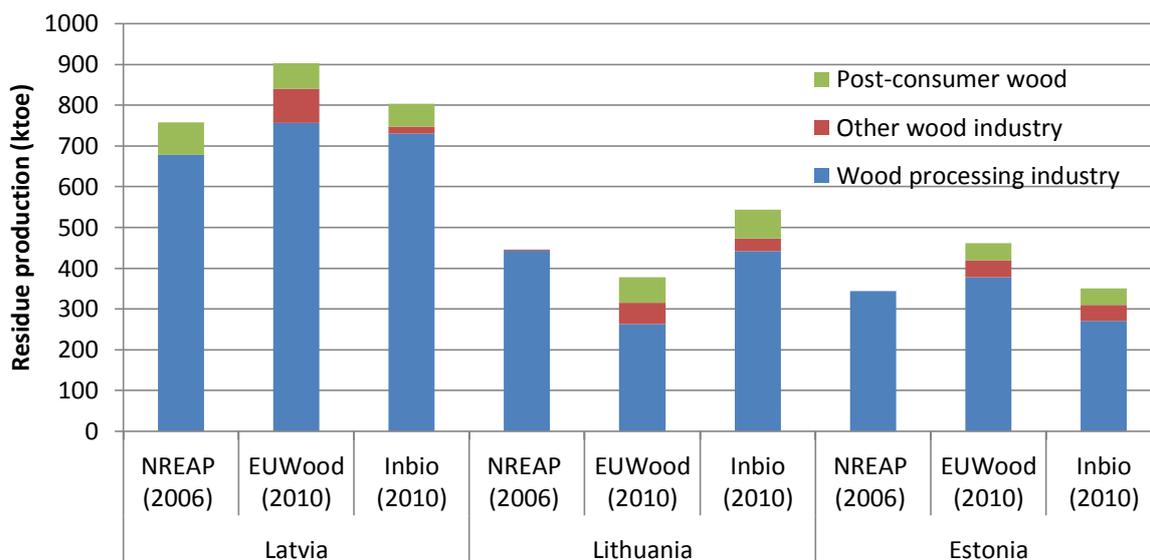


Figure 48 Current production of wood residues in the Baltic Countries, comparison with other studies

Figure 49 compares the future production of residues in Poland the NREAP, Green-X (Hoefnagels, et al., 2011) and EUWood (A1 scenario) (Mantau, 2010). Note that the NREAP and Green-X show the

potential in 2020, whereas EUWood and this study present the potential production of residues for 2030. EUWood and the NREAP both show a smaller amount of residues from the wood processing industry, because the data on sawnwood production is based on the incorrect current production (similar to figure 47). Further, all studies show a large share of PCW in the potential production of residues.

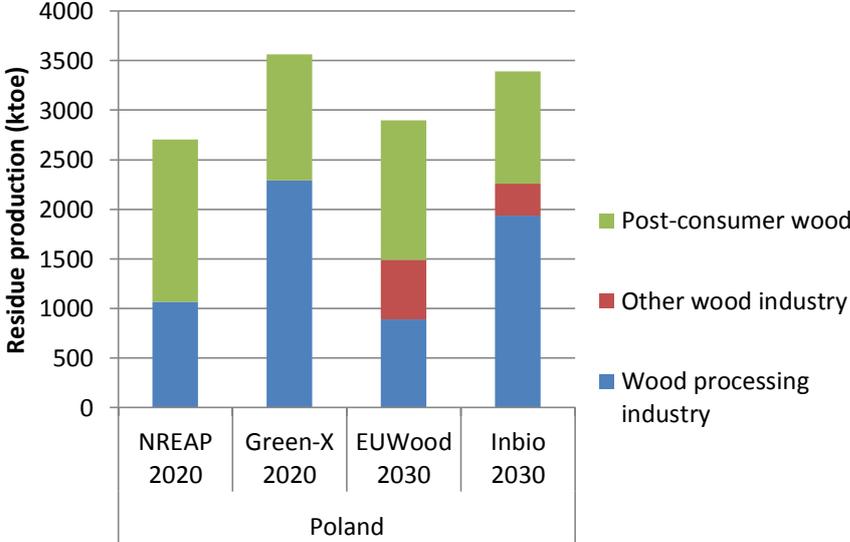


Figure 49 Future (2020-2030) production of residues in Poland, comparison to other studies

Figure 50 compares the future production of residues in the Baltic Countries to the NREAP, Green-X and EUWood . For the Latvia, the NREAP is not available. The Green-X data shows a much smaller residue production from the wood processing industry. Possibly this is due to the different time horizon, as the green-x data is for 2020 and the other data for 2030. The Latvian wood industry is expected to grow significantly. A similar, but less extreme, trend is visible for Lithuania and Estonia. The EUWood report assumes the other wood industry to grow significantly, whereas this study assumes only a slight increase.

