Interreg

Co-funded by the European Union

IPA ADRION

FULAR

Deliverable 2.1.1.

Scouting Report: best material solutions for sustainable furniture product design

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

Interreg Co-funded by the European Union

IPA ADRION

FULAR

FULAR - IPA-ADRION00373

Shaping new paths towards FUrniture circularity

Deliverable 2.1.1.

Scouting Report: best material solutions for sustainable furniture product design

Work package:	2 - Preparatory work towards circular models integration in furniture
Activity:	2.1 - Scouting best green material solutions for furniture sector
Revision:	FINAL
Due Date:	31.08.2025.
Date of submission:	31.08.2025.

Authors:

George Ntalos, Dimitrios Koutsianitis, Andromachi Mitani, Konstantinos Ninikas, Pinelopi Alexaki, Dimitra Dimou (University of Thessaly – Special account of research grants, Department of Forestry, Wood sciences & Design)

Polona Hafner, Jožica Gričar (Slovenian Forestry Institute)

Erika Valentinčić (Wood Industry Cluster)

Goran Rodić, Saša Karalić (Development agnency of City of Prijedor "PREDA"

Prof. Dritan Ajdinaj, PhD. Erald Kola, MSc. Françeska Delia (Wood Industry Cluster Albania)

dr Goran Milić, Marko Veizović, Jelena Matić, dr Aleksandar Lovrić (University of Belgrade – Faculty of Forestry)

Zvijezdana Pejić, Magdalena Aleksić, Hrvoje Rukavina (Competence Centre Ltd. for research and development)

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

Document Content

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

1. Executive Summary

Unlike the traditional "take-make-dispose" model, the circular economy aims to keep resources in use for as long as possible, minimising waste while maximising the value of products. This model aims to create a closed-loop system where materials are continuously cycled back into the economy, reducing environmental impact and promoting sustainability.

The model of a circular economy presents an alternative to linear system of accelerating waste production. It aims to conserve natural resources by substituting products with services and designing things to be used again and again before the materials are recovered. Finally, materials are recovered and recycled back into new resources, reflecting the cycling of elements in natural systems, in which the waste from one process is the food for another.

The circular economy in the wood and furniture sector focuses on minimizing waste, extending the life of materials, and promoting sustainability throughout the product lifecycle.

2. Context of FULAR Project (Shaping new paths towards FUrniture circularity)

The IPA ADRION region is known for its long tradition of furniture production thanks to its rich forestry resources. However, differences in approaches and development have led to varying uses of local wood, post-production waste, and consumer waste. Small and medium-sized enterprises (SMEs), regardless of their size and capacities, face challenges in introducing greener and more sustainable production processes in order to align their operations with EU strategies and guidelines. At the same time, consumers are becoming increasingly focused on circular economy and sustainability when purchasing products.

The FULAR project addresses these challenges through a set of activities aimed at enhancing the circular economy and implementing new solutions in the furniture sector. The consortium, which includes partners from IPA and ERDF countries, brings together universities, research institutes, sectoral clusters, development agencies, and entrepreneurship centres from Greece, Italy, Albania, Bosnia and Herzegovina, Serbia, Slovenia, and Croatia. The transnational approach enables collaboration between different actors and networks, developing joint solutions relevant to the entire program area and transferable beyond the project region.

The main goal of the project is to identify concrete and cost-effective ways to promote sustainability in the wood sector. Activities include research into SMEs' and consumers' perceptions of the circular economy, analysis of best practices, and identification of the most innovative and cost-efficient technologies. The project will also explore the best materials for sustainable furniture production, using local wood, secondary raw materials from post-production, and materials from consumer waste. To stimulate innovation, FULAR will organize a circular design competition and three international workshops on materials engineering. Winning projects will be prototyped and tested, demonstrating the application of innovative circular solutions. A special focus will be placed on capitalizing project results through a dissemination and transferability plan beyond FULAR.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

3. Introduction to the dedicated work package (WP2)

One of the main expected results of FULAR is the delivery of practical guidelines for the implementation of the circular economy in the furniture production sector.

WP 2 will provide scientific and technological evidence on selected sustainable materials and the main cost-effective technologies and techniques to bring the furniture sector towards the adoption of a circular way of thinking.

The crucial segment of WP2 is adoption of the guidelines which implies set of preparatory activities to be completed, with the main purpose to foster integration of circular business models in regional (Adriatic - Ionian region) furniture industry. Focus of these activities is on individuation of practical solutions based on the studies (including the ones labelled as “scientific”) regarding circular materials and innovative technologies and techniques introduced among the transnational forest-based industries.

Specific studies and research activities will be conducted by the partners in two separate project activities:

- **Activity 2.1 Scouting best green material solutions for furniture sector.** Analysis will be conducted for the individuation of 3 different types of sustainable materials to use. More specifically, wood species, post-industrial wood raw materials, and furniture parts of end-life items will be studied and strategically selected to individuate the best suited material solutions and bring furniture production towards the implementation of circular economy approaches. This study phase will enable the disposal of a selection of 3 best green solutions for the furniture sector – one innovative material per type of resource listed above. As a result of the analysis process, a Report on best material solutions for sustainable furniture products will be provided to allow the increase of knowledge on the most eco-friendly materials in the sector. The analysis will then be used as input, together with results coming from other project activities (primarily A 2.2), for the development of the Guidelines Manual for the implementation of a circular economy for the furniture sector.
- **Activity 2.2 Scouting cost-effective technologies for circular production.** Technology is directly related to lower waste generation and optimal resource utilisation. Nowadays, individuating innovative technologies and techniques can make the difference and be one of the main instruments to make a successful transition to a circular economy. Therefore, exploring innovative and best cost-effective technologies to process, reuse, and recycle, and reassemble materials from discarded furniture and production waste will enable the identification of the most suited ones for the furniture sector, in terms of costs and practical implementation. Potentials of the design software currently in use or prepared for future application will be explored, with the results disseminated to the SMEs. Consequently, new approaches in marketing will be considered, implying business models based on the multiple options for re-use of purchased items, including partial re-construction and re-assembling.

Upon the completion of the activities, by using findings and acknowledgments gained within, partnership will develop manual (guidelines) containing strategic guidelines for the specific case of the furniture companies. Compiling of the guidelines document will be performed within Activity 2.3 Practical guidelines for circular economy implementation in furniture sector. The document will have a specific practical importance for the SMEs, as they would be in a better position to work on the development of their own circular business models. Furthermore, they will be in position to be more

competitive in the arrangements, which are providing them with an option to dispose of the used furniture, depending on the type of the materials. The document will be shared with the sectoral actors of the Adriatic - Ionian area and it will be aimed at summarising strategic information which could be helpful for the SMEs to start implementing circular economy models into their production processes.

4. Introduction to the dedicated D.2.1.1. Scouting Report: best material solutions for sustainable furniture product design

This report presents the results of Activity 2.1, which focused on identifying the most suitable sustainable material solutions for circular furniture production. The activity supports the objectives of Work Package 2, aiming to strengthen scientific and technological understanding of eco-friendly material options and promote the shift toward circular economy practices in the wood and furniture industry.

Through a structured scouting process, three types of materials were analyzed: Wood species – locally relevant species suitable for recycling, reuse, or improved circular use, Post-industrial wood raw materials – side-streams and by-products from industrial processing that can be reintroduced into production, and Reused components from end-of-life furniture – material parts or assemblies that retain functional or structural value.

The selection process was based on desk research, stakeholder consultations, and data collected in project activities. Criteria included technical properties, environmental impact, potential for integration into existing production processes, and alignment with circular economy principles. A validation workshop was held to review findings and confirm the final selection of three best-fit materials - one from each category.

This report provides a summary of the analysis conducted, including material characteristics, opportunities for reuse or reintegration, and examples of existing good practices. It also addresses how the integration of these materials can reduce environmental impact, limit resource wastage, and enhance knowledge within the sector. The findings will feed directly into the development of practical guidelines for companies, especially SMEs, supporting them in the transition toward more circular, resource-efficient furniture design and production.

5. Overview of Forestry and Wood Industry in the IPA Adrion countries

A structured overview of the forestry and wood processing sectors in partner countries provides a basis for understanding the regional context of wood resource use. Each project partner collected data from national statistical offices, sectoral reports, scientific publications, and company sources to present the key characteristics of the forest-based sector in their respective area.

The information includes the extent and structure of forest areas, types of forests and ownership, as well as the composition of tree species and annual volumes of harvested forest products. Insights into forest management practices further reflect how natural resources are maintained and utilized across regions.

In addition, partners reported on the overall structure and performance of the wood processing industry, including business activity, employment, production output, exports, and the most common product types. The analysis also identifies dominant value chains and highlights specific regional strengths that may offer a comparative advantage in future development of sustainable and circular wood-based solutions.

5.1. Greece

5.1.1. Forests, forest management and wood industry

Forest management in Greece operates under a centralized regulatory framework led by the Ministry of Environment and Energy, supported by regional Forest Directorates. Greek forests cover approximately 30.3% of the national territory (3.9 million ha as of 2023), with a growing stock of 707.469 m^3 (of which conifers 243.140 m^3, and broadleaves 464.329 m^3), reflecting a significant natural asset both ecologically and economically.

Management practices are guided by sustainable forest management (SFM) principles as per EU directives and include:

- Silvicultural interventions such as selective logging, natural regeneration, and reforestation.
- Fire prevention and recovery planning, a critical concern given Greece's frequent wildfire, especially during summer months.
- Biodiversity conservation within Natura 2000 protected areas, covering a considerable portion of Greece's forest ecosystems.
- Use of forest maps and land registries (recently digitized) to address longstanding land tenure disputes.

However, Greece still faces challenges including:

- Fragmented private ownership, which complicates cohesive forest management.
- Limited mechanization and aging forestry workforce.
- Insufficient forest road infrastructure in remote mountainous regions.

In terms of tree species, Oak dominates the growing stock with over 230.471 m³, followed by Quercus with around 194.806 m³ and Pinus with around 184.341 m³. Other important species include fir, picea, populus and castanea sativa.

In Greece, in 2023, the production of logs amounted to 1,36 million m³, followed by the production of firewood in the amount of 0,95 million m³ and production of roundwood for industrial use in the amount to 0,41 million m³.

