BASAJAUN

Building a Sustainable Joint between Rural and Urban Areas through Circular and Innovative Wood Construction Value Chains

D1.3

Guidelines to foster building with wood

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Executive summary

Wooden construction has great development potential in Europe and in the world. It is based on a renewable and inexhaustible source of raw material, which is wood. However, this potential is still not fully exploited, while broader use of wood in construction could bring significant benefits, not only in environmental but also in social and economic terms. Innovative technologies that allow rapid construction of energy-efficient wooden buildings, including multi-storey, are a great opportunity for wooden construction development. Therefore, it is important to foster building with wood, indicate the opportunities it brings and its benefits, but also take into account the barriers limiting its development.

The aim of the report was to prepare guidelines for fostering wooden building and to indicate conditions of its development.

The report covered:

- indication of major development opportunities for wooden construction in Europe and in the world, taking into account technical, political, economic and societal aspects,
- identification of significant barriers inhibiting the development of the use of wood in construction, including its weaknesses and threats in the technical, political, economic and societal context,
- assessment of the potential of using recycled wood in the construction sector, including estimating the potential supply of post-consumer wood waste and wood by-products,
- gathering examples of best practices in wood recycling in different countries based on case studies,
- basic characteristics of the regulatory framework and operational environment for recycled wooden products in chosen countries of the project partners,
- identification of key economic, social, environmental and technical benefits of using wood and wood products in construction.

Methods used for preparation of the report include survey research (two surveys directed to wood construction stakeholders (business, academia and administration) and end-users, statistical analysis of wood waste potential, and desk research (review of literature, published and unpublished materials, case studies and internet sources).

As a result of the analyses, it was found that it is possible to increase the use of wood and wood products in the construction sector by meeting a number of specific technical, societal, economic and political criteria. Wood and wood products have great development potential in the construction sector, which is not yet fully utilized but definitely should be. On the one hand, this is conditioned by the need to revise current policies and operational frameworks at the national and EU level, which should include various types of instruments aimed at increasing the use of wood in the construction sector to a broader extent than before, and, on the other hand, by removal of significant restrictive barriers to the use of wood in construction by stimulating the demand for wood through its promotion in society. In addition to satisfying social needs, the development of wooden construction also brings a number of economic and environmental benefits.

The results of the wood waste analysis and waste management practices in different countries will be used for a holistic assessment of wood recycling possibilities and barriers in the construction sector and will feed WP2, which deals with the technical aspects and specific environmental benefits of wood recycling in construction.

In practice, it is possible to use knowledge obtained by the wood sector companies (in particular from the wooden construction industry) for both current operational purposes and setting strategic development directions, as well as that obtained by institutions and bodies of central and local administration to determine directions of socio-economic development. The accumulated knowledge can also be the basis for the strategy of promoting wooden construction and the use of wood in construction.

Document history

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Glossary

Acronym	*Full term*
BSE	Building Sink Effect
BWR	Basic Work Requirements for construction
CARB	The California Air Resources Board
CDW	Construction and Demolition Waste
CE	Commission Européenne
CEN	European Committee for Standardization
CER	Certified Emission Reduction
CLT	Cross-Laminated Timber
CN	Combined Nomenclature
CPA	Classification of Products by Activity
CPR	Construction Products Regulation
EAP	Environment Action Programme
EoW	End-of-Waste
EPF	European Panel Federation
ERP	Etablissements Recevant du Public
EU	European Union
EWP	Engineered Wood Products
FAO	Food and Agriculture Organization
FSC	Forest Stewardship Council
GHG	Greenhouse Gas
IAQ	Indoor Air Quality
LER	European Waste List
OQAI	*Observatoire de la Qualité de l'air Intérieur*
OSB	Oriented Strand Board
PEFC	Programme for the Endorsement of Forest Certification
PEMAR	State Framework Plan for Waste Management in Spain
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
REP	Extended Producer Responsibility
RH	Relative Humidity
UNECE	United Nations Economic Commission for Europe
VOC	Volatile Organic Compounds
WFD	Waste Framework Directive
WP	Workpackage

1 Introduction

According to the sustainable development paradigm, it is essential to integrate economic, environmental and social aspects in development policy. New challenges are defined at the European level, such as building a circular and low-carbon economy. Challenges related to urbanization, migration and aging of societies stimulate the search for new solutions in construction and urban development. Wooden construction can be the answer to many current key challenges, mainly due to its features, such as a relatively short construction time, low construction weight, energy efficiency, and low emission. Wooden houses are friendly to their residents (have a positive effect on health) and the environment, they are also durable and easy to rebuild or modernize. The use of wood in construction is also one of the most desirable directions of utilising its resources, due to high added value, innovation potential, possible environmental benefits and the long period of storing the embodied carbon. Wooden construction, therefore, falls under the category of broadly understood "green" and "sustainable" construction and fits into the basic trends of "future building"[1].

The aim of the report was to prepare guidelines for fostering wooden building and to indicate conditions for its development. To this end, a series of analyses were conducted, which involved 9 partners from 7 different countries.

The report analyses opportunities for and barriers to the increase in the use of wood in construction. Two questionnaires, prepared with the joint participation of project partners, were used to assess the significance of these opportunities and barriers.

The report also focuses on wood wastes (post-consumer wood waste and wood by-products) and their potential supply in Poland, France, Finland, and all of Europe. These wood wastes have great potential when properly managed and even their partial use, e.g. in the construction sector, would allow measurable savings of forest wood resources, thus bringing significant economic and ecological benefits.

Bearing in mind the EU's Circular Economy Action Plan (2015), the European Green New Deal (2019) and the objectives of BASAJAUN project, the report includes the possibilities, barriers and exemplary best practices in wood recycling for wood construction. Also, an analysis of the regulatory framework and operational environment for using recycled wood products in construction was prepared.

The report indicates benefits of using wood and wood products in construction, including, inter alia, the relatively short construction time, low weight of construction, energy saving, low emission, friendliness to residents (including positive impact on health) and the environment, as well as durability and ease of reconstruction or modernization. These features make wood not only a beneficial choice from an environmental point of view, but also an effective tool for climate change mitigation.

In addition to satisfying housing needs, the development of wooden construction also brings economic, societal, environmental and technical benefits.

[1] Bidzińska G., Szostak A., Leszczyszyn E., Augustyniak D., Budownictwo drewniane stymulatorem rozwoju rynku mieszkaniowego w Polsce in: Ekodom – Innowacyjne Biomateriały i Rozwiązania dla Budownictwa Drewnianego, Sieć Badawcza Łukasiewicz - Instytut Technologii Drewna, Poznań 2019.

2 Opportunities and barriers to increase in the use of wood in the construction sector

In many countries wooden construction is still encountering some barriers, which can be of different nature and importance. With changing social and political environment and technological development, there are more and more opportunities which could boost the use of wood in the construction sector, as well as wood construction itself. The aim of this analysis is to define potential barriers and opportunities and assess their importance.

Opportunities and barriers to the increase in the use of wood in construction can be analysed in four aspects, i.e. technical, societal, economic, and political. A survey questionnaire was prepared to determine the most important opportunities and barriers. Opportunities were understood as external drivers, while 'internal' features and properties of wood/wood products were considered strengths (benefits) and are included in the further part of the report. Barriers were defined as weaknesses and threats (resulting from both the features and properties of wood itself and the features of the external environment).

The first stage of the analysis was to create a list of opportunities and barriers in line with the afore mentioned aspects. This part was carried out by 4 partners: ITD (Poland), FCBA (France), LUKE (Finland) and TIC (Chile). Each partner proposed at least 3 opportunities and barriers in the areas of technology, economy, society and policy, which were further checked for duplicates and grouped. As a result, a list of 43 opportunities and 61 barriers was drawn up. In the second step, two surveys were drawn up based on the proposed opportunities and barriers: one for the entities directly related to the wood construction sector (producers, representatives of public administration and experts in the field of wood construction from academia/research institutions – see attachment 1) and one for end-users (consumers – see attachment 2). In both surveys a five-point Likert scale was used as a measurement method. The first survey, addressed to the entities related to the construction sector, included questions with the help of which respondents had to assess the importance of opportunities for and barriers to the increase in the use of wood in construction. The second survey, addressed to society, concerned issues as the associations of customers with a wooden house, their opinion on wooden construction, and the important aspects encouraging people to live permanently in a wooden house.

Respondents to the survey were selected using purposive sampling because of its suitability for the research purposes. The main criterion of the respondent selection was their type of activity linked to the wood construction sector. In the case of end users, the survey was sent to the general society, which is the main consumer of wooden houses. The surveys were sent on December 20th, 2019, to the partners to task 1.3 (9 partners from 7 countries). Each partner to task 1.3 was going to collect 10 questionnaires from the entities directly related to the construction sector, including 5 from producers, 3 from experts in the field of wooden construction from academia/research institutions and 2 from representatives of public administrations, and, additionally, ca. 10 surveys from end-users.

Approximately 2.5 months after sending out the surveys, a total of 96 responses from producers, experts and public administration and 88 responses from end-users were collected. The obtained data underwent a reduction process which consisted of data control, editing and describing, as well as tabulation and aggregation. During the data editing process, the intelligibility of the questions was checked. The survey results are presented using graphs supplemented with written comments.

2.1 Producers, experts, public administration results

2.1.1 Survey population

42% of women and 58% of men participated in the survey about the opportunities for and barriers to the increase in the use of wood in the construction sector (Figure 1).

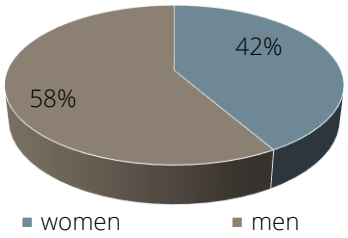

Figure 1 Gender of stakeholders participating in the survey

Respondents representing academies, universities and research institutes dominated (39%), 65% of them were men – Figure 2. Another large group of respondents (33%) were business representatives, i.e. enterprises related to the forestry-wood sector. Men also dominated in this activity group (59%). Representatives of public administration constituted 16% (of which 60% were women), and other respondents 12%, mainly associations, federations and networks from forestry-wood sector (of which 58% were men).

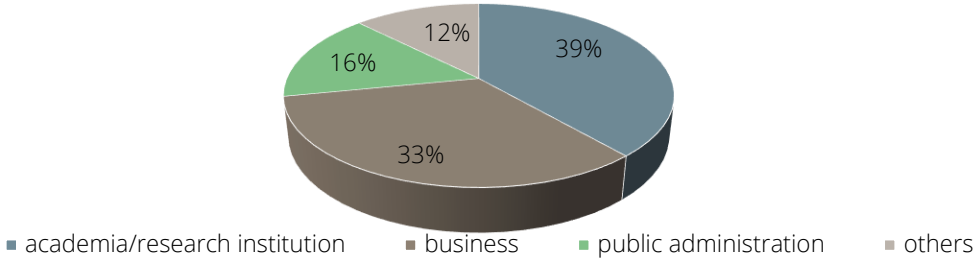

Figure 2 Respondents type of activity

2.1.2 Opportunities to increasing the use of wood in the construction sector

12 technical opportunities to increase the use of wood in the construction sector were presented to the respondents. They were to express their opinion on how much they agree with them – Figure 3. According to the respondents, technical opportunities that could most significantly influence the development of wooden construction were: i) the possibility of using wood in larger/higher structures (81% of respondents definitely or rather agreed with this statement); ii) standardization and regulations which would make it possible to treat used wood like other construction materials (78%); iii) further development of environmentally sound wood modification techniques aiming at durability, dimensional stability, and mechanical performance (77%). In contrast, 51% and 40% of respondents, definitely or rather disagreed, respectively, that the search for new building solutions in the context of increasingly frequent earthquakes or the need for increasing building speed and repair simplicity (due to the increased frequency of natural disasters) may be an opportunity for the development of the construction sector.

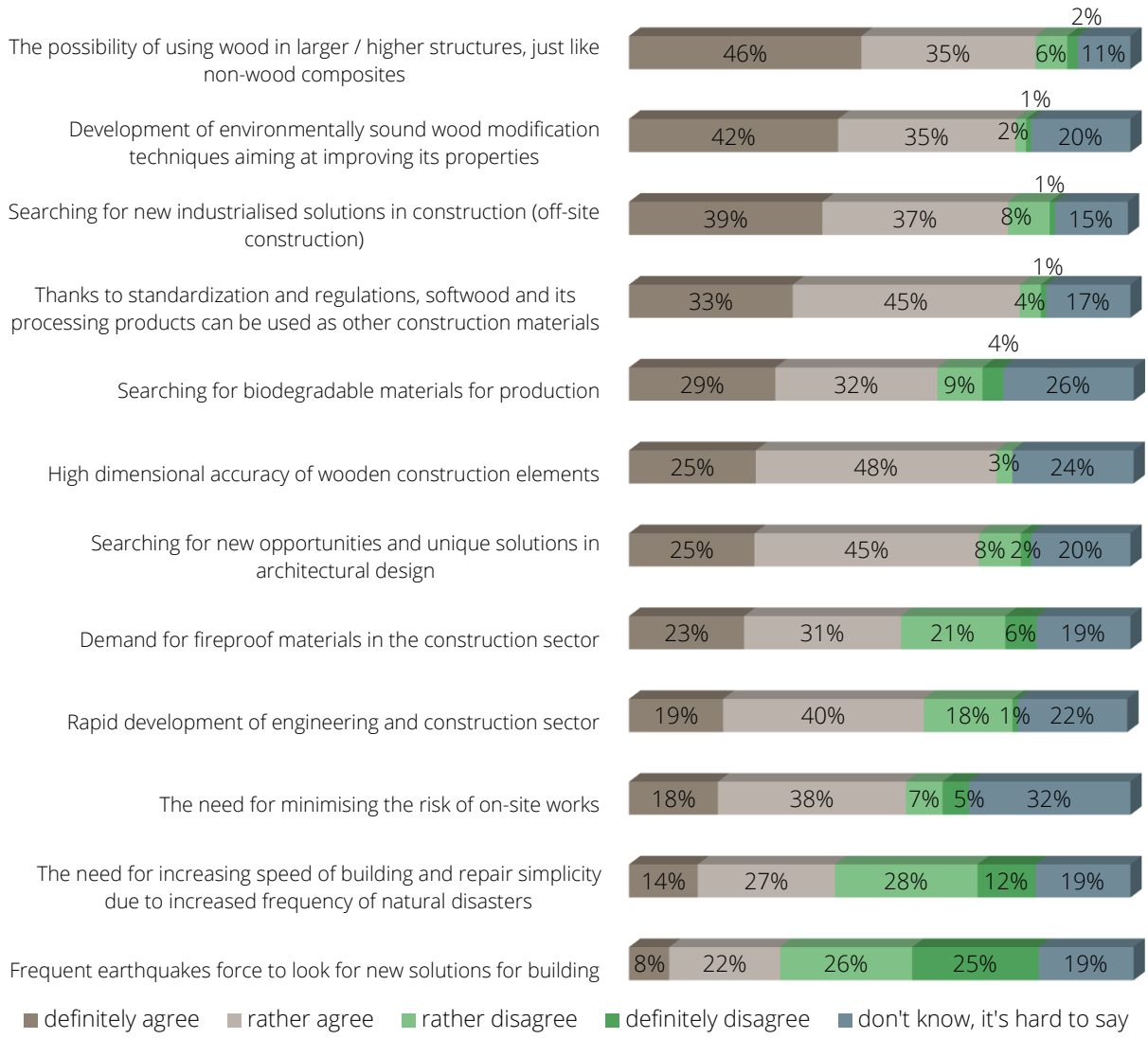

Figure 3 Respondents' assessment of technical opportunities to increase the use of wood in the construction sector

The project members identified 13 societal opportunities that may influence increasing the use of wood in the construction sector. According to the respondents, the most significant opportunities, with which they definitely or rather agreed were: i) the global trend towards greening the cities and using more natural materials both in buildings and interiors (88%); ii) rising eco-awareness among the societies and developing new eco-trends and preferences among customers (87%); iii) societal perceptions of wood as a natural and friendly material (79%) – Figure 4. The following opportunities gained the least recognition among the respondents: deficit on the housing markets in many countries (44% of respondents definitely or rather agreed with this statement) and a variety of preferences of consumers who demand that materials are available in many different variants (40%).

Figure 4 Respondents' assessment of societal opportunities to increase the use of wood in the construction sector

The respondents were also acquainted with 8 economic opportunities which may contribute to increasing the use of wood in the construction sector (Figure 5). The respondents definitely or rather agreed with the majority of presented opportunities, giving the greatest recognition to: i) searching for new high value-added products and activities to develop the forestry sector and provide new green jobs (79%); ii) the pursuit of cost reduction in construction by shortening building time (also 79%); iii) searching for new solutions allowing reduction of energy used for heating (passive buildings, energy-plus buildings) – 73%. In both cases, 21% of respondents definitely or rather disagreed that searching for sources of cheap renewable energy or looking for cost reduction in maintenance and use of buildings may be the opportunity for the development of wooden construction.

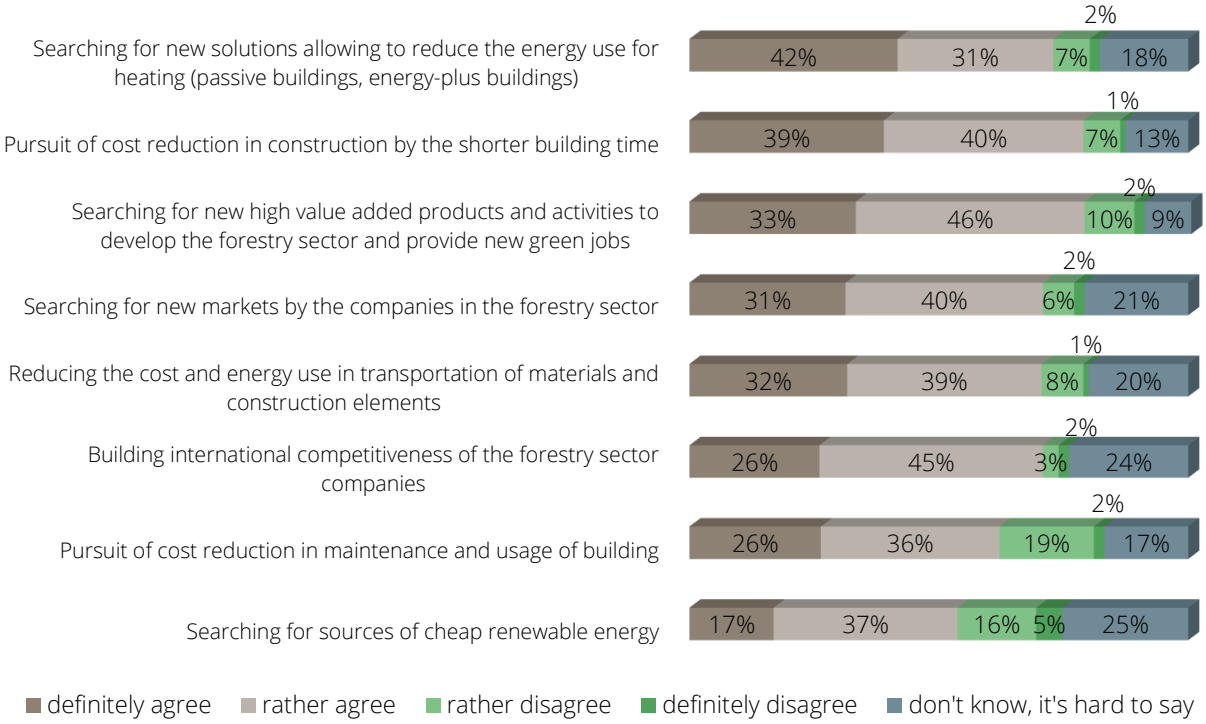

Figure 5 Respondents' assessment of economic opportunities to increase the use of wood in the construction sector

Political changes are another factor that may be a driver of the use of wood in the construction sector. From the proposed 10 opportunities closely related to wooden construction, the respondents selected 3 most important, which over 80% of respondents definitely or rather agreed with – Figure 6. These were the following: i) supporting the development of bioeconomy (85%); ii) sustainable forest management, increasing carbon sink in forest and taking care of afforestation and forest renewal (83%); iii) the growing need for low-emission products and buildings due to the climate change (82%). According to the respondents, the political opportunities which may have less impact on the construction sector were: the growing need for renovation of old construction stock, e.g. in Europe (55% of respondents definitely or rather agreed with this statement) and modern town/city planning and creation of 'landmarks' in public areas (53%).

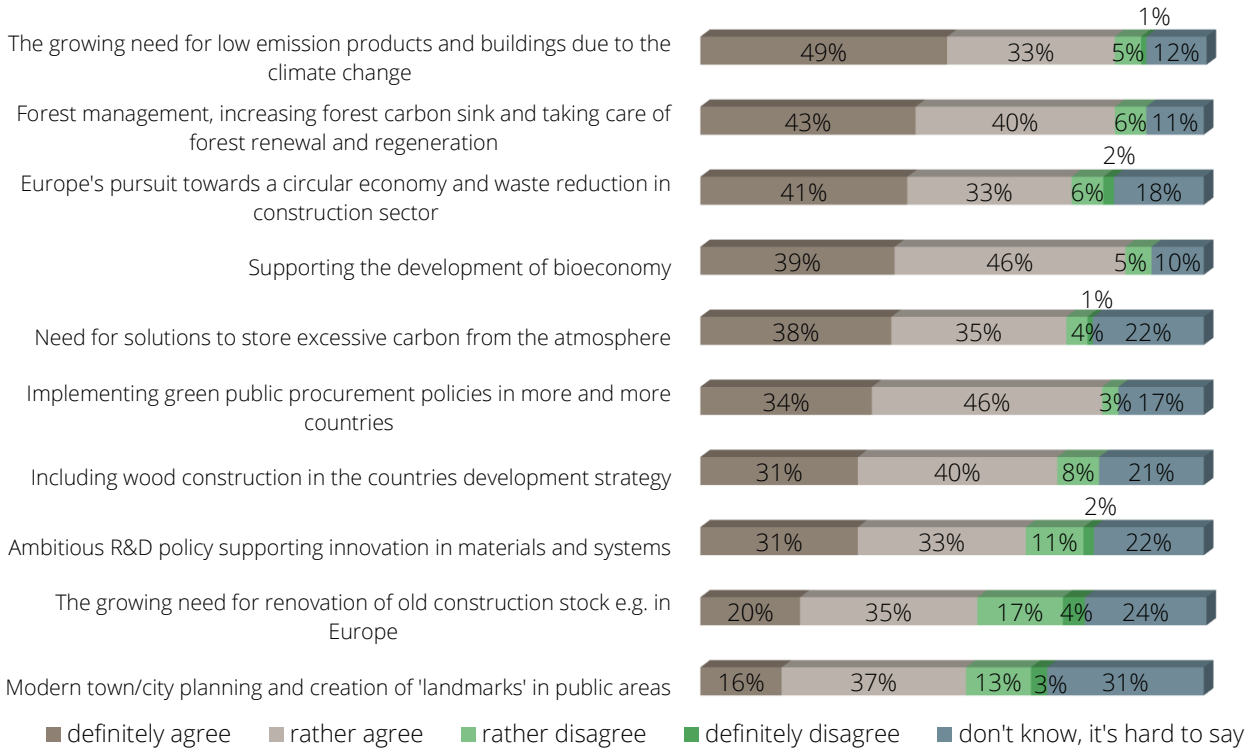

Figure 6 Respondents' assessment of political opportunities to increase the use of wood in the construction sector

2.1.3 Barriers limiting the increase in the use of wood in the construction sector

The respondents were also asked to indicate barriers limiting the increase in the use of wood in the construction sector. Of the proposed 13 technical barriers that could affect the development of the wood construction, more than half of respondents definitely or rather agreed with the following: i) wood deterioration caused by biotic factors, e.g. fungi, insects, algae, lichen (58%); ii) wooden constructions require high-quality construction elements and very good knowledge of technical and assembly principles (56%); iii) the aesthetic deterioration of wood used on the exterior parts of houses, e.g. discolouration, wear, abrasion (53%) –Figure 7. In addition, 61% and 54% of respondents, definitely or rather disagreed, respectively, that a barrier to the increase in the use of wood in construction may be the fact that some wooden construction products does not meet the energy efficiency regulations or the buildings are settling in the ground ("working") for the first years.