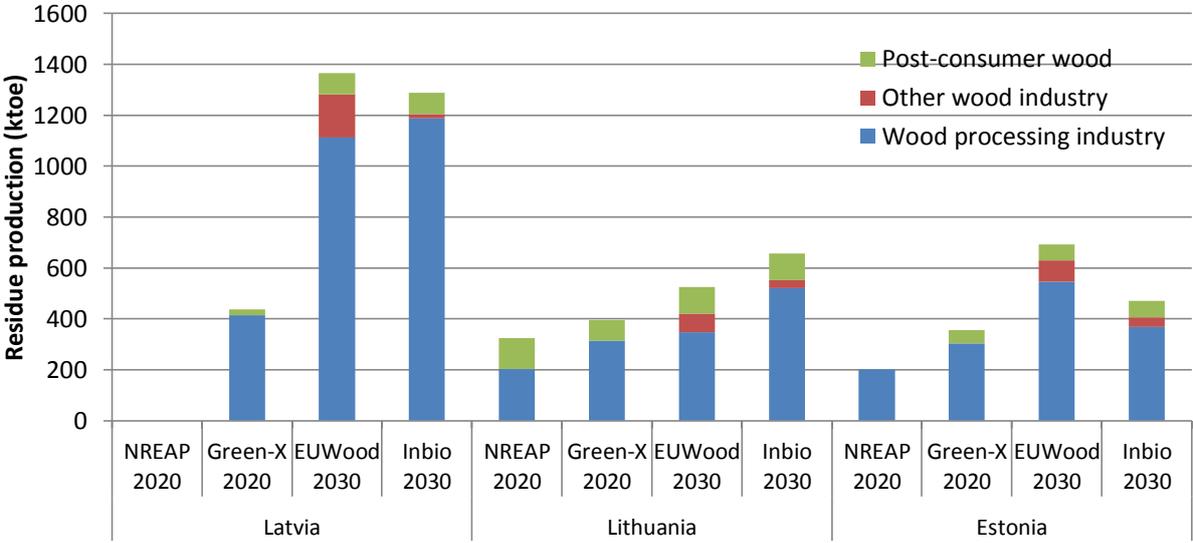


Figure 50 Future (2020-2030) production of residues, comparison to other studies

7.4 Barriers

7.4.1 Language barrier

This study has been conducted within the Inbio consortium including partners from the Netherlands and the U.S. To deal with language barriers, support from local institutes (Poland: BAPE and Regional Directorate of Polish State Forests District Gdansk, Latvia: Ekodoma) was provided during a 6 week field trip/internship at selected organizations. Still, the Polish language was a significant barrier. Interviews were only possible with the help of an interpreter, even at larger companies. Problems lie partly in the hierarchic structure of the companies and the country as a whole. It was not possible to only speak to employees (which are younger, and speak more foreign languages) without a higher manager or director. English or German was rarely spoken, especially by older employees.

7.4.2 Market structure

Due to the closed nature of the market in Poland, the field trip failed to create a proper empirical image of the market. The competition among market actors is very strong and companies do not see the added value of sharing market information with research institutes. Governmental institutes do not get complete insight in the market structure. Combined with the language barrier, this makes it hard for a foreign research institute to get access to reliable empirical data.

A questionnaire was sent out to 120 companies in Poland (Appendix D), in both the wood processing industry and the other wood industry. The questionnaire was translated to Polish to eliminate the language barrier. However, even after a second sending and phone calls, none of the approached companies responded to the questionnaire. Telephone interviews (as far as possible) also did not deliver the desired result either. The companies were not prepared to share information on their production process.

8 Conclusion

The goal of this study was to assess the potential of a selection of low valued residue streams for the Baltic Countries and Poland, that can be used for the production of industrial certified pellets that can be transported to the Rotterdam harbour.

The results of the wood resource balance show that secondary residues from the wood processing industry are to a large extent, already used. Figure 51 shows the residue balance for the Baltic Countries and Poland. Technical potential for unused residues in the Baltic Countries and Poland combined, is 7.5 Mm³, largely consisting of tertiary residues.

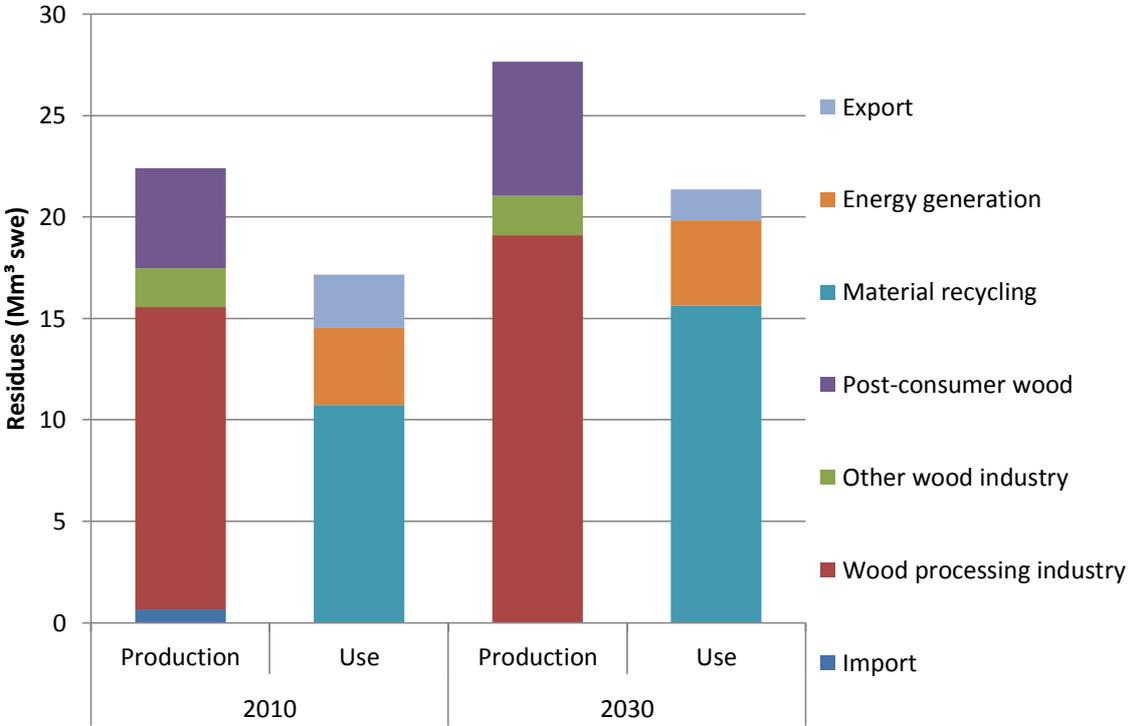


Figure 51 Production and use of residue streams per category in the Baltic Countries and Poland for 2010 and 2030

Figure 52 shows the production and use of residues per country. The largest technical potential of unused wood residues is available in Poland. The potential of tertiary residues in Poland is estimated to be 3.68 Mm³ swe and all secondary residues are already used in this region. In Lithuania, the technical potential is 0.36 Mm³ swe, unused tertiary residues account for 70% of the potential. The technical potential for Latvia is 0.68 Mm³, where unused tertiary residues account for 33%. The potential in Estonia is insignificant, as current residues are to a large extent already used, and large amounts residues (including possible chipped roundwood, sold as residues) are exported.