The production of conifer logs in 2023 in Greece, amounted to 0,27 million m³ and the production of broadleaf logs amounted to 1,09 million m³.

The production of conifer firewood, amounted to 0,08 million m³, the production of broadleaf firewood amounted to 0,87 million m³, the production of conifer roundwood for industrial use amounted to 0,19 million m³, and the production of broadleaf roundwood for industrial use amounted to 0,22 million m³.

Within the traditional sectors of forestry and wood processing (A02 Forestry and logging, C16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials, and C31 Manufacture of furniture + C32 other manufacturing), Greece has approximately 11.275 of business entities. These entities collectively employed approximately 39.750 of workers, and generated approximately a revenue of 2.067 million EUR.

In Greece, total roundwood import amounts to 196.000 m³, compared to much lower export of 42.336 m³. Within industrial roundwood, conifers dominate the import (46.445 m³), while export is more balanced between conifers (10.828 m³) and broadleaves (8.696 m³). Firewood represents a major share of trade, with import of 144.359 m³ and export of 22.778 m³. Overall, Greece is a net importer of roundwood and firewood, with stable trade flows.

5.1.2. Identification of Value Chains in Forestry and Wood Processing

The forestry value chain in Greece spans from raw material extraction to end-user products, incorporating the following stages:

- Upstream (Primary Production)
  - Harvesting of roundwood, primarily broadleaves (oak, chestnut, poplar), and conifers (pine, fir).
  - Firewood production for local energy use, with volumes reaching 946.849 m³ in 2023, reflecting rural demand.
- Midstream (Primary Processing)
  - Sawmills processing coniferous and broadleaf logs (over 1,35 million m³ total in 2023) into:
    - Sawnwood
    - Wood chips and particles (e.g., 55.212 kg exported in 2023)
  - Production of industrial roundwood (used in packaging, construction, furniture cores), with a 2023 output of 412.256 m³.
- Downstream (Secondary Processing)
  - Manufacturing of furniture (C31+C32) and wood-based panels (e.g., MDF/HDF).
  - Paper and pulp production (C17), though modest, is part of the chain, with high export value.
  - Biomass energy and pellet production (D35), an emerging segment due to energy transition policies.

- Support Services
  - Transport, logistics, equipment supply, and technical forestry consulting are ancillary but vital contributors to the chain.
- End Markets
  - Domestic consumption (heating, construction, furniture).
  - Exports, primarily to neighboring Balkan countries, though overall export volumes are still low compared to EU averages.

5.1.3. Comparative Advantages of the Area

Greece's forestry and wood processing sectors hold several comparative advantages:

- Biodiversity-rich forests
  - Unique species like Castanea sativa, high-value Quercus spp., and aromatic/medicinal plants make Greek forests ecologically and economically distinctive.
- Climatic suitability for diverse forest types
  - The varied climate and terrain enable a mix of Mediterranean and temperate species, supporting both hardwood and softwood value chains.
- Renewable energy potential
  - A growing bioenergy market enhances the use of forest biomass (firewood and pellets), contributing to energy diversification.
- Rising demand for sustainable products
  - Greece benefits from EU Green Deal policies and circular economy goals, aligning with sustainable wood products and low-carbon materials.
- EU funding and structural support
  - Access to EU rural development funds (e.g., CAP, Interreg) promotes investments in forest infrastructure, technology, and innovation.

5.2. Italy - Friuli Venezia Giulia Region

5.2.1. Forest, forest management and wood industry

Friuli Venezia Giulia Region has a forested area of approximately 320.000 ha, with 93% located in the mountains and 7% in the plains. Over recent decades, the forested territory has undergone significant expansion: from 165,000 hectares in the 1960s (21% of the regional territory) to 323,362 hectares in 2015 (41% of the regional area), primarily involving previously agricultural private mountain areas.

Forest ownership is currently divided between 60% private forests and 40% public forests. Approximately 60% of the forests are intended for timber production, while the remaining portion serves primarily protective purposes[1].

Based on data from the latest National Inventory of Forests and Forest Carbon Sinks – INFC (year 2015), the following figures were recorded in Friuli Venezia Giulia Region:

- Forest area: 373.614 ha, of which 323.392 ha are tall trees forests
- Annual increase in wood mass: 1.689.390 m^3 per year (5,2 m^3/ha/year)

[1] https://www.legnofvg.it/?page_id=27336

According to data by RAFVG, 170.536 m³ were harvested in 2023.

From the last available 2007 INFC (most recent detailed data available) the structure of forest areas is as follows):

- Coastal formations: 139 ha
- Oak-hornbeam and hornbeam woods: 2.865 ha
- Oak woods and chestnut groves: 18.502 ha
- Manna ash-hophornbeam and hophornbeam-oak woods: 35.835 ha
- Maple-ash and maple-linden woods: 14.157 ha
- Birch woods: 30 ha
- Beech forests: 77.718 ha
- Black pine and Scots pine forests: 42.857 ha
- Spruce-beech forests: 26.748 ha
- Fir, spruce-fir and fir-spruce-beech forests: 18.915 ha
- Spruce forests: 25.085 ha
- Larch forests: 3.791 ha
- Alder groves (black and white alder, outside riparian zones): 93 ha
- Black locust stands and other anthropogenic formations: 6.964 ha
- New forest colonizations: 5.368 ha
- Reforestations: 6.370 ha
- Other lowland forest areas (non-mountain): 6.769 ha
- Other floodplain forest areas (non-mountain): 164 ha
- Other riparian forest areas (non-mountain): 4.123 ha
- Other formations: 897 ha

There are 506 forestry-related businesses operating in mountain areas, employing total of 1.222 workers. In the timber harvesting sector specifically, 180 companies are active, employing 400 workers[2].

According the regional register of forestry companies, updated as of April 2025, 291 registered companies is possessing the technical and professional skills required to carry out silvicultural and timber harvesting activities, as well as forest-related works and services[3].

Timber harvesting operations represent the primary and operational activity in the management of forest resources.

These operations include the extraction of timber from forests - i.e., cutting and hauling wood - with the goal of meeting the economic needs of landowners and society, while also ensuring the environmental and social functions that forests provide.

To ensure that timber harvesting complies with forest regulations, which safeguard sustainability and the multifunctional role of forests, all harvesting activities must be communicated, authorized, and monitored using procedures and technical tools appropriate to the scale and nature of the logging operations.
The required procedures and technical tools for forest harvesting operations are as follows:

[2] https://www.filieralegnofvg.it/bosco-fvg/
[3] https://www.regione.fvg.it/rafvg/cms/RAFVG/economia-imprese/agricoltura-foreste/foreste/FOGLIA12/

- No obligation for harvesting operations considered as very limited in scale, i.e., up to 15 m³ in high forests and up to 1.000 m² in coppice forests, on unplanned properties.
- Cutting Declaration (DT) for harvests up to 200 m³ in high forests and up to 25.000 m² in coppice forests, excluding the cases with no obligation mentioned above. The DT must also be submitted for emergency logging without volume limits, such as cutting dead, windthrown, or fire-damaged trees, or trees that must be removed for construction or forest road works. The DT must be submitted by the forest owner to the competent local Forest Inspectorate, which takes note of the declaration.
- Forest and Environmental Rehabilitation Project (PRFA): this is a cutting plan prepared by an agronomist or forest specialist for harvests equal to or greater than 200 m³ in high forests and 25.000 m² in coppice forests. The PRFA must be submitted by the forest owner to the Forest Inspectorate for approval. For harvests between 200 and 1.000 m³ in planned forest properties, the PRFA is submitted as an attachment to the DT.

5.2.2. Identification of value chains in forestry and wood processing

Friuli Venezia Giulia Region has developed a well-structured and innovative forest-wood value chain, rooted in sustainable forest management, local cooperation and diversified transformation processes. The entire system, from certified forest resources to advanced wood products, reflects an integrated model that prioritizes environmental, economic and social sustainability.

Sustainable forest management is the foundation of the value chain in FVG. The region is a national leader in forest certification, with over 98.570 hectares certified under the PEFC scheme, making it the second most certified region in Italy. There is also increasing application of dual certifications (FSC and PEFC), such as in the Fusine Forest.

Group certification projects, involving both public and private forest owners, currently engage around 16 companies and 3.200 ha, promoting accessibility and shared responsibility.

Cooperatives and territorial clusters unite forest owners, processors and users to promote short supply chains and enhance traceability and certification.

Regional and EU funds, such as the 2021–2027 ERDF (FESR) with a 6,5 million EUR budget, support modernization, sustainability and digital traceability. Furthermore, Regional Law 3/2021 incentivizes companies innovating in the wood-furniture chain and encourages circular economy practices.

The region’s primary wood processing sector includes sawmills and panel manufacturers. The number of companies certified for Chain of Custody (CoC) under PEFC continues to grow, with 160 active firms in FVG and 236 new certifications in 2024 alone. These companies produce glulam, boards and sawn timber used in construction and packaging. Support from clusters and cooperatives ensures efficient and traceable processes, enhancing the competitiveness of local enterprises.

FVG is historically known for its Chair District located in areas like Manzano and San Giovanni al Natisone, where skilled artisans and modern manufacturers coexist. A multitude of SMEs produce certified furniture, often labeled to highlight regional origin and sustainability. This district is emblematic of how tradition and innovation can merge, producing high-quality wooden furniture with strong export potential.

The wood value chain in FVG is increasingly diversified through innovative uses and emerging bioeconomy sectors:

- Biomass production from short-rotation coppices (e.g., poplar and willow) is already active, contributing to the region's renewable energy goals;
- FVG is also involved in the production of resonance wood, highly valued in crafting musical instruments;
- Non-wood certifications are also growing, with pilot projects involving pine-infused beer and PEFC-certified truffles, demonstrating the versatility of forest-based products.

Regional institutions and cooperatives provide technical assistance, training, digital tools (MRP/ERP), branding strategies, and certification support. Community involvement is central, with initiatives creating jobs in mountain areas, promoting participatory forest management, and reinforcing ecosystem-based economies.

Friuli Venezia Giulia Region stands out due to:

- Certified sustainability, opening access to premium international markets.
- Cooperative and network models that foster innovation and scale economies.
- Structured funding frameworks (EU and regional) driving modernization and digital transition.
- Diversified value chains, spanning from furniture and energy to biotech and forest-based gastronomy.