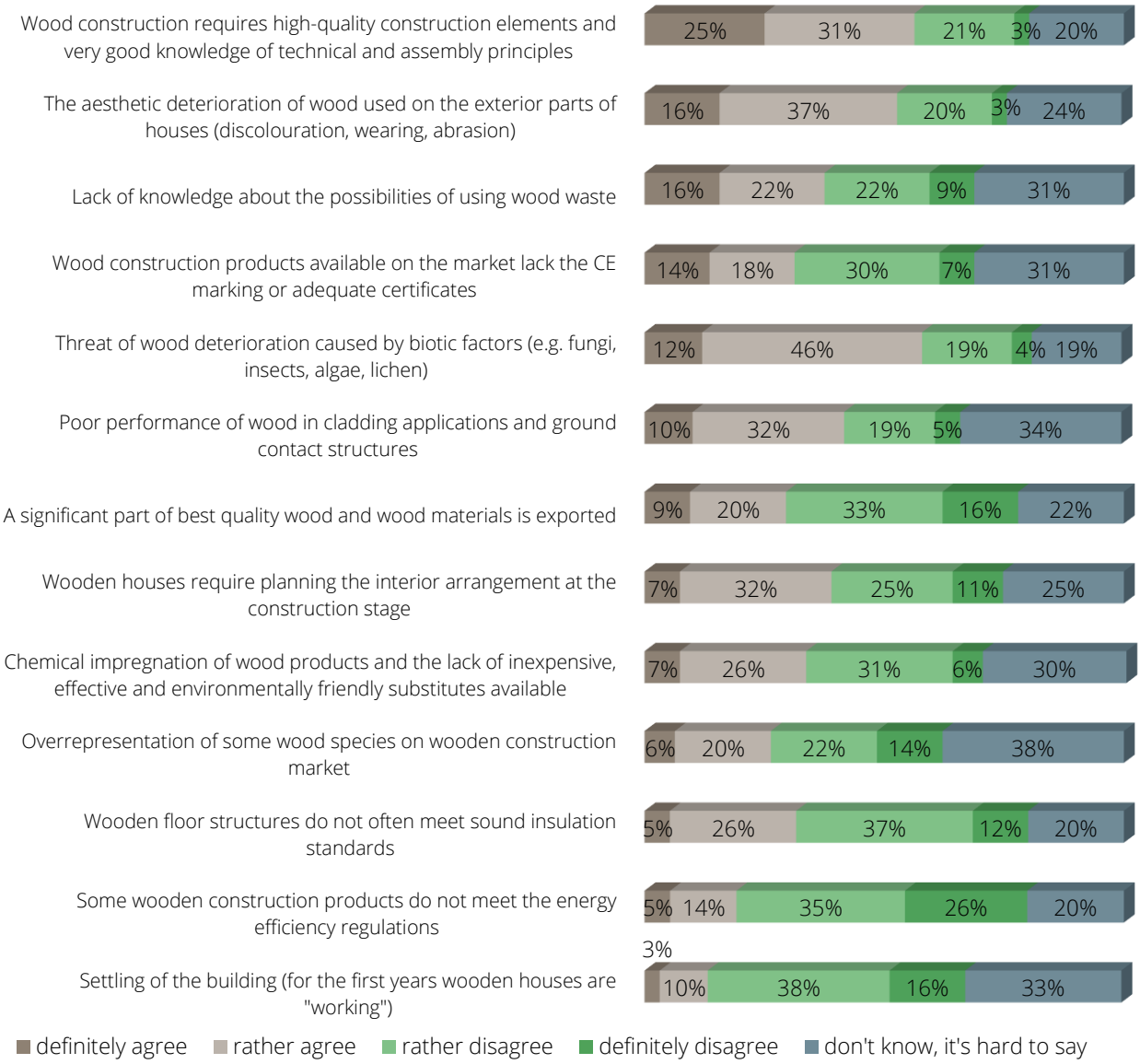

Figure 7 Respondents' assessment of technical barriers limiting the increase in the use of wood in the construction sector

In the case of social barriers, the respondents definitely or rather agreed that the barrier to development is the popular belief that wooden constructions mean high fire risk (85%) – Figure 8. In addition, the respondents also classified the following as significant development barriers: insufficient academic training designed to educate specialists in modern timber construction technologies (81%) or lack of attractive educational programs explaining the advantages of wood and wooden construction (78%). Of the 12 societal barriers that could affect the construction sector, the following were considered the least important by the respondents: using the appearance of wood by producers of plastics, building ceramics, etc. (30%) or lack of societal acceptance of afforesting the agricultural land (37%).

Figure 8 Respondents' assessment of societal barriers limiting the increase in the use of wood in the construction sector

The dominant category of barriers that can limit the increase in the use of wood in construction was economic barriers of which 21 were identified. 95% of respondents definitely or rather agreed with them at the level of at least 25% – Figure 9. A barrier which 90% of respondents definitely or rather agreed with was: "the construction sector is extremely rigid and market uptake of new materials/solutions is a long-term process". On the other hand, according to the respondents, the least important barriers to the use of wood in construction were: i) environmental degradation reducing the available supply of high-quality wood (47%); ii) import of wood and wood products for wooden constructions (46%); iii) fluctuations of the price of wood and wooden products (45%).

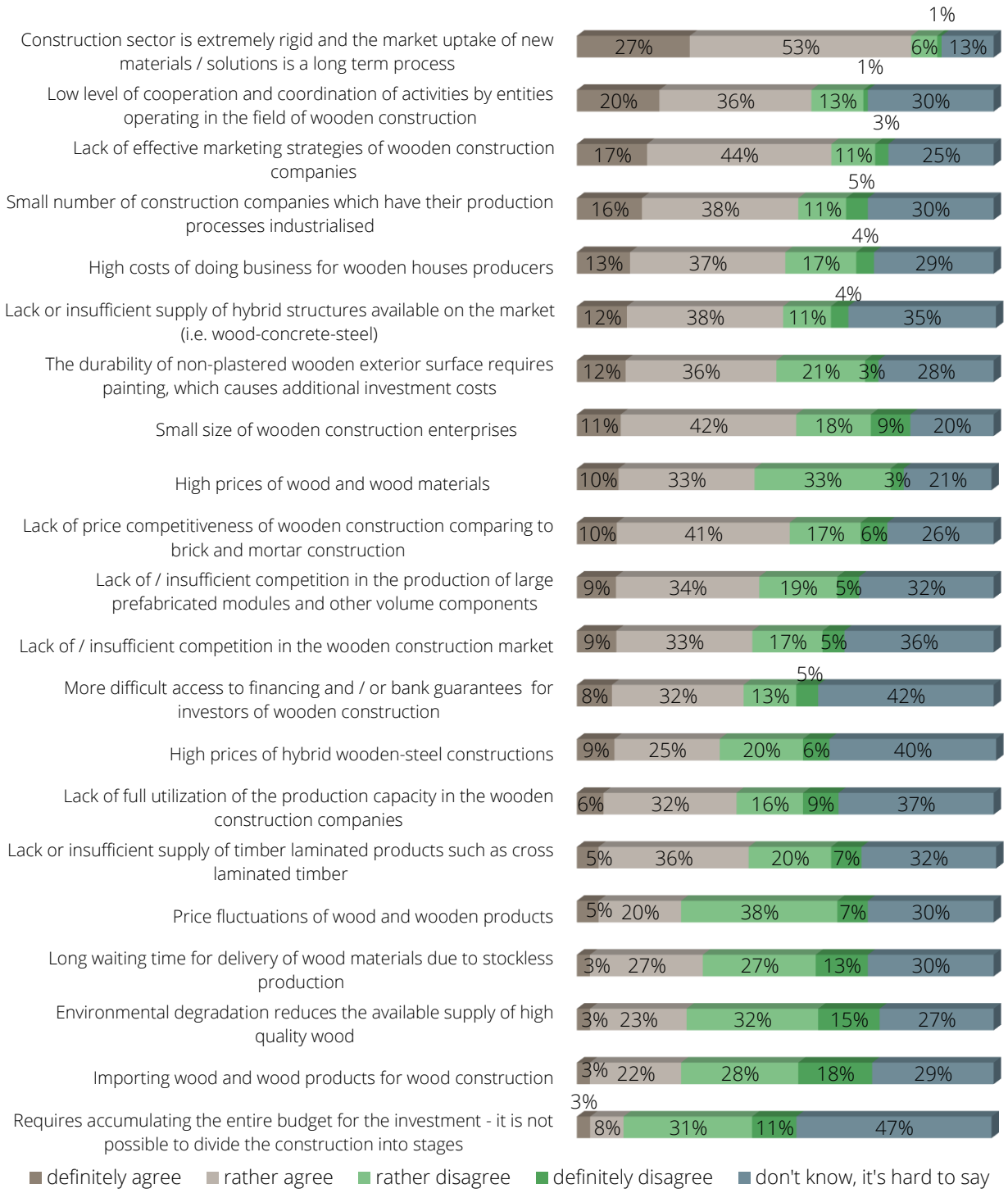

Figure 9 Respondents' assessment of economic barriers limiting the increase in the use of wood in the construction sector

15 potential policy barriers that may limit the development of wood products in the construction sector have also been identified. About 3/4 of respondents definitely or rather agreed that these barriers include: i) lack of an ambitious public policy encouraging research, development and innovation in the wood industry (77%); ii) strong and effective political lobbying of the producers of dominant building materials, e.g. concrete and steel (75%); iii) low public funds for research and development (R&D) in the construction industry (73%) – Figure 10. On the other hand, a significantly smaller number of respondents (35%) definitely or rather agreed that the lack of or non-compliance

with regulations regarding wooden structures in seismic areas is a barrier to the development of wooden construction.

Figure 10 Respondents' assessment of political barriers limiting the increase in the use of wood in the construction sector

2.2 End-users results

The respondents' answers show that the survey entitled "Opinion on wood houses" was answered by 54% of women and 46% by men (Figure 11).

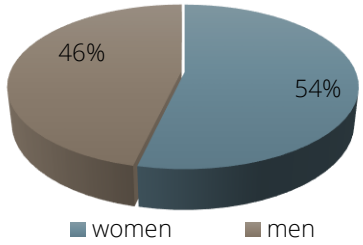

Figure 11 Gender of end-users participating in the survey

Over 61% of respondents (59% of women and 63% of men) understood the meaning of the term "wooden house" as a year-round single-family house (Figure 12). About 1/4 of respondents associated wooden house with a summer house (23% of women and 34% by men). Interestingly, 13% of women associated wooden house with a multi-family house with few storeys and 5% with a public building.

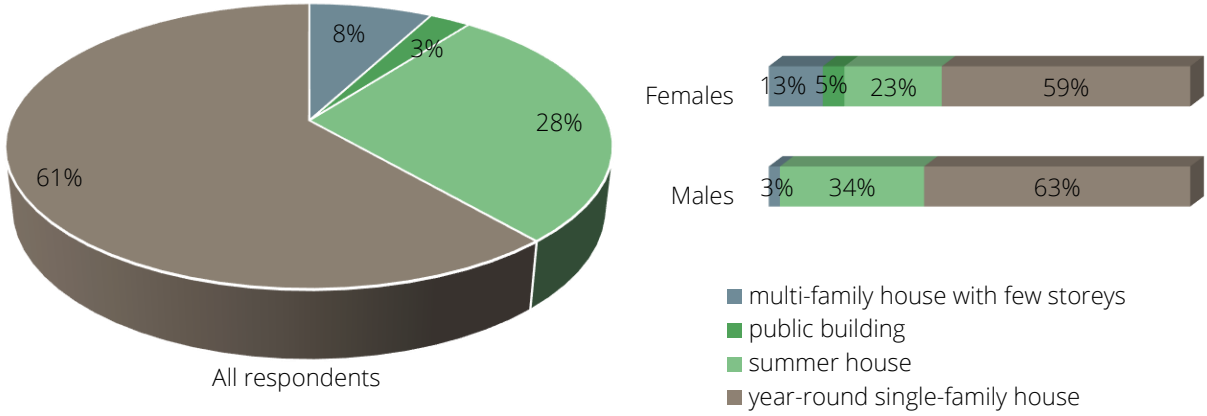

Figure 12 Personal understanding of the meaning of the term "wooden house"

Respondents participating in the survey expressed their opinion on wooden houses. The vast majority of the participants said that wooden houses are healthy and friendly for residents (83% of respondents definitely or rather agreed with this statement) – Figure 13. The same number of indications was admitted to the statement that a wooden house can be built in a shorter period of time than a masonry building. Over half of respondents agreed that wooden house cools down quickly, but also heats up quickly. In addition, a similar number of the surveyed agreed that building a wooden house is cheaper than building a brick house. More than 1/3 of respondents definitely or rather disagreed with the statement that the maintenance of a wooden house is cheaper than that of a brick house and 42% of respondents have no knowledge of this topic.

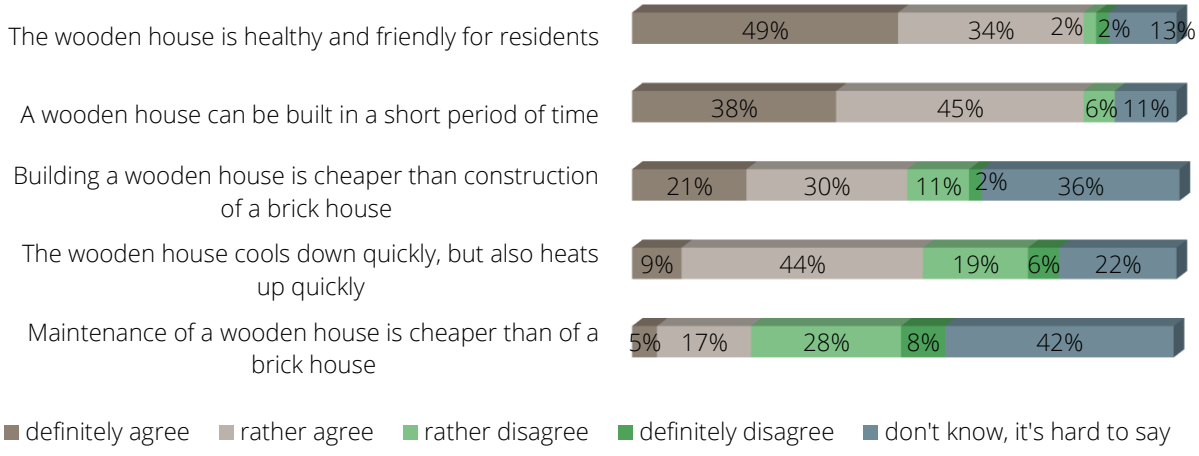

Figure 13 Assessment of positive statements regarding wooden houses

In the case of negative statements regarding wooden houses, almost half of respondents definitely or rather agreed that these houses are impermanent and require frequent maintenance (51%), and that they are flammable (45%) – Figure 14. In addition, over 1/3 of respondents agreed with the statements that wooden houses are susceptible to moisture (37%) and exposed to pests (36%). On the other hand, 32% of respondents agreed with the statement that there is lack of professionals on the market who can build a wooden house.

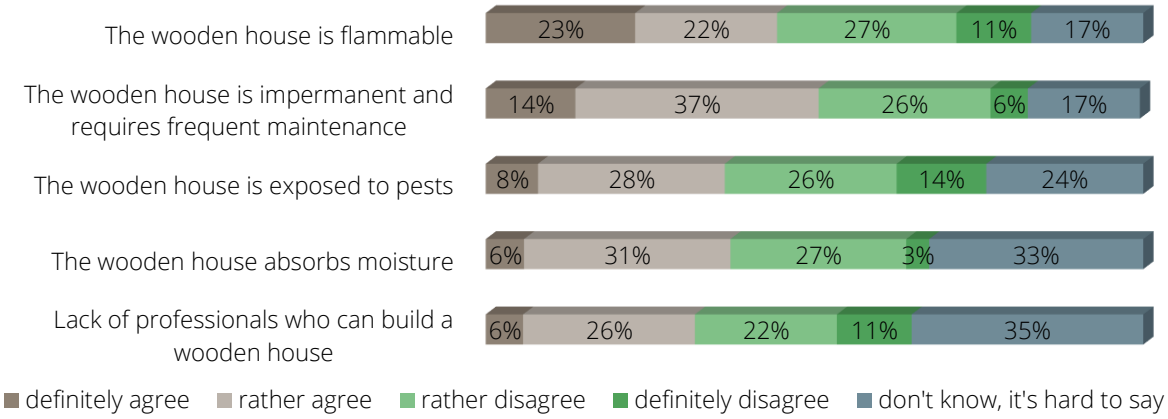

Figure 14 Assessment of negative statements regarding wooden houses

End-users participating in the study were also asked what would motivate them to live in a wooden house (Figure 15). The most important aspects, assessed by the respondents, included: i) guarantee of safety, quality and durability of the structure (88% of respondents definitely or rather agreed with this statement); ii) the ecological nature of wooden construction (84%); iii) lower construction/maintenance costs of a wooden house (79%). The availability of modern projects, design and government subsidies for construction costs were also very important for the respondents (71% and 67% of respondents, respectively, agreed with these statements). According to the respondents (57%), the least motivating aspect were (potentially) favorable credit conditions.

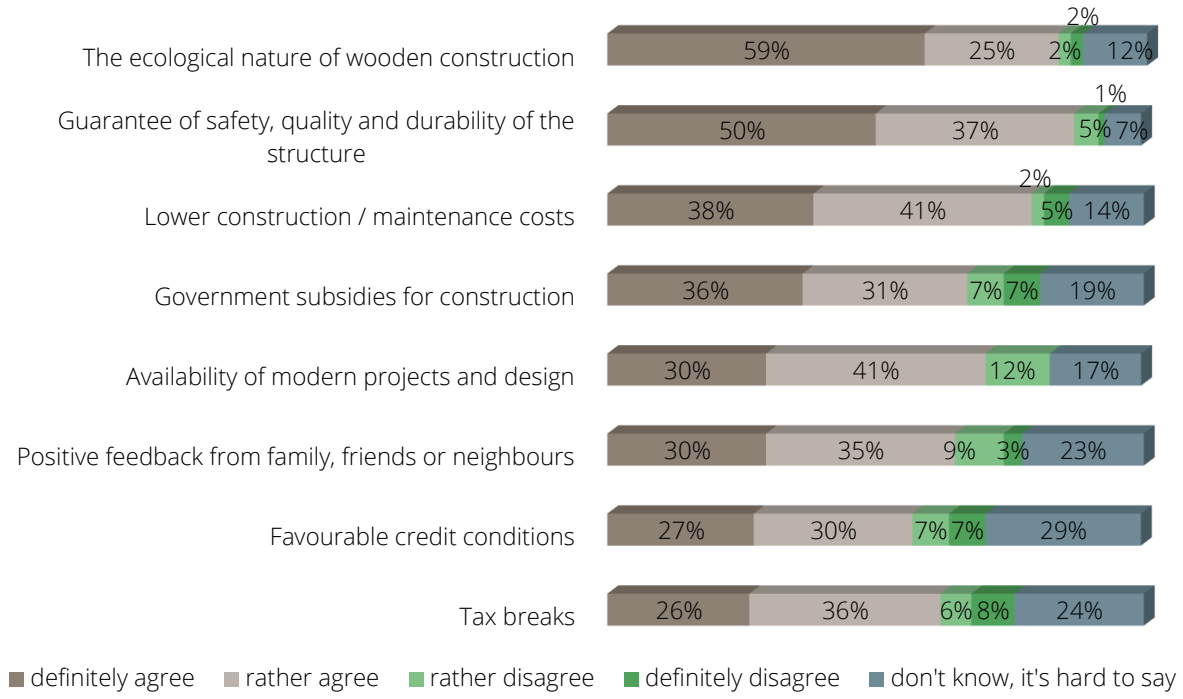

Figure 15 Assessment of aspects motivating people to live in a wooden house

3 Estimating the potential supply of post-consumer wood waste and wood by-products

The first task was to estimate the potential supply of wood waste and determine the amount that could potentially be used in the construction sector. The results will be one of the inputs to task 2.1, where a holistic zero-waste strategy in the wood-based construction will be defined. The analysis of the potential supply of wood by-products and post-consumer wood was be based on a simplified model approach. It was prepared for the 3 countries where rural-urban pilot demonstration will take place (Poland, France and Finland)[2] and also at the European Union level.

For a start, a short glossary of terms connected with wood recycling was created:

Post-consumer wood[3] – waste originating from final wood products whose life cycle ended (i.e. which are unsuitable for further use, worn out or withdrawn from use) and which were used as final products at least during their first useful life.

Wood by-products[4] – waste originating from the wood sector, i.e. from manufacturing where wood and its derivatives are comprehensively processed; wood by-products are generated at the subsequent stages of wood processing into wood materials and final wood products[5].

Recycling[6] – a recovery process in which waste is reprocessed into products, materials or substances used for their original purpose or other purposes; this includes reprocessing of organic material (organic recycling), but excludes energy recovery and reprocessing into materials which will be used as fuels or for filling excavations.

Resources of post-consumer wood waste and wood by-products may be reused for material purposes (in the production process of wood materials) and energy purposes (combustion with energy recovery); however, this study assumes the priority of use for material purposes.

Methodological approach[7]:

Due to the information barrier (data concerning post-consumer wood waste and wood by-products, which are be found in national and EU reporting, most often are incomplete and inconsistent), it was necessary to employ methodical solutions that use a model approach (based on previous research

[2] Rural-urban pilot demonstration is a part of WP7.
[3] Ratajczak E., Szostak A., Bidzińska G., Herbeć M., Potential resources of post-consumer wood waste in Poland, Journal of Material Cycles and Waste Management 2018, Vol, 20, Issue 1, pp. 402-413. DOI: https://doi.org/10.1007/s10163-017-0593-5 JMCW-D-16-00387.2.
[4] Ratajczak E., Szostak A., Bidzińska G., Leszczyszyn E., Market in wood by-products in Poland and their flows in the wood sector, Drewno. Prace naukowe. Doniesienia. Komunikaty 2018, vol. 61, no. 202, pp. 5-20. DOI: https://doi.org/10.12841/wood.1644-3985.301.05.
[5] In principle, wood by-products are not waste as defined by the EU regulations transposed to the Member States' regulations. Waste is any substance or item which the owner disposes of, intends to dispose of or is obligated to dispose of, while wood by-products may be treated as by-products from wood processing, whose main goal is not the production of wood by-products, and moreover further use of these by-products is certain. They may be used directly without further processing (different from standard industrial practice), they are manufactured as an integral part of the production process, they fulfil all considerable requirements (including legal) regarding the product, environmental protection and life and health of people. European Union, Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.
[6] Szostak A., Ratajczak E., Bidzińska G., Leszczyszyn E., Dolska J., Herbeć H., Zasoby drzewnych produktów ubocznych powstających w sektorze drzewnym, Instytut Technologii Drewna, Poznań 2016.
[7] Früwald A., Wood Industry in Europe – main trends, Drewno. Prace Naukowe. Doniesienia. Komunikaty 2003, vol. 46, no. 169, pp. 73-90.

and expert knowledge) to determine potential resources of post-consumer wood waste and wood by-products. Wherever possible, the obtained results were supplemented with data from other sources.

According to the adopted method, the potential supply of post-consumer wood waste and wood by-products is derived from the annual average consumption of wood for material purposes, i.e. the consumption of industrial roundwood (meaning raw material without fuelwood).

Main assumptions:

- 68.75% of wood materials is generated from 100% mass (expressed in tonnes) of raw material (industrial roundwood);
- 72.73% of final wood products is generated from 100% mass (expressed in tonnes) of wood materials;
- 87.5% of post-consumer wood waste is generated from 100% mass (expressed in tonnes) of final wood products.

3.1 Potential supply of post-consumer wood waste in Poland, France, Finland and European Union

Simplified method of estimating the potential supply of post-consumer wood waste

Statistic reporting of the EU countries (both the classification of goods and services, i.e. Statistical Classification of Products by Activity in the European Community (CPA 2008) and List of PRODucts of the European COMmunity (PRODCOM List)) and the classification of goods in foreign trade, i.e. Combined Nomenclature (CN)) does not include codes directly and unambiguously referring to post-consumer wood waste. Therefore, to estimate the potential of post-consumer wood waste, it was necessary to use the model approach.