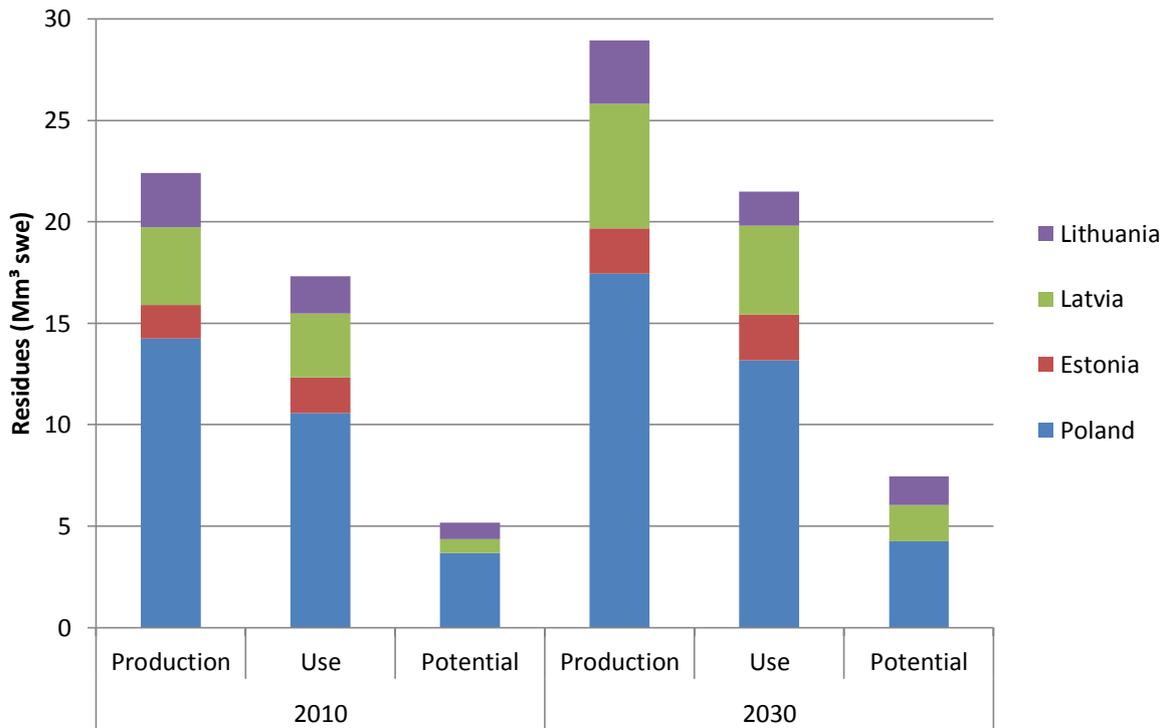


Figure 52 Production and use of residue streams per country in the Baltic Countries and Poland for 2010 and 2030

On the long term, the wood markets in Poland and the Baltic Countries are expected to grow significantly. However, the growth of the residues is not linear due to more efficient processes and different product outputs. As Estonia is still expected to export large amounts of residues, the potential is expected to remain insignificant. Figure 51 and 52 present the potential for 2030: the potential is estimated to rise 25%, to 5.9 Mm³ in 2030.

The available data, both in literature and empirical data gathered for this research, was not sufficient to assess the economic potential of the available residues streams. This would require more and different feedstock costs and spatially explicit data on the availability of the residue streams. As this was not available, a cost supply curve containing the costs of mobilization could not be constructed. Figure 53 provides an indication of the costs of wood pellets, transported to Rotterdam based two cases. Transportation and stevedoring accounts for about 20% of the total costs, the feedstock costs accounts for about 35% of the total costs. The largest costs are pelletization, with 45% of the total costs.

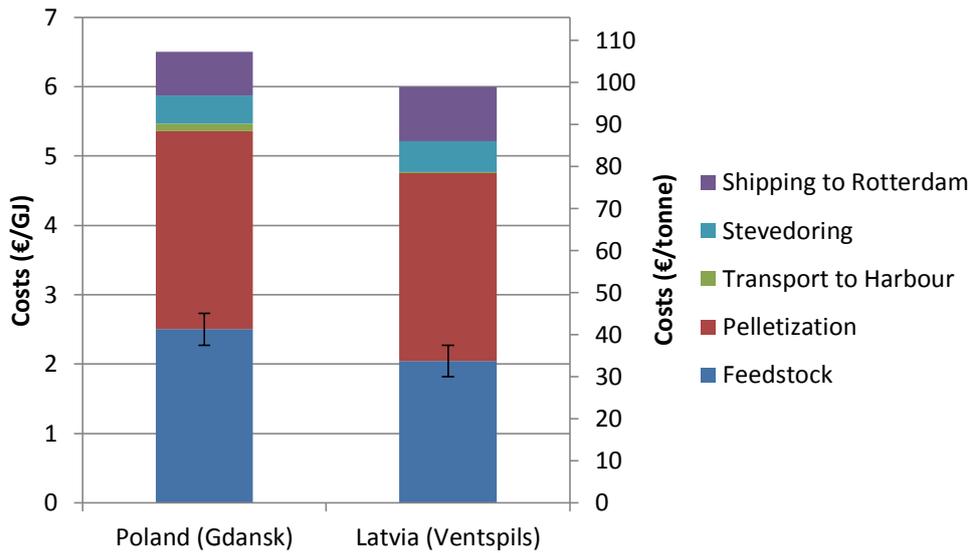


Figure 53 Pellet costs in Rotterdam

It can be concluded that at this point, there are not large amounts of unused secondary wood residues in the Baltic Countries and Poland. Wood residues are available, but they mainly consist of tertiary residues, which are (at this point) to a large extent not mobilized. However, little information is available on the technical availability of this stream, and it may need extensive treatment before it can be used for wood pellet production.

9 Recommendations for further research

Secondary residues are at this point to a large extent already used. Further research on the economic availability is therefore not feasible at an independent research institution. One should be prepared to compete with the current industry. A commercial feasibility study is needed with a monetary prospective.

Tertiary residues have high promises in Poland, but there is very little information on the composition of the post-consumer wood. Extensive local empirical research is needed to provide more information on the actual economic availability of this potential. This large potential for tertiary residues raises an interesting question: which production processes, which currently use clean residues or roundwood can be substituted by PCW, and which are more tolerant to contaminations. Research is needed on which streams are replaceable by PCW. This would possible free large amounts of clean residues for wood pellet production.

In order to calculate the roundwood input and residue output of the different production steps in the wood industry, recovery ratios (RR) and share of input materials are used. These assumptions are based on literature data which provides country specific parameters or European averages. However, in reality these parameters may well be plant specific as they rely on the used technology and the quality of the input materials. The sensitivity analysis showed that the recovery ratios and share of input material for wood based panels and sawnwood production are sensitive for changes in the output. A more spatially explicit (bottom up) approach with location specific parameters, and smaller regions, is needed to increase the certainty of the output. This will require data on plant level, and should start by identifying all wood industry in a certain region and (begin) monitoring these parameters.