5.2.3. Comparative advantages of the area

Friuli Venezia Giulia Region stands out as a regional and European leader in the forestry and wood-processing sectors. Its strategic position, rich natural endowment and long-standing industrial tradition make it uniquely competitive in this value chain.

One of FVG's most remarkable assets is its forest coverage. Nearly 43% of the region is forested - around 300.000 ha - placing it among the most wooded regions in Italy. These forests are not only abundant but also home to high-quality tree species such as Norway spruce, beech and larch. These species are particularly valued for their applications in structural timber, high-end furniture and even musical instruments, where the famed "resonance wood" is used for crafting stringed instruments. Moreover, sustainability is a priority: large portions of FVG's forests are certified under PEFC and FSC standards, ensuring responsible forest management and enhancing market credibility.

Geographically, FVG enjoys a privileged location. As a border region with Austria and Slovenia, it serves as a bridge between Italy and Central Europe. This facilitates not only cross-border trade in wood and timber products but also participation in transnational innovation initiatives. The Port of Trieste, one of the most important commercial ports in the Adriatic, provides access to global markets, while the region's robust rail and road infrastructure supports efficient transportation and short, optimized supply chains.

FVG also boasts a rich industrial heritage in woodworking and furniture manufacturing. The renowned *Distretto della Sedia* (Chair District), centered in Manzano, is internationally recognized for its excellence in furniture production, both artisanal and mass-market. Here, generations of skilled labor have combined traditional craftsmanship with cutting-edge design and automation technologies. The region has developed strong vertical integration, allowing businesses to manage the full production process from raw timber to finished product. This industrial strength is reinforced by a dense network

of public and private cooperation. The region was home to Italy's first forestry cluster, integrating actors across the entire value chain. Organizations such as *Legno Servizi* play a key role in managing forest resources, ensuring certification and promoting local wood. These efforts are supported by regional and EU funding, such as FESR and rural development programs, which finance innovations in machinery, sustainable practices and international competitiveness.

Innovation is another key pillar of FVG's comparative advantage. The region has embraced biomass energy, eco-design and timber-based green building solutions such as cross-laminated timber (CLT) and prefabricated wooden structures. In addition to timber, the region is diversifying into certified non-wood forest products, such as honey, truffles and pine derivatives, adding further value through sustainability labeling.

FVG is also well-positioned in terms of funding and certification. A high percentage of its forests are certified, which builds trust with environmentally conscious consumers. Furthermore, the region benefits from major EU initiatives like the Green Deal and NextGenerationEU, which support circular economy projects and sustainable forest-based innovation.

Finally, forestry and wood industries in FVG contribute significantly to rural development and social cohesion, especially in mountain areas such as Carnia. By promoting local supply chains (*filiera corta*) and community forestry models, the region not only captures local value but also strengthens resilience in remote communities.

In summary, Friuli Venezia Giulia Region combines natural wealth, industrial know-how, innovation and coordinated governance to form a dynamic and sustainable forestry and wood-processing ecosystem. It is a model for how regions can harness local resources and knowledge to thrive in the green economy.

5.3. Slovenia

5.3.1. Forest, forest management and wood industry

Slovenia is the third most forested country in Europe and ranks among the top 30 countries globally. Forests are the dominant landscape element, covering 58% (1.176.000 ha) of the entire territory.

The majority of Slovenian forests represent beech, spruce-beech, and beech-oak forests (70%), which have a relatively high productive capacity. Slovenian forests are home to approximately 70 different tree species, as well as to a large number of shrubs. The tree composition varies across different regions of Slovenia due to the highly diverse growing conditions. Beech predominates in the Dinaric Alps and the eastern part of Slovenia, while coniferous dominate in the northern part of Slovenia on high plateaus, where spruce is particularly prevalent in the forest stock.

Today, 77% of forests in Slovenia are privately owned, 20% are owned by the state and 3% are owned by the municipalities. Forest ownership has changed in recent decades, primarily due to the process of denationalization. The ratio of state and private forest areas has shifted from 34:66 in 1996 to 20:80 in 2023. Private forest properties are highly fragmented. The average forest property is only around 3 ha and is often further divided into several separate parcels. According to the latest data, there are already 282.500 forest properties in Slovenia, owned by 409.000 forest owners. Such a high degree of

fragmentation, along with the number of owners and co-owners of forests, makes professional work and the optimal use of wood in private forests more difficult.

The total growing stock of Slovenia is 357 million m3 or 304 m3/ha. In the growing stock, beech (33%) and spruce (30%) are the most common tree species. They are followed by fir (7,4%), oaks (7,1%), pines (5,4%) and other broadleaves (14%). Together, broadleaves make up 54% of the growing stock, while coniferous trees account for 46%.

The total annual increment of Slovenia is 8,8 million m3 or 7,4 m3/ha. The annual potential felling is 7.1 million m3, of which annual felling of conifers is 4.2 million m3 (57%) and broadleaves is 1,8 million m3 (43%).

Forests have very important economical role in Slovenia, as it has few other natural resources. Forest management, while ensuring the ecological and social functions of forests, is focused on producing high-quality timber, which is a crucial foundation for the development of the wood industry. The share of forests, available for forest production, is 91%. The Regulation on Protective Forests and Forests with Special Purposes defines forest reserves (1%) and protective forests (8%), where all activities that could in any way alter the existing natural condition and affect the uninterrupted natural development in the future are prohibited, or where forest management is restricted and strictly defined, respectively.

In Slovenia, forests have been managed for decades based on the principles of sustainability and multifunctionality. Forest management planning involves the process of collecting, processing, and storing forest data, setting goals, guidelines, and measures, and controlling management activities. In the process of forest management planning, the forest management plans provide guidelines for directing forest development at various spatial levels – regional, landscape, and stand level. Plans are mandatory for the management of all forests and are created for all forests, regardless of ownership. The plans comprehensively address the forest ecosystem while also considering forest management aspects and wildlife management.

According to the data in 2024, within the traditional sectors of forestry and wood processing (A02 Forestry and logging, C16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials, and C31 Manufacture of furniture + C32 other manufacturing, Slovenia has 1.451 of business entities (amount to 2% of all business entities). These entities collectively employed 15.422 of employees (amount to 2,84% of all employees), and generated a revenue of 2.614 million EUR (amount to 1,81% of total economy revenue).

Slovenia's imports and exports in the forestry and wood processing sectors for 2021–2023 describe that:

- Total roundwood trade shows a declining trend in imports (from 888.770 m³ in 2021 to 629.541 m³ in 2023) while exports remain high, peaking at 1.388.390 m³ in 2022 and slightly decreasing to 1.366.563 m³ in 2023. Industrial roundwood represents the bulk of trade. Conifers dominate imports but exports are more balanced, with broadleaf roundwood exports higher than conifers in 2021 and 2022.
- Logs for sawmilling and veneer show stable trade in conifers, with imports slightly decreasing (286.639 m³ in 2021 to 233.535 m³ in 2023) and exports increasing (285.667 m³ to 346.756 m³).
- Wood for pulp and paper trade is primarily coniferous, with exports rising over time (238.893 m³ in 2021 to 293.474 m³ in 2023), while imports fluctuate.

- Firewood imports and exports show a gradual decrease in imports (177.590 m³ to 152.007 m³) and relatively stable exports approximately 200.000 m³).

According to the data, foreign trade volumes for roundwood and firewood between 2021 and 2023, it can be determined consistent export surplus in roundwood, underscoring the role of Slovenian timber in international markets. Particularly notable is the surplus in broadleaved wood for industrial use, while exports of coniferous saw logs show steady growth through 2023. At the same time, a downward trend in imports can be observed across many categories, which may indicate increasing domestic supply or reduced reliance on foreign inputs.

5.3.2. Identification of value chains in forestry and wood processing

The forest-wood value chain in Slovenia integrates sustainable, multifunctional, and close-to-nature forest management with wood processing, design, manufacturing, and marketing of wood products and other wood-based components, as well as the utilization of wood residues and waste for energy production[4]. All segments of this value chain are present in Slovenia, identified as five primary value chains (P1…P5), two chains to ensure a circular economy (K6, K7) and three chains of higher processing stages to produce higher value-added products were identified. The effective functioning of the entire value chain depends on the efficient operation of all its segments; however, in Slovenia, some of these segments are no longer performing optimally.

Value chains have been assessed in terms of the long-term challenges facing the domestic forestry and timber value chain. Given climate change, an increase in the proportion of hardwoods and a rise in the share of lower-quality assortments are to be expected[5].

Identification of value chains in the Slovenian forestry and wood processing:

Primary value chains:
- P1 – Sawn timber
- P2 – Veener
- P3 – Wood for pulp and panels (composites, paper)
- P4 – Other industrial wood (chemical processing)
- P5 – Lowest quality roundwood (energy)

The hardwood sawn timber processing value chain (P1) is functional up to the second level of technological complexity; however, the processing into construction sawn timber is currently not operational. The P3 value chain is presently active only to a very limited extent at the primary technological level, specifically in the segment of plywood production. Other industrial hardwood (P4) is currently processed only at the basic technological level.

Value chains of higher processing levels
- S8 - Final wood products (interior furnishing, musical instruments, sports equipment, packaging, coverings …)
- S9 - Building with wood (connection with the construction industry)
- S10 - Transport vehicles (connection with the transport sector)

[4] https://www.gov.si/podrocja/podjetnistvo-in-gospodarstvo/lesarstvo/
[5] 2023, Identifikacija verig vrednosti v slovenskem gozdno-lesnem biogospodarstvu

Within these value chains, numerous new uses of hardwood are emerging, along with innovative products that increase both the potential quantity of wood usage and the added value in the products. These value chains are relatively high-tech and also require significant investments

Value chains to ensure a circular economy:

- K6 - Residues
- K7 – Waste wood

These two value chains do not directly draw their resources from the forest, but rather originate from specific segments of the primary (P1-P5) and secondary (S8-S10) value chains, including products after the end of their use. The value chain is weak in the segment of incorporating secondary wood material as a raw material source (K6, K7), often due to issues with raw material collection and the presence of inorganic contaminants in them. However, there is untapped potential in the field of biorefining[6].