In accordance with the adopted approach the potential supply of post-consumer wood waste results from the average annual consumption of coniferous and non-coniferous industrial roundwood (roundwood for material processing), assuming that[8]:

- 43.75% post-consumer wood waste is generated from 100% mass (expressed in tonnes) of consumed raw wood material (industrial roundwood) – each unit of used raw wood material (industrial roundwood) gives approx. 0.4375 of post-consumer wood waste.

Additionally, it is assumed that[9]:

- the consumption of roundwood for material processing (industrial roundwood) equals the volume of harvested industrial roundwood adjusted for net export (consumption = removals + import - export),

[8] Früwald A., Wood Industry in Europe..., op. cit.
[9] Ratajczak E., Szostak A., Bidzińska G., Drewno pouzytkowe w Polsce, ed. E. Ratajczak, Wydawnictwo Instytutu Technologii Drewna, Poznań 2003, p. 49; Ratajczak E., Szostak A., Bidzińska G., Herbeć M., Potential resources of post-consumer wood waste... op. cit; Bidzińska G., Szostak A., Herbeć M., Ratajczak E., Opracowanie metody szacowania zasobów drewna pouzytkowego pochodzącego z sektora budowlanego w Polsce (ss. 90), Instytut Technologii Drewna, Poznań 2013.

- the average annual consumption of industrial roundwood is calculated based on the 10-year period (2009-2018) to mitigate annual fluctuations,
- for converting the volume (cm3, m3) of industrial roundwood to mass the average wood density at 15% moisture content is used:
- for coniferous wood: 0.500 g/cm3 (500 kg/m3),
- for non-coniferous wood: 0.700 g/cm3 (700 kg/m3).

It is assumed that the potential base of post-consumer wood waste for the construction sector may be the amount of post-consumer wood waste (percentage of total volume) which in practice, due to organisational, technical-technological and economic reasons, can be used in further material processing (assuming the priority of material use of post-consumer wood waste). Therefore, it is mainly packaging made of solid wood[10]:

- pallets (flat pallets and pallet collars of wood, box pallets and load boards of wood),
- other packaging materials such as crates, boxes, barrels, wooden cable-drums etc.

Such post-consumer wood waste can be potentially used in its entirety for material purposes, mainly in the production of wood-based panels (particleboards (without OSBs) and fibreboards) for the construction sector. It is assumed that the average life cycle of wood packaging is 4 years[11]. It is also assumed that:

- the average annual consumption of wooden packaging is calculated based on the 4-year period (2015-2018) to mitigate annual fluctuations,
- for converting the mass of wooden packaging to volume content (cm3, m3) the conversion factor: 500 g/cm3 (500 kg/m3) will be used.

The adopted model approach does not allow for foreign trade in post-consumer wood waste due to the lack of comprehensive data. It is estimated that the recommended item CN 4401 40 also includes wood waste other than post-consumer wood waste.

Estimating the potential supply of post-consumer wood waste

According to the methodology adopted, potential resources of post-consumer wood waste in the analysed countries (originating from used wood products with finished life cycle, i.e. from used furniture, builder's carpentry and joinery products, packaging, flooring materials, buildings and structures, railroad elements, wooden garden products, elements of furnishing etc.) were estimated based on the average consumption of industrial roundwood in recent years (2009-2018) (Table 1, Annex 3).

[10] Ratajczak E., Szostak A., Bidzińska G., Herbeć M., Recykling drewna pożytkowego w Niemczech i Polsce, Documentation of the task 2.2. The potential of post-consumer wood in Poland, Project WPN/3/2012, ReGaP/Task 2.2./D-1.
[11] Ratajczak E., Szostak A., Bidzińska G., Drewno pożytkowe..., op. cit.; Ratajczak E., Bidzińska G., Szostak A., Herbeć M., Resources of post-consumer wood waste originating from the construction sector in Poland, Resources, Conservation and Recycling 2015, pp. 93-99. DOI: https://doi.org/10.1016/j.resconrec.2015.02.008

Table 1 Potential, estimated resources of post-consumer wood waste in Poland, France, Finland and European Union

Post-consumer wood waste	*Poland*	*France*	*Finland*	*EU*
		million m^3		
- coniferous	11.5	7.0	20.6	121.8
- non-coniferous	3.8	3.0	5.6	35.6
total	15.3	10.0	26.2	157.4
		million tons		
- coniferous	5.7	3.5	10.3	60.7
- non-coniferous	2.7	2.1	3.9	24.9
total	8.4	5.6	14.2	85.8

** forest trade in post-consumer wood waste is not taken into account*

Source: based on the assumptions and annex 3.

Theoretically, the largest resources of post-consumer wood waste should have been found in Finland in recent years – more than 26 million m3 (12 million tonnes). In the European Union such resources were estimated to have been 157 million m3 (almost 85 million tonnes). Depending on the organisation of the collection system of this waste, technical-technological possibilities and economic conditions of its processing, this waste is and can be used differently in particular countries, i.e. for material processing and energy purposes. It is assumed that waste from used solid wood products, primarily wooden packaging (including pallets) is mainly used for material purposes (predominantly in the production of wood-based panels, including for the construction industry) (Table 2, Annex 4).

Table 2 Potential, estimated supply of post-consumer wood waste for the construction sector (originating from used wooden packaging) in Poland, France, Finland and European Union

Post-consumer wood waste for construction sector	*Poland*	*France*	*Finland*	*EU*
Million m^3	1.8	6.9	0.5	52.7
Million tonnes	0.9	3.5	0.2	26.4

Source: based on the assumptions and annex 4.

According to estimates resulting from the adopted method, France is the place where potentially the largest amount of post-consumer wood waste for the construction industry should have been found in recent years – 3.5 million tonnes (6.9 million m3). In European Union the amount of said waste is estimated to be more than 26 million tonnes (almost 53 million m3).

The information gained directly from the project partners suggests that:

- in France the average percentage of post-consumer wood waste redirected to the production process of wooden materials (hence, potentially, to be allocated to the construction sector) was 11.5% in the years 2014-2016 and 22.4% in the years 2009-2015; therefore, 0.6 million tonnes (1.1 million m3) and 1.3 million tonnes (2.3 million m3), respectively, of the estimated total volumes of post-consumer wood waste should have been returned to the production process annually,

- in 2018 in Finland 24%[12] of wooden packaging was recycled and the supply of post-consumer wood waste could have ranged from 250 to 350 thousand tonnes[13] annually in recent years.

According to Faostat data (http://www.fao.org/faostat/en/#data/FO), sent by the national correspondents on the forest-based sector statistics to the UNECE Committee on Forests and Forest Industry, the volume of recovered post-consumer wood in the years 2017-2018 equalled:

- 246.7-260 thou. tonnes in Poland (however, this is only an estimate of the consumption of post-consumer wood waste in the production of particleboards),
- 6.4 million tonnes in France,
- 347.2-403.8 thou. tonnes in Finland, and
- 25.6-25.8 million tonnes in European Union.

Data collected by Eurostat can also suggest the volume of the resources of used wooden packaging which, as previously mentioned, is the most suitable for reuse in material processing (Packaging waste by waste management operations and waste flow (https://ec.europa.eu/eurostat/data/database; env_waspac)). In this case, packaging waste means all types of packaging or packaging materials covered by the definition of waste contained in the framework directive on waste 2008/98/EC, excluding production residues[14] (Table 3).

According to Eurostat, the percentage of material recycling from wooden packaging waste is diverse in the analysed countries and ranged from 10% in Finland to more than 30% in other countries in 2017 (while the EU average was approximately 39%). This demonstrates huge, yet still not taken, opportunities to manage used wooden packaging in all countries of the European Union.

The presented analysis indicates that there are huge, but presently difficult to estimate unambiguously (due to the existing information barrier), resources of post-consumer wood waste, both in the analysed countries and in the entire European Union. Considering the importance of post-consumer wood waste management for the development of circular/zero-waste economy, it is necessary to create a system of comprehensive information (statistic classifications, reporting system) concerning this type of recyclables, both at the level of particular countries and at the EU level.

Table 3 Packaging waste by waste management operations and waste flow in Poland, France, Finland and European Union in the year 2017

Wooden packaging	*Poland*	*France*	*Finland*	*EU*
		1000 tonnes		
Waste generated	1402.1	2366.4	225.2	14385.0
Recovery	506.8	941.1	220.7	9171.0
Recycling	454.8	727.9	32.7	5760.0

[12] https://rinkiin.fi/for-firms/packaging-statistics [accessed: 31.03.2020].
[13] Häkämies S., Lähdesmäki-Josefsson S., Pitkämäki A., Lehtonen K. 2019. Puupohjaisen rakennus- ja purkujätteen kiertotalous. Loppuraportti 20.12.2019, Gaia Consulting; Salmenperä H., Sahimaa O., Kautto P., Dahlbo H., Haavisto T., Wahlström M., Bachér J., Laine-Ylijoki J., Vahvelainen S., Espo J., Reaching the waste recycling targets requires significant actions (2016) & Policy Brief 20/2016. Government´s analysis, assessment and research activity. Report 53/2016. Valtioneuvoston selvitys ja tutkimustoiminnan julkaisusarja http://tietokayttoon.fi/julkaisu?pubid=15201, https://tietokayttoon.fi/julkaisu? pubid =15201 [accessed: 31.03.2020].
[14] https://ec.europa.eu/eurostat/cache/metadata/en/env_waspac_esms.htm#meta_update1581698012972 [accessed: 31.03.2020].

Recycling - material	454.8	727.9	23.2	5598.0
		%		
Recovery	36.1	39.8	98.0	63.8
Recycling	32.4	30.8	14.5	40.0
Recycling - material	32.4	30.8	10.3	38.9

Source: Eurostat, https://ec.europa.eu/eurostat/data/database ; env_waspac [accessed: 31.03.2020].

3.2 Potential supply of wood by-products in Poland, France, Finland and European Union

Simplified method of estimating the potential supply of wood by-products

Wood by-products are another category which is not unambiguously and comprehensively defined in statistic reporting of European countries (by types and origins). Therefore, to estimate their potential, it was necessary to adopt the model approach.

In accordance with the adopted approach the potential supply of wood by-products results from the average annual consumption of coniferous and non-coniferous industrial roundwood (roundwood for material processing), assuming that[15]:

- 50% of wood by-products is generated from 100% mass (expressed in tonnes) of consumed raw wood material (industrial roundwood) – each unit of used raw wood material (industrial roundwood) gives approximately 0.5 unit of wood by-products.

Additionally, it is assumed that[16]:

- the consumption of roundwood for material processing (industrial roundwood) equals the volume of harvested industrial roundwood adjusted for net export (consumption = removals + import - export),
- the average annual consumption of industrial roundwood is calculated based on the 10-year period (2009-2018) to mitigate annual fluctuations,
- for converting the volume (cm3, m3) of industrial roundwood to mass the average wood density at 15% moisture content is used:
    - for coniferous wood: 0,500 g/cm3 (500 kg/m3),
    - for non-coniferous wood: 0,700 g/cm3 (700 kg/m3).

It is assumed that there is foreign trade in wood by-products in the analysed countries. The volume of exports and imports of wood by-products was estimated based on the average from the years 2015-2018, to mitigate annual fluctuations, and on the classification of goods in foreign trade according to

[15] Früwald A., Wood Industry in Europe..., op. cit.
[16] Ratajczak E., Szostak A., Bidzińska G., Drewno poużytkowe... op.cit.; Ratajczak E., Szostak A., Bidzińska G., Leszczyszyn E., Market in wood by-products in Poland... op. cit.; Szostak A., Bidzińska G., Leszczyszyn E., A study of trends in productivity of raw and other materials in the Polish wood processing industry in 1970-2015, Intercathedra 2018, no. 3/36, p. 307-314; Leszczyszyn E., Wood by-products and their use in Poland in a context of the direct survey of wood producers, Intercathedra 2018, no 1/34, p. 35-43.

Combined Nomenclature. The following items were considered (CN 2018):

- CN 4401 21 00 – Wood in chips or particles: coniferous,
- CN 4401 22 00 – Wood in chips or particles: non-coniferous,
- CN 4401 40 10 – Sawdust and wood waste and scrap, not agglomerated – sawdust,
- CN 4401 40 90 – Sawdust and wood waste and scrap, not agglomerated – other.

It is assumed that the potential base of post-consumer wood waste for the construction sector may be the amount of post-consumer wood waste (percentage of total volume) which in practice, due to organisational, technical-technological and economic reasons, can be used in further material processing (assuming the priority of material use of wood by-products). It is primarily composed of solid wood by-products (excluding bark) and wood-based materials by-products. These by-products are generated at different stages of wood processing (but not from furniture or the pulp and paper industry). According to the estimates, the base volume is approximately 55-60% of the potential total supply of wood by-products. Such wood by-products can be used primarily in the production of wood-based panels (particleboards, including OSBs, and fibreboards) for the construction sector[17].

Estimating the potential supply of wood by-products

According to the adopted methodology, potential resources of wood by-products in the analysed countries (originating from successive stages of wood processing into materials and products) were estimated based on the average consumption of industrial roundwood in recent years, i.e. in the years 2009-2018, (Table 4, Annex 3). It is estimated that the largest resources could have been generated in Finland – according to the estimates resulting from the adopted method it could have been 18 million tonnes (33 million m3), while in the European Union such resources could have equalled approximately 104 million tonnes (189 million m3) in recent years.

Table 4 Potential, estimated resources of wood by-products in Poland, France, Finland and European Union

Wood by-products	*Poland*	*France*	*Finland*	*EU*
Million m^3	18.0	11.5	32.9	189.0
Million tonnes	10.1	6.5	18.1	103.7

Imports and exports of wood by-products was taken into account.

Source: based on the assumptions and annex 3.

In line with the assumptions, 55%-60% of the volume of theoretically estimated resources of wood by-products can be allocated to material processing (in such scenario, the rest of the resources would be used for energy purposes). Simultaneously, these resources also mean that there is potential, estimated supply of wood by-products for the construction sector (Table 5). The largest supply should have been observed in Finland and probably equalled 10-11 million tonnes, while in the European Union the potential resources of wood by-products for the construction sector were estimated to have been 57-62 million tonnes.

[17] Szostak A., Ratajczak E., Bidzińska G., Leszczyszyn E., Dolska J., Herbeć J., Zasoby drzewnych produktów ubocznych powstających... op. cit.

Table 5 Potential, estimated supply of wood by-products for the construction sector in Poland, France, Finland and European Union

Wood by-products	*Poland*	*France*	*Finland*	*EU*
Million m^3	9.9-10.8	6.3-6.9	18.1-19.8	104.0-113.4
Million tonnes	5.6-6.1	3.6-3.9	10.0-10.9	57.0-62.2

Source: based on the assumptions and annex 5.

The information gained directly from the project partners suggests that:

- in France the average percentage of wood by-products redirected to the production process of wooden materials (the total of which, potentially, can be allocated to the construction sector) was 10.2% in the years 2014-2016 and 16.0% in the years 2009-2015; therefore, 0.7 million tonnes (1.2 million m3) and 1 million tonnes (1.8 million m3), respectively, of the estimated total volumes of wood by-products should have been returned to the production process annually,
- in 2013 in Finland 13.2 million m3 of wood by-products was produced along with wood consumption of 73.9 million m3 (including fuelwood), of which 7.7 million m3 (4.6 million tonnes) was reused and 5.5 million m3 (3.3 million tonnes) was used for energy purposes[18].

Similarly to the case of post-consumer wood waste, to gain complete knowledge of the market in wood by-products (due to the importance of the issue), one should, firstly, order and make legible the EU reporting system concerning this subject and, secondly, strive for optimisation of the system of collection and reuse of these by-products (so they are reused to a larger extent than before).

To supplement the incomplete and very scattered knowledge of the resources of potential wood recyclables, one should mention that Eurostat runs an information base concerning generation of wastes as defined by the EU directives. The base is so organised to correspond to the waste catalogue (wastes are divided into groups, subgroups and by origin: municipal – connected with living of people, and industrial – connected with economic activity)[19]. The Eurostat base also contains data concerning wood wastes[20] (table 6).

Not all generated resources of wood waste can be managed. Nevertheless, using even part of them, also in the construction sector, would bring measurable savings of raw wood material from forest, which would result in considerable economic and ecological benefits (such as mitigation of water, soil and air pollution and minimisation of losses connected with storage and accumulation of this pollution) which would be favourable to environmental protection and the quality of human life, and this is the basis for the sustainable development idea.

[18] Sokka L., Koponen K., Keränen J.T., 2015. Cascading use of wood in Finland – with comparison to selected EU countries. VTT Research Report VTT-R-03979-15, https://www.vtt.fi/inf/julkaisut/muut/2015/VTT-R-03979-15.pdf [accessed: 31.03.2020].

[19] European Waste Classification for Statistics, version 4; Commission Regulation (EU) No 849/2010 of 27 September 2010 amending Regulation (EC) No 2150/2002 of the European Parliament and of the Council on waste statistics, https://ec.europa.eu/eurostat/ramon/other_documents/ewc_stat_4/index.cfm?TargetUrl= DSP_EWC_STAT_4 [accessed: 31.03.2020]; DECISIONS COMMISSION DECISION of 18 December 2014 amending Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC of the European Parliament and of the Council OJ 2014 L 350. In principle, the catalogue of waste does not include waste which was classified as by-products, but it encompasses part of post-consumer wood waste (wooden packaging, waste from building sites, from refurbishment and disassembly of building structures and road infrastructure). The information concerns entities (factories) which manufacture in total more than 1 thou. tonnes of waste annually, excluding municipal waste, or which have 1 million tonnes and more of accumulated waste.

[20] These are codes from the waste catalogue (excluding hazardous waste): 150103, 030105, 030101, 030301, 170201, 191207, 200138.

Table 6 Generation of wood wastes in Poland, France, Finland and European Union in the year 2016

Wood wastes	*Poland*	*France*	*Finland*	*EU*
	million tonnes			
Total (all Nace activities and households)	2.6	6.4	4.7	53.0
- Manufacturing	2.3	2.8	4.2	24.0
- Construction	0.07	1.6	0.3	8.8

Wood wastes non-hazardous.

Source: Eurostat (https://ec.europa.eu/eurostat/data/database), env_wasgen [accessed: 31.03.2020].

4 Wood circular economy practices

According to the European Green Deal, the EU has made a clear commitment to build a sustainable, circular economy[21], but some barriers to the reduction, reuse and recycling of wood waste still exist. Achieving this aim requires innovative business models and systemic thinking, which will allow overcoming the observed lock-in in linear business paradigm. In this section, few selected examples of best practices are presented to illustrate different, possible ways of increasing the circularity in the wood sector. For this purpose, existing reports and results of other European and national projects (e.g. BioReg, ROSEWOOD, WoodCircus, and CircWaste) have been reviewed and searched for specific case studies of business models, value chain design and policy initiatives connected to wood recycling. Sample cases were selected and shortly described to depict the diversity of wood recycling strategies.

Collecting waste wood

ECOLEGNO and Saviola (Italy)[22]

Mauro Saviola Group is one of the leading companies in Italy active in four business areas: wood (Saviola), chemicals (Sadepan), furniture (Composad), and biosciences (Saviolife). Saviola, operating in the wood industry, produces an entire range of particle boards with 100% recycled wood. 1.5 million tons of waste wood is collected yearly, including wooden construction and building demolition waste, pallets, chips, old furniture, packaging, processing residues, and fruit boxes. Waste wood is gathered through a network of collection platforms Ecolegno located in Norther Italy, Lombardy and Emilia-Romagna, close to the major urban centres. Additionally, Mauro Saviola Group collaborates with more than 1000 municipalities and local municipal utilities.

After collecting, waste wood is subjected to rigorous qualitative control to ensure that adequate chemical and physical requirements are met. Then, it is cleaned and separated from other materials that may be also recycled. Waste, that is not suitable for panel production, is burned with energy recovery.

System of recycling of impregnated wood (Finland)[23]

In Finland impregnated wood waste is treated as separately recyclable waste. Therefore, it must be taken to a specific collection point at a landfill, to the waste station or to building materials retailer/enterprise that is selling new impregnated wood. Waste management centres are responsible for sorting and forwarding impregnated wood waste, in consequence they are offering very homogenous product for recycling. Non-recyclable wood is burned as hazardous waste.

Business models – wood cascading

Spačva (Croatia)[24]

Spačva is a producer of a range of wood products including floorings, doors, staircases as well as veneer, pellets, briquettes, plates, and glued elements. The company is fully utilizing raw wood material

[21] European Commission, 2019, Communication from the Commission to the European Parliament, The European Council, the Council, the European Economic and Social Committee And the Committee of the Regions: The European Green Deal, COM/2019/640.
[22] Cocchi M. et al., 2018, BioReg, Absorbing the Potential of Wood Waste in EU Regions and Industrial Bio-based Ecosystems, D1.2 State of the Art Technical Report, EUBIA, pp. 60-62; www.grupposaviola.com/en [accessed 25.03.2020].
[23] Verkasalo, E. et al., 2020, WoodCircus, Underpinning the vital role of the forest-based sector in the Circular Bioeconomy, D2.2 Resource Efficiency, Side Streams and Value Chain Analysis – WP2 Final Report, Luke & Cosmob, p. 110; www.kestopuu.fi/en/product-info/common-questions.html [accessed 28.03.2020].
[24] www.rosewood-network.eu [access 28.03.2020]; www.spacva.eu [accessed 28.03.2020].

using the residues from each processing stage for further production. Bark left after debarking of logs is used for energy production needed to dry wood. Sawdust and other waste remaining after the preparation of logs in the veneer machine is utilized for manufacturing of pellets and low-quality veneer parts. Flitch residues are processed further in the sawmill – quality parts are input in flooring/door production and lower quality elements in pellet and briquette manufacturing. Waste originating from the final step of processing is also used for pellet and briquette production. At the end, the only wood residue left is ash.

Business models – reuse of post-consumer wood

ReWin windows – M SORA (Slovenia)[25]

Slovenian company M SORA, producing doors and windows, has developed a timber window ReWin which is made of discarded wood from old windows. Manufacturing ReWin window required recovering wood in good condition and cleaning it of wood preservatives. Additionally, M SORA held a talent competition for design students, which collected ideas for new products made from recovered wood, such as park benches, parquet-style wall coverings, and furniture. Such products contribute to the reduction of the amount of discarded wood which is landfilled or burned.

Altholz (Austria)[26]

Altholz-Baumgartner & Co GmbH is offering old, reclaimed timber in different forms and shapes, including beams, rafters, boards and lamellas, as well as final products made from recovered wood, such as flooring, wall and ceiling coverings. Apart from standard products, tailor-made solutions are also provided. The company is dismantling wood and preparing it for international sale, preserving the unique traces of previous woodworking (often hand-made), wear and natural weathering. Wide range of applications includes construction, exteriors, interiors (flooring, walls, shops, saunas etc.), furniture, doors, and art objects.

Wood recycling and social innovation

Touch Wood – Emerge (UK)[27]

Emerge 3R is a social business group, based in Manchester, promoting the idea and practice of waste reduction, reuse and recycling, resource efficiency and sustainable consumption. Touch wood is an initiative of Emerge 3R operated by Emerge Recycling, which started in 2013 as a member of the National Community Wood Recycling Project (NCWRP). Touch Wood provides collection, sale and upcycling of waste wood from construction sites and other sources. Collected waste include all types of waste timber, wood composites, furniture, wooden items (regardless of type, condition or contamination — except creosoted). After collecting the wood is sorted – part of it goes for sale, and part stays in the Touch Wood workshop, where qualified joiners work with volunteers, providing them training and support, and manufacture together high-quality items for sale. The volunteers are often jobseekers who may gain new skills and improve self-esteem in this way.

[25] mapviewer.rosewood-network.eu [access 28.03.2020]; Ugovšek A., 2018, Project ReWin presented at 6th development day of forest-timber sector, 15.03.2018, www.m-sora-blog.com/single-post/2018/03/15/Project-ReWin-presented-at-6th-development-day-of-forest-timber-sector [accessed 27.03.2020]; https://ec.europa.eu/enviro nment/ecoap/about-eco-innovation/business-fundings/slovenian-company-makes-new-windows-old-materials_en [accessed 27.03.2020].

[26] mapviewer.rosewood-network.eu [access 28.03.2020]; www.altholz.net/en [access 28.03.2020].

[27] Cocchi M. et al., 2018, BioReg, Absorbing the Potential... op. cit., pp. 67-68; www.communitywoodrecycling.org.uk/stores/emerge [accessed 28.03.2020]; emergemanchester.co.uk/ touchwood [accessed 28.03.2020].