Further, local partners are needed to cope with the language barrier and market structure.

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Appendix A UNECE Country groupings with similar forest product sectors

Table 19 Country groupings with similar forest product sectors (Fonseca, 2010)

Country	Group
Albania	1
Bosnia and Herzegovina	1
Croatia	1
Montenegro	1
Serbia	1
The FYR of Macedonia	1
Republic of Moldova	1
Andorra	2
Portugal	2
Spain	2
Austria	3
Slovenia	3
Belgium	4
Luxembourg	4
Netherlands	4
Denmark	4
Bulgaria	5
Romania	5
Turkey	6
Cyprus	6
Greece	6
Israel	6
Malta	6
Czech Republic	7
Slovakia	7
Hungary	7
Estonia	8
Latvia	8
Lithuania	8
Finland	9
Norway	9
Sweden	9
France	10
Monaco	10
Germany	11
Ireland	12
United Kingdom	12
Italy	13
San Marino	13
Liechtenstein	14
Switzerland	14
Belarus	15
Poland	15
Ukraine	15
Armenia	16
Azerbaijan	16
Georgia	16
Kazakhstan	16
Kyrgyzstan	16
Tajikistan	16
Turkmenistan	16
Uzbekistan	16
Russian Federation	17
Canada	18
United States of America	18
Iceland	19

Appendix B Questionnaire English



Utrecht University

Residues from wood processing

[Na polska, kliknij tutaj](#)

Currently wood fuels are mainly produced from clean sawdust from saw mills. Alternative wood resources are available that can be used for the production of industrial wood pellets.

Utrecht University (the Netherlands) is conducting a market study commissioned by the Dutch government to quantify the potential of wood residues in Poland that are:

- Currently underutilized
- Sold at low prices (for markets such as process heat)
- Land filled

Examples of residues are :

- Dust, chips and shavings (from planing, milling and drilling)
- Trimmings
- Rejections
- Peeler cores
- Square-cuttings
- Wood waste.

Your company is identified to be a possible supplier in Poland, and we therefore ask you to fill in the questionnaire below.

Please make the following statements for one (1) location/plant only. If there are more plants within your company, please fill in the questionnaire for each plant.

Answering the questionnaire is voluntary, partly answering is possible. Participants will receive a free final report of the research to wood residues in Poland.

Answers are treated **confidential**, and will be generalised to the whole industry and region, before use.

Please specify the type of company

- Sawmill
- Veneer & Plywood production
- Wood based panels production
- Furniture production
- Garden products
- Wood pallets
- Other:

What wood residues are available at your company?

Please fill in for your company: The accumulated residues during production

	Type of residues generated	Amount (Unit: m3/year bulk)	Source of the residues	When available? (Whole year or specify)
1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
4	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
5	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

* Indicates Response Required

Next >>

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Residues from wood processing

How much of these residues are currently not used, disposed or sold below market value? (please specify per residue stream)

	Amount (m3/year bulk)	Price (z/m3)
1	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>
3	<input type="text"/>	<input type="text"/>
4	<input type="text"/>	<input type="text"/>
5	<input type="text"/>	<input type="text"/>
Other (specify)	<input type="text"/>	<input type="text"/>

What are the barriers (e.g. no good price/market, contamination)

- No market possibilities
- Low price
- Contamination
- Seasonal availability
- Other:

What is the current destination for the residues?

	Domestic sale	Export
Please specify:	<input type="text"/>	<input type="text"/>

Which products produces your company?

	Product	Production capacity	Actual production (2010)	Input material for the production
1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
4	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
5	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

* Send me a free digital report

* Suggestions/Comments:

* Indicates Response Required

Appendix C Questionnaire Polish



Utrecht University

Wykorzystanie odpadów z przerobu drewna i pozostałości drzewne

[For English, Click here](#)

W chwili obecnej paliwa bazujące na drewnie są produkowane głównie z czystych trocin z tartaków. Dostępne są jednakże alternatywne zasoby drewna, które mogłyby być wykorzystane do produkcji przemysłowej peletów drzewnych.

Uniwersytet w Utrechcie (Holandia) prowadzi badanie rynku zlecone przez rząd holenderski mające na celu oszacowanie potencjału odpadów drzewnych w Polsce, które są:

- Obecnie nie w pełni wykorzystane
- Sprzedawane po niskich cenach (np. wykorzystanie technologiczne ciepła)
- Pozostające w terenie

Przykładami odpadów z przerobu drewna są:

- Pył, wióry i trociny (po procesie strugania, frezowania, wiercenia)
- Obcinanie
- Odrzuty poprodukcyjne
- Rdzenie po okorowaniu
- Zręby powierzchniowe
- Odpady drewniane

Państwa firma została zidentyfikowana jako możliwy dostawca tego typu odpadów w Polsce i dlatego prosimy o wypełnienie poniższej ankiety.

Proszę o wypełnienie jednego kwestionariusza dla danej lokalizacji/zakładu przerobu. Jeśli przedsiębiorstwo posiada kilka zakładów proszę o wypełnienie kwestionariusza dla każdego zakładu osobno.

Wypełnienie kwestionariusza jest całkowicie dobrowolne, będę wdzięczny również za częściowe jego wypełnienie.

Państwa odpowiedzi są poufne i będą stanowiły odzwierciedlenie całej branży i regionu.

Uczestnicy otrzymają bezpłatny raport końcowy z badań na temat odpadów drzewnych w Polsce.

* Nazwa przedsiębiorstwa * Adres

* Nazwa kontaktowa * Numer telefonu * Adres Email

- * Typ przedsiębiorstwa/profil produkcji
- Tartak drzewny
 - Fabryka okleiny i sklejki
 - Przemysł płyt drzewnych
 - Przemysł meblarski
 - Meble ogrodowe
 - Fabryka palecie
 - Inne (określ)

Jakie odpady drzewne dostępne są w Twojej firmie?

Jak dużo odpadów i resztek drzewnych wytwarza się podczas produkcji? Jeśli możliwe, wyszczególnij według produktu.