5.3.3. Comparative advantages of the area

Slovenia is one of the most forested countries in Europe. This provides a sustainable and reliable source of raw materials for the wood industry, ensuring a consistent supply for processing. It is known for producing high-quality timber (wood auctions) and wood products.

Forest management plans ensure that forest ecosystems are managed in a sustainable way and many Slovenian wood assortments carry certifications such as FSC or PEFC.

Wood semi-finished products and products play an important role in the functioning of value chains in other sectors as well. They have established markets and a high potential for substituting other materials, indicating strong innovation potential.

In certain value chains, there is sufficient domestic expertise, along with existing collaboration and connections with educational and research institutions. In some value chains, a further advantage is the relatively slow rate of technological obsolescence, which enables lower operating costs for companies.

5.4. Bosnia and Herzegovina

5.4.1. Forest, forest management and wood industry

Bosnia and Herzegovina is the country with the highest share of forests and the largest variety of forest species in the Western Balkans. Due to their natural and diverse structure, as well as extensive natural regeneration, they represent crucial resources for the further development of the economy and society. Forests and forest land in B&H encompass an area of 3.231.500 ha out of which 1.652.400 ha are of high forests and 1.252.200 ha are coppice forests. The rest of the area includes shrubs, bare land and other woodland. These data point to the fact that about 63% of B&H territory is covered with forests and forest land.

[6] 2023, Identifikacija verig vrednosti v slovenskem gozdno-lesnem biogospodarstvu

Around 79,14% or 2.247.311 ha of the forests are publicly owned (owned by FBiH - 1.241.336 ha, Republic of Srpska - 1.003.003 ha, and Brčko District – 2.972 ha), while about 20,86% or 592.439 ha are privately owned (owned by FBiH - 277.130 ha, Republic of Srpska - 306.783 ha, and Brčko District – 8.526 ha). Approximately 81,50% of the forests are predominantly natural, covering various developmental stages, with high forests making up 47,60%, and coppice forests (low forests) accounting for 33,9%. Coppice forests are the result of large-scale clear-cutting in high forests during the period from 1918 to 1941 and post-war reforestation efforts.

The ratios of high forests and coppice forests are diametrically opposed when comparing public and private ownership. While the state owns 72% of high forests, private forest owners are predominantly found in relation with coppice forest (around 62% of total coppice forests). Public forests comprise most of the high forests, which are more profitable and under systematic forest management. The state manages the better forest sites in the country and uses the opportunity for afforestation and conversion of coppice forests to high forests.

Total growing stocks amounted to 385.518.072 m^3 (in FBiH – 183. m^3 or 215 m^3/ha, in RS – 202,2 m^3 or 266,65 m^3/ha). In FBiH broadleaves make up 105.843.657 ha of the growing stock, while coniferous trees account for 77.161.810 ha. Data on growing stock in the RS by category of broadleaves and coniferous trees are not available.

The total annual increment of B&H is 9,4 million m^3 (in FBiH – 4,3 million m^3 or 5,10 m^3/ha, in RS – 5,1 million m^3 or 6,78 m^3/ha), of which annual increment of conifers is 4 million m^3, and broadleaves is 5,4 million m^3.

The annual potential felling is 6.377.865 m^3 (in FBiH – 3.013.971 m^3, RS – 3.363.894 m^3), and the annual felling is 4.796.068 m^3 (in FBiH – 2,3 million m^3, in RS – 2,4 million m^3).

There is a clear trend of increasing forest and forest land areas in B&H over the past fifty years. The cause of this increase is a greater extent, the overgrowth of agricultural land. Non-forested forest land covers around 500.100 ha (18,5%), of which approximately 392.300 ha are suitable for afforestation.

The forests are characterized by a great diversity of types due to the country's excellent geographical position and various climatic influences, ranging from coastal Mediterranean forests to mountain forests in central Bosnia and Herzegovina (Mediterranean, sub-Mediterranean, and temperate continental climate zones). There are over a hundred tree species. The main types of trees are fir, spruce, white and black pine, beech, various oak species, with smaller numbers of noble hardwoods like maple, elm, ash, and fruit trees (cherry, apple, pear).

The total growing stock in the Republic of Srpska amounts to 201,6 million m^3, with an annual harvest of 3,4 million m^3. The largest share is found in tall forests with natural regeneration (160,5 million m^3), dominated by beech, fir, and spruce. Coppice forests account for 28,5 million m^3, mainly beech and oak, while forest cultures add 9,8 million m^3, led by spruce and pine species. Tall degraded forests make up a minor share with 2,9 million m^3. Overall, broadleaves (120,4 million m^3) slightly exceed conifers (81,2 million m^3) in both stock and harvest, confirming the dominant role of beech, fir, spruce, and oak in the wood industry of the Republic of Srpska.

The total growing stock in the FB&H amounts to 183 million m^3, with an annual harvest of about 3 million m^3. The majority is concentrated in high forests (159,2 million m^3), almost evenly split between conifers

(77,2 million m³) and broadleaves (82 million m³). Coppice forests contribute an additional 23,8 million m³, entirely composed of broadleaves. Overall, broadleaves dominate the structure with 105,8 million m³ of growing stock and 1,62 million m³ of annual harvest, compared to conifers with 77,2 million m³ and 1,39 million m³ respectively.

The total production of forest assortments in B&H in 2024 has been 3,6 million m^3. The production of assortments of coniferous tree species has been 1,9 million m^3 and while the production of assortments of broadleaf is 1,6 million m3.

The largest production related to the production of logs in amount to 1,7 million m^3, and followed by the production of firewood in amount to 1,1 million m^3. The production of Wood for pulp and paper has been 0,5 million m^3.

The total production of forest assortments in B&H in 2024 (3,6 million m^3) has been decreased by 3,32% compared to the same period in 2023. (3,7 million m^3).

Within the traditional sectors of forestry and wood processing (A02 Forestry and logging, C16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials, and C31 Manufacture of furniture), there are a total of 1.850 business entities operating in B&H that submit financial reports to the relevant authorities. In 2023, these entities collectively employed 38.916 workers and generated a total revenue of 1.942.171.915 EUR.

The majority of business entities operated within sector C16 – Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials - i total 1.165 (62.97%), followed by sector C31 – Manufacture of furniture with 386 (20.87%), and A02 Forestry and logging with 299 (16,16%) business entities.

The highest revenues were recorded by business entities operating in sector C16 – Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials - i total 1.011.795.623 EUR (52,10%), followed by those in sector C31 – Manufacture of furniture with 572.829.475 EUR (29,49%), and A02 Forestry and logging with 357.546.817 EUR revenues (18,41%).

The highest average number of employees was recorded by business entities operating within sector C16 – Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials - 17.382 average number of employees (44,67%), followed by entities in sector A02 – Forestry and logging with 11.011 (28,29%), and Manufacture of furniture with 10.523 average number of employees (27,04%).

An analysis of the financial performance indicators of business entities shows that the main actors in the forestry and wood processing industry are companies engaged in primary processing, which generate the lowest level of new added value. This is a highly unfavorable situation for this sector of the economy in B&H.

The foreign trade of B&H wood industry and forestry sector shows a stable export orientation, with exports consistently exceeding imports both in volume (kg) and value (EUR) over the period 2021–2023. In 2023, exports from the wood sector amounted to 814.214.623 EUR , which is 12,3% less than exports in 2022. Furniture accounted for 43% of total exports, amounting to 336 million EUR , which is

3,9% less than in 2022, when exports reached 349.6 million EUR. The most exported items were wooden and upholstered seats, followed by living and dining room furniture, wooden bedroom furniture, and other wooden furniture. Sawn timber and components reach export 203.4 million EUR in 2023, though showing a downward trend compared to 2022. Boards and veneer display highly volatile trade, with imports largely constatly exceeding exports. There was a noticeable decline in the export of all product groups in 2023, except for wooden prefabricated houses. Around 86% of the total wood industry exports in 2023 were realized in the top 15 export markets, with the most important export partners being: Germany, Croatia, Italy, Serbia, Slovenia, Austria, the Netherlands, and France. In addition to the European Union countries, exports were also made to China, Turkey, Switzerland, and the United Kingdom.

In 2023, total imports in the wood sector amounted to 267.283.778 EUR , which is 11% less than in 2022, when imports totaled 300.205.413 EUR. All product groups experienced a decline in imports in 2023, except for wooden furniture. The highest import volumes came from: Croatia, Serbia, Austria, Poland, and the Czech Republic.

The decision on the temporary ban on the export of certain forest timber assortments led to a reduction in exports, which increased the availability of timber assortments for the domestic economy and resulted in a significant decrease in the import of forestry products. Boards and veneers saw a decrease in value, although the quantity of imports in both 2022 and 2023 remained nearly the same. Parquet and construction joinery recorded a slight decline in imports in 2023 compared to 2022. Imports of wooden furniture showed a modest increase.

According to the Constitution of B&H, matters of foreign trade and international forestry obligations are within the competence of the institutions of B&H, specifically the Ministry of Foreign Trade and Economic Relations of BiH. Forest management and forest land management are under the jurisdiction of the entities (FBiH and RS) and the Brčko District. The institutions in the two entities and the Brčko District are responsible for developing and implementing forestry policies and regulations. In the FBiH, these responsibilities are further decentralized to the cantonal level (10 cantons).

Each administrative area manages its forests through the ministries responsible for forestry.

In FBiH, forestry falls under the jurisdiction of the Federal Ministry of Agriculture, Water Management, and Forestry. The Federal Forestry Administration was established to plan the development of forestry. According to the FBiH Forest Law, the federal minister has delegated the management and governance of forests to cantonal ministers responsible for forestry matters through contracts. In the Republic of Srpska, forestry falls under the jurisdiction of the Ministriy of agriculture, water management, and forestry. Since 2022, in Republic of Srpska, the wood processing and furniture industry is also under the jurisdiction of the Ministry of Agriculture, water management and forestry.

Forest management in both entities has been transferred to public enterprises established by legislative authorities, i.e., parliaments/assemblies, which are not funded by the budget.

In the FBiH, the assemblies of all ten cantons have established one forestry enterprise per canton. The cantonal minister responsible for forestry contracts the management of state forests to these companies for a period of five years, and the company is accountable to the cantonal ministry for its work.