Wood recycling and construction – policy initiatives

Fast-Track Deconstruction Initiative (Vancouver, Canada)[28]

There are many initiatives around the globe to promote deconstruction of the buildings rather than demolition, which allows recovering materials that can be further reused in new construction projects, minimizing at the same time demand for raw materials. One of the examples is fast-track deconstruction programme offered by the city of Vancouver (Canada), which encourages the wood recovery from deconstruction sites. Contractors may apply either for deconstructions permit or for demolition permit. In the first case, they must ensure that at least 75% of all building materials (hazardous and banned materials excluded) will be redirected for reuse or energy recovery, but they also gain reduction in landfilling fee for dumping up to 15 tonnes of material that cannot be reused/recovered. Deconstruction permits are also issued earlier than building/development permits which allows starting deconstruction work faster.

Material chain approach to waste policy (The Netherlands)[29]

Policy framework adopted by the Dutch government does not concern only wood but also other waste, including construction and demolition (C&D) waste. Nevertheless, it is an interesting example of integrated waste policy, which takes circular economy policies one step further. The Netherlands introduced a chain-oriented waste approach with its second National Waste Management Plan (2009-2021), moving away from end-of-the-pipe recycling solutions to focusing on the whole material chains to ensure taking into account all environmental effects of the chain as a whole, and, consequently, to increase the effectiveness of the environmental policy. The country is aiming to build a circular economy by 2050 and to achieve this goal it has deployed a range of policy measures on waste management including:

- 5Rs waste hierarchy (reduction and prevention, re-use, material recycling, energy recovery, incineration and landfilling);
- stringent standards for disposal and recycling;
- economic instruments such as waste tax paid by citizens or high landfill taxes;
- planning at national level, cooperation with municipal and regional governments;
- extended Producer Responsibility programmes,
- notification and registration of waste transports;
- control and enforcement (including landfill ban on construction and demolition waste and closed borders to the transportation of waste).

The government has identified the priority sectors and material chains – one of them is construction, which have its own waste management plans. The chain approach includes the establishment of partnerships (facilitated by the government) between the value chain stakeholders, where each of the material streams submits an action plan to provide detailed measures on reducing the environmental impact of the chain by 20%. The reduction of impacts is calculated in terms of the amount of end-of-life waste, the volume of CO2 emissions, pollution from toxic substances, and land use.

[28] Howe J. et al., 2013, The Current State of Wood Reuse and Recycling in North America and Recommendations for Improvements, Dovetail Partners, pp. 139-142.

[29] FAO, UNECE, 2016, Promoting sustainable building materials and the implications on the usage of wood in buildings. A review of leading public policies in Europe and North America, Geneva, pp. 42-46; Ministry of Housing, Spatial Planning and the Environment, 2010, Getting ahead with a successful chain approach, Hague; Ministry of Infrastructure and the Environment, Ministry of Economic Affairs, 2016, A Circular Economy in the Netherlands by 2050. Government-wide programme for a Circular Economy, Hague.

5 Regulatory framework and operational environment for wooden recycled products

5.1 European Union

EU policies and strategies

EU policies and strategies for the material resource efficiency and waste management are closely related. The following strategies and documents are the main pillars of the policy framework related to recovery and recycling of waste materials at the EU, national and local level:

- The 7th Environment Action Programme (EAP) – with the objective to "turn the Union into a resource-efficient, green, and competitive low-carbon economy";
- Waste Framework Directive (2008/98/EC, amended 2018/851) – defines the waste hierarchy in waste management, setting waste prevention as the highest priority and introducing the end-of-waste concept and also specific recovery targets;
- Roadmap to a Resource Efficient Europe (COM(2011) 571 final);
- Resource efficiency opportunities in the building sector (COM(2014) 445 final);
- Towards a circular economy: A zero waste programme for Europe (COM(2014) 398 final);
- Circular Economy Package is an overarching policy that also covers waste legislation. It is therefore not possible to distinguish between policies related only to waste legislation or circular economy concepts. Closing the loop – An EU action plan for the Circular Economy published in 2015 defining 5 priority areas (one of them construction and demolition), latest update published in 2020 focusing on initiatives along the entire life cycle of products, targeting for example their design, promoting circular economy processes, fostering sustainable consumption, and aiming to ensure that the resources used are kept in the EU economy for as long as possible;
- Sustainable Products in a Circular Economy – Towards an EU Product Policy Framework contributing to the Circular Economy, describes EU policies on products that influence the transition to a circular economy in selected priority areas;
- European Green Deal (2020) providing a roadmap to boost the efficient use of resources by moving to a clean, circular economy and to restore biodiversity and cut pollution;
- The revised Eco-design directive gives measures for 10 products, e.g. requirements for reparability and recyclability, which aims at contributing to circular economy objectives by improving the life span, maintenance, reuse, upgrading, recyclability and waste handling. Previously, Eco-design directive focussed on the requirements for energy consumption that have already been implemented in the eco-design directive, which have, for example, notably increased the energy efficiency of vacuum cleaners. In the future, Eco-design directive may be widened to cover other products such as furniture.

Sustainable use of natural resources is a globally recognized challenge for countries, economies and societies. This challenge is reflected, inter alia, in the EUROPE 2020 strategy adopted by the EU in 2010 under the name, "A strategy for smart, sustainable and inclusive growth" (Commission Communication COM (Brussels 3.3.2010)). As part of this strategy, two flagship projects are planned in which the increase in resource efficiency is clearly highlighted. These are:

- "A resource-efficient Europe";
- “An industrial policy for the globalization era”.

It is foreseen that at the national level the Member States will have to apply building energy efficiency regulations, standards and market instruments, such as taxes, subsidies and public procurement, to reduce energy and resource consumption, while using structural funds for investments in energy efficiency in public buildings and more effective recycling.

At the EU level, the Commission declared, among other things, to:

- support production technologies and methods that reduce the use of natural resources and increase investment in EU natural goods;
- review regulations to support the service and manufacturing sectors in the optimal use of resources through more efficient recycling methods.

"European Green Deal" is the new policy of the European Commission aiming for Europe to become a climate neutral continent by 2050. One of the tools to achieve this ambitious goal is "Sustainable product policy". It is assumed that "Sustainable product policy" will contribute to a significant reduction of waste. Complete elimination of waste is not possible, which is why actions are needed to regain its economic value by creating legal, financial and technical conditions encouraging entrepreneurs to participate in a solid and integrated single market for secondary raw materials and by-products. In the document published on 11.12.2019 (Brussels, COM (2019) 640 final) there are no direct references to construction waste, including wood waste; however, it is obvious that this group of waste should also be the subject of measures aimed at reducing waste, and then managing it in economical and environmentally efficient way.

EU Product regulation: Construction Products

The Construction Products Regulation (305/2011) concerns “any product or kit which is produced and placed on the market for incorporation in a permanent manner in construction works or parts thereof and the performance of which has an effect on the performance of the construction works with respect to the basic requirements for construction works".

Construction works as a whole and in their separate parts must be fit for their intended use, particularly taking into account the health and safety of persons involved throughout the life cycle of construction. Subject to normal maintenance, construction works must satisfy the following basic work requirements for construction (BWR) for an economically reasonable working life.

The efforts of the European Commission to increase the use of recycled materials and products in construction are reflected in Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9th March 2011 laying down harmonized conditions for the marketing of construction products and repealing Council Directive 89/106/EEC (OJ 2011 L 88).

CE-marking is mandatory in all EU countries for construction products covered by a harmonised product standard or a construction product that conforms to a European Technical Assessment which

has been issued for the product. The CPR (Regulation No 305/2011) requires that harmonised test methods are used in the performance declarations in order to remove trade barriers between the Member States.

Two of the BWR are related to environmental issues and sustainability, i.e. BWR3 "Hygiene, health and environment" and BWR7 "Sustainable use of natural resources".

BWR7 is a new basic works requirement for the CPR. Reuse, durability and raw and secondary materials are mentioned particularly in BWR7. According to BWR7, the construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and in particular ensure the following:

(a) reuse or recyclability of the construction works, their materials and parts after demolition;
(b) durability of the construction works;
(c) use of environmentally compatible raw and secondary materials in the construction works.

This requirement clearly indicates, starting from the design stage of construction works, the obligation to use materials and construction products from recycling or produced from recyclable materials as widely as possible. It is clear that this requirement also applies to wood and wood products.

The explanatory memorandum to CPR states that in order to assess the sustainable use of resources and the environmental impact of buildings, the product's environmental declarations should be used whenever possible. So far, this statement has been only a voluntary recommendation, not an obligation of the producer.

To harmonize the European approaches to the assessment of sustainability of buildings, the European Committee for Standardization (CEN) has developed a number of standards. These are: EN 15804:2012+A2:2019, CEN/TR 16970:2016, CEN/TR 17005:2016, EN-15643-1:2010, EN-15643-2:2011, EN-15643-3:2012, EN-15643-4:2012, EN-15643-5:2017, EN 16309:2014+A1:2014, and EN 16627:2015[30]. The use of recycled wood does not exclude the application of these standards.

Sustainable aspects are also presented in BWR3 "Hygiene, health and the environment". The focus is on the presence of dangerous substances in construction products and their release into soil, ground water, marine waters or surface water and their emissions into indoor air in the form of toxic gases, radiation or particles (Annex I of the CPR No 305/2011):

"The construction works must be designed and built in such a way that they will, throughout their life cycle, not be a threat to the hygiene or health and safety of workers, occupants or neighbours', nor have an exceedingly high impact, over their entire life cycle, on the environmental quality or on the climate during their construction, use and demolition, in particular as a result of emissions of dangerous substances, volatile organic compounds (VOC), greenhouse gases or dangerous particles

[30] EN 15804:2012+A2:2019 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products; CEN/TR 16970:2016 Sustainability of construction works – Guidance for the implementation of EN 15804; CEN/TR 17005:2016 Sustainability of construction works – Additional environmental impact categories and indicators – Background information and possibilities – Evaluation of the possibility of adding environmental impact categories and related indicators and calculation methods for the assessment of the environmental performance of buildings; EN-15643-1:2010 Sustainability of construction works – Sustainability assessment of buildings – Part 1: General framework; EN-15643-2:2011 Sustainability of construction works – Assessment of buildings – Part 2: Framework for the assessment of environmental performance; EN-15643-3:2012 Sustainability of construction works –Assessment of buildings – Part 3: Framework for the assessment of social performance; EN-15643-4:2012 Sustainability of construction works –Assessment of buildings – Part 4: Framework for the assessment of economic performance; EN-15643-5:2017 Sustainability of construction works – Sustainability assessment of buildings and civil engineering works – Part 5: Framework on specific principles and requirement for civil engineering works; EN-16309:2014+A1:2014 Sustainability of construction works – Assessment of social performance of buildings – Calculation methodology; EN-16627:2015 Sustainability of construction works – Assessment of economic performance of buildings – Calculation methods.

into indoor or outdoor air".

In the case of some wooden products it may relevant to test the emissions of dangerous substances, volatile organic compounds (VOC), into indoor air. The European Committee for Standardization (CEN) has also published a test method for the measurement of emission into indoor air (EN 16516 "Construction products: Assessment of release of dangerous substances. Determination of emissions into indoor air"). Currently the harmonised product standards (hENs) are being revised to include BWR3 regulations into them.

The possibilities for introducing a common class declaration system to assess the performance of construction products with respect to the release and emission of dangerous substances have been evaluated in the EU Commission. The purpose of the class declaration system is to introduce classes for numerical data obtained from testing (e.g. a specific class means that the test results are within a specified range). Ideally, the national legislation can then refer to certain classes for specific materials used in certain application.

The extensive use of recycled construction materials and products cannot lead to a possible increase in the risk to human health and life or the environment, which is why the substantiation of Regulation No. 305/2011 (CPR) stresses the need to include the information on the content of hazardous substances in the Declarations of Performance. Pursuant to this Regulation, the basic types and permissible levels of hazardous substances in certain construction products are specified in harmonized technical specifications, most often in harmonized European standards. For example, the relevant standard for the producers of wood-based panels intended for construction is EN 13986:2004+A1:2015 "Wood-based panels for use in construction – Characteristics, evaluation of conformity and marking". This standard, like other harmonized standards for wood construction products, defines the rules of testing and assessment of formaldehyde and pentachlorophenol levels. Due to the steadily growing share of recycled wood in the production of wood-based panels, in particular chipboard, regulations on hazardous substances are becoming increasingly important and in certain situations may hinder the use of recycled wood in construction.

The assessment of the content of dangerous substances in wood construction products cannot be narrowed down only to formaldehyde and pentachlorophenol, but has to consider the list of substances referred to in art. 31 and 33 of Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18th December 2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (OJ 2006 L 396). In addition, the specific need for information on the content of hazardous substances in construction products should be carefully considered in order to complete the list of hazardous substances. It would guarantee a high level of health and safety protection for workers using construction products and users of construction works.

Provisions of Regulation No 305/2011 are transposed into the law of the Member States of the European Union.

Waste legislation

When a product becomes waste, the management of the waste is legislated in the Waste Framework Directive (2008/98/EC, amended by directive (EU) 2018/851). The regulatory burden of waste status relates to the restrictions in waste management and several administrative obligations (permits, registrations, transport documents, book-keeping and reporting) that are intended to control waste

operations (storage, transport and handling). On the other hand, if the waste related product or material is substituted for certain product, also the regulations concerning the product being substituted for (e.g. Construction Products Regulations), including standards, have to be followed. However, REACH does not cover waste.

Waste is defined by Article 3 (1) of the Waste Framework Directive (WFD; 2008/98/EC, revised 2018/851): "Waste means any substance or object which the holder discards or intends or is required to discard." Waste might be in a solid or liquid state or in solution or suspension. The WFD gives definitions of waste treatment and disposal activities (e.g. recovery, reuse and backfilling) and also includes a methodology for waste to end the waste status or to be classified as a by-product.

There are also differences between the EU Member States in the interpretation of product or waste status.

The Waste Framework Directive (WFD) 2008/98/EC includes the option to set so-called End-of-Waste (EoW) criteria under which specified waste fractions shall cease to be waste. If these criteria are fulfilled, the material will no longer be classified as waste but instead it will become a product subject to free trade and use (although for specific purposes). Article 6 of the WFD regulates the circumstances under which certain specified types of waste cease to be waste. This "end-of-waste" status is reached when the waste has undergone a recovery operation, including recycling, and complies with specific criteria to be developed in accordance with the following cumulative conditions:

a) it has a specific application (automatically fulfilled when reused);
b) a market or demand exists for it (automatically fulfilled when reused);
c) it fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products;
d) its use will not lead to overall adverse environmental or human health impacts (can contain dangerous substances in paints if they are stabilized).

There are three different ways to implement the EoW concept, i.e. through the EU or national criteria or by decision made on case-by-case basis.

The EU Waste Framework Directive requires the Member States of the European Union to take the necessary measures to achieve a minimum of 70% (by weight) re-use, recycling and other material recovery (including backfilling) of non-hazardous construction and demolition waste by 2020. Tightening the EU regulation puts pressure on more sustainable use of materials in construction and on closing material loops. The Commission is now considering new reuse and recycling targets for material-specific fractions such as wood in construction and demolition waste.

The EU landfill directive (1999/31/EC) obliges the Member States to reduce the amount of biodegradable municipal waste that they landfill to 35% of the 1995 levels by 2016 (for some countries by 2020) due to the production of methane from such waste decomposing on landfills. The Council Decision (2003/33/EC) also give some limits of disposal of waste (e.g. organic) on landfills for inert waste and landfills for hazardous waste. The restrictions concerning landfilling of biodegradable fractions create the need for sustainable reuse and recycling solutions of different wood waste fractions.

Waste is to be classified as non-hazardous or hazardous according to the EU list of waste (2014/955/EU). In the list, a certain type of waste is defined by a six-digit code. The different types of waste are divided into 20 chapters based on the origin and characteristics. Chapter 17 groups together "Construction and demolition wastes (including excavated soil from contaminated sites)", but some waste that can be found in a building (e.g. furniture, package) can be linked to other chapters.

The Eurostat data on waste (e.g. amount and treatment) is agglomerated based on the classification on the list of waste.

5.2 Poland

Policies and strategies

Guidelines resulting from Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9th March 2011 have also been introduced in Poland in the form of relevant regulations, i.e. the Construction Law (Journal of Laws of 2019, item 1186, as amended) and the Act on Construction Products (Journal of Laws of 2004 No. 92, item 881, as amended).

On 14th February 2017 Polish Government adopted "The Strategy for Responsible Development till 2020 (including the perspective till 2030)". It is a key applicable document in the medium- and long-term economic policy. The Strategy envisages development of a new separate document regarding the state's raw material policy.

The basic assumption of this policy is the transition to a circular economy by building an efficient and effective management system for all types of mineral resources in the entire value chain and the resources possessed by Poland, as well as by introducing appropriate legal and institutional changes. The activities planned till 2030 include the support for innovation in the exploitation, processing and use of raw materials from secondary circulation, from the resource created by post-consumer and production waste as well as by anthropogenic secondary deposits. The project "State Raw Material Policy" was drawn up and published in 2018. The implementation of the raw material policy is to serve the rational management of mineral resources and raw materials from secondary sources, as well as to set directions of geological and mining research and investments in accordance with the current state of knowledge and development of the country. Unfortunately, these documents do not refer to the only fully renewable raw material which is raw wood material.

Waste regulations

In September 2012 the Ministry of Regional Development published "The National Development Strategy 2020", which draws attention to a complete an effective waste management system in Poland. The strategy stresses the importance of both waste prevention and maximum recovery of raw materials and/or energy. However, the strategy has neither a direct reference to construction nor to the use of recycled wood products in construction.

On the other hand, wood from building demolitions is subject to the Act on waste dated 14th December 2012 (consolidated text of 15th March 2019, Journal of Laws 2013, item 21, as amended) and the classification according to the Regulation of the Minister of Climate of 2nd January 2020 regarding the catalogue of waste (Journal of Laws 2020, item 10). Waste from the construction, renovation and disassembly of buildings and road infrastructure is included in the waste catalogue in group 17. There are no formal obstacles to the use of demolition wood classified as waste belonging to group 17 02 01, but if it is classified as group 17 02 04 (Wood waste, glass and plastic containing or contaminated with hazardous substances (e.g. wooden railway sleepers), it may not be possible to reuse it. The reuse of wood items originating from recovery, including recycling, is hindered by the lack of a detailed catalogue of wood waste (post-consumer wood) that allows classification of various wood waste without the need for difficult and costly testing of wood for the presence of hazardous substances.

Waste treatment processes (and waste resulting from them) should neither pose a threat to human life and health nor to the environment and must comply with the provisions on environmental protection in Poland (Environmental Protection Law, Journal of Laws 2001 No. 62, item 627, as amended) and current waste management plans (National Waste Management Plan 2022, Monitor Polski 2016 item 784).

5.3 Spain

Policies and strategies

In Spain the transition to a circular economy is recently taking some significant steps. A wide range of administrative, business and social strategic initiatives have been incorporated in recent years in line with what has been marked by the EU. In the light of ongoing experiences, it is expected that a more sustainable socio-economic development based on a low-carbon economy is expected to be achieved soon. In this sense, the role of wood and wood-based products is crucial.

The policy instruments include the Spanish government's proposal of a Circular Economy Strategy 2030[31], pending since 2018. The key areas of intervention of this strategy are production, consumption, waste management, secondary raw materials, and water reuse. Among other actions to be promoted in the production, key area is the support of the production of wood and other forest raw materials.

Moreover, the Bioeconomy Spanish Strategy 2030[32] was been developed with the objective of boosting the economic activity and the improvement of the competitiveness and sustainability of manufacturing sectors that are linked to the use of biologically based resources, promoting generation of knowledge and its use for the development and application of derived technologies, collaboration throughout the science and technology system and public and private Spanish entities. The Strategy envisages (without specific measures until now) improvement in the lifetime of wood products in their traditional uses (construction, packaging, furniture, ...etc).

Furthermore, there is progress in developing strategies and specific programs at the regional and local level. The remarkable cases are Catalonia, Andalusia, and the Basque Country.

In Catalonia, The Strategy for boosting the Green Economy and the Circular Economy[33] was drawn up. Its objectives are aligning the government's strategy regarding competitiveness with the smart, sustainable and integrative growth lines postulated by the European Union, as well as increasing business leadership and the ability to move companies and society towards a green and circular economy.

In Andalusia, the Andalusian Circular Bioeconomy Strategy[34] was approved in 2018. It focuses on bioeconomy activities that are less developed in the community and, therefore, need greater

[31] España Circular 2030 Por un #FuturoSostenible. Borrador para información pública Febrero 2018, http://www.prodetur.es/prodetur/AlfrescoFileTransferServlet?action=download&ref=25675460-51d5-487d-8b78-9388f20aa763
[32] Estrategia española de BioeconomíaHorizonte 2030. http://bioeconomia.agripa.org/download-doc/102163
[33] Estratègia d'Impuls a l'economia verda i a l'economia circular, http://mediambient.gencat.cat/ca/05_ambits_dactuacio/empresa_i_produccio_sostenible/economia_verda/impuls_economia_verda
[34] Andalusian Circular Bioeconomy Strategy, http://www.bioeconomiaandalucia.es/documents/1056091/1056698/Estrategia+Andaluza+Bioeconomia+Circular+%5BEABC%5D+%5B18.09.2018%5D/e0b87df0-73a8-43f 2-ba9d-da0ad9b312e9

institutional support through the implementation of specific actions facilitating their take-off and consolidation in the medium and long term. Forestry is one of these bioeconomy sectors.

Recently, the Basque Country has implemented the Euskadi Circular Economy Strategy 203035 with the vision of positioning the Basque Country as a Europe-leading region in a circular economy, where the environment becomes a key factor in sustainability, competitiveness and job creation, and economic growth decouples from resource consumption waste generation and greenhouse gas emissions. Among the different defined strategic objectives, there is the increase in the circular material use rate by 30% what will reduce the dependence on imports and/or extracting raw materials and, additionally, contribute to reduction of waste that would be landfilled otherwise.

Moreover, the Basque Country has also stablished the Basque Alliance for the Bioeconomy[36] with the objective to create a network of business actors that will help strengthen the economic model of making products based on biological resources, to establish a structured collaboration between institutions and technology centres, and to develop this mode of production.

Waste regulations

In the past decade the Spanish construction sector achieved high activity rates, making it one of the most relevant triggers of the Spanish economy. This situation caused an extraordinary effect as regards waste generation, i.e. the Royal Decree 314/2006 of March 17th constituted the Technical Building Code with several parts dedicated to wood construction but none of them is related to residues[37]. These residues constitute the category called construction and demolition wastes. The Royal Decree 105/2008 of February 1st regulates the production and management of construction and demolition waste.

Today the environmental problem caused by these waste streams (that includes its generation and its treatment) remains unresolved in most cases. Article 9th, of Law 22/2011 of July 28th on waste and contaminated soils, empowers the government to establish specific provisions regarding the production and management of different types of wastes with the final objective of preventing their environmental impact. Similarly, the final provision of Law 34/2007 of November 15th on air quality and protection of the atmosphere, empowers the government to regulate the terms and conditions relating to the obligation of waste producer.

Royal Decree 105/2008 defines the concept of the producer of construction and demolition waste. Among the obligations of such producer, there is inclusion of a management study of construction and demolition waste that will be produced in the construction project. The study should include, inter alia, estimated quantity of waste, its intended destination, as well as an assessment of costs of waste management which should be part of the project budget.

The Royal Decree also establishes the conditions that the producers of construction and demolition waste must comply with in general as well as specific conditions of waste recovery.

One of the reasons why satisfactory levels of recycling of construction and demolition waste are not currently achieved is the fact that it is mostly disposed of on landfills at a very low cost, without prior treatment and often without complying with the requirements established in Royal Decree 1481/2001 of December 27th. To solve this situation, the Royal Decree prohibits the deposit without prior treatment and demands the establishment of systems of fees that would discourage the deposit of

[35] Estrategia de Economía Circular de Euskadi 2030, https://www.ihobe.eus/publicaciones/estrategia-economia-circular-euskadi-2030-2
[36] Alianza Vasca por la Bioeconomía, https://www.euskadi.eus/alianza-vasca-para-la-bioeconomia/web01-a2bioeko/es/
[37] Código Técnico de la Edificación, www.codigotecnico.org

recoverable waste on landfills or waste in the case of which previous treatment has been limited to a mere classification.