Typ (wióry, trociny, zrębki, odpady, etc.) Ilość (m3 ogółem) Źródło (przerzynka, przycinka, odpady, etc.) Dostępność sezonowa (czy odpady są dostępne przez cały rok, czy też produkcja odbywa się sezonowo)

1	2	3	4	5
<input type="text"/>				
<input type="text"/>				
<input type="text"/>				
<input type="text"/>				
<input type="text"/>				

* Indicates Response Required

[Next >>](#)

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Wykorzystanie odpadów z przerobu drewna i pozostałości drzewne

Jaka ilość tych odpadów jest obecnie niewykorzystana, a jaka przeznaczona do sprzedaży poniżej wartości rynkowej? (określ według źródła pochodzenia odpadów)

	Ilość (m3 ogółem)	Cena (tł/m3)
1	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>
3	<input type="text"/>	<input type="text"/>
4	<input type="text"/>	<input type="text"/>
5	<input type="text"/>	<input type="text"/>
Other (specify)	<input type="text"/>	<input type="text"/>

Jakie występują bariery

- Rynek
- Słaba cena
- Zanieczyszczenia
- Dostępność sezonowa
- Inne (określ)

Jaki jest obecny cel dla odpadów drzewnych

	Sales lokalnar	Eksportor
Proszę określić	<input type="text"/>	<input type="text"/>

Określ (w ilości szt.) możliwości produkcyjne oraz faktyczną produkcję (2010)

Produkty	Możliwości produkcyjne	Faktyczną produkcję	Co jest podstawowym materiałem wykorzystywanym do produkcji
1	<input type="text"/>	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>	<input type="text"/>
3	<input type="text"/>	<input type="text"/>	<input type="text"/>
4	<input type="text"/>	<input type="text"/>	<input type="text"/>
5	<input type="text"/>	<input type="text"/>	<input type="text"/>

* Chcę otrzymać darmowy raport końcowy (drogą elektroniczną)

Tak

* Sugestie / komentarze

* Indicates Response Required

<< Previous Submit

Appendix D List of approached companies in Poland

Company	City	Category	Source
Instytut Włókien Naturalnych	Poznań	Accociation	OIGPM
STOWARZYSZENIE PRODUCENTOW PLYT DREWNOPOSCHODNYCH W POLSCE	Czarna Woda	Associations/Resear ch	
ABIS Przedsiębiorstwo Sp. z o.o.	Siedlemin	Furniture	OIGPM
Amica Wronki S.A.	Wronki	Furniture	OIGPM
Armet Bis Sp. z o.o.	Gdynia	Furniture	OIGPM
ASADENA SP. Z O.O.	Śmigiel	Furniture	OIGPM
Bialskie Meble Sp. z o.o.	Biała Podlaska	Furniture	OIGPM
Bydgoskie Fabryki Mebli S.A.	Bydgoszcz	Furniture	OIGPM
COALA PPH	Tuchów	Furniture	OIGPM
Com40	Nowe Skalmierzyce	Furniture	OIGPM
COMFORT COLLECTION SPÓŁKA Z O.O.	PIECKI	Furniture	OIGPM
DOMCZAR Artur Zawadzki	Łomża	Furniture	OIGPM
DOMM	Hajnówka	Furniture	OIGPM
DREHABUD s.j.	Nidzica	Furniture	OIGPM
F.S. Favorit Furniture Szczytno Sp. z o.o.	Szczytno	Furniture	OIGPM
Fabryka Mebli BALMA S.A.	Tarnowo Podgórne	Furniture	OIGPM
Fabryka Mebli Biurowych MDD Sp. z o.o.	Sępólno Krajeńskie	Furniture	OIGPM
Fabryka Mebli Biurowych MIKOMAX Sp. z o.o.	Łódź	Furniture	OIGPM
Fabryka Mebli Filipek	Węgrów	Furniture	OIGPM
Fabryka Mebli GAWIN Andrzej Gawin	Międzybórz	Furniture	OIGPM
Fabryka Mebli Okrętowych FAMOS Sp. z o.o.	Starogard Gdański	Furniture	OIGPM
Fabryka Mebli STOLKAR	Brodnica	Furniture	OIGPM
Fabryki Mebli Forte S.A.	Ostrów Mazowiecka	Furniture	OIGPM
FAWRE Sp z o.o.	Gdańsk	Furniture	OIGPM

Company	City	Category	Source
Flair Poland Sp. z o.o.	Kobylnica	Furniture	OIGPM
Formaplan Polska Sp. z o.o.	Wolbórz	Furniture	OIGPM
FURNIKO Fabryka Mebli Biurowych	Koszalin	Furniture	OIGPM
Gamet S.A.	Toruń	Furniture	OIGPM
Herkules Sp. z o.o.	Szamotuły	Furniture	OIGPM
Indeco Pomorze Sp z o.o.	Gdańsk	Furniture	OIGPM
JBM Firma Produkcyjno-Handlowo-Uslugowa Spółka Jawna Jacek Bergiel, Renata Bergiel	Zamość	Furniture	OIGPM
K&R Design s.c.	Warszawa	Furniture	OIGPM
KLASIKUS Producent Mebli Klasycznych	Świdnik	Furniture	OIGPM
Kler S.A.	Dobrodzień	Furniture	OIGPM
KLOSE - Pomorska Fabryka Mebli	Nowe k. Świecia	Furniture	OIGPM
KLOSE Czerska Fabryka Mebli Sp. z o.o.	Czersk	Furniture	OIGPM
KLOSE Gościcińska Fabryka Mebli Sp. z o.o.	Gościcino	Furniture	OIGPM
Krośnieńskie Fabryki Mebli KROFAM Sp. z o.o.	Krosno	Furniture	OIGPM
Kuncar Sp. z o.o.	Mikołów-Borowa Wieś	Furniture	OIGPM
Laguna Sp. z o.o.	Pruszcz Gdański	Furniture	OIGPM
Logo Design Sp. z o.o.	Koronowo	Furniture	OIGPM
LUDWIK STYL Fabryka Mebli Twaróg	Rogoźno Wielkopolskie	Furniture	OIGPM
Martela Sp. z o.o.	Warszawa	Furniture	OIGPM
MEBELUX Sp. z o.o.	Ostróda	Furniture	OIGPM
Meblarska Spółdzielnia Pracy DĄB	Gdynia	Furniture	OIGPM
Meblarska Spółdzielnia ZRYW	Wejherowo	Furniture	OIGPM
Meble Dębowe Ludwik&Olech	Wągrowiec	Furniture	OIGPM
MEBLOBUK s.j.	Skórzewo k/Poznania	Furniture	OIGPM
Międzynarodowe Targi Poznańskie Sp. z o.o.	Poznań	Furniture	OIGPM
MTI-FURNINOVA POLSKA Sp. z o.o.	Kętrzyn	Furniture	OIGPM
Ostroszowicka Fabryka Mebli S.A.	Ostroszowice	Furniture	OIGPM