In the Republic of Srpska a single company has been established to manage all state forests. It includes 23 forest estates, Center for Seed and Nursery Production, Research Development and Project Center, Center for Karst Management and Forestry house "Ognjište". A Directorate of Public Enterprises is established to perform joint and professional tasks in a Public Enterprise. In the framework of individual forest farms, and with the aim of more efficient operations, forest administrations, work units and districts were formed. It is accountable to the Ministry of Agriculture, Forestry, and Water Management of the Republic of Srpska.

5.4.2. Identification of value chains in forestry and wood processing

Over the past 15 years, the furniture production and wood processing sector in B&H grown from a low-value-added sector, that mainly depletes resources, into one of the sectors that contributes the most.

There is a large number of actors in the broader value chain of furniture production and wood processing in B&H. The value chain now starts with companies evolving into integrators and market research agents, involved in product market placement, with expertise in design and industry trends in furniture production.

As the value chain in furniture production and wood processing becomes more complex, it is possible to identify many suppliers, with those providing solid wood still representing its foundation and most important part. As much as 90% of these suppliers are public forestry companies, which represent a significant burden and obstacle to further business development, depending on their output products. The main reason is their inability to provide furniture manufacturers with a transparent and fair distribution of wood assortments.

Next in the value chain are manufacturers that are in different segments and stages of development, mostly involved in contract manufacturing. There are a small number of companies that have started building their own brands, and their number is growing.

In this part of the value chain, it is possible to identify business entities along the value exploitation chains through the technical possibilities of processing and includes:

- Primary wood processing (mining timber, wood for gardens, construction timber (sawn wood), wood packaging, etc.)
- Wood processing (planed products, parquet, laminated wood, wood components, wooden toys, etc.)
- Production of wooden components (windows, doors, wooden beams, wooden roof structures, etc.)
- Production of wood-based materials (veneer; plywood, tabletops, chipboard, fiberboard, MDF boards, OSB boards, etc.)
- Furniture production (upholstered furniture, beds, chairs and tables, modular furniture for living and bedrooms, kitchen furniture, office furniture, small furniture, institutional furniture, etc.)

The furniture production and wood processing sector is growing, developing, and becoming more complex than it once was. Manufacturers stand out in the processing of solid wood into components (furniture parts and panels) and in the production of finished products, using upholstery and mixed materials (metal, glass, stone, leather, textiles), which provides the wood industry and furniture production with an interesting opportunity for growth.

Companies providing servicing, engineering, and maintenance services in the furniture production and wood processing value chain are advancing.

Once everything is produced and packaged, it is important to ensure timely and appropriate transport and general logistics. All of this used to be done within the factories themselves, but today these services are outsourced due to the necessary specialization.

At the end of this value chain are customers and consumers (furniture recycling and rental companies still do not exist in Bosnia and Herzegovina), ranging from small showrooms and individuals to large groups and retail chains that buy furniture. They have the greatest impact on dynamics and production in general. The market B&H is still small, so companies are mainly focused on exports, primarily to EU countries.

There are several organizations influencing the furniture production and wood processing sector, ranging from policymakers, to local authorities and various other bodies implementing these policies. Additionally, an important segment of the value chain in furniture production and wood processing consists of various institutions that support this sector, such as chambers of commerce, various municipal and regional development agencies and projects, consulting firms, educational institutions and training centers, as well as transport, logistics, and financial institutions.

5.4.3. Comparative advantages of the area

B&H is among the most forested countries in the region and all of Europe, with forests and forest land covering approximately 63 percent of its territory. It also has the greatest diversity of forest species in the Western Balkans.

In addition to the fact that the wood processing and furniture production industries base their development on the use of domestic raw materials, which are distributed throughout the entire territory of BiH, this industry also has a long-standing tradition and is the oldest industrial sector in the country. It is traditionally export-oriented and is one of the few industries that consistently show a high surplus in foreign trade. The reasons for this lie in B&H favorable geographic location (proximity to EU markets), lower operating, energy, and labor costs, which allow businesses to produce high-quality standard furniture at a price lower than that of competitors for the same level of quality.

In terms of equipment, about two-thirds of wood processing companies operate with machinery that is between 5 and 10 years old, and with that level of equipment, they are capable of achieving the desired production quality. They also possess the necessary standards and certifications that enable them to access the European Union market and use domestic raw materials from companies that hold the FSC standard for forest management.

5.5. Albania

5.5.1. Forest, forest management and wood industry

According to the Albanian National Forest Inventory 45,6% of Albania, approximately 1,2 million hectares is covered with forests. Forests (46,5%) and pastures (19,1%, equivalent to 547.682 hectares)

together cover approximately 65% of the country's area, or about 0,65 hectares per capita (ANFI, 2021). In comparison, forests and wooded land in the EU cover 0,36 hectares per capita.

Publicly owned forest land in Albania is predominant at 1,161,000 hectares (97%), with a minor share of private forests, which according to the National Institute of Statistics (INSTAT), remained stable at 28,780 hectares (3%) in 2023. Public forests are managed primarily by municipalities (76% or 910,000 hectares), except for forests within protected areas (21%) that are managed by the National Agency for Protected Areas (INSTAT, 2023).

The total growing stock of Albania is 57.700.000 m^3. Annual growth of growing stock is 1.360.000 m^3, and the potential annual harvest is 1.100.000 m^3.

Based on the silvicultural system, forests are primarily composed of coppice forests (23%) and high forests (32%), which together represent the dominant share of forest area.

The total growing stock is concentrated in broadleaved forests (38,4 million m^3), followed by coniferous forests (11,5 million m^3, mainly black pine and silver fir). Mixed forests contribute smaller volumes, with broadleaved-dominated stands at 4 million m^3 and coniferous-dominated stands at 3,9 million m^3. Data on annual harvest is not available.

The standing volume is estimated at about 57,7 million m^3. Although high forests cover about 32% of the forest area, they have about 73% of the standing volume of timber

15% of the forest area is covered by beech forests, which have c.a. 40% of the standing volume (c.a. 23 million m^3) and 14% of the forest area covered by coniferous forests, which have c.a. 24% of the standing volume (c.a. 15 million m^3). The main coniferous species are black pine and silver fir.

The largest production is related to firewood production, amounting to 695,000 m^3 (the vast majority is produced from broadleaf species), followed by roundwood for industrial use amounting to 4,000 m^3.

Within the traditional sectors of forestry and wood processing (A02 Forestry and logging, C16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials, and C31 Manufacture of furniture + C32 Other manufacturing), there are a total of 950 business entities operating in Albania. In 2023, these entities collectively employed 7.780 of workers, which 1.187 are self employed and generated a total revenue of 186.386 million EUR (INSTAT 2024).

In 2022, the value of exports reached approximately 40 million EUR, while imports amounted to around 114 million EUR. The main import partner is Turkey with an import volume of 35 million EUR. Other important partners are Greece (over 10 million EUR), Italy (8 million EUR), Bosnia and Herzegovina (7.5 million EUR), Montenegro (7 million EUR) etc. The main export partner is Italy (21 million EUR), followed by Greece (8 million), Germany (2 million), Kosovo (1,7 million), France (1.4 million) etc.

Nowadays, wood processing and furniture industry meets a considerable part of the Albanian domestic market needs with wooden products targeting mainly low-cost products for low-income customers, while import of furniture products continues and expands mainly for high class well-developed modern furniture.

Being a small market, the possibility of capacity expansion based on the local market is impossible, so more and more companies are oriented towards export.

Albania also imports significant volumes of ready-made furniture, including office, kitchen, and other furniture. Office and kitchen furniture are imported primarily from Italy.

The main products produced in-country and exported are semi-finished elements for chairs, tables, and other articles for export, chairs, bedroom furniture, tables, doors, windows, and flooring.

In 2016, the Government of Albania transferred forest management (with the exception of protected areas) to all 61 Local Government Units (LGUs) of the country, and implemented a ten-year moratorium on harvesting with the goal of reducing the unsustainable harvesting of wood in the country. Exceptions to the moratorium permit LGUs to harvest only in three cases:

1. for fuelwood to meet local needs of households and large users;
2. for change of land use;
3. for sanitary forest activities needed for forest regeneration.

LGUs are solely responsible for the supply of fuelwood for heating for citizens and institutions within their area of jurisdiction and describe the processes that need to be followed. LGUs have the right to harvest fuelwood themselves, contract private forestry firms to harvest fuelwood, and permit households to collect fuelwood for their own use.

To date, three models have been employed by LGUs to meet this need. In one model, the LGUs have taken responsibility for the production, transport and delivery of harvested wood. In the other two models, LGUs have contracted private forestry firms to manage some or all of the activities. In all three models, households are permitted to collect fuelwood from forests under a modest fee system, but only for their own needs.

5.5.2. Identification of value chains in forestry and wood processing

Albania's forestry and wood processing sectors include companies engaged in four main types of activities: harvesting, trading wood materials, wood processing and fuelwood production.

Harvesting: Harvesting is primarily carried out by logging companies and includes tree felling, timber sorting and timber transport. Logging companies provide the raw material for fuelwood. Under the Moratorium, LGUs determine where harvesting can occur and how much can be harvested. A minor quantity of the material produced from the occasional thinnings meets the technical criteria for sawlogs and is used for the production of sawn timber. Currently, 25%÷30% of wood volume in the form of residues is lost during harvesting due to a reliance on manual labour, and insufficient transportation technology*.

Trading: More than 90 percent of raw materials, primarily wood-based panels for domestic furniture industry, are imported. This development is also conditioned by the inability of Albania's forest resources to supply the wood and furniture industry with raw material, due to their degraded state. A considerable number of trading companies also carry out value-adding operations, based on customer needs (UDA & DIAVA 2018).

Wood processing: Wood processing activities transform unprocessed round wood into sawn lumber (primary processing), and furniture/construction materials (secondary processing). Companies engaged in wood processing activities secure the raw materials through directly harvesting wood through concessions with LGUs (all forestry companies are also engaged in the activity of log sawing), by purchasing raw materials from importing companies or also import it directly themselves. Primary wood processing activities in Albania are carried out by sawmills. In addition to producing sawn timber, some sawmills also produce solid wood panels. The secondary processing companies produce a variety of products, including furniture, doors, windows, parquet and stairs using beech, black pine, fir, maple, oak, walnut and various exotic wood species. Secondary processers are increasingly reliant on imported sawn wood and wood composite panels. While imported wood is considered to be high quality, it is more expensive than locally produced wood. Both, primary and seconadry processing generate a significant amount of residues (c.a. 35%) including slabs, strips, chips, sawdust and panel residues. All of them, except of panel residues, are used for pellet production.