In general, industrial waste management planning policies are developed based on the waste hierarchy established in the current regulations at the European level, which can be summarized as: Prevention, Reuse, Recycling, Recovery and Disposal.

In Spain, there is a PEMAR (State Framework Plan for Waste Management) in which the section of industrial waste does not indicate that there is a specific legislation for industrial waste, as if there is for construction and demolition waste.

As indicated in Law 22/2011 of July 28th on contaminated waste and soil, it is the role of the state to prepare PEMAR but the role of the Autonomous Communities is to develop their own waste management plans. The management plans, inter alia, analyse the regulatory framework and the evolution of waste management in recent years and, based on the waste generation forecasts, establish the strategic lines to be developed. They also set the objectives to be achieved at the end of the period of validity and define the necessary infrastructures for management of waste which is the object of a given plan.

For example, the planning information prepared by the Basque Government within its authority incorporates:

- Waste prevention and management plan 2020 of the CAV;
- Environmental Framework Program 2020.

As for wood wastes, there is a description of each type of them. In the Official State Gazette (nº 43 of Tuesday, February 19th, 2002) there is a list of LER waste (European Waste List), which describes the codes used at the European level for each type of wood residues. The different typologies described in general within the wood streams are associated with the CER codes given in Table 7.

Table 7 Details of CER codes for wood waste

Residue	*CER CODES*	*Description*
Furniture shaped wood	200138	Bulky municipal waste
Pruning wood	200201	Park and garden waste
Beaches	020107	Forestry waste
Wooden pallets-boxes	150103	Wooden packaging
Other industrial wood waste	030105	Sawdust, shavings, cuttings, wood, boards and veneers
Industrial packaging mix	150103	Wooden packaging
Public works waste	170201	Construction and demolition waste
Wood shavings	030105	Sawdust, shavings, cuttings, wood ...
Wood chips	030301	Bark and wood waste

5.4 Portugal

Policies and strategies

The guidelines from Regulation (EU) no. 305/2011 of the European Parliament and of the Council of 9th March 2011 have been introduced to the Portuguese law with Decree-Law no. 130/2013 laying down harmonized conditions for the marketing of construction products.

With the National Strategy for Green Public Procurement (ENCPE) 2020 (Resolution of the Council of Ministers 38/2016 of July 29th) the government strengthens its promotion of pollution reduction, reduction of consumption of natural resources and, inherently, increases the efficiency of systems.

The Portuguese government adopted the National Action Plan for the Circular Economy 2017-2020 (Resolution of the Council of Ministers 190-A/2017 of December 11th); however, there has been slow progress in the recycling rate of municipal waste and the European Commission included Portugal as one of the countries at risk of missing the EU 2020 target. The Portuguese industry has shown lack of innovation or investment in waste management. One of the reasons might be the fact that Portugal is relatively rich in mineral resources.

Waste regulations

Based on the EU Waste Framework Directive 2008/98/EC, Portugal published Decree-Law no. 46/2008 of March 12th, amended by Decree-Law no. 73/2011 of June 17th. This decree promotes the application of waste management hierarchy. Poor management of construction and demolition waste poses an environmental threat. By applying the waste hierarchy to waste management, waste prevention is set as the highest priority and also recovery targets are set. A target of 70% for the reuse, recycling and recovery of CDW generated until 2020 was established. In addition, the government also set the goal to incorporate at least 5% of recycled CDW in public construction works (Ministério do Ambiente e do Ordenamento do Território, 2011).

The Portuguese government adopted a national strategy in the form of the Waste Management Plan for 2014-2020 (Resolution of the Council of Ministers 11-C/2015 of March 16th). This strategy includes the target set in the EU Waste Framework Directive.

Wood waste in Portugal represents less than 5% of total waste being collected. Most of wood waste in Portugal comes from commercial and industrial use, with wood transformation as a majority contributor, and building and demolition being only a fraction of the contribution. A small part of that is hazardous wood waste[38]. Wood waste management is not well-developed, but a large part of wood waste is collected and reused. Wood waste is being recovered, reused or recovered for energy.

Wood is not one of the main materials used for construction in Portugal. More traditional construction materials are used for several reasons, i.e. economic factors, the lack of training for new technologies, and low qualifications of construction workers. However, the Portuguese society shows strong support for the circular economy initiatives and environmental protection measures[39].

[38] https://www.ine.pt Statistics Portugal
[39] https://ec.europa.eu/environment/eir/pdf/report_pt_en.pdf

5.5 Finland

Policies and strategies

According to the Finnish Material Efficiency Programme, material efficiency in production means sparing use of natural resources, effective management of secondary flows and wastes, reduction in the volume of waste, and recycling of materials at different phases of the product's life cycle. The goal is also to reduce the harmful impacts on the environment throughout the product's life cycles. Material efficiency can be seen at different stages of the value chain: in the production, refining, trade, and consumption of raw materials, as well as the sustainability of products or opportunities for reuse, recycling, and waste recovery.

Finland sees resource efficiency as an opportunity to solve many challenges. The government objective is to replace imported fossil fuel-based energy with clean and renewable domestic energy and to see the growth in clean-tech businesses, sustainable use of natural resources, diversified rural enterprises, and efficient circular economy, all contributing to the creation of new jobs.

Bioeconomy, as a key strategy in Finland, is strongly connected with resource efficiency. Over the decades Finland has accumulated considerable expertise in refining biomasses and created a strong industrial framework. Finland is the EU's most forested Member State and wood plays more important role in the Finnish economy than in any other EU country. A sustainable and cascading use of wood is reflected in the Finnish Bioeconomy Strategy and National Forest Strategy 2025. The main target of the national forest strategy is to encourage the use of wood based and other renewable products in public procurement; to support investment aimed at demonstrating bio-products and bio-services on a commercial basis; and to create incentives to develop Finnish wooden construction and wooden furniture and interior design sectors.

The Finnish Ministry of the Environment, which also controls the construction sector, has launched several funding programmes and initiatives to improve the material and energy efficiency in the construction sector. Material efficiency in the field of real estate and construction also calls that the prerequisites for reuse and recycling of construction materials, especially wood, should be improved.

Product regulations

Finland has no notified regulation for indoor emissions from construction products and furniture. However, a volunteer Indoor Climate Classification with criteria for so-called "M1-certified building material" was introduced in 1996. M1-classification sets limit values for the emission of volatile organic compounds (VOC), formaldehyde, and ammonia – also the acceptability of the odour associated with the material is assessed. Emissions are measured in constant temperature (T: 21 degrees Celsius) and relative humidity conditions (RH: 50%). Though the classification is voluntary, the use of M1-classified, low-emitting materials has markedly increased and resulted in improved indoor air quality in new Finnish buildings. To date, there are over 10,000 M1-classified building products on the market (The Finnish Building Information Foundation 2020). Untreated wood, with the exception of some tropical hardwoods, is included in the best emission class M1 together with non-coated metals, bricks, natural stone, glass, and ceramic tiles.

Waste regulations

The EU Waste Directive was implemented in 2012 by a reform of the Waste Act (646/2011) in Finland. In addition to the Waste Act, separate regulations specifying the Waste Act were published, the most important of which in the case of construction and demolition wastes are the Government Decree on

waste (179/2012) and the landfill regulation (331/2013). The reformed waste legislation aims at changing Finnish legislation to better reflect the current waste and environmental policy priorities and the European Union legislation. The principle of all waste related activities is to reduce the volume and harmfulness of wastes generated.

In addition to increasing the recovery rate of construction wood waste, the Finnish Waste Act 646/2011 defines the hierarchy of waste treatment on the basis of the EU Waste Framework Directive 2008/98/EC. The purpose of the waste hierarchy is to avoid waste generation, but if it is generated, to control its treatment. The 'polluter pays' principle ratified in the Waste Act, as well as the extended producer responsibility, are used as controls to avoid production. Thus, the producer either pays the costs of waste treatment or carries the responsibility of the final disposal of the waste.

In Finland, the national waste legislation (the Government Decree on Waste (179/2012)) requires separated collection and recovery for several waste fractions, such as non-impregnated or hazardous wood wastes generated in the construction and demolition processes.

In Finland, VTT has compiled 4-step quality grading guidelines for wood wastes. Grades A and B end up in energy production and thus are not subject to the Waste Act but to the European standard EN 14961-1 for solid fuels. Grade A contains untreated wood or wood products, whereas grade B consists of chemically treated or coated wood that does not contain any halogenated organic compounds and heavy metals. Grades A and B, therefore, include untreated wood, pallets and other wooden packages, miscellaneous wood wastes, and furniture. Grade C includes wood that may contain heavy metals and organic halogenated compounds, such as fluorine, chlorine, bromine, or iodine. Grade D stands for pressure impregnated wood materials and is classified as hazardous waste because of the impregnation chemicals, such as copper, chromium or arsenic. Grade D wood may only be landfilled according to the practices for the environmentally hazardous wastes or incinerated in a boiler with specifically designed smoke filtration systems.

In general, wood waste from new construction is included in grade B if its origin is known. Wood waste from demolition sites shall be classified as grade C, unless it can be documented that the wood is not chemically treated. Wood waste from renovation can either compare to wood from new construction or demolition. Mixed wooden package wastes that may consist of various different materials is classified as grade B, unless it is pest treated or contaminated during use. If wooden packaging is made entirely of untreated wood, it can be classified as grade A.

The legislation sets targets for material recycling of construction and demolition wastes (CDW). The effective CDW recycling is challenged by the fact that Finland is a large country with a sparse population. This means that CDW generation is dispersed and transportation distances are long. Material recycling of wood waste is especially challenging. Despite several research and development projects aiming to find new ways of recycling wood, the degradation of wood during use and the treatments of wood limit its usability as material.

The EU Waste Directive and the Finnish Waste Decree require 70% of CDW to be recovered as material by 2020, excluding combustion. Since wood comprises a large share of Finland's building materials, achieving this goal is challenging. Wooden CDW is often technically or economically unsuitable for re-use or recycling, particularly as building materials that feature strict quality requirements. Therefore, recovering energy from wooden CDW has been a viable option in Finnish climatic conditions, also reducing Finland’s dependency on fossil fuels.

Research is going on to develop new products (e.g. panels and wood-plastic composites) by using fibres from wooden CDW – there are already some products on the market. However, the recyclability

of these products also needs to be assessed, especially if wood fibres are mixed with other materials. In Central Europe the recycled wood waste is used in manufacturing of particleboards. Long transport distances of wastes to the particleboard manufacturer (in Finland only one manufacturer that is 100% supplied by virgin sawdust from the neighbouring sawmill), requirements and quality controls on the input materials (removal of impurities, waste sorting needs), and also logistics of the finished particle board to foreign customers due to the limited domestic use have prevented the use of C&DW in particle board production so far.

5.6 France

Product regulations

The French spend nearly 80% of their time in enclosed spaces (OQAI[40], 2006), i.e. nearly 20 hours out of 24 hours. At the same time, due to the evolution of thermal regulations in construction, buildings are becoming more and more airtight. A high concentration of various pollutants specific to indoor air and a long time of breathing in of this pollution lead to health problems, which is why public authorities want to introduce relevant legislations.

Many elements of interior design contribute to Indoor Air Quality (IAQ), such as building materials, design products etc. Wood-based panels are widely used as furniture and building materials. Therefore wood-based panel manufacturers and furniture manufacturers have a common interest in addressing the following IAQ issues:

- clarify the requirements and see clearly in the different test methods classically used (perforator, gas analysis, chamber method, etc.),
- sharing standards (labels, certifications),
- provide panels with very low formaldehyde content and provide evidence that is easy to implement and understand,
- accompany the development of French furniture exports by adapting to the regulatory constraints of each country.

The sources of indoor air pollution are multiple and complex. There is a wide variety of pollutants, i.e. physical (particles, fibres, and radioactive gases), bio-contaminants (moulds, bacteria, viruses, allergens etc.), chemical (carbon monoxide, volatile organic compounds (VOCs), formaldehyde etc.).

France was a pioneer in this field creating the Indoor Air Quality Observatory (OQAI) in 2001. The aim of the OQAI is to gain better understanding of indoor pollution, its origins and its dangers, in particular through the measurement campaigns carried out in housing, nurseries and schools, offices and so-called energy-efficient buildings.

The health and economic stakes related to IAQ are high. In France, the impact of poor indoor air quality is estimated at 19 billion euros per year. Actions to improve IAQ, whether in housing or in establishments accepting visitors (Etablissements Recevant du Public ERP) were implemented.

Three events since then have clarified this regulatory framework:

[40] http://www.oqai.fr/userdata/documents/Document_133.pdf

- the National Health and Environment Plan (3rd PNSE since 2004), the Grenelle Environment Round Table (2007),
- the National Action Plan on IAQ (2013),
- the so-called "Grenelle 2" Act No. 2010-788 of 12 July 2010, which resulted in two types of specific actions:
  - air quality monitoring in ERP: Decree no. 2011-1727 of December 2nd, 2011, on the monitoring of formaldehyde and benzene set thresholds not to be exceeded in the short and long term in ERPs. If the investigation value for formaldehyde reaches 100 µg/m^3, an ERP operator must implement an action plan;
  - informing the public with the labelling of commonly used products. The decree for construction products is in force since 2011:
    - Decree 2011-321 of March 23rd, 2011, and its implementing order of April 19th, 2011, set terms and conditions for the labelling of construction products or wall or floor coverings and paints and varnishes on their emissions of volatile pollutants. Since 1st January 2012, certain construction and decorative products must be labelled regarding their level of volatile pollutant emissions. The person placing the product on the market is obliged to affix a label ranging from A+ to C (low to high emission) on the product or its packaging,
    - ten pollutants are targeted: formaldehyde, acetaldehyde, toluene, tetrachloroethylene, xylene, trimethylbenzene, dichlorobenzene, ethylbenzene, 2-butoxyethanol, and styrene. Total VOC emissions (Total VOCs) were also retained. The decree of 19th April 2011 specifies in its annexes the test method for characterizing VOC and formaldehyde emissions (ISO 16000 parts 3, 6, 9, 10 and 11 standards) and the limit thresholds for the emission classes (A+ to C);
  - for furniture products, also covered by the Grenelle law, the decree is not published yet.

Waste regulations

Wood wastes include both industrial waste generated within the wood sector (secondary wood processing companies) and so-called post-consumer waste generated at the end of the life of a wide range of wood-based products used by different sectors (construction, households and communities, distribution, and the tertiary sector). Construction waste, although not used by final consumers, is usually considered as post-consumer waste.

It should be noted that related sawmill products (bark, sawdust, slabs, chips, short offcuts etc.), provided they have not been abandoned, are not legally waste but coproducts (De Reboul and Olivier 2016). Waste is defined by European Directive 2008/98/EC as "any substance or object which the holder discards or intends or is required to discard" (OJEU 2008). Some residues from the secondary processing of wood are also considered coproducts and not waste (when the manufacturer is remunerated for the sale of these coproducts).

This double variety of the sectors of origin and the products of origin of wood waste induces a diversity in waste characteristics and explains the existence of a diversity of treatment methods. The same European directive defines a regulatory hierarchy of waste prevention and treatment methods, specified when it was transposed into French law in Article L541-1-1 of the French Environmental Code (JORF (2010)), with, in order of priority, prevention, re-employment, re-use, recycling, other recovery, particularly energy recovery, and disposal. Re-employment and re-use are distinguished by the absence and existence, respectively, of the transition to an intermediate status of waste, i.e. re-employment is a mode of prevention, re-use is a mode of treatment.

One example of re-use and treatment case is described for a pallet[41]:

- reuse (or "reconditioning") of pallets before they are abandoned and become waste, reuse of furniture or structural parts;
- reuse of used pallet boards for the reconditioning of other pallets (the dismantling of the boards on used pallets is referred to in the regulations as "preparation for re-use"), furniture or structural parts;
- recycling of shredded material from used pallets or other wood waste in the form of chipboard, animal bedding, equestrian surfaces or mulch;
- energy recovery from shredded used pallets (a product that was legally removed from the status of waste, see section II.3.1.1) in a biomass plant (collective boiler room), other energy recovery in incineration units with an energy efficiency of more than 65% (industrial boiler rooms);
- disposal on landfill or incineration without or with energy recovery (with an efficiency below 65%) of used pallets or other wood waste (cement works, etc.).

We can see that the example of pallets, from Deroubaix and Quint (2019), helps to clarify the differences in regulatory status because it illustrates the different modes of prevention and treatment for the same product.

In France an "A, B, C" classification system is used by professionals but without any precise regulatory basis:

- Class A designates clean wood without any additives or very weak wood (pallets with cubes of agglomerated wood for example). In practice, this class is mainly used for packaging wood.
- Class C designates potentially hazardous wood, i.e. wood that may present one or more of the hazardous properties listed in Annex III of Directive 2008/98/EC and defined according to concentration thresholds for substances classified as dangerous for these different properties. In practice, this class mainly includes impregnated wood containing metallic trace elements and creosote-treated wood.

[41] According to to 94/62/EC Packaging and packaging waste requirements and its amendments:
- EN 13193 (2000) "Packaging - Packaging and the environment - Terminology";
- EN 13427 (2004) "Packaging - Requirements for the use of European Standards in the field of packaging and packaging waste";
- CEN/TR 13695-2 (2005) "Packaging - Requirements for measuring and verifying the four heavy metals and other dangerous substances present in packaging, and their release into the environment - Part 2: Requirements for measuring and verifying dangerous substances present in packaging, and their release into the environment";
- EN 13428 (2004) "Packaging - Requirements specific to manufacturing and composition - Prevention by source reduction";
- EN 13429 (2004) "Packaging – Reuse";
- EN 13430 (2004) "Packaging - Requirements for packaging recoverable by material recycling";
- CEN/TR 13688 (2008) "Packaging - Material recycling - Report on requirements for substances and materials to prevent a sustained impediment to recycling";
- EN 13431 (2004) "Packaging - Requirements for packaging recoverable in the form of energy recovery, including specification of minimum inferior calorific value";
- EN 13432 (2000) "Packaging - Requirements for packaging recoverable through composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging";
- FD/CR 13695-1 (2000) "Packaging - Requirements for measuring and verifying the four heavy metals and other dangerous substances present in packaging and their release into the environment - Part 1: Requirements for measuring and verifying the four heavy metals present in packaging".

- Class B is defined by deducting the other two. In practice, it includes wood containing adhesives (e.g. process panels) or having undergone finishing process (paint, varnish, etc.).

For recycling into particleboard, the European Panel Federation (EPF) requires all its members, in a harmonised manner across the European Union, to comply with chemical contaminant thresholds for both waste wood used in the manufacturing of particleboard and the resulting particleboard. However, these are only voluntary industry benchmarks and not regulations (EPF 2001, 2002). These thresholds are based on the NF EN 71-3 standard concerning the safety of toys likely to come into contact with the mouth considered relatively strict, supplemented by the thresholds for creosote and pentachlorophenol[42].

The specifications for the purchase of waste wood from particleboard manufacturers vary from one company to another with regard to undesirable materials and particle size (Deroubaix et al. 2017). As in the case of biomass power plant 2910-B, not all class B waste is compatible with the EPF thresholds. As a result, panel manufacturers generally source in the intermediate class A-B or directly in class B when they have an integrated sorting platform.

5.7 Sweden

Policies and strategies

Under the Swedish Environmental Code each municipality is responsible for ensuring that household waste within the municipality is transported and recycled or disposed of. The term household waste refers to waste that comes from households and equivalent waste from businesses such as restaurants, shops, offices etc.

Every municipality is required by law to have its own waste and sanitation ordinance which consists of a waste plan and regulations for waste management. Municipalities can collaborate and draw up common regional waste plans.

The municipalities are working at increasing rates to promote the prevention and reuse of waste. Preparation for reuse of household waste is also part of the municipal responsibility. The municipalities also have a duty to inform about waste management and about the content of the waste plans.

Product regulations

Sweden has producer responsibility for:

- recyclable paper,
- packaging,
- waste electrical and electronic equipment (WEEE),
- tyres,
- cars,
- batteries,
- pharmaceuticals.

Producers are responsible for collecting and disposing of end-of-life products. This means that there

[42] Annex C of standard NF EN ISO 17225-1 on solid biofuels.

must be suitable collection systems and treatment methods for recycling.

Producer responsibility is also intended to encourage producers to develop products that are more economic with resources, easier to recycle and do not contain substances which are harmful to the environment.

In their information about waste, the municipalities are also obliged to inform about the responsibility of producers. This is done, inter alia, through the national waste portal sopor.nu, which is collaboration between Avfall Sverige[43] and several other actors.

Reuse is defined as a measure that involves a product or component that is not waste being used again for the same purpose as it was originally intended. Preparing for reuse involves waste management that applies to inspection, cleaning or repair to enable products or components submitted as waste to be reused.

More than half of the country's recycling centres have simpler means for accepting materials for reuse, such as clothes and furniture, often in collaboration with aid organizations that sell or donate the material. There are also recycling centres with recycling parks that have expanded operations, such as repairs and sales. Several municipalities have plans to develop their recycling centre to a centre for repair, rental, borrowing, and exchanging and sharing activities.

To facilitate the prevention and reuse work of the municipalities, "Avfall" Sverige has published a guide that explains the legal requirements.

Waste regulations

Sweden offers innovative solutions and extensive know-how in waste collection and recycling. It is a global leader when it comes to dealing with and recycling waste. The waste-to-energy systems we have developed have given waste a value.

Swedish waste management prevents the creation of waste is the top step in the waste hierarchy. It is the priority of both Swedish and European waste legislation. The waste hierarchy priority is:

- waste prevention
- reuse
- material recycling and biological treatment
- other recycling, e.g. energy recovery
- disposal, e.g. to landfill.

Hazardous waste can be treated using one or more of these methods, depending on its properties. Waste that may contain hazardous substances should not be recycled, but rather phased out of the eco-cycle. In the strategy, there is not direct reference to construction, or specifically the use of recycled wood products in construction.

Recycling means that the waste will be used as replacement for another material. Preparation for reuse is also a recovery operation. According to the definition, preparation for reuse means inspecting, cleaning or repairing any item that is waste so it can be reused without further treatment.

Material recovery saves energy and natural resources, thereby reducing environmental impact.

[43] Avfall Sverig is the swedish waste agency.

Biological treatment closes the eco-cycle and returns nutrients to the soil. With biological treatment, the waste is treated through anaerobic digestion (treatment without access to oxygen) or composting (treatment with access to oxygen, which is known as aerobic treatment). Anaerobic digestion produces digestate for fields as well as biogas, which can be used as vehicle fuel. Compost is a soil conditioner which can be used in gardens, parks and landscaping.

Energy recovery is a method ideally suited for waste which cannot be recycled in any other way. Recovering energy from waste provides both district heating and electricity.

Landfilling is a treatment method for waste that cannot or should not be recycled. Landfilling entails waste being stored in a manner that is safe in the long-term. Sending organic or combustible waste to landfill is prohibited.

5.8 Chile

Product regulations

The Ministry of Housing and Urbanism has incorporated sustainability as an essential attribute in its housing programs, developing the Application Manual for the certification of sustainable living. Certification requires that the content of volatile organic compounds (VOCs) be within the established margins and in the case of use of agglomerated woods, it must be demonstrated that they do not contain urea-formaldehyde through tests, certificates or compliance with any of the following alternatives for the maximum allowable emission of urea-formaldehyde:

1. NCh 3391: Chilean Standard for wood - fibreboard and particleboard that establishes the maximum formaldehyde emission limit. Requirement: Limit concentration of 0.21 ppm.

2. EN 13986-2004 "wood-based panels for use in construction – Characteristics, evaluation of conformity and marking". It is a standard focused on wood construction products, which defines tests and evaluation of formaldehyde levels. Requirement: using tests of standards EN 717-1, EN 120, EN 717-2, the material must be class E1.

3. CARB compliant certificate: The California Air Resources Board (CARB) developed a set of standards for formaldehyde emissions in 2009. The program is similar to the European program (E0, E1 or E2). Manufacturers must send samples of their boards to independent laboratories, and those laboratories measure formaldehyde emissions and issue certificates. Products must have CARB certificate to be legal for sale in California. Like the European program, a product cannot be said to be CARB compliant if it has not been independently tested and certified as such. Requirement: Phases 1 or 2.