Company	City	Category	Source
P.P.H. SPAR MEBLE	Chojnice	Furniture	OIGPM
P.P.H.U. ALLMAX-SERWIS	Kraków	Furniture	OIGPM
P.W. INTERKRES s.j. S.Smyk i Z. Mazurek	Zamość	Furniture	OIGPM
Państwowe Przedsiębiorstwo Przemysłu Meblarskiego i Budownictwa	Potulice	Furniture	OIGPM
Pfleiderer Grajewo S.A.	Grajewo	Furniture	OIGPM
Pfleiderer Prospan S.A.	Wieruszów	Furniture	OIGPM
PHZ ZIMAX Wiesław i Helena Zimnochowie s.j.	Białystok	Furniture	OIGPM
POL - LEIM - HOLZ Sp. z o.o.	Leszno	Furniture	OIGPM
Poli-Eco Tworzywa Sztuczne spółka z o.o.	Żary	Furniture	OIGPM
PPH SKAR-POL	Wągrowiec	Furniture	OIGPM
PPHU 'ALLMAX-SERWIS'	Kraków	Furniture	OIGPM
PROFIm Sp. z o.o.	Turek	Furniture	OIGPM
REJS Spółka z o.o.	Rypin	Furniture	OIGPM
SITAG Formy Siedzenia Sp. z o.o.	Swarzędz	Furniture	OIGPM
Spółdzielnia Pracy Stolarskiej Przyszłość	Jelenia Góra	Furniture	OIGPM
Starpol Biuroserwis Sp. z o.o.	Puławy	Furniture	OIGPM
SZYNAKA - MEBLE Sp. z o.o.	Lubawa	Furniture	OIGPM
Taurus Sp. z o.o.	Dobroszyce	Furniture	OIGPM
Technodrew Polska Sp. z o.o.	Zawadzkie	Furniture	OIGPM
TOREKO	Toruń	Furniture	OIGPM
TOREX Sp. z o.o.	Piątek	Furniture	OIGPM
Trimex Sp. z o.o.	Szczeczeszyn	Furniture	OIGPM
Versal Sp. z o.o.	Warszawa	Furniture	OIGPM
Zakład drzewny KIMEX s.j. E. G. Buda	Biłgoraj	Furniture	OIGPM
Zakład Stolarski Piętrus	Bobrowo	Furniture	OIGPM
EUROSERVICE S.C.	Szczecin / Gdansk	Pallets	Website
Firma Paletex	Gdansk	Pallets	Website

Company	City	Category	Source
For Pak. Formela A	Gdansk	Pallets	Website
Pal-Drew Piotr Żabiński	Elbląg	Pallets	Website
PPH LESTER	Kwidzyn	Pallets	Website
PPHU Eko-Pol	Swidnik	Pallets	Website
SWiE	Gdynia	Pallets	Website
Wiol-Pal	Gdynia	Pallets	Website
Zakrzewski M. Skup palet	Gdynia	Pallets	Website
Bielsko Pomorskie sawmill	Lębork	Sawmill	Sawmilldatabase
KACZKAN Zakład Produkcji Drzewnej	Małdyty	Sawmill	RDLP
KLON Sp. z o.o.	Złotów	Sawmill	RDLP
Koszalinskie Przedsiębiorstwo Przemysłu Drzewnego	Szczecinek	Sawmill	Sawmilldatabase
Krakus	Kostrzyn nad Odrą	Sawmill	Website
Łąccy-Kończygłowy Sp. z o.o.	Kończygłowy	Sawmill	RDLP
MGJ Sp. z o.o.	Leśniewo	Sawmill	RDLP
Murow Sawmill	Murow	Sawmill	Sawmilldatabase
NORDTECHNIK Sp. z o.o.	Sopot	Sawmill	RDLP
Oddział Golblat	Goleniow	Sawmill	Sawmilldatabase
Pilarex	Ryjewo	Sawmill	RDLP
Poltarex Sp. z o. o.	Lębork	Sawmill	RDLP
PPD „ Fornitex” Sp. z o. o.	Wejherowo	Sawmill	RDLP
PPH Kaszub	Wejherowo	Sawmill	RDLP
PPHU „TARTAK Szymerkowski”	Gdańsk	Sawmill	RDLP
PPUH „SCANDPOL”	Sulęczyno	Sawmill	RDLP
Przedsiębiorstwo Produkcyjno–Handlowe „Kaszub	Wejherowo	Sawmill	Sawmilldatabase
Przedsiębiorstwo TIM TARTAK - SKŁAD DREWNA	Gdynia	Sawmill	RDLP
Tartak Drewbal	Nowa Wieś Lęborska	Sawmill	RDLP
Tartak Elektryczny	Somonino	Sawmill	RDLP
Tartak POLDREWEX	Izbica Kujawska	Sawmill	Website