Pellet production: Pellet production is a subset of the category of fuelwood activities that includes activities that transform sawdust and other wood residues into pellets which are used as a source of fuel. Pellet producers have been operating in Albania since 2008. Many of them are involved in other activities in the fuelwood sector, such as wood processing more generally, and/or harvesting, and produce pellets as a means of using residues produced from these activities. Since pellets are made with materials that cannot be processed for other purposes, they are an efficient way to use wood biomass.

The production of pellets includes several main components:

- *Chipping and milling:* Raw materials are chipped and crushed to produce wood material 3-5mm in size.
- *Drying:* The crushed materials is dried to the appropriate moisture content (6%-8%).
- *Pelleting:* Dried wood material is pressed into pellets
- *Cooling:* Pellets are cooled to a dry, hard shape.
- *Packing:* Pellets are packed for delivery and use.

Direct value chain subjects in forestry and wood processing:

- Forests (public);

In addition to LGUs, forests in Albania fall under the responsibility of other stakeholders.

Forestry governance in the country is shared among several key institutions, each with distinct roles in policy formulation, forest management, monitoring, inspection, and enforcement. The Ministry of Tourism and Environment (MTE) is primarily responsible for policy formulation and approval of forest management plans. Local Governing Units (LGUs) are tasked with developing forest management plans, as well as forest monitoring and inspection activities at the local level. The State Inspectorate of Environment and Forestry (SIEF) has a strong oversight function, being responsible for forestrz inspection, monitoring, and enforcement. This distribution of responsibilities reflects a multi-level governance structure, where policy is set nationally, planning and monitoring are carried out locally, and enforcement is centrally coordinated.

- Value chain of forestry and wood processing in Albania, showing the flow of wood materials from forests to final consumers is:

Forest resources originate from the Forest Fund, which includes areas managed by the National Agency of Protected Areas and Local Government Units (LGUs). These provide the annual harvested volume, including firewood, residues, thinnings, and roundwood.

Sawmills play a central role, processing roundwood into sawn timber and generating residues. Residues are directed to pellet producers (producing pellets for households and institutions) and to furniture producers. Sawn timber and wood-based panels (both locally produced and imported) feed into furniture producers and construction material producers. These generate finished products such as furniture, doors, parquet, stairs, and wooden houses.

Finished products move through retail, wholesale, and direct buyers, reaching the construction sector, households, and large users (e.g., schools, public institutions, hotels, restaurants).
Imports of wood-based materials (roundwood, sawn timber, panels) supplement domestic supply, feeding directly into sawmills, furniture, and construction material producers.

Overall, it's a multi-layered value chain, where local forest resources are combined with imported materials, processed through sawmills, and converted into pellets, furniture, and construction materials that serve both households and institutional/industrial consumers.

5.5.3. Comparative advantages of the area

Despite the poor state of the forestry sector, the wood and furniture industry has continued to invest in capacity expansion and new technologies. Although investments decreased in 2021 due to the COVID-19 pandemic, the overall investment trend from 2015-2021 shows that both total investments and those in new technologies doubled during this period. This upward investment trend is expected to continue in the coming years.

The component of investments in machinery and equipment has the same upward trend. It is mainly about investments in machinery or CNC production lines.

Despite currently low production levels, pellet manufacturing firms have expressed interest in expanding their capacity. Producers identify the main barriers to increased production as: lack of necessary raw materials (residues), insufficient collection of residues during harvesting operations, and restrictions on importing residues from other countries (Law No. 156, dated 28.10.2013 "ON SOME AMENDMENTS TO LAW NO. 10463, DATED 22.9.2011 'On Integrated Waste Management'"). Despite these challenges, producers report successfully securing raw materials through imports, excluding residues. They remain optimistic due to high international pellet prices and expect these favorable prices to continue in the future.

5.6. Serbia

5.6.1. Forests, forest management and wood industry

Forest management in Serbia is rooted in the principles of sustainable use, regeneration, and multifunctionality, and is regulated through officially approved 10-year forest management plans. According to the latest national data, Serbia has approximately 2.85 million ha of forest, with a growing

stock of 557 million m^3 (of which conifers 71 milion m^3, and broadleaves 486 milion m^3) and an annual increment of 14.3 million m^3, of which annual increment of 1,8 milion m^3 and broadleaves 12,5 milion m^3. The average growing stock per hectare is around 195 m^3, which is below the EU average but steadily increasing.

The annual allowable cut in Serbia is estimated at 5 to 6 million m^3, while actual annual felling is between 3.1 and 3.5 million m^3. This indicates a significant level of underutilization, particularly in private forests. The gap between allowable and actual harvest highlights both a conservation safeguard and a missed economic opportunity, especially in the context of biomass and fuelwood utilization.

Forest ownership is divided between public and private sectors. Public forests account for 41,7% (1.191.000 ha) of the total forest area and are managed by Public Enterprise “Srbijašume” (approximately 892.000 ha), Public Enterprise “Vojvodinašume” (around 127.000 ha), and national park administrations (covering about 171.000 ha). The remaining 58,3% (1.664.000 ha) of the forest area is privately owned, mostly by individuals, typically in small and fragmented plots. This fragmentation presents challenges for coordinated management and efficient utilization of forest resources.

In terms of stand structure, around 65% of forests in Serbia are natural coppice stands. These stands are generally less productive and more degraded, especially in privately owned forests. Natural high forests make up 26% of the total area, while about 8% consists of artificially established stands. High forests are mostly located in public ownership and are managed using silvicultural interventions such as thinning, sanitation, and regeneration cuts to ensure long-term productivity and ecological stability.

The composition of forest stands by mixture reveals that 45% of forests are pure broadleaf, 42% are mixed broadleaf, 7% are pure coniferous, and 3% are mixed broadleaf and coniferous stands. In terms of tree species, beech (Fagus sylvatica) dominates the growing stock with over 200 million m^3, followed by various oak species (Quercus spp.) with around 145 million m^3. Other important species include hornbeam, black locust, poplar, spruce, pine, and fir.

A significant portion of public forests in Serbia is FSC certified. PE “Srbijašume” manages over 850.000 hectares of forest under FSC Forest Management certification, while PE “Vojvodinašume” holds FSC certification for approximately 127.000 hectares. Some national parks, such as Fruška Gora, also follow FSC standards, although management approaches may vary depending on conservation priorities.

Private forests are rarely certified and generally lack formal management plans. Nevertheless, there are ongoing efforts to improve their management through training programs, advisory services, and the promotion of forest owner associations.

In Serbia, in 2023, the largest production related to the production of logs, and it amounted to 3,3 million m^3, and followed by the production of firewood amounted to 1,73 million m^3 and production of roundwood for industrial use amounted to 1,33 million m^3. The production of wood for pulp and paper has been 0,1 million m^3.

The production of conifer logs in 2023 in Serbia, it amounted to 0,4 million m^3 and the production of broadleaf logs registered a decrease, and amounted to 2,9 million m^3.

The production of conifer firewood, amounted to 0,13 million m^3, and the production of broadleaf firewood registered a decrease, and amounted to 1,6 million m^3, and the production of conifer

roundwood for industrial use amounted to 0,23 million m^3, and the production of broadleaf roundwood for industrial use amounted to 1,6 million m^3.

Within the traditional sectors of forestry and wood processing (A02 Forestry and logging, C16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials, and C31 Manufacture of furniture + C32 other manufacturing, Serbia has approximately 3.300 of business entities. These entities collectively employed approximately 51.000 of workers, and generated approximately a revenue of 1.940 million EUR.

There is no large-scale production of wood-based chemicals such as biofuels, bioplastics, or specialty wood chemicals in Serbia. Charcoal production (for barbecue fuel) does exist in rural areas, converting wood to a chemical product via pyrolysis; however, this is small-scale and often falls under traditional production rather than large chemical factories.

Accordint to the data on imports and exports of roundwood and firewood in Serbia for the years 2021–2023, roundwood for industrial use shows fluctuating trends:

- Conifer imports decreased from 18.000 m^3 in 2021 to 7.000 m^3 in 2023, while exports varied, peaking at 11.000 m^3 in 2023.
- Broadleaf imports also declined, from 49.000 m^3 in 2021 to 19.000 m^3 in 2023, with exports dropping significantly from 78.000 m^3 in 2021 to 30.000 m^3 in 2023.

Firewood trade shows no imports across all three years, while exports were 11.000 m^3 in 2021, declining to 8.000 m^3 in 2022, and absent in 2023.

For logs for sawmilling and veneer, as well as wood for pulp, paper, and other industrial uses, lack data.

Overall, the data highlights a decreasing trend in both imports and exports of broadleaf roundwood and firewood, while conifer trade fluctuates but remains modest.

Detailed foreign trade data (for roundwood) is largely unavailable. Even the presented export figures should be taken with caution, as actual volumes are likely higher due to exports in the form of flitches and semi-processed wood not clearly recorded in official statistics.

5.6.2. Identification of value chains in forestry and wood processing

The forestry and wood processing sector in Serbia holds significant potential for transitioning toward a circular bioeconomy, with an increasing number of value chains oriented not only around traditional material processing, but also around resource efficiency, waste minimization, and cascading use of wood.

The well-established value chain begins with forest management and logging and extends to the production of high-value final products. After felling, roundwood is sorted into assortments such as sawlogs, veneer logs, pulpwood, and firewood, which are then directed to primary processors. The sawlogs are processed in numerous sawmills across the country (especially in rural areas), the majority of which are SMEs, contributing to local employment and rural development. In fact, sawmills alone make up about 49% of all wood-processing companies, reflecting the abundance of small-scale operations. Serbia has a strong tradition of hardwood processing, with beech and oak being the most frequently used species due to their abundance and high quality. In the primary processing stage, the

focus is on maximizing the yield from each log, with offcuts, bark, and sawdust mainly being used for heat energy production.