Waste regulations

Currently, there is a Recycling law whose objective is that that at least 30% of generated waste should be recycled in Chile. The central instrument of this regulation is the Extended Producer Responsibility (REP), which essentially forces manufacturers and importers of six priority products (i.e. lubricating oils, electrical and electronic devices, batteries, containers and packaging, tires and batteries) to recover a percentage of their products once their useful life ends (MMA, 2016).

Although the Ministry of the Environment could incorporate new products in the future through regulations, the law is still very limited in Chile. Other broad sectors are still outside this new legal

framework, such as the construction sector which is the largest producer of waste, whose share varied between 26% and 34% in the period 2000-2009, considering the total in the country, and was approximately 5.7 million tons of 16.9 million in total (Conama, 2010). Furthermore, within the framework of the National Strategy for Sustainable Construction (ENCS), the Sustainable Construction Code (MINVU-BRE, 2014) establishes four main categories of sustainability: Energy, Water, Waste, and Health.

6 Benefits of using wood and wood products in construction

6.1 Economic benefits

At present, architects and engineers are designing landmarks in cities such as bridges, government offices, schools or factories, looking for wood to express contemporary beauty rooted in nature and show respect for the environment. Wood also began to be increasingly used in housing, nurseries and schools, religious, administrative, cultural and exhibition buildings. The flexibility of lightweight modular wood construction is particularly suited for halls and factories, as well as bridges, sound barriers, hydraulic engineering and avalanche control[44].

Therefore, it seems that capturing the economic benefits of using wood and wood products, especially in the construction sector, is very important and requires a broad, holistic approach. Many of the potential benefits emerge over the long term and are dispersed in society, from individual families to local communities. Additionally, the benefits of using wood and wood products in the construction sector may have an impact on the government departments, local authorities and public services. It could therefore be said that the economic benefits of using wood manifest themselves throughout the economy (macroeconomic benefits with benefits to the public sector) and can offer advantages to consumers.

Macroeconomic benefits

Wooden building technologies are an interesting and sustainable solution to improve urban citizens' lifestyles, while supporting local and national businesses and economies[45]. The wood construction sector has high potential for job creation, improved industrial competitiveness, regional development, and the development of a strong export industry[46]. The use of local renewable resources may influence the improvement of rural infrastructure, increase in employment, economic diversification, tax-base, and many other areas. Therefore, the development of wooden construction value chain can have a number of positive effects on local rural economies[47].

Švajlenka et al. (2017) in their analysis observe that wooden houses built using prefabrication method have benefits such as reduced construction time, lower overall construction costs, and more interesting architectural appearance. In addition, the modern production process, partly or completely possible in the factory, increases health protection and safety in the workplace, and also reduces the use of materials and the amount of construction waste, and thus results in lower CO2 emissions to

[44] CEI-Bois, Tackle Climate Change: Use Wood, 2011, p. 60-67, www.cei-bois.org

[45] Franzini F., Toivonen R., Toppinen A., Why Not Wood? Benefits and Barriers of Wood as a Multistory Construction Material: Perceptions of Municipal Civil Servants from Finland, Buildings 2018, 8, 159; doi:10.3390/buildings8110159.

[46] Domac, J., Richards, K., & Risovic, S., Socio-economic drivers in implementing bioenergy projects, 2005, Biomass and Bioenergy, 28(2), 97–106.

[47] Lehtonen O., Okkonen L., Regional socio-economic impacts of decentralised bioeconomy: a case of Suutela wooden village, Finland, Environ Dev Sustain, 2013, 15:245–256 DOI 10.1007/s10668-012-9372-6; Ritter M., A., Skog K., Bergman R., Science Supporting the Economic and Environmental Benefits of Using Wood and Wood Products in Green Building Construction, 2011, United States Department of Agriculture, Forest Service, Forest Products, Laboratory, General Technical Report, FPL–GTR–206.

the environment as well as reduction of energy and water consumption[48]. According to Smola's (2011) calculations, energy consumption for the production of a wood unit is 3 times lower than for the production of bricks, 4 times lower in the case of cement production and 6 times lower in the case of concrete production[49].

The potential environmental impact of a building after it has reached the end of its service life should also be considered as there will be savings of every cost. Following the primary use, there are many secondary or tertiary applications for the wood construction waste that maintain its value. Furthermore, wood waste from demolition of houses can be recovered as material, thus avoiding its disposal at landfills. Thanks to alternative options such as reuse, recycling and energy recovery, building of wooden houses contributes to lower greenhouse gas emissions, which can bring economic benefits for the country[50].

Benefits for consumers

Monitoring the costs associated with the construction of a house can be the main tool of measuring the economic value of wooden houses. The experimental study of Švajlenka et al. (2017) compares particular house built using prefabricated wooden construction with a traditional masonry construction technology. The benefits of wooden houses over brick structures were discussed as regards selected economic parameters. One of them was the construction time, where comparison showed that the construction time of wooden house was 48% shorter than that of masonry house. In addition, the authors demonstrated that the construction costs of wooden house were 15% lower than those of masonry house. The differences in weight of the structures were also compared. The weight of wooden building was 74% lower than that of masonry construction. Therefore, it is possible to design a narrower foundation in the case of wooden construction. In practice, this means using less concrete and a smaller number of transport rides for construction. The authors estimated that, the number of rides in the case of wooden house decreased by 57% compared to the number of rides needed for masonry construction[51].

The most energy-efficient buildings are made of materials that resist heat flow. Wood is a natural thermal insulator which loses less heat due to conduction than other building materials. Wood cellular structure endows it with natural thermal insulation, which keeps out the cold in winter and the heat in summer. Wooden houses easily comply with thermal insulation regulations; however, adding insulation, it could be easy to build ultra-low energy houses or even zero-energy houses. The lower-capacity heating systems mean significantly reduced running costs. Wood thermal efficiency also means slimmer walls, thus leaving up to 10% more space than in the case of other building constructions[52]. Thus, wood as a building material is usually associated with high energy efficiency building systems.

Wooden buildings can be easily adapted to the prevailing conditions. Wooden houses allow easier and cheaper expansion of existing buildings or rebuilding, and prolongation of service life of the existing structure by making it easier to adapt it to changing needs (e.g. change of the building's orientation,

[48] Švajlenka J., Kozlovská M., SpišákováM., The benefits of modern method of construction based on wood in the context of sustainability, Int. J. Environ. Sci. Technol., 2017, 14:1591–1602, DOI 10.1007/s13762-017-1282-6.
[49] Smola J., The construction and use of low-energy and passive houses, 2011, Grada, pp 352 in: Švajlenka J., Kozlovská M., SpišákováM., The benefits of... , op. cit.
[50] Ramage M. H. et al., The wood from the trees: The use of timber in construction, Renewable and Sustainable Energy Reviews 68 (2017) 333–359, http://dx.doi.org/10.1016/j.rser.2016.09.107.
[51] Švajlenka J., Kozlovská M., SpišákováM., The benefits of... , op. cit.
[52] CEI-Bois, Tackle Climate Change: Use Wood, 2011, p. 60-67, www.cei-bois.org

its floor plan, the number of rooms, interior design, and the overall appearance). Thanks to the light weight of wooden houses, such operations as loft conversion, adding an extra storey, extension, removing walls or just modernization are simpler, cheaper and more practical; while in many cases especially loft conversion can be done only in wood[53].

6.2 Societal benefits

Apart from economic benefits, the growing use of wood in buildings, particularly (but not only) in wood construction, could contribute to social development and better fulfilment of different social needs. Main benefits in this area are connected to the following:

- human health and wellbeing,
- employment and migration,
- forests and ecosystem services,
- trends, preferences and personalization.

It is assumed that the use of wood in the interior of buildings has a positive effect on the interior air quality and human health (for example through humidity buffering, soft acoustics, and stress-relieving atmosphere), although the scientific measurement of the relationships between these variables is challenging[54]. The impact of wood and forests on the human mind has been the subject of extensive research in different parts of the world. Japan and Norway have conducted research which suggests that wood has a positive psychological effect, owing to the harmonious architectural solutions, relaxing color palette, and pleasant living environment. Wood as a building material, stimulate aesthetic pleasure, reinforce peaceful feeling and make people feel good[55].

The results of first studies in this area seem to back up this assumption. According to available literature reviews, studies examining the psycho-physiological effects of wood use in interior have revealed that in most cases wood lowers the autonomic stress reactivity reflected in, inter alia, cortisol levels, skin conductance levels, blood pressure, and heart rate[56]. The stress-relieving effects of wood have been tested in several different environments, including school and healthcare settings. Also, in self-assessment study designs it was revealed that wood influences the subjective wellbeing of people and their emotional state. Wood is often the respondents' preferred choice as it comes to different interior finishing materials and they describe it as "warm", "comfortable", "relaxing", "natural", and "inviting"[57]. However, people's responses can vary with respect to wood species, the type of product, and surface treatment[58]. On the other hand, some adverse effects are possible, mainly related to the

[53] CEI-Bois, Tackle Climate Change: Use Wood, 2011, p. 60-67, www.cei-bois.org
[54] Hurmekoski E., How can wood construction reduce environmental degradation?, European Forest Institute, Joensuu 2017, p. 5-6.
[55] Boulet S., Caractérisation du confort hygrothermique et acoustique dans les constructions à base de bois, Thèse de Doctorat. Université de Savoie, 2009, 262 p; Sakuragawa S., Miyazaki Y., Kaneko T., Makita T., Influence of wood wall panels on physiological and psychological responses, Journal of Wood Science, 2005; Rice J. et al., Appearance wood products and psychological well-being, Wood and fiber science, vol. 38 iss. 4, 2007.
[56] Augustin S., Fell D., Wood as a restorative material in healthcare environments, FPInnovation, 2015; Burnard, M.D., Kutnar A., Wood and human stress in the built indoor environment: a review, Wood Science and Technology, vol. 49 (2015), pp. 969-986.
[57] Rice J. et al., Appearance wood products..., op.cit., p. 658.
[58] Nyrud A. Q., Bringslimark T., Is interior wood use psychologically beneficial? A review of psychological responses toward wood, Wood and Fiber Science vol. 42 Iss. 2, 2010, p. 208.

emissions of volatile organic compounds (especially, in the case of treated wood) and formaldehyde from wood-based panels and engineered wood, and problems related to the transmission of sound[59].

The growing demand for wood materials from the construction sector may boost regional and rural development and strengthen the urban-rural linkages. This was already mentioned in the section concerning the economy, but it has also an important social dimension. First of all, demand growth usually means more jobs in the local economy, which is even more beneficial when the manufacturers start to offer products of higher added value (e.g. engineered wood products for construction). This results in higher wages, the emergence of new professions and better opportunities for career development. Forestry and wood industries have also a great potential to decrease the level of poverty in tropical countries where millions of people depend on forests for livelihood (mainly through small scale private plantations supplying wood for local, high-value production)[60]. The development of local economy can mitigate depopulation, which is observed in rural areas in many countries. Retaining young people in rural regions contributes to more efficient use of resources, more vital demographic structure, and better provision of services[61].

The increased use of wood provides market incentives for forest land owners to keep the land forested by assuring the revenue from selling timber[62]. Forests in turn provide a wide range of cultural/societal ecosystem services, including tourism and recreation opportunities, health and wellbeing benefits, nature and aesthetic experiences, as well as spiritual values[63]. Additionally, they provide a range of indirect benefits for current and future generations, mainly related to the environmental protection and climate change mitigation[64]. On the other hand, intensive and large-scale production of biomass may not support a lot of these services, and multi-functional and multi-species forests are perceived as the most effective in enhancing societal benefits[65].

The use of wood is in line with some current trends in consumer preferences. Wood a natural and renewable material has a certain appeal for people who seek contact with nature and cherish ecological values. It helps transform urban spaces and interiors into more citizen friendly. A wide range of available materials with different finishes allows personalization of wooden interiors and facades. Last, but not least, wooden construction (especially prefabricated/modular wood construction) allows much greater flexibility than that of brick-and-mortar buildings in terms of potential extension, merging of buildings or even moving the house to another location. Thus, it answers to the needs of the new group of dynamic and mobile consumers.

6.3 Environmental benefits

Wood is a widely available and, in most cases, sustainably sourced raw material in boreal and

[59] Ibidem, p. 203.
[60] Nambiar E.K.S., Re-imagining forestry and wood business: Pathways to rural development, poverty alleviation and climate change mitigation in the tropics, Forest Ecology and Management no. 448, 2019, pp. 160-173.
[61] Lehtonen O., Okkonen L., Regional socio-economic impacts of decentralised bioeconomy: a case of Suutela wooden village, Finland, Environment, development and sustainability, vol. 15 iss. 1, 2013, p. 247.
[62] Ritter M.A. et al, Science supporting the economic and environmental benefits of using wood and wood products in green building construction, General technical report FPL-GTR-206, United States Department of Agriculture, Madison 2011, p. 1.
[63] Tyrväinen L. et al, How does the forest-based bioeconomy relate to amenity values?, Winkel G., (ed.), Towards a sustainable European forest-based bioeconomy, What Science Can Tell Us no. 8, European Forest Institute, Joensuu 2017, p. 92
[64] FAO, State of the World's Forests. Enhancing the socioeconomic benefits from forests, Rome 2014, p. 14.
[65] Tyrväinen L. et al, How does the forest-based bioeconomy relate... op.cit.; Ramage M.H. et al., The wood from the trees: The use of timber in construction, Renewable and Sustainable Energy Reviews, vol. 68, 2017, pp. 333-359.

temperate regions. The growing stock in Europe has grown for decades based on sustainable forest management, which is motivated by stable demand for timber. Out of the three construction materials available in industrial volumes, i.e. concrete, steel, and wood, wood is the only renewable. At present, forest certificates cover only a minor part of world's forests, but the majority of traded timber comes from certified forests. For example, in Finland approximately 85% of forests are PEFC certified and 10% are FSC certified (mostly overlapping, i.e. forests with two certificates)[66].

As a result of photosynthesis, every cubic metre of wood grown absorbs approximately 800-900 kg of carbon dioxide from the atmosphere[67]. In order to have any real climate effect, the carbon storages have to keep the captured carbon for a long period of time before releasing it back to the atmosphere as a result of decomposing or burning. The production of carbon storing goods, such as wood products, has two possible climate effects: firstly, immediate physical storage of carbon molecules keeping them away from the atmosphere and, secondly, the substitution of products with worse environmental performance. Although the physical carbon storage in wooden construction products is negligible in the real climate change mitigation discourse, it plays a significant role contributing to the sustainable forestry which, in turn, has true measurable climate impacts[68]. The vitality and volumetric increment of forests and other biomasses is important, since the amount of carbon stored in living trees and organic soil biomass is within a magnitude comparable to the entire CO2 volume in the atmosphere[69].

The volume of total biogenic carbon stored in Europe's forests is estimated to be approximately 13 billion tons, growing approximately 167 million tons per annum[70]. In the greenhouse gas (GHG) inventory report accounting, which is nowadays required from each country in the European Union, wooden construction products represent the longest half-life (the time required for a quantity to reduce to half of its initial value), i.e. 25 to 35 years, of all wood-based products. Hence, the long-lifecycle wood products are beneficial to the producer country in terms of the GHG inventory accounting.

Long-lifecycle wood products, typically used in building or infrastructure construction, are one way to keep carbon molecules away from the circulation. Heräjärvi (2019) introduced a dynamic measure Building Sink Effect BSE that relates nation's annual CO2 emissions to the amount of carbon stored in buildings during the same year in the form of long-lifecycle wood products. BSE is intended to quantify the carbon sink created by building construction and, particularly, assess its role in compensation of the nation's annual human-caused carbon dioxide emissions.

Climate effects of wooden buildings and, in particular, material substitution effects brought by them are complex. Material and energy substitution effects of wood were discussed by Leskinen et al. (2018). Their literature review covered 51 studies dealing with the emission effects of using wood and non-wood materials. A majority of the studies indicated that the use of wood products was associated with lower fossil and process-based emissions than in the case of non-wood products. Leskinen et al. (2018) concluded that the average substitution factor of structural construction wood products was 1.3. In case of Norway spruce, which is the most common construction timber species in Europe, the substitution factor of 1.3 means that using one cubic metre of spruce wood (dry density approximately

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420 kg/m3, carbon content assumed at 210 kg) to substitute non-wood products in structural use results in an average reduction of C emission equalling 1.3 x 210 kg = 273 kg[71].

Wood volume and the subsequent carbon storage in forests have been almost doubled and the annual growth has been doubled, thus creating a considerable carbon sink in Finland during the past 60 years. Simultaneously, the annual drain has increased by one third. This indicates the peculiar characteristics of market economy within the framework of renewable raw material: material can be both utilized and volumetrically increased at the same time. This system works as long as the pre-condition of value creation for forest owner is fulfilled, i.e. the produced material has a considerable or expected value to its grower. Since more than 70% of the stumpage income is derived from sawlogs in Finland and most of the wood products are applied in the construction value chains, it is obvious that the construction sector is a great contributor to Finnish carbon storages. However, it is not from the view of carbon storage growth in built structures, but the growth of carbon storage of forests[72].

Statements about wood as a substitute of concrete in the construction sector are, however, hypothetical in climate perspective: global volumetric production of concrete is 20 times higher (ca. 10 billion m3/a) than the total production of wood products (ca. 0.5 billion m3/a). Hence, timber construction, being one piece in a puzzle of actions towards a better and more climate-wise future, does not make a difference alone. Forests play a considerable role as carbon sink. Such role was initially created and, hopefully, will also be maintained in the future by the growing use of wood products in the construction sector.

Production processes of wood products are energy efficient: the incineration of side products (bark, sawdust, chips, off-cuts etc.) typically produces more energy than needed in the actual production processes. Energy needed to produce a unit of steel or concrete is approximately 5-25 times higher than energy needed to produce a unit of wood products. Still, production of any construction material causes CO2 emissions. If calculated per square metre of a house built using different structural materials, the production of virgin steel and concrete element generates at least ten times higher CO2 emissions compared to the value for sawn timber and glulam. Therefore, wooden construction products have considerably smaller environmental footprint than the steel- or concrete-made, both in terms of energy intensity and emissions.

Re-use and recycling of demolished wood products is still in its initial phase, especially in Northern Europe where burning for energy has been the traditional way of utilizing wood waste[73]. This has been reasoned by the cold climate and large demand for electricity per capita. The situation is completely different from that in Central and Southern Europe, where particleboard industries utilize most of demolition wood as a raw material. However, the renewing European Union waste legislation issues considerable challenges to further develop the re-use and recycling of all materials and products. At present, metal, plastic, glass, paper, and paperboard recycling is decades ahead of wood product recycling. Even environmentally sound modification processes improving the technical properties of wood products may cause difficulties in re-using or recycling practices, which may decrease their overall environmental performance[74].

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The weight of wood as a structural member is clearly lower than the weight of its main competitors which are concrete and steel. This fact makes wood cheaper and more energy efficient in terms of transport, handling and assemble. Lightness also enables building of extra floors on top of old concrete element houses without compromising the load bearing capacity of existing structures. The low weight and ease of processing with handheld tools, even the non-electric, is another competitive advantage of wood in comparison to steel or concrete: if necessary, wood can be easily reshaped (sawed, split, cut, carved, bored) or reassembled on site (glued, using metal plates, screws, nails) without consuming much energy or producing environmentally harmful or hazardous waste.

The biggest challenge of humankind is to preserve the planet for further generations. There is a growing need for solutions to tackle this challenge. In order to be feasible, such solutions must be both available and affordable to the people, and, furthermore, their technical performance has to be equal to or better than that of the competing less sustainable solutions[75]. Since the construction activities are responsible for half of the exploitation of the world's natural resources and produce 40% of waste globally, even minor improvement in the sustainability of the construction value chains may make a big environmental difference. It is a great opportunity for wood, since it is the only renewable material available for industrial construction processes and has also many other indisputable features contributing to sustainability.

6.4 Technical benefits

The forestry-wood sector represents a major opportunity for construction sector. The wood is characterised by a light weight, high degree of prefabrication, low storage costs, and is easy to assembly - all these outstanding advantages may lead to a steady increase of wood constructions in market share.

Wood is an ecological and renewable material par excellence and has, as previously stated, definite advantages. Its technical, thermal and energetic performance is reflected in its lightness compared to traditional materials (a wooden building with a floor area of 100 m² and two storeys weighs 70 tons, compared to 200 tons with traditional materials[76], which translates to less thick foundations), its increased resistance and repairability, and the possibility of using mixed systems (such as a concrete column-and-beam structure with a wooden envelope for example). Today, new engineered wood products (EWP) such as Cross-Laminated Timber (CLT), become the popular alternative of concrete in mid- and high-rise constructions due to their optimized properties which meet the specific needs of structural design. Moreover, expanding a wooden building is also relatively easy.

Another advantage of wood is that most of the structural work in timber construction comes from the dry sector. Without drying time, the assembly of structures, components and prefabricated elements as well as the assembly is carried out continuously, which reduces the construction time. The financial costs incurred by the future owners are reduced. Wood, a noble housing material, brings to these projects' aesthetic and functional solutions in perfect integration with their environment. Prefabrication and offsite process are comparable to car industry. It enables manufacturing methods

[75] Heräjärvi H., Marttila J., The importance of cleantech business for the development of future wood products industries, Drewno 2016, Vol. 59, No. 197: 165-178.
[76] www.cndb.org

based on "lean" construction[77] that speed up the process and enhance quality of production. The benefits of lean construction reach the customer, business, management and staff:

- The customer gets a more consistent service, improves flexibility, responsiveness, construction time and product quality and a lower cost;
- Business as a better cash flow and productivity reduce stock holding, improve asset utilization, environmental benefits, increase profit and improve customer relationship;
- Management gains by better collaboration between design, general contractor and sub-contractor, more reliability processes, less crisis management, improve staff flexibility and morale and delegation of the responsibilities;
- Staff receive improved safety and job satisfaction, greater ownership of work area, more pleasant work environment, less stress and immediate feedback of their performance.

The strength-to-density ratio is very high, which is an advantage of wood over its competitors. This high ratio has a significant impact on the dead load of a structure. For the same strength, wood is the lightest structural material. As an example, a beam with a single span of 7.3 m supporting an unweighted load of 14.4 kN/m, in addition to its own weight, will have characteristics like inTable 8.

Table 8 The ratio of strength to density of example construction materials

Material	*Concrete*	*Steel*	*Glulam beam*
Bending strength (MPa)	30	350	30,6
Density (kg/m³)	2 400	7 850	560
Ratio (x106 N-m/kg)	0.013	0.044	0.055

The strength of wood varies according to, on one hand, species and, on the other hand, factors such as the direction and duration of loading, density, moisture content and natural defects. When a timber structural element is to be drilled or notched, the reduction in cross-section ends up in the weakening of the element, just like it happens with other materials.

Although wood is a combustible material, wooden structures have good fire behaviour. The loss of the resistance of a burning wooden element is essentially explained by a loss of section (0,8 mm/min) and not by a physical-mechanical modification of the section of unburned wood. This is mainly due to the following properties:

- When wood burns, the formation of a layer of carbonized wood protects the core part of the elements, the thermal conductivity of this layer being 5 times lower than that of wood;
- The rise in temperature due to the fire causes very little loss of strength in the wood element (unlike steel, which changes from an elastic to a plastic behaviour with growing temperature);
- The bounded water contained in the wood acts as a retardant since wood only ignites if moisture content, MC = 0%.

[77] Simon le Roux et al. Investigating the interaction of building information modelling and lean construction in the timber industry, World Conference on Timber Engineering, Aug.22-25, 2016, Vienna,Austria.

The multitude of forms of use (solid wood, fibre, chemistry and energy) and traditional and innovative products made from wood undoubtedly make it possible to respond to new opportunities for growth, which stem from economic, societal, environmental and technical concerns. As a renewable resource, wood can be a product of interest with regard to certain fossil sources (and their derivatives) which are becoming scarcer and whose prices are consequently destined to rise. These substitutions are envisaged not only in the field of energy (biomass) but also in more complex fields of use, made exploitable by technological progress and advances in research and development. However, this favourable context for several years is still not enough to spontaneously trigger a boom in the wood market.