Company	City	Category	Source
Tor - Pal Sp. z o. o	Kwidzyn	Sawmill	RDLP
Wielbark	Wielbark	Sawmill	Cost 44
ZPD Lębork	Lębork	Sawmill	RDLP
ZPD Rakowiec	Mała Karczma	Sawmill	RDLP
Barlinek S.A.	Barlinek	Veneers	Cost 44
Przedsiębiorstwo Przemysłu Drzewnego Fornitex	Wejherowo-Bolszewo	Veneers	Cost 44
Wyrob Oklein Naturalnych „Bracia Mrozik	Lublin	Veneers	Cost 44
Bydgoskie Zakłady Sklejek SKLEJKA-MULTI S.A.	Bydgoszcz	Wood based panels	Wood-Based Panels Producers Association of Poland
FABRYKA Sklejka-Pisz SA	Pisz	Wood based panels	FEIC
FIBRIS S.A.	Przemysł	Wood based panels	Wood-Based Panels Producers Association of Poland
HARDEX S.A.	Odrzańskie	Wood based panels	Wood-Based Panels Producers Association of Poland
HOMANIT POLSKA Sp z .o.o. i Spółka Spółka komandytowa	Karlino	Wood based panels	Wood-Based Panels Producers Association of Poland
Instytut Technologii Drewna	Poznań	Wood based panels	Wood-Based Panels Producers Association of Poland
KLINGSPOR Sp. z o.o.	Bielsko-Biała	Wood based panels	Wood-Based Panels Producers Association of Poland
KRONOPOL Sp. z o.o.	Żary	Wood based panels	Wood-Based Panels Producers Association of Poland
Orzechowskie Zakłady Przemysłu Sklejek	Orzechowo	Wood based panels	Wood-Based Panels Producers Association of Poland
Ośrodek Badawczo-Rozwojowy Przemysłu Płyt Drewnopochodnych Sp. z o.o.	Czarna Woda	Wood based panels	Wood-Based Panels Producers Association of Poland
Paged-Sklejka S.A.	Morąg	Wood based panels	Wood-Based Panels Producers Association of Poland
PAGED-SKLEJKA SA	Morag	Wood based panels	FEIC
PFLEIDERER Grajewo S.A.	Grajewo	Wood based panels	Wood-Based Panels Producers Association of

Company	City	Category	Source
			Poland
Piotrkowskie Zakłady Przemysłu Sklejek Sp. z o.o.	Trybunalski	Wood based panels	Wood-Based Panels Producers Association of Poland
Polspan Ltd	Szczecinek	Wood based panels	EPF
PROZEMAK S.A.	Warszawa	Wood based panels	Wood-Based Panels Producers Association of Poland
SCHATTDECOR Sp. z o.o.	Tarnowo Podgórne	Wood based panels	Wood-Based Panels Producers Association of Poland
SILEKOL Sp. z o.o.	Kędzierzyn Koźle	Wood based panels	Wood-Based Panels Producers Association of Poland
Sklejka - EKO S.A.	Ostrów Wielkopolski	Wood based panels	Wood-Based Panels Producers Association of Poland
Sklejka-Pisz PAGED S.A.	Pisz	Wood based panels	Wood-Based Panels Producers Association of Poland
SKLEJKA-PISZ PAGED Spółka Akcyjna	Pisz	Wood based panels	Wood-Based Panels Producers Association of Poland
STEICO S.A.	Czarnków	Wood based panels	
Stowarzyszenie Dom Drewniany	Gdańsk	Wood based panels	Wood-Based Panels Producers Association of Poland
ZAKŁADY PRZEMYSŁU SKLEJEK BIAFORM S.A.	Białystok	Wood based panels	Wood-Based Panels Producers Association of Poland

Appendix E Trip report

For the resource assessment on low-value biomass streams in the Baltic Countries and Poland a site visit has been conducted by Berry de Jong to Poland and the Latvia. The aim of the visit was to meet with umbrella organizations and stakeholders for data and information on the top-down assessment of biomass resources and to interview companies in wood processing industry sectors in the supply regions for the bottom-up assessment. This report summarizes the results of this site visit.

1. Poland

Main location: Baltic Energy Conservation Agency (BAPE), Gdansk

Trip summary

In Poland, 90% of the forests are state owned by the Polish State Forest. The visited Pomerania region in the North of Poland has the highest forest cover (about 35% against a national average of 29%). The large share of state owned forest Due to the big monopoly of the state forest of the market, the company is both hated and loved by the industry, and has a lot of information on the wood industry.

Residues from the first processing industry are largely depended on the quality of the wood logs. The State forest district Gdansk revealed that the quality distribution of the wood is heavily skewed to lower quality logs.

The language barrier in Poland is much larger than expected. Interviews were only possible with the help of an interpreter, even in larger companies. Problems lie partly in the hierarchic structure of the companies and the country as a whole. It was not possible to only speak to employees (which are younger, and speak more languages) without a higher manager or director. English or German is rarely spoken, especially by older employees.

Poland has a very large sawmill industry, processing over 14Mm³/yr. The majority of the wood is processed in few large sawmills, the rest is scattered over more than 9000 sawmilling plants over the country. First processing industry in Poland suffers a severe lack of wood. Average utilization rate of contacted sawmills is less than 60% of the maximum capacity.



Figure 54 Pulpwood drying in the forest



Figure 55 Sawdust

Clean residues from first processing industry are sorted and sold to the board industry. Bark is sold as garden materials. Square cuttings from smaller sawmills are sold for domestic use. It is stressed by the stakeholders that this domestic market is very important in Poland. Many households are dependent on cheap heating fuels from both forestry residues and residues from sawmills.



Figure 56 Square cuttings from sawmilling

2. The Baltic Countries (Latvia)

Main location: Ekodoma, Riga (Latvia)

The forest cover in Latvia is very high (over 55%), making the wood processing industry Latvia's largest industrial sector. Approximately 60 companies are contacted by Berry de Jong, resulting in about 20 interviews both by phone and with visits.



Figure 57

The first wood processing industry (sawmills, plywood) in Latvia is also short of wood on the market, although not as high as in Poland. Utilization rates are high, but so are roundwood prices. Larger sawmills have their own chipper, to produce wood-chips from their residues. Clean residues (from debarked logs) are sold to the pulp and paper industry in Scandinavian. Lower quality residues (cuttings with bark) are chipped and sold to pellet industry, most large sawmills are connected to a neighbouring pellet plant.

For smaller sawmills, the local market is the main buyer for the residues. There is an increasing demand for residues for small scale district heating systems, and domestic use. Clean, high value residues are still sold to local pellet plants.

There is one big plywood manufacturer in Latvia, where they use all their residues (including bark peelings) for process heat. Investments have been done recently to allow the use of their own residues for process heat. Although there are a lot of residues, this still does not cover their demand for heat, and the company buys extra chips to supply them.



Figure 58

The secondary processing industry is very scattered into small manufactures. All contacted furniture producers use their own residues for process heat, and very few sell the remaining to a nearby district heat system. Some furniture manufactures indicate that they actually have to pay for their wood waste,

but these streams are contaminated with glue.

Domestic wood waste is at this point not separately collected. Wood waste from for example scrapped shipping pallets is only in very small amounts available because there is not a big trade market in Latvia, other than wood products.