The secondary processing stage includes the production of a wide range of wood products such as solid wood furniture, parquet flooring, veneers, wood-based panels (e.g., particleboard, plywood, MDF), and biomass products like pellets and briquettes. Furniture manufacturing is a particularly important sub-sector and represents a major part of Serbia's wood industry exports. The sector includes both larger industrial manufacturers and a large number of small craft workshops focused on custom or niche production. Serbian manufacturers specialize in solid wood furniture (especially dining and living room furniture made of oak and beech), upholstered furniture, office furniture, as well as mattresses and related furnishings. A notable portion of production is custom or design-oriented, building on a legacy of woodworking craftsmanship. The furniture sector is highly export-oriented and in 2023 approached EUR 700 million. Within the panel industry, Serbia has one particleboard manufacturer (Kronospan in Lapovo), one MDF producer (Simpo ŠIK in Kuršumlija), and two plywood producers (Novi Drvni Kombinat and Simpo ŠIK).

In recent years there is interest toward production of engineered wood products (e.g. CLT, glulam) and biocomposites. The value chain also includes ancillary industries such as packaging, bioenergy, and paper production. While the pulp and paper industry is less developed than the wood processing and furniture sectors, it is still an important part of the broader value chain. The sector comprises more than 600 companies, although many are small packaging producers and converters; the sector is actually dominated by a few large mills. The total export of the paper industry was approximately EUR 800 million in 2023, making it the largest of the forest-based industries by export value (but still with trade deficit due to high import). Major products include packaging paper and cardboard (corrugated boxes, paperboard) and household/sanitary paper products. The Umka cardboard mill is a significant domestic producer of recycled paperboard, and the industry increasingly relies on recycled fibers and imported pulp, as Serbia has limited domestic pulp production.

The wood industry structure is somewhat fragmented – a few larger firms operate modern mills and panel factories, but the majority are small sawmills or workshops. This fragmentation presents opportunities for better utilization of wood residues and value-added processing. However, vertical integration is limited, with most companies specialized in only one stage of the value chain—whether logging, primary processing, or secondary manufacturing.

5.6.3. Comparative advantages of the area

Serbia possesses a range of comparative advantages that position its forestry and wood processing sector for further growth and integration into regional and global value chains. One of the country's key strengths lies in its abundant and diverse forest resources, covering nearly 40% of the national territory. With a growing stock of close to 500 million cubic meters of hardwoods, Serbia has a solid raw material base, particularly in high-quality hardwood species such as beech and oak, which are in high demand across Europe and worldwide. Although species like hornbeam, black locust, and some other native hardwoods are currently underutilized, they offer significant future potential, especially in light of changing market demands and climate adaptation needs. In particular, black locust and other drought-tolerant hardwoods may play an increasingly important role as forest composition and harvesting strategies evolve.

Another important advantage is the country's geostrategic location, which provides convenient access to both EU markets and regional trading partners. The country benefits from preferential trade agreements with the EU, CEFTA, and EFTA countries, as well as growing logistics and transport infrastructure. While the road network is relatively well developed, with several international corridors crossing the country, the rail transport system remains underdeveloped. However, major modernization projects are currently underway and are expected to significantly improve connectivity, reduce logistics costs, and enable more efficient export flows in the near future.

The Serbian wood industry is also supported by a skilled labor force and a strong tradition of craftsmanship, particularly in furniture and interior design. Many companies combine long-standing woodworking skills with modern production technologies, enabling the creation of both standardized and custom-made, design-oriented products.

Labor and operating costs in Serbia remain competitive compared to Western Europe, which supports the growth of export-oriented SMEs, especially in rural areas. Moreover, development programs increasingly support digitalization, green transition, and innovation in the wood sector, including energy efficiency, use of wood residues, and sustainable sourcing.

Finally, Serbia's forestry and wood industry has strong untapped potential in the utilization of by-products and the development of circular business models. Wood residues such as sawdust, bark, offcuts, shavings, and even wastewater from hydrothermal processes are increasingly viewed as valuable secondary raw materials. These can feed into the production of composite panels, biomaterials, or even bio-based chemicals. With improved infrastructure and coordination, industrial symbiosis – whereby one industry's by-product becomes another's input – could be fostered between sawmills, furniture producers, panel manufacturers, and other industries. This would not only increase material efficiency but also open space for innovation-driven enterprises.

The furniture sector, already Serbia's leading value-added exporter within the wood industry, is especially well-positioned to benefit from these developments. By integrating circular and bio-based materials – such as panels or components made from wood industry residues – furniture producers can diversify their product lines, reduce dependency on virgin materials, and respond to growing market demand for sustainable and low-carbon products. At the same time, adopting eco-design, modular construction, and repairable or reusable product models can extend product life cycles, support remanufacturing, and open up new business opportunities in line with the principles of the circular economy.

5.7. Croatia

5.7.1. Forest, forest management and wood industry

The total area of forests and forest land in Croatia covers approximately 2.76 million ha, representing around 49 % of the country's land surface. The overall standing volume is estimated at about 552,6 million m³ (Conifers – 124,8 million m^3, Broadleaves – 427,8 m^3), with an average annual increment of 12,2 million m³ (Conifers – 2,4 million m^3, Broadleaves – 9,8 m^3), indicating a relatively stable and well-managed forest resource. Average standing volume is roughly 200 m³ per hectare. The annual allowable cut in Serbia is 7,5 million m^3, while actual annual felling is 5,5 million m^3.

Forest ownership in Croatia is predominantly public: about 76% (2.097.318 ha) of all forests belong to the Republic of Croatia, while the remaining 24% (661.721 ha) are privately owned. Public forests are managed by Hrvatske šume d.o.o., the state-owned company responsible for some 2 million ha of forests and forest land. Private forests are often small and fragmented, which poses challenges for effective supervision, planning and operational management.

In structural terms, Croatian forests are mainly natural. High (seed-origin) forests account for roughly 56% of the area, whereas low coppice forests cover about 14%. The most widespread tree species are European beech (*Fagus sylvatica*), pedunculate oak (*Quercus robur*), sessile oak (*Quercus petraea*), silver fir (*Abies alba*), European hornbeam (*Carpinus betulus*) and Norway spruce (*Picea abies*). Other important components include downy oak, black pine, common hornbeam and sweet chestnut. Stands are typically mixed, which strengthens ecosystem resilience and habitat stability.

On average, around 6 million m^3 of gross timber is harvested each year, fully respecting sustainability principles because removals remain within the limits of the annual increment. This balance secures the long-term equilibrium between utilisation and regeneration. Most harvesting takes place in state forests, while private forests contribute far less owing to limited organisation, difficult accessibility and the absence of detailed management plans.

Hrvatske šume d.o.o. holds FSC® (Forest Stewardship Council) certification covering more than 2 million ha of state forests, demonstrating compliance with high environmental and social standards of forest management. Certification is rare among private forests, yet recent initiatives - particularly training programmes and owner associations - are encouraging greater uptake of planned management in the private sector.

Forest management in Croatia is oriented toward multiple functions - protective, ecological, social and productive. Forests play a key role in climate-change mitigation, soil and water protection, biodiversity conservation and rural development, especially through wood-processing activities and forest-based tourism[7].

5.7.2. Identification of value chains in forestry and wood processing

The forestry and wood-processing sector in Croatia holds considerable growth potential within the framework of a circular bio-economy. The wood-based value chain is increasingly oriented toward sustainable resource use, higher material efficiency and reduced waste. Cascade utilisation of wood and full exploitation of every part of the raw material are becoming the dominant approach, ensuring both competitiveness and environmental sustainability.

The value chain starts with sustainable forest management, largely overseen by the state-owned company Hrvatske šume d.o.o.. After harvesting, logs are sorted into various assortments—saw logs, veneer logs, technical timber and fuelwood—which are then delivered to primary processors. Primary processing, carried out mainly in sawmills and facilities producing sawn timber, is present in every region, especially Slavonia, Gorski Kotar and Lika. Croatian sawmilling relies heavily on pedunculate oak, a high-quality export product, as well as beech and silver fir.

[7] https://adria-balkan.fsc.org/hr/sume-u-hrvatskoj
https://www.hsups.hr/privatne-sume-u-hrvatskoj/
https://www.drvo-namjestaj.hr/vijesti/gospodarenje-sumama-u-rh-u-vlasnistvu-drzave-je-vise-od-2-milijuna-ha-suma/

Most sawmills are small and medium-sized enterprises that typically operate locally and form the backbone of rural economies. Primary processing generates large volumes of residues—sawdust, bark and off-cuts—that are increasingly used to produce biomass fuels such as pellets and briquettes, further integrating the sector into a circular economic model. To a lesser extent, residues are also employed for electricity and heat generation.

Secondary processing encompasses the manufacture of furniture, finished flooring (parquet, laminate), veneers and wood-based panels (particleboard, MDF, OSB). Furniture production is the most important segment of secondary processing and the leading export product of Croatia's wood industry. The country has a long tradition in furniture manufacturing, particularly solid-wood furniture made from oak and beech. The market includes large companies (e.g. Spin Valis, Mundus Viridis, Ancona Group, Prima Group) alongside many small workshops and specialist producers offering designer or custom-made pieces.

In the panel industry, Croatia hosts several active manufacturers such as Bjelin Otok d.o.o., Strizivojna Hrast d.o.o., DIV HM d.o.o. and the Pervanovo Group, known for innovative wood flooring. Domestic production of particleboard and MDF remains limited, with some raw materials imported. Nevertheless, there is growing interest in engineered wood products—such as CLT panels and glulam—which aligns with the national strategy of adding value to forest resources.

The value chain also covers numerous related industries, including packaging, biomass, the paper sector, eco-design and sustainable construction. Although pulp and paper production is not highly developed, Croatia does have manufacturing facilities for paper and packaging (e.g. DS Smith Belišće). This segment increasingly relies on recycled fibres and imported pulp, as Croatia lacks large-scale primary pulp production.

The wood-processing sector in Croatia is fragmented: most companies are SMEs specialising in only one phase of production. Vertical integration is still limited, though there are positive examples in Slavonia and Međimurje where firms have combined multiple stages—from sawmilling and component manufacture to the production of finished furniture or flooring.

Raising added value and improving value-chain efficiency are key challenges and strategic objectives set out in the National Plan for the Development of Wood Processing and Furniture Manufacturing 2022–2030. That document highlights digitalisation, environmental standards, certification and internationalisation as the main drivers of future sector growth.