7 Conclusion

Modern wood products used in construction should be constantly developed and adapted to changes. Nowadays, it is the market that verifies the activity of construction companies and it is a specific activity consisting in constructing houses directly for a specific recipient (investor, individual customer) based on a contract concluded with him. The construction, therefore, directly meets the needs of buyer, who in turn accepts or rejects the effects of construction company activity, thus deciding its current and future condition. Therefore, investors' behaviour/preferences regarding the purchase of products from the construction industry are important for increasing the use of wood and wood products in construction. Among these preferences we can distinguish the cost of material and the quality and safety it offers.

Wooden houses and wooden construction products should meet the challenges issued to modern construction, i.e. the speed of implementation, low energy demand, high quality and repeatability, low implementation costs, and environmental protection. According to the respondents participating in the survey, the most important opportunities for increase in the use of wood and wood products in the construction sector include:

- the global trend towards greening the cities and use more natural materials in both buildings and interiors,
- rising the eco-awareness among societies and developing new eco-trends and preferences among customers,
- supporting the development of bioeconomy,
- sustainable forest management, increasing carbon sink in forest and taking care of afforestation and forest renewal,
- the growing need for low emission products and buildings because of the climate change,
- the possibility of using wood in larger/higher structures,
- searching for new high value-added products and activities to develop the forestry sector and provide new green jobs,
- pursuit of cost reduction in construction by shortening building time,
- standardization and regulations, which allow treating used wood like other construction materials.

Apart from these opportunities, there is a number of barriers limiting the use of wood and wood products in construction. They are of technical, societal, economic or political nature. The surveys helped identify the most important of them, which are:

- construction sector is extremely rigid and market uptake of new materials/solutions is a long term process,
- popular belief that wooden constructions mean high fire risk,

- insufficient academic training designed to educate specialists in modern timber construction technologies,
- the lack of attractive educational programs explaining the advantages of wood and wooden construction,
- the lack of an ambitious public policy encouraging research, development and innovation in the wood industry,
- strong and effective political lobbying of the producers of dominant building materials, e.g. concrete and steel,
- low public funds for research and development (R&D) in the construction industry,
- wood deterioration caused by biotic factors e.g. fungi, insects, algae, lichen,
- wooden constructions require high-quality construction elements and thorough knowledge of technical and assembly principles.

As a result of the research, it was found that wood waste (post-consumer wood and wood by-products) in Poland, France, Finland and all of Europe has great potential, which should be properly managed. In the European Union the estimated potential of post-consumer wood waste may be at the level of almost 53 million m3 and of wood by-products at the level of approximately 104.0-113.4 million m3. Using even some part of it, e.g. in construction, would allow measurable savings of wood from the forest, thus bringing significant economic and ecological benefits. However, the presented analysis indicates that it is currently difficult to unequivocally estimate (due to the existing information barrier) the potential amount of wood waste that can be used in construction in the countries covered by the survey as well as throughout the European Union. Considering the importance of wood waste management for the development of a circular/zero-waste economy, it is necessary to create a system of comprehensive information (statistic classifications, reporting system) concerning this type of recyclables, both at the level of particular countries and at the EU level. In addition, due to the significance of the problem, it would be desirable to optimize the acquisition system and re-use it (to a greater extent than before) to gain full knowledge of its market. Additionally, good practices of business models, value chain solutions and policy measures concerning wood recycling can be found, but there is still a substantial opportunity for innovation in these areas to make wood circular economy more profitable and widespread in different European countries.

The presented analysis of the regulatory framework and operational environment for using recycled wood products in construction shows a wide variety of documents and directives regulating the markets and usage of wood and its products. Depending on the form of their use, wood products may be subject to regulatory frameworks concerning environmental protection, health care, fire resistance, building or product safety, and proper waste management. Hence, the operational frameworks influence the conduct of the entire industry and individual wood building companies, including the purposes, directions and tools of this activity. It is therefore important to clarify and harmonize them at the national and European Union level. It would also be useful to harmonize technical requirements for buildings and eliminate restrictions resulting from outdated regulations (e.g. in Poland there is currently no multi-storey construction, mainly due to fire regulations that allow construction of wooden structures up to 12 m high). The national and EU quality standards, relevant provisions, norms and guidelines for the design, manufacture, supervision and assembly of wooden structures should be clear, up-to-date and coherent. It is also important that legislation ensures safety without creating

barriers to innovative solutions in wooden construction. From the waste management point of view, the unambiguous and simple-to-use waste catalogue seems of great importance to developing further innovative circular solutions in wooden construction. Failure to meet the above requirements would limit the opportunities for increase in the use of wood and wood products in the construction sector.

The analysis of the benefits of using wood and wood products in the construction sector identified the following advantages:

- short construction time (multi-family house – 4.5-5 months, single-family house – 3 months),
- no seasonality (the possibility of building a house at any time of the year),
- energy saving (lower heat energy consumption by 35-40%),
- low energy consumption costs (lower by approximately 25%),
- low construction weight (compared to brick construction – 60% lighter), which allows building houses in low-bearing areas,
- small thickness of external walls (maximum 32 cm: 16-24 cm structural elements + 5-10 cm cladding, while the walls of house in brick technology – up to 65 cm), which can increase the area of the house by 10%,
- durability and strength of the structure (e.g. in terms of fire resistance – 22 mm thick fireproof cladding means that its burning time is ca. 120 minutes),
- resistance to weather conditions (e.g. winds),
- easy reconstruction and modernization, especially for modular constructions, repeatability,
- ecological "healthy home", the ability to self-regulate humidity creates a unique microclimate of the interior of the house.

These advantages may result from the external or internal environment of the construction sector and are of a diverse nature, including economic, social, environmental or technical.

In summary, wood and modern wood products are excellent structural and architectural materials that can compete with their non-wood substitutes. They perfectly fit into the trend towards sustainable development and towards constructing facilities using natural materials and combining them with the equipment in modern installations. They are materials enabling one to construct both single- and multi-storey residential buildings and various public buildings. They are also building materials with great potential in the event of modernization of existing buildings made in brick technology. Construction based on wood and its derivatives can definitely be considered ecological and energy-saving.

The development of wooden construction and the use of wood in construction are mainly determined by the development and implementation of wide-ranging, permanent and effective promotion of wood in society, constant and effective transfer of knowledge in the field of wooden construction, and modern home construction technologies. In addition, it requires strategic, primarily legal (e.g. harmonization of building standards, introduction of new standards regarding thermal requirements or standards for the construction and design of wooden houses), and economic actions (financial support, e.g. preferential loans, subsidies, exemptions from tax, surcharges).

Ultimately, the analyses and survey results justify the statement that wood and wood products can and should be used in construction to a greater extent than before. It can be assumed that there are actual reasons for increasing their use in construction by creating their market and demand for wooden houses. It depends, however, on quick undertaking of a number of actions of both strategic and operational nature at the national, European and global level, as well as the development of tools/instruments to effectively implement these assumptions in economic practice.

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9 Annex

9.1 Annex 1. The opportunities and barriers to increase the use of wood in construction - survey questionnaire for the entities directly related to the wood construction sector

The opportunities and barriers to increase the use of wood in construction - survey questionnaire for the entities directly related to the wood construction sector producers, (representatives of public administration and experts in field of wood construction from academies/research institutions).

Informed Consent for Anonymous Interview / survey

*This general informed consent model is designed to support **BASAJAUN** researchers in the deployment of an informed consent procedure that intends to comply with the ethical standards acknowledged by the European Commission in H2020 projects regarding research with human participants when inviting them to participate in an **anonymous interview/survey** designed to avoid the processing of any personal data.*

***If this anonymity cannot be achieved by design**, an informed consent that also asks for consent regarding personal data processing and that complies with General Data Protection Regulation and national law must be used.*

*Support of ethics experts and/or data protection officers or legal departments must in any case be sought to **adapt the model to the specific cases.***

INFORMED CONSENT

Project acronym	BASAJAUN		
Project Name	Building a Sustainable Joint between rural and Urban areas through circular and innovative wood construction value chains		
Grant Agreement no.	862942	**Financed by**	EUROPEAN COMMISSION
Start date	01/10/2019	**End date**	31/09/2023
Programme	H2020	**Website**	www.basajaun-project.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862942

INTRODUCTION

You have been invited to take part in a research study. Before deciding on participation, please read this document carefully. The document is divided in two sections:

- **Information sheet**, including the information about the aims of the study, the organisation responsible and contact researcher(s), the terms of your participation and the processing of the information that you may provide
- **Informed consent form**, to consent on participation by written if you decide to participate

Please read the document and ask any questions you may have to be completely sure to understand all the proceedings and implications of your participation in the study.

1. INFORMATION SHEET

1.1. **PURPOSE OF THE STUDY**

This study is part of the BASAJAUN research project, funded by the European Commission, and running from 01/10/2019 to 30/09/2023.

Short summary of the project's objectives:

The BASAJAUN project is developing sustainable wood value chains for the construction sector. One of the project tasks deals with **the barriers and opportunities** for the wood-based construction. Some activities focused on the users can be carried out to determine their perception regarding wood construction. The purpose of this study is to obtain the users and stakeholders feedback to define such barriers and opportunities,

Research method - The research method will be an anonymous online interview/survey. The interview/survey will take 10 minutes.

Results of the study - The results of the study will be integrated in the project report "D1.3 – Guidelines to foster building with wood". As the interviews/surveys are anonymous, and the responses will be aggregated into conclusions, no personal data will be processed nor published.

Risks, discomforts or disadvantages versus benefits of participating - No particular risks, discomforts or disadvantages are foreseen for participants in this study. On the other hand, with your answers you would be providing an important contribution to research and development in the area of wood-construction.

In any case, your participation shall be entirely voluntary, and you have the right to refuse to participate and to withdraw participation or data at any time (before giving consent of after) without any consequences.

Consent expression - If you agree to participate, your consent will be expressed by ticking a box at the end to this information sheet.

Questions or clarifications: For any questions or clarifications that you may need, please ask the contact researcher(s) identified here below (section 1.4 of this information sheet).

1.2. **INFORMATION / DATA NEEDED TO PERFORM THE STUDY**

The anonymous information that you may provide will be exclusively used to perform the study.

This model assumes:

-that the informed consent form only includes date and a tick-box to give consent. The reason of this is avoiding handwritten signature, because some handwritten signatures may include personal identifiers / data (name and surname).

It will be removed at the date of completion of the study**.**

This model assumes:

- that the GA obligation of keeping records for a period of five years after the payment of the balance (Article 18) can be met by documenting the methodology followed to perform the study instead of keeping the information itself (interviews/surveys answered by participants)

- that the information provided by participants will not be re-used for further research purposes.

The study is expected to conclude by 29/02/2020.

Date of the expected approval of the periodic or final reports of the project period where the deliverables related to the study will be approved by the EC.

1.3. **ANONYMITY OF THE INFORMATION PROVIDED**

Information on anonymisation procedures, during the study including possible publications, and organisational and technical procedures put in place. For example:

- The interview/survey has been designed to avoid obtaining personal data from you
- Only generalized, broad categories are used regarding age, gender or type of occupation
- The researchers will perform an anonymity check before merging the anonymous information resulting from participants answers and delete, pseudonymise, generalise or categorise any datum that could lead to indirect identification of the participant or any other third person
- The informed consent form only includes date and a tick-box to give consent
- Privacy in publications: the anonymisation procedure assures also that only anonymised information and conclusions will be used in any possible publication arising from the research study or containing references to it.
- All information provided by participants will be deleted at the date of completion of the study.

1.4. **ORGANISATION RESPONSIBLE and CONTACT RESEARCHER(S)**

SIEC BADAWCZA LUKASIEWICZ – INSTYTUT TECNOLOGII DREWNA is the organisation responsible of the study within project BASAJAUN.

The contact researcher(s) you can contact regarding the participation in this study:

- 'Ewa Leszczyszyn' e_leszczyszyn@itd.poznan.pl
- Dobrochna Augustyniak D_augustyniak@itd.poznan.pl

2. CONSENT SIGNATURE PAGE

I hereby declare:

• I am 18 years or older and I am competent to provide consent;

This model assumes that the research is not involving children (or other persons unable to give consent). If it does, the guidance included in EU Grants: Horizon 2020 Guidance —How to complete your ethics self-assessment: V6.0 – 23.07.2018

http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/ethics/h2020_hi_ethics-self-assess_en.pdf

• I have been fully informed about the aims and purposes of this study and the conditions of participation;

• I understand that there is no compulsion to participate and that, if I choose to participate, I may at any stage withdraw my participation.

…… *Date (dd/mm/yyy)*

☐ *Tic box for acceptance (X)*

Respondent: ☐ business,
☐ public administration,
☐ academia/research institution,
☐ other, please specify: .....

Gender: ☐ Female ☐ Male

1. Opportunities to increase the use of wood in the construction sector:

1.1 Technical

(indicate the significance of the opportunities for the construction sector in your country with an x mark on a scale of 1 to 5, where: 1 – definitely disagree, 2 – rather disagree, 3 – don't know, it's hard to say, 4 - rather agree, 5 – definitely agree)

Specification	1	2	3	4	5
Rapid development of engineering and construction sector.	☐	☐	☐	☐	☐
Searching for new industrialised solutions in construction (off-site construction).	☐	☐	☐	☐	☐
The need for minimising the risk of on-site works.	☐	☐	☐	☐	☐
Frequent earthquakes force to look for new solutions for building.	☐	☐	☐	☐	☐
The need for increasing speed of building and repair simplicity due to increased frequency of natural disasters.	☐	☐	☐	☐	☐
Demand for fireproof materials in the construction sector.	☐	☐	☐	☐	☐
Searching for new opportunities and unique solutions in architectural design.	☐	☐	☐	☐	☐
Further development of environmentally sound wood modification techniques aiming at durability, dimensional stability, and mechanical performance: thermal modification, non-biocide impregnation, etc.	☐	☐	☐	☐	☐
The possibility of using wood in larger / higher structures, just like non-wood composites (Glulam, LVL, CLT and other EWP's).	☐	☐	☐	☐	☐
Searching for biodegradable materials for production.	☐	☐	☐	☐	☐
Thanks to standardization (CE marking) and regulation (EC5), softwood and its processing products (panels, LVL, solid wood, glue products, etc.) can be used as other construction materials such as concrete or iron.	☐	☐	☐	☐	☐
High dimensional accuracy of wooden construction elements.	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

1.2 Societal

(indicate the significance of the opportunities for the construction sector in your country with an x mark on a scale of 1 to 5, where: 1 – definitely disagree, 2 – rather disagree, 3 – don't know, it's hard to say, 4 - rather agree, 5 – definitely agree)

Specification	1	2	3	4	5
Rising eco-awareness among the societies and development of new eco-trends and preferences among customers.	☐	☐	☐	☐	☐
Global trend of greening the cities and use more natural materials both in buildings and interiors.	☐	☐	☐	☐	☐
Regulations (e.g. environmental) forcing the changes in behaviour or building culture.	☐	☐	☐	☐	☐
Societal perceptions of wood as natural and friendly material.	☐	☐	☐	☐	☐
Population growth and urbanisation of new areas, e.g. requiring lighter construction.	☐	☐	☐	☐	☐
Development of cities in some regions of the world and the need of extension of buildings in high density areas.	☐	☐	☐	☐	☐

Deficits on housing markets in many countries.	☐	☐	☐	☐	☐
The need of assuring the high indoor air quality, reduce stress and allergies and increase overall human well-being.	☐	☐	☐	☐	☐
Need for development of anti-bacterial and environmentally friendly materials for use e.g. in hospitals.	☐	☐	☐	☐	☐
Supporting the development of local / rural economy (enterprise growth and new jobs) by buying locally made products.	☐	☐	☐	☐	☐
Shortages of social housing in some countries which need fast and reliable construction technologies.	☐	☐	☐	☐	☐
Incentives and educational programmes promoting the use of wood in construction.	☐	☐	☐	☐	☐
A variety of consumer preferences which demands materials that are available in many different variants (e.g. colours, glossiness etc.).	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

1.3 Economic

(indicate the significance of the opportunities for the construction sector in your country with an x mark on a scale of 1 to 5, where: 1 – definitely disagree, 2 – rather disagree, 3 – don't know, it's hard to say, 4 - rather agree, 5 – definitely agree)

Specification	1	2	3	4	5
Searching for new high value added products and activities to develop the forestry sector and provide new green jobs.	☐	☐	☐	☐	☐
Searching for new markets by the companies in the forestry sector.	☐	☐	☐	☐	☐
Building international competitiveness of the forestry sector companies.	☐	☐	☐	☐	☐
Searching for new solutions allowing to reduce the energy use for heating (passive buildings, energy-plus buildings).	☐	☐	☐	☐	☐
Pursuit of cost reduction in construction by the shorter building time.	☐	☐	☐	☐	☐
Reducing the cost and energy use in transportation of materials and construction elements.	☐	☐	☐	☐	☐
Pursuit of cost reduction in maintenance and usage of building.	☐	☐	☐	☐	☐
Searching for sources of cheap renewable energy.	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

1.4 Political

(indicate the significance of the opportunities for the construction sector in your country with an x mark on a scale of 1 to 5, where: 1 – definitely disagree, 2 – rather disagree, 3 – don't know, it's hard to say, 4 - rather agree, 5 – definitely agree)

Specification	1	2	3	4	5
Supporting the development of bioeconomy.	☐	☐	☐	☐	☐
Europe's pursuit towards a circular economy and waste reduction in construction sector.	☐	☐	☐	☐	☐
Need for solutions to store excessive carbon from the atmosphere.	☐	☐	☐	☐	☐
Forest management, increasing forest carbon sink and taking care of forest renewal and regeneration.	☐	☐	☐	☐	☐
The growing need for low emission products and buildings due to the climate change.	☐	☐	☐	☐	☐
Ambitious R&D policy supporting innovation in materials and systems.	☐	☐	☐	☐	☐
The growing need for renovation of old construction stock e.g. in Europe.	☐	☐	☐	☐	☐
Including wood construction in the countries development strategy.	☐	☐	☐	☐	☐
Implementing green public procurement policies in more and more countries.	☐	☐	☐	☐	☐

Modern town/city planning and creation of 'landmarks' in public areas.	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

2. Barriers to increase the use of wood in construction sector:

2.1 Technical

(indicate the significance of the barrier for the construction sector in your country with an x mark on a scale of 1 to 5, where: 1 – definitely disagree, 2 – rather disagree, 3 – don't know, it's hard to say, 4 - rather agree, 5 – definitely agree)

Specification	1	2	3	4	5
Wood construction requires high-quality construction elements, extremely high accuracy and very good knowledge of technical and assembly principles.	☐	☐	☐	☐	☐
Wooden houses require planning the interior arrangement at the construction stage and applying appropriate reinforcements in places where it is planned to place heavier objects.	☐	☐	☐	☐	☐
Threat of wood deterioration caused by biotic factors (e.g. fungi, insects, algae, lichen).	☐	☐	☐	☐	☐
The aesthetic deterioration of wood used on the exterior parts of houses (discolouration, wearing, abrasion).	☐	☐	☐	☐	☐
Overrepresentation of some wood species on wooden construction market.	☐	☐	☐	☐	☐
Poor performance of wood in cladding applications and ground contact structures.	☐	☐	☐	☐	☐
Lack of knowledge about the possibilities of using wood waste.	☐	☐	☐	☐	☐
Wooden floor structures do not often meet sound insulation standards.	☐	☐	☐	☐	☐
Settling of the building (for the first years wooden houses are "working").	☐	☐	☐	☐	☐
Chemical impregnation of wood products and the lack of inexpensive, effective and environmentally friendly substitutes available.	☐	☐	☐	☐	☐
Some wooden construction products do not meet the energy efficiency regulations.	☐	☐	☐	☐	☐
Wood construction products available on the market lack the CE marking or adequate certificates.	☐	☐	☐	☐	☐
A significant part of best quality wood and wood materials is exported.	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

2.2 Societal

(indicate the significance of the barrier for the construction sector in your country with an x mark on a scale of 1 to 5, where: 1 – definitely disagree, 2 – rather disagree, 3 – don't know, it's hard to say, 4 - rather agree, 5 – definitely agree)

Specification	1	2	3	4	5
Perceiving harvesting of the trees for production purposes as a threat to the environment by the society.	☐	☐	☐	☐	☐
Popular belief that timber construction means low standard and/or temporary construction.	☐	☐	☐	☐	☐
Popular belief that timber construction means high fire risk.	☐	☐	☐	☐	☐
Lack of ecological awareness of the construction investors and developers.	☐	☐	☐	☐	☐
Lack of societal acceptance of afforesting the agricultural land.	☐	☐	☐	☐	☐
Low public awareness of the features, advantages and possibilities of wooden construction, including the materials and technologies used.	☐	☐	☐	☐	☐

Low availability of publications directed to the general public on wooden construction (its strengths and weaknesses, practical hints etc.).	☐	☐	☐	☐	☐
Lack of attractive educational programs explaining the advantages of wood and wooden construction.	☐	☐	☐	☐	☐
Shortage of skilled labour.	☐	☐	☐	☐	☐
Insufficient academic training designed to educate specialists in modern timber construction technologies.	☐	☐	☐	☐	☐
Lack of advanced knowledge/skills among construction companies/architects about ventilation and isolation systems for wooden buildings	☐	☐	☐	☐	☐
Using the appearance of wood by producers of plastics, building ceramics, etc.	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

2.3 Economic

(indicate the significance of the barrier for the construction sector in your country with an x mark on a scale of 1 to 5, where: 1 – definitely disagree, 2 – rather disagree, 3 – don't know, it's hard to say, 4 - rather agree, 5 – definitely agree)

Specification	1	2	3	4	5
Construction sector is extremely rigid and the market uptake of new materials / solutions is a long term process.	☐	☐	☐	☐	☐
Lack of / insufficient competition in the wooden construction market.	☐	☐	☐	☐	☐
Lack of / insufficient competition in the production of large prefabricated modules and other volume components.	☐	☐	☐	☐	☐
Lack or insufficient supply of timber laminated products such as cross laminated timber.	☐	☐	☐	☐	☐
Lack or insufficient supply of hybrid structures available on the market (i.e. wood-concrete-steel).	☐	☐	☐	☐	☐
Low level of cooperation and coordination of activities by entities operating in the field of wooden construction.	☐	☐	☐	☐	☐
High costs of doing business for wooden houses producers related to the development and implementation of innovative solutions in production, as well as financing modern equipment.	☐	☐	☐	☐	☐
Lack of price competitiveness of wooden construction comparing to brick and mortar construction.	☐	☐	☐	☐	☐
Price fluctuations of wood and wooden products.	☐	☐	☐	☐	☐
High prices of wood and wood materials.	☐	☐	☐	☐	☐
High prices of hybrid wooden-steel constructions.	☐	☐	☐	☐	☐
The durability of non-plastered wooden exterior surfaces is often improved by painting, which causes additional investment and maintenance costs.	☐	☐	☐	☐	☐
More difficult access to financing and / or bank guarantees for investors due to the limited market penetration of wooden construction.	☐	☐	☐	☐	☐
Requires accumulating the entire budget for the investment - it is not possible to divide the construction into stages.	☐	☐	☐	☐	☐
Small size of wooden construction enterprises.	☐	☐	☐	☐	☐
Lack of full utilization of the production capacity in the wooden construction companies.	☐	☐	☐	☐	☐
Environmental degradation reduces the available supply of high quality wood.	☐	☐	☐	☐	☐

Importing wood and wood products for wood construction.	☐	☐	☐	☐	☐
Long waiting time for delivery of wood materials due to stockless production.	☐	☐	☐	☐	☐
Small number of construction companies which have their production processes industrialised.	☐	☐	☐	☐	☐
Lack of effective marketing strategies of wooden construction companies.	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

2.4 Political

(indicate the significance of the barrier for the construction sector in your country with an x mark on a scale of 1 to 5, where: 1 – definitely disagree, 2 – rather disagree, 3 – don't know, it's hard to say, 4 - rather agree, 5 – definitely agree)

Specification	1	2	3	4	5
Lack or mismatch between national legislation, EU directives and policies regarding wooden construction and wood products.	☐	☐	☐	☐	☐
Lack of / ineffective public policy on climate change mitigation.	☐	☐	☐	☐	☐
Environmental regulations are not adjusted to the specifics of wood industry and wood construction sector.	☐	☐	☐	☐	☐
Lack of ambitious public policy encouraging research, development and innovation in the wood industry.	☐	☐	☐	☐	☐
Low public funding for research and development (R&D) in the industry.	☐	☐	☐	☐	☐
Lack of proper strategic planning regarding forest policy with the reference to wooden construction.	☐	☐	☐	☐	☐
Lack of consistent regulations and guidelines for municipal authorities regarding spatial planning and building requirements.	☐	☐	☐	☐	☐
No equal treatment of construction materials by fire safety regulations.	☐	☐	☐	☐	☐
Lack or inadequacy of regulations on wooden structures in seismic areas (i.e. seismic design codes).	☐	☐	☐	☐	☐
Lack of standardization in manufactured wood construction products (walls, floors, etc.).	☐	☐	☐	☐	☐
Strong and effective political lobbying of the producers of dominant materials (concrete and steel).	☐	☐	☐	☐	☐
Lack of / ineffective governmental and non-governmental programmes promoting the usage of wood.	☐	☐	☐	☐	☐
Lack of / ineffective governmental and non-governmental programmes promoting wooden construction.	☐	☐	☐	☐	☐
Insufficient or ineffective financial support from the state for the development of wooden construction sector (credit preferences, tax exemptions, etc.).	☐	☐	☐	☐	☐
Lack of incentives for wood construction companies to locally source wood.	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

9.2 Annex 2. The opportunities and barriers to increase the use of wood in construction - survey questionnaire for the end users.