Although reports and theory would suggest differently, Mr. Grīnbergs, director Granuls pellet plant, states that the current pellet production volume of the market in Latvia is about 800.000 tons/yr. When it comes to resources, he states that the residue market is saturated, and about 40% of the raw material used to produce these 800.000 tons of pellets is roundwood (pulp and firewood).

This means that the price ceiling for the residue market is either already reached, or will be reached soon. The price will then be the same as the price of roundwood (pulp logs and firewood). One big pellet producer went bankrupt last year in Latvia, and three smaller pellet plants went bankrupt as well.

In general, the Baltic market is threatened by the upcoming market in Africa and Asia. The Baltic countries not produce good quality pellets, but they are too expensive.

3. Conclusion

In conclusion, the Latvian wood processing industry is relatively efficient. Due to a lack of residues on the current market, pellet producers are already using roundwood as raw material for their pellets, and have thoroughly research their market.

Further, upcoming use of wood waste for domestic heating will even further decrease the potential of residues for pellet production. Heating boilers have lower requirements and users are willing to pay a much higher price than pellet producers, since local heating is a bare necessity in winter.

For Poland, the situation is different. Here, domestic use of wood and wood residues is also rising, but the wood processing industry is still not much innovated. A further research will therefore be conducted among the Polish processing industry. With help from Polish partners, a questionnaire has been set up in Polish, in order to lower the language barrier.

Appendix F Turnover per industry

Table 20 Turnover per industry in 2008 (M€) (Eurostat 2010)

Turnover (M€)	Poland	Estonia	Lithuania	Latvia
Construction	2,351	440	212	94
Packaging	686	80	75	80
Other	822	25	36	29
Furniture	8,192	389	886	210

Appendix G Packaging waste statistics

Table 21 Packaging waste Poland (Eurostat, 2008)

Poland	Not recovered	Energy recovery	Recovery other than energy recovery	Incineration with energy recovery at waste incinerators	Material recycling	Other forms of recycling (including composting)	Waste generated	Recovery
Paper and cardboard packaging waste	515,159	59,557	457	10,398	595,510	11,787	1,192,868	677,709
Plastic packaging waste	405,227	103,235	510	14,447	142,056	931	666,406	261,179
Wooden packaging waste	355,810	234,263	84,083	57	195,173	7,431	876,817	521,007
Metallic packaging waste	117,613	0	104	0	79,140	9,928	206,785	89,172
Glass packaging waste	486,350	0	0	0	343,470	7,459	837,279	350,929
Other packaging waste	0	0	0	0	0	0	0	0

Table 22 Packaging waste Estonia (Eurostat, 2008)

Estonia	Not recovered	Energy recovery	Material recycling	Other forms of recycling (including composting)	Waste generated	Recovery
Paper and cardboard packaging waste	17,711	7	39,545		57,263	39,552
Plastic packaging waste	38,137	2,550	11,916		52,603	14,466
Wooden packaging waste	670	217	53	3,733	4,673	4,003
Metallic packaging waste	6,155		3,478		9,633	3,478
Glass packaging waste	3,778		33,629		37,407	33,629
Other packaging waste	0					

Table 23 Lithuania Packaging waste (Eurostat, 2008)

Lithuania	Not recovered	Energy recovery	Material recycling	Waste generated	Recovery
Paper and cardboard packaging waste	14,704		43,275	57,979	43,275
Plastic packaging waste	21,031	3,885	6,338	31,254	10,223
Wooden packaging waste	26,531	7,771	9,849	44,151	17,620
Metallic packaging waste	4,109	0	4,407	8,516	4,407
Glass packaging waste	24,633		19,690	44,323	19,690
Other packaging waste	0				

Table 24 Packaging waste Latvia (Eurostat, 2008)

Latvia	Not recoverd	Energy recovery	Recovery other than energy recovery	Material recycling	Waste generated	Recovery
Paper and cardboard packaging waste	21,714	8	0	60,287	82,009	60,295
Plastic packaging waste	34,683	0	0	19,458	54,141	19,458
Wooden packaging waste	25,616	1,866	77	17,597	45,156	19,540
Metallic packaging waste	4,092	0	0	6,946	11,038	6,946
Glass packaging waste	14,440	0	0	45,875	60,315	45,875
Other packaging waste	7,846	0	0	199	8,045	199

Appendix H Future developments forest sector and wood processing industry

This section shows the expected development of the wood industry in Poland and the Baltic Countries.

Table 25 Product balance Outlook Poland (UNECE and FAO, 2011)

		Reference scenario		Maximising carbon	Promoting wood energy	
		2010	2030	2030	2030	
Product balance						
Production	Sawnwood	8.95	17.00	17.00	15.95	Mm3 RWE
	Wood-based panels	13.69	16.64	16.64	16.18	Mm3 RWE
	Paper and paperboard	12.34	23.36	23.36	22.73	Mm3 RWE
	Total	34.98	57.00	57.00	54.86	Mm3 RWE

Table 26 Product balance Outlook Latvia (UNECE and FAO, 2011)

		Reference scenario		Maximising carbon	Promoting wood energy	
		2010	2030	2030	2030	
Product balance						
Production	Sawnwood	7.99	11.17	11.17	10.36	Mm3 RWE
	Wood-based panels	1.15	2.27	2.27	2.26	Mm3 RWE
	Paper and paperboard	0.12	0.23	0.23	0.23	Mm3 RWE
	Total	9.26	13.67	13.67	12.84	Mm3 RWE

Table 27 Product balance Outlook Lithuania (UNECE and FAO, 2011)

		Reference scenario		Maximising carbon	Promoting wood energy	
		2010	2030	2030	2030	
Product balance						
Production	Sawnwood	4.12	4.96	4.96	4.92	Mm3 RWE
	Wood-based panels	1.04	1.54	1.54	1.50	Mm3 RWE
	Paper and paperboard	0.43	0.67	0.67	0.67	Mm3 RWE
	Total	5.59	7.17	7.17	7.09	Mm3 RWE

Table 28 Product balance Outlook Estonia (UNECE and FAO, 2011)

		Reference scenario		Maximising carbon	Promoting wood energy	
		2010	2030	2030	2030	
Product balance						
Production	Sawnwood	4.44	4.50	4.50	4.56	Mm3 RWE
	Wood-based panels	0.81	1.03	1.03	1.03	Mm3 RWE
	Paper and paperboard	0.22	0.95	0.95	0.67	Mm3 RWE
	Total	5.47	6.48	6.48	6.26	Mm3 RWE