The opportunities and barriers to increase the use of wood in construction - survey questionnaire for the end users.

Informed Consent for Anonymous Interview / survey

*This general informed consent model is designed to support **BASAJAUN** researchers in the deployment of an informed consent procedure that intends to comply with the ethical standards acknowledged by the European Commission in H2020 projects regarding research with human participants when inviting them to participate in an **anonymous interview/survey** designed to avoid the processing of any personal data.*

***If this anonymity cannot be achieved by design**, an informed consent that also asks for consent regarding personal data processing and that complies with General Data Protection Regulation and national law must be used.*

*Support of ethics experts and/or data protection officers or legal departments must in any case be sought to **adapt the model to the specific cases.***

INFORMED CONSENT

Project acronym	BASAJAUN		
Project Name	Building a Sustainable Joint between rural and Urban areas through circular and innovative wood construction value chains		
Grant Agreement no.	862942	**Financed by**	EUROPEAN COMMISSION
Start date	01/10/2019	**End date**	31/09/2023
Programme	H2020	**Website**	www.basajaun-project.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862942

INTRODUCTION

You have been invited to take part in a research study. Before deciding on participation, please read this document carefully. The document is divided in two sections:

- **Information sheet**, including the information about the aims of the study, the organisation responsible and contact researcher(s), the terms of your participation and the processing of the information that you may provide
- **Informed consent form**, to consent on participation by written if you decide to participate

Please read the document and ask any questions you may have to be completely sure to understand all the proceedings and implications of your participation in the study.

3. INFORMATION SHEET

1.5. **PURPOSE OF THE STUDY**

This study is part of the BASAJAUN research project, funded by the European Commission, and running from 01/10/2019 to 30/09/2023.

Short summary of the project's objectives:

The BASAJAUN project is developing sustainable wood value chains for the construction sector. One of the project tasks deals with **the barriers and opportunities** for the wood-based construction. Some activities focused on the users can be carried out to determine their perception regarding wood construction. The purpose of this study is to obtain the users and stakeholders feedback to define such barriers and opportunities,

Research method - The research method will be an anonymous online interview/survey. The interview/survey will take 10 minutes.

Results of the study - The results of the study will be integrated in the project report "D1.3 – Guidelines to foster building with wood". As the interviews/surveys are anonymous, and the responses will be aggregated into conclusions, no personal data will be processed nor published.

Risks, discomforts or disadvantages versus benefits of participating - No particular risks, discomforts or disadvantages are foreseen for participants in this study. On the other hand, with your answers you would be providing an important contribution to research and development in the area of wood-construction.

In any case, your participation shall be entirely voluntary, and you have the right to refuse to participate and to withdraw participation or data at any time (before giving consent of after) without any consequences.

Consent expression - If you agree to participate, your consent will be expressed by ticking a box at the end to this information sheet.

Questions or clarifications: For any questions or clarifications that you may need, please ask the contact researcher(s) identified here below (section 1.4 of this information sheet).

1.6. **INFORMATION / DATA NEEDED TO PERFORM THE STUDY**

The anonymous information that you may provide will be exclusively used to perform the study.

This model assumes:

-that the informed consent form only includes date and a tick-box to give consent. The reason of this is avoiding handwritten signature, because some handwritten signatures may include personal identifiers / data (name and surname).

It will be removed at the date of completion of the study**.**

This model assumes:

- that the GA obligation of keeping records for a period of five years after the payment of the balance (Article 18) can be met by documenting the methodology followed to perform the study instead of keeping the information itself (interviews/surveys answered by participants)

- that the information provided by participants will not be re-used for further research purposes.

The study is expected to conclude by 29/02/2020.

Date of the expected approval of the periodic or final reports of the project period where the deliverables related to the study will be approved by the EC.

1.7. **ANONYMITY OF THE INFORMATION PROVIDED**

Information on anonymisation procedures, during the study including possible publications, and organisational and technical procedures put in place. For example:

- The interview/survey has been designed to avoid obtaining personal data from you
- Only generalized, broad categories are used regarding age, gender or type of occupation
- The researchers will perform an anonymity check before merging the anonymous information resulting from participants answers and delete, pseudonymise, generalise or categorise any datum that could lead to indirect identification of the participant or any other third person
- The informed consent form only includes date and a tick-box to give consent
- Privacy in publications: the anonymisation procedure assures also that only anonymised information and conclusions will be used in any possible publication arising from the research study or containing references to it.
- All information provided by participants will be deleted at the date of completion of the study.

1.8. **ORGANISATION RESPONSIBLE and CONTACT RESEARCHER(S)**

SIEC BADAWCZA LUKASIEWICZ – INSTYTUT TECNOLOGII DREWNA is the organisation responsible of the study within project BASAJAUN.

The contact researcher(s) you can contact regarding the participation in this study:

- 'Ewa Leszczyszyn' e_leszczyszyn@itd.poznan.pl
- Dobrochna Augustyniak D_augustyniak@itd.poznan.pl

4. CONSENT SIGNATURE PAGE

I hereby declare:

• I am 18 years or older and I am competent to provide consent;

This model assumes that the research is not involving children (or other persons unable to give consent). If it does, the guidance included in EU Grants: Horizon 2020 Guidance —How to complete your ethics self-assessment: V6.0 – 23.07.2018

http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/ethics/h2020_hi_ethics-self-assess_en.pdf

• I have been fully informed about the aims and purposes of this study and the conditions of participation;

• I understand that there is no compulsion to participate and that, if I choose to participate, I may at any stage withdraw my participation.

…… *Date (dd/mm/yyy)*

☐ *Tic box for acceptance (X)*

Opinion on wooden houses

Gender: ☐ Female ☐ Male

1. What do you associate the term wooden house with? *(Please indicate 1 answer).*

☐ Summer house ☐ Year-round single-family house

☐ Multi-family house with few storeys ☐ Public building

2. Express your opinion about wooden construction in your country *(please put the x mark on a scale of 1 to 5, where: 1 – definitely disagree, 2 – rather disagree, 3 – don't know, it's hard to say, 4 - rather agree, 5 – definitely agree)*

Specification	1	2	3	4	5
The wooden house is healthy and friendly for residents.	☐	☐	☐	☐	☐
The wooden house is flammable.	☐	☐	☐	☐	☐
A wooden house can be built in a short period of time.	☐	☐	☐	☐	☐
The wooden house is exposed to pests.	☐	☐	☐	☐	☐
Lack of professionals who can build a wooden house.	☐	☐	☐	☐	☐
Building a wooden house is cheaper than construction of a brick house.	☐	☐	☐	☐	☐
The wooden house cools down quickly, but also heats up quickly.	☐	☐	☐	☐	☐
The construction of a wooden house is impermanent and requires frequent maintenance.	☐	☐	☐	☐	☐
Maintenance of a wooden house is cheaper than of a brick house.	☐	☐	☐	☐	☐
The wooden house absorbs moisture.	☐	☐	☐	☐	☐
Other *(please specify)*.....	☐	☐	☐	☐	☐

3. Indicate to what extent the following aspects would encourage you to live in a wooden house *(please put the x mark on a scale of 1 to 5, where: 1 – definitely disagree, 2 – rather disagree, 3 – don't know, it's hard to say, 4 - rather agree, 5 – definitely agree)*

Specification	1	2	3	4	5
Lower construction / maintenance costs.	☐	☐	☐	☐	☐
Government subsidies for construction.	☐	☐	☐	☐	☐
Guarantee of safety, quality and durability of the structure.	☐	☐	☐	☐	☐
Tax breaks.	☐	☐	☐	☐	☐
The ecological nature of wooden construction.	☐	☐	☐	☐	☐
Positive feedback from family, friends or neighbours.	☐	☐	☐	☐	☐
Availability of modern projects and design.	☐	☐	☐	☐	☐
Favourable credit conditions.	☐	☐	☐	☐	☐
Other *(please specify)*.....	☐	☐	☐	☐	☐

9.3 Annex 3. Removals, export, import and consumption of industrial roundwood in Poland, France, Finland and European Union in the years 2009-2018

Country	*Category*	*Industrial roundwood (without wood fuel)*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*average 2009-2018*
			Million m^3										
Poland	removals	- coniferous	23.4	24.4	25.0	25.1	25.8	27.5	27.9	29.3	32.3	33.2	27.4
		- non-coniferous	7.1	6.9	7.2	7.9	8.0	8.2	7.9	7.8	7.8	8.1	7.7
		total	**30.5**	**31.3**	**32.2**	**33.0**	**33.8**	**35.7**	**35.8**	**37.1**	**40.1**	**41.3**	**35.1**
	export	- coniferous	0.9	1.5	1.6	1.7	2.6	2.4	2.2	2.3	2.5	4.7	2.2
		- non-coniferous	0.07	0.1	0.2	0.2	0.2	0.3	0.2	0.3	0.3	0.6	0.3
		total	**1.0**	**1.6**	**1.8**	**1.9**	**2.8**	**2.7**	**2.4**	**2.6**	**2.8**	**5.3**	**2.5**
	import	- coniferous	0.8	0.9	1.7	0.9	1.1	1.3	1.4	1.3	0.8	0.5	1.1
		- non-coniferous	1.1	1.4	1.7	1.6	1.2	1.3	1.1	1.2	0.9	0.6	1.2
		total	**1.9**	**2.3**	**3.4**	**2.5**	**2.3**	**2.6**	**2.5**	**2.5**	**1.7**	**1.1**	**2.3**
	consumption	- coniferous	23.3	23.8	25.1	24.3	24.3	26.4	27.1	28.3	30.6	29.0	26.3
		- non-coniferous	8.1	8.2	8.7	9.3	9.0	9.2	8.8	8.7	8.4	8.1	8.6
		total	**31.4**	**32.0**	**33.8**	**33.6**	**33.3**	**35.6**	**35.9**	**37.0**	**39.0**	**37.1**	**34.9**
France	removals	- coniferous	20.9	21.2	19.6	16.5	16.5	17.1	16.5	16.5	16.7	17.0	17.9
		- non-coniferous	8.2	8.4	8.8	8.4	8.0	8.7	8.5	8.8	8.7	8.7	8.5
		total	**29.1**	**29.6**	**28.4**	**24.9**	**24.5**	**25.8**	**25.0**	**25.3**	**25.4**	**25.7**	**26.4**

	export	- coniferous	3.5	5.0	4.8	2.7	2.7	2.3	2.1	2.0	1.9	1.8	2.9
		- non-coniferous	1.6	1.7	1.6	1.9	1.8	2.1	2.2	2.0	2.2	2.2	1.9
		total	**5.1**	**6.7**	**6.4**	**4.6**	**4.5**	**4.4**	**4.3**	**4.0**	**4.1**	**4.0**	**4.8**
	import	- coniferous	1.0	1.3	1.1	1.0	0.9	1.2	1.0	1.1	0.9	0.9	1.1
		- non-coniferous	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.3
		total	**1.5**	**1.7**	**1.5**	**1.4**	**1.2**	**1.5**	**1.3**	**1.4**	**1.2**	**1.1**	**1.4**
	consumption	- coniferous	18.4	17.5	15.9	14.8	14.7	16.0	15.4	15.6	15.7	16.1	16.1
		- non-coniferous	7.1	7.1	7.6	6.9	6.5	6.9	6.6	7.1	6.8	6.7	6.9
		total	**25.5**	**24.6**	**23.5**	**21.7**	**21.2**	**22.9**	**22.0**	**22.7**	**22.5**	**22.8**	**23.0**
Finland	removals	- coniferous	33.8	42.7	45.6	44.6	46.1	46.6	45.2	48.2	51.5	56.1	46.0
		- non-coniferous	7.1	8.4	8.3	7.7	9.2	8.9	8.9	9.5	9.8	11.1	8.9
		total	**40.9**	**51.1**	**53.9**	**52.3**	**55.3**	**55.5**	**54.1**	**57.7**	**61.3**	**67.2**	**54.9**
	export	- coniferous	0.5	0.5	0.7	0.6	0.8	0.7	0.7	0.8	0.9	1.3	0.7
		- non-coniferous	0.03	0.01	0.02	0.003	0.03	0.02	0.02	0.01	0.04	0.2	0.04
		total	**0.5**	**0.5**	**0.7**	**0.6**	**0.8**	**0.7**	**0.7**	**0.8**	**0.9**	**1.5**	**0.8**
	import	- coniferous	2.0	2.3	2.3	1.5	1.8	1.5	1.2	1.5	1.1	2.0	1.7
		- non-coniferous	1.8	4.0	3.4	3.9	4.9	4.8	4.5	4.4	3.7	4.9	4.0
		total	**3.8**	**6.3**	**5.7**	**5.4**	**6.7**	**6.3**	**5.7**	**5.9**	**4.8**	**6.9**	**5.7**
	consumption	- coniferous	35.3	44.5	47.2	45.5	47.1	47.4	45.7	48.9	51.7	56.8	47.0
		- non-coniferous	8.9	12.4	11.7	11.6	14.1	13.7	13.4	13.9	13.5	15.8	12.8
		total	**44.2**	**56.9**	**58.9**	**57.1**	**61.2**	**61.1**	**59.1**	**62.8**	**65.2**	**72.6**	**59.8**
EU*	removals	- coniferous	242.0	268.9	270.2	256.4	260.9	272.9	274.6	280.6	284.9	304.0	271.5

		- non-coniferous	63.5	70.7	75.0	77.4	75.4	76.7	76.6	78.1	76.9	82.1	75.3
		total	**305.5**	**339.6**	**345.2**	**333.8**	**336.3**	**349.6**	**351.2**	**358.7**	**361.8**	**386.1**	**346.8**
	export	- coniferous	19.8	23.1	25.6	22.1	25.8	26.1	24.0	25.4	26.5	31.8	25.0
		- non-coniferous	7.9	11.7	13.5	13.0	13.7	14.0	11.9	11.5	11.4	12.2	12.1
		total	**27.7**	**34.8**	**39.1**	**35.1**	**39.5**	**40.1**	**35.9**	**36.9**	**37.9**	**44.0**	**37.1**
	import	- coniferous	24.1	30.7	30.9	28.2	33.3	33.2	33.4	34.6	33.3	37.5	31.9
		- non-coniferous	12.5	17.7	19.4	19.3	20.7	21.4	18.7	18.4	16.3	17.6	18.2
		total	**36.6**	**48.4**	**50.3**	**47.5**	**54.0**	**54.6**	**52.1**	**53.0**	**49.6**	**55.1**	**50.1**
	consumption	- coniferous	246.3	276.5	275.5	262.5	268.4	280.0	284.0	289.8	291.7	309.7	278.4
		- non-coniferous	68.1	76.7	80.9	83.7	82.4	84.1	83.4	85.0	81.8	87.5	81.4
		total	**314.4**	**353.2**	**356.4**	**346.2**	**350.8**	**364.1**	**367.4**	**374.8**	**373.5**	**397.2**	**359.8**

* EU - without Malta and Cyprus.

Source: Statistics Poland (https://stat.gov.pl/); LUONNONVARAKESKUS (Luke), Finland; Faostat (http://www.fao.org/faostat/en/#data/FO).

9.4 Annex 4. Production, export, import and consumption wooden packaging in Poland, France, Finland and European Union in the years 2015-2018

Country	*Category*	*Wooden packaging*	*2015*	*2016*	*2017*	*2018*	*average 2015-2018*
			1000 tonnes				
Poland	production	- cases, boxes, crates, drums and similar packaging of wood; cable-drums	113.7	122.7	122.2	101.7	115.1
		- cases, boxes, crates, drums and similar packaging of wood (excluding cable-drums)	85.0	92.3	92.9	59.5	82.4
		- cable-drums of wood	28.7	30.4	29.3	42.2	32.7
		- pallets, box pallets and other load boards of wood	1658.1	1774.7	1870.5	2040.2	1835.9
		- flat pallets and pallet collars of wood	1575.6	1684.9	1774.0	1907.6	1735.5
		- box pallets and load boards of wood	82.5	89.8	96.5	132.6	100.4
		- casks barrels, vats, tubs, and coopers products and parts thereof of wood (including staves)	4.8	5.0	12.2	23.3	11.3
		total	**1776.6**	**1902.4**	**2004.9**	**2165.2**	**1962.3**
	export	**total**	**1182.7**	**1151.1**	**1202.6**	**1435.9**	**1243.1**
	import	**total**	**136.1**	**147.7**	**165.1**	**202.2**	**162.8**
	consumption	**total**	**730.0**	**899.0**	**967.4**	**931.5**	**882.0**
France	production	- cases, boxes, crates, drums and similar packaging of wood; cable-drums	376.5	366.4	394.9	377.3	378.8
		- cases, boxes, crates, drums and similar packaging of wood (excluding cable-drums)	347.0	335.5	363.7	343.9	347.5
		- cable-drums of wood	29.5	30.9	31.2	33.4	31.3
		- pallets, box pallets and other load boards of wood	2577.6	2567.4	2825.8	2785.8	2689.1
		- flat pallets and pallet collars of wood	2527.9	2511.4	2763.5	2733.8	2634.1
		- box pallets and load boards of wood	49.7	56.0	62.3	52.0	55.0
		- casks barrels, vats, tubs, and coopers products and parts thereof of wood (including staves)	110.9	111.1	138.6	140.4	125.2

		total	3065.0	3044.9	3359.3	3303.5	3193.1
	export	total	248.8	224.0	230.6	233.3	234.2
	import	total	419.6	476.3	522.4	561.7	495.0
	consumption	total	3235.8	3297.2	3651.1	3631.9	3453.9
Finland	production	- cases, boxes, crates, drums and similar packaging of wood; cable-drums	33.0	32.1	28.8	30.7	31.2
		- cases, boxes, crates, drums and similar packaging of wood (excluding cable-drums)	21.2	20.6	18.0	16.2	19.0
		- cable-drums of wood	11.8	11.5	10.8	14.5	12.2
		- pallets, box pallets and other load boards of wood	242.7	200.1	205.6	213.5	215.5
		- flat pallets and pallet collars of wood	114.3	74.1	76.3	84.6	87.3
		- box pallets and load boards of wood	128.4	126.0	129.3	128.9	128.2
		- casks barrels, vats, tubs, and coopers products and parts thereof of wood (including staves)	0.4	0.4	0.5	0.5	0.5
		total	276.1	232.6	234.9	244.7	247.2
	export	total	28.7	30.5	38.2	49.2	36.6
	import	total	22.5	23.7	29.4	29.1	26.2
	consumption	total	269.9	225.8	226.1	224.6	236.8
EU	production	- cases, boxes, crates, drums and similar packaging of wood; cable-drums	3574.2	3569.3	3751.8	3242.0	3534.4
		- cases, boxes, crates, drums and similar packaging of wood (excluding cable-drums)	3224.5	3218.8	3371.1	2849.0	3165.9
		- cable-drums of wood	349.7	350.5	380.7	393.0	368.5
		- pallets, box pallets and other load boards of wood	20721.0	21360.5	22939.5	26728.3	22937.3
		- flat pallets and pallet collars of wood	17016.3	17578.7	18970.5	23442.7	19252.0
		- box pallets and load boards of wood	3704.7	3781.8	3969.0	3285.6	3685.3
		- casks barrels, vats, tubs, and coopers products and parts thereof of wood (including staves)	151.7	153.2	189.2	187.5	170.4
		total	24446.9	25083.0	26880.5	30157.8	26642.1
	export	total	5093.8	5437.0	5698.3	6196.9	5606.5

import	total	4754.6	5100.1	5558.7	5879.9	5323.3
consumption	total	24107.7	24746.1	26740.9	29840.8	26358.9

Poland – manufactured production of wooden packaging; France, Finland and EU – sold production.
Production, exports and imports by Prodcom list (Nace Rev. 2).
Converter: 1 paleta = 25 kg, 1 piece of cases, boxes, crates, drums and similar packaging of wood = 10 kg.

Source: Statistics Poland (https://stat.gov.pl/); Eurostat (https://ec.europa.eu/eurostat/data/database), DS-066341, DS-1060915;

9.5 Annex 5. Export and import wood by-products in Poland, France, Finland and European Union in the years 2015-2018

Country	*Category*	*Wood by-products*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*average 2009-2018*
Poland	export	1000 m^3	574.6	606.4	520.5	354.9	594.6	910.7	854.9	827.1	990.7	1000.0	723.4
		1000 tonnes	368.9	383.9	332.8	176.7	345.2	519.3	506.6	485.6	579.9	582.9	428.2
	import	1000 m^3	318.3	485.2	699.8	1601.3	1346.0	1114.7	1778.7	2074.5	1641.5	2237.3	1329.7
		1000 tonnes	199.3	303.8	442.1	984.0	830.7	1800.3	1117.7	1302.6	1028.8	1406.2	941.6
France	export	1000 m^3	1661.0	1773.7	1913.3	903.9	1318.7	1343.7	1447.3	926.6	947.6	891.3	1312.7
		1000 tonnes	1009.0	1083.2	1103.4	551.2	806.1	819.8	879.5	566.1	580.6	549.7	794.8
	import	1000 m^3	1221.6	574.0	1377.7	1266.9	1192.8	1582.1	1526.3	1394.4	1407.5	1887.3	1343.1
		1000 tonnes	745.0	353.8	839.3	771.0	728.0	967.6	932.4	854.4	864.2	1152.1	820.8
Finland	export	1000 m^3	451.8	747.7	645.0	433.6	375.4	422.5	217.2	183.0	199.4	172.8	384.8
		1000 tonnes	278.8	457.0	395.1	266.7	229.5	257.6	135.2	114.3	124.4	106.6	236.6
	import	1000 m^3	3444.7	4300.4	3822.6	3768.8	3557.6	2904.0	2935.0	2904.1	2844.5	3262.0	3375.4
		1000 tonnes	2137.3	2674.1	2384.5	2345.1	2213.2	1805.8	1823.7	1805.7	1774.1	2035.5	2099.9
EU	export	1000 m^3	19044.4	22868.3	19404.9	13065.8	14420.7	15491.5	14787.7	13363.3	13829.7	13765.9	16004.2
		1000 tonnes	11614.8	13950.2	11890.3	8045.1	8861.3	9502.5	9073.8	8225.2	8537.7	8497.9	9819.9
	import	1000 m^3	27797.9	35866.9	28365.9	24634.8	23191.8	23841.7	21995.7	20740.0	21215.9	23356.9	25100.8
		1000 tones	16967.5	21902.1	17425.5	15094.3	14239.2	14632.7	13506.1	12794.9	13117.7	14421.5	15410.1

Conversion factors: wood in chips or particles: coniferous and non-coniferous - 625 kg/m^3, sawdust – 500 kg/m^3, other – 700 kg/m^3.

Source: Statistics Poland (https://stat.gov.pl/); Faostat (http://www.fao.org/faostat/en/#data/FO).

Basajaun is a European innovation action about sustainable building with wood. The main objective is to demonstrate how wood construction chains can be optimized to foster both rural development and urban transformation whilst being connected with sustainable forest management in Europe. The consortium comprises 29 partners from 12 countries including 8 leading research and technology organizations, 3 universities, 15 companies and 4 other public and sectoral organizations. The project is coordinated by the Tecnalia Research and Innovation Foundation in Spain

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