5.7.3. Comparative advantages of the area

The Republic of Croatia possesses a range of comparative advantages that support the development of forestry and wood processing, particularly in the context of the transition toward a sustainable circular bio-economy and the strengthening of competitiveness in regional and international markets. One of Croatia's key strengths lies in its high degree of forest cover—almost 50 % of the national territory is wooded, and these forests are largely natural and ecologically stable. Croatia is endowed with abundant hardwood reserves, especially pedunculate oak, beech, ash and hornbeam, which rank among the most valued species on the European market. In addition, the high level of preservation and biodiversity of forest ecosystems represents an added value in terms of environmental protection and climate-change adaptation.

Croatia's geostrategic position is another advantage: the country is a member of the European Union and lies at the intersection of major transport corridors between Central and South-East Europe. Access to the Adriatic Sea enables efficient maritime export and import of raw materials and products, while a well-developed road and rail infrastructure further facilitates distribution and connectivity with neighbouring markets. The Port of Rijeka, as a strategic gateway for goods from Asia and the Mediterranean, has the potential to strengthen the sector's logistics capacity even further.

Croatia boasts a long tradition in wood processing and furniture making, rooted in centuries-old craft and industrial heritage. The country has an extensive network of small and medium-sized enterprises specialising in design, handcrafted production, restoration and customised furniture, alongside larger industrial manufacturers that supply both domestic and export markets. A skilled workforce, an expanding number of vocational-education programmes and access to modern technologies further underpin the sector's competitiveness.

Production costs in Croatia are lower than in the more developed EU member states, and government incentive schemes - including grants for production modernisation, digital transition, energy efficiency and the introduction of innovations - actively support the sector's transformation toward higher added value and a reduced carbon footprint.

Croatia's wood-processing and furniture sector is showing growing interest in using by-products (sawdust, bark, off-cuts, waste wood) to produce biomass, composite panels and even biocomposites and eco-friendly insulation materials. There is considerable scope for developing industrial symbiosis, whereby by-products from one segment of production become raw materials for another—for example, between sawmills, pellet producers and companies manufacturing wood-based panels and furniture. Such business models support the circular economy, reduce waste volumes and create new value streams.

The furniture-manufacturing segment, already one of the leading exporters within the wood industry, is particularly well positioned to integrate circular materials and apply eco-design principles. Modular construction, reparability and recyclability are increasingly sought-after features on European markets, and Croatian companies are progressively adopting these concepts. This opens opportunities for expansion into markets with high sustainability standards, such as the Scandinavian countries, Germany and Austria.

Ultimately, Croatia possesses strong potential to develop domestic added value, reduce the export of raw logs and reinforce the local processing chain. Through strategic planning, innovation and the promotion of cooperation within the sector, it is possible to make even better use of the existing natural, spatial and human resources and to position Croatia as a leader in sustainable development within the wood sector of the Adriatic-Ionian region.

5.8. Conclusion

The regions covered by the FULAR project have different forest resources and levels of development of the wood industry.

FULAR

Greece has limited forest areas with a growing stock, reflecting a significant natural asset both ecologically and economically. Management practices are guided by sustainable forest management (SFM) principles as per EU directives. The wood industry mainly depends on imports. The forestry value chain in Greece spans from raw material extraction to end-user products.

Italy has limited forest areas but an extremely developed wood-processing and furniture industry, with strong brands and design. It imports raw materials but exports high value-added final products. Friuli Venezia Giulia Region stands out as a regional and European leader in the forestry and wood-processing sectors. It also boasts a rich industrial heritage in woodworking and furniture manufacturing. The renowned Distretto della Sedia (Chair District), centered in Manzano, is internationally recognized for its excellence in furniture production, both artisanal and mass-market. Generations of skilled labor have combined traditional craftsmanship with cutting-edge design and automation technologies. Friuli Venezia Giulia Region has developed a well-structured and innovative forest-wood value chain, rooted in sustainable forest management, local cooperation and diversified transformation processes.

Slovenia is one of the most forested countries in Europe. This provides a sustainable and reliable source of raw materials for the wood industry, ensuring a consistent supply for processing. It is known for producing high-quality timber (wood auctions) and wood products. The forest-wood value chain in Slovenia integrates sustainable, multifunctional, and close-to-nature forest management with wood processing, design, manufacturing, and marketing of wood products and other wood-based components, as well as the utilization of wood residues and waste for energy production.

Bosnia and Herzegovina has rich forest resources and a long tradition in the wood industry. The forests are characterized by a great diversity of types due to the country's excellent geographical position and various climatic influences. However, value chains are poorly developed. Primary production dominates, generating the least added value. It is traditionally export-oriented. The reasons for this lie in B&H favorable geographic location (proximity to EU markets), lower operating, energy, and labor costs, which allow businesses to produce high-quality standard furniture at a price lower than that of competitors for the same level of quality.

Albania has limited forest resources, which is why a significant share of wood is imported. Imports of wood-based materials (roundwood, sawn timber, panels) supplement domestic supply, feeding directly into sawmills, furniture, and construction material producers. Albania’s forestry and wood processing sectors include companies engaged in four main types of activities: harvesting, trading wood materials, wood processing and fuelwood production. In recent years, there has been a noticeable trend of increasing investments in new technologies (mainly in machinery or CNC production lines), which can contribute to higher productivity and production.

Serbia has a growing wood industry and considerable forest potential. It has a solid raw material base, particularly in high-quality hardwood species such as beech and oak, which are in high demand across Europe and worldwide. Also, it has a strong tradition of hardwood processing. Furniture manufacturing is a particularly important sub-sector and represents a major part of Serbia’s wood industry exports. The Serbian wood industry is also supported by a skilled labor force and a strong tradition of craftsmanship, particularly in furniture and interior design. Many companies combine long-standing woodworking skills with modern production technologies, enabling the creation of both standardized and custom-made, design-oriented products

Croatia has significant forest resources and a developed wood industry, particularly in furniture production. Croatia is endowed with abundant hardwood reserves, especially pedunculate oak, beech, ash and hornbeam, which rank among the most valued species on the European market. It can boasts a long tradition in wood processing and furniture making, rooted in centuries-old craft and industrial heritage. Croatia has an extensive network of small and medium-sized enterprises specialising in design, handcrafted production, restoration and customised furniture, alongside larger industrial manufacturers that supply both domestic and export markets.

5.9. Regulatory Framework for Wood Species and Waste and By-Product Use in the Furniture Sector

Legal and regulatory conditions play an important role in shaping which wood species and wood-based materials are permitted or favoured in the furniture and wood product sectors. Across project partner countries, these regulations address a wide range of aspects, from forest management and biodiversity protection to timber trade, product safety, and public procurement.

The regulatory environment influences not only the availability of certain species but also the use of by-products, recycled wood and imported materials. In many cases, compliance with specific legal provisions is a prerequisite for accessing public markets or international trade. National and regional frameworks are further reinforced through the implementation of EU regulations and international conventions, contributing to the wider goals of sustainable resource use and environmental protection.

Legal and regulatory conditions for influencing the use of waste and by-products in furniture production and wood processing also show how suitable or restrictive a country's legislative and political system is for utilizing waste and by-products in circular business models. In all partner countries within the project, these regulations cover a wide range of aspects. They provide definitions of waste/by-product categories, which is important since by-products can often be reintroduced into the production cycle without being treated as waste. These regulations also define how waste should be collected, stored, treated, recycled, or used in production.

An overview by country highlights the most relevant legal instruments and their potential impact on material selection.

5.9.1. Greece

In Greece, wood-species selection and Waste and by-product use for the production of furniture and wood products and is shaped primarily by EU regulations and specific Greek forestry legislation

- The **EU Regulation 995/2010** (EU Timber Regulation - EUTR) applies in Greece and prohibits the trade of illegally harvested wood and its products in the EU. There are specific obligations for producers/importers, like the documentation of the legal origin of the wood, the implementation of due diligence systems and the recording of wood species, origin and suppliers.

- The **EU Deforestation-Free Regulation** (EUDR 2023/1115) which replaces the EUTR (from December 30, 2024 onward), will be implemented in Greece through the Ministry of Environment

and Energy, which will designate the competent authorities and procedures for the supervision and compliance with the regulation. The regulation aims to minimize the impacts of deforestation and forest degradation from products imported into the EU. The application of the regulation for large operators and traders starts from 30 December 2025, while for small businesses from 30 June 2026.

- The **Regulation for Endangered Species – CITES**, where Greece is a party of the CITES Convention, which is designed to protect endangered species from the impacts of international trade and aims to make trade sustainable and prevent species from becoming extinct due to over-exploitation. In Greece timber species such as mahogany (Swietenia spp.), palisander (Dalbergia spp.), and rosewood are subject to strict restrictions and special import/export permits and certifications are required.

- The **Greek forestry legislation** (Law 998/1979 and amendments) regulates the management and logging of forest resources, providing for, i) the prohibition of logging without a relevant permit (individual or contractor), ii) the protection of indigenous species (e.g. Abies cephalonica, black pine), iii) the regulations for private and public forests logging, iv) control of forest products transportation through the forest services.

- The product quality and safety regulations that the furniture manufacturing companies in Greece must comply with consist of the **REACH Directive** for chemical substances (e.g. glues, varnishes on wood), the **ELOT and CE marking standards** for mechanical strength, formaldehyde emissions, and fire safety, as well as the **safe use of recycled wood** based on its chemical properties.

Additionally, there are restrictions on imports of wood species from specific countries, as well as the control of imports being carried out by customs authorities for certifications of origin (e.g. FSC, PEFC). There is a ban on imports from certain regions due to violation of environmental rules (e.g. timber from illegally logged forests in Africa or Asia). Furthermore, the Greek regulatory framework applies a set of environmental and ecological constraints for sustainable forest management and for strengthening the circular economy and the use of recyclable or certified materials. Finally, incentives or subsidies for the use of local wood species from agroforestry systems (e.g. chestnut, oak) have been applied.

- **Waste Framework Directive (2008/98/EC) and Greek Waste Law (Laws 4042/2012 & 4819/2021)**
  Greek legislation fully harmonizes national law with the EU Waste Framework Directive, establishing clear definitions for by-products and the end-of-waste status. This means that specific production residues, such as wood offcuts, sawdust, or other woody waste, can be reused or recycled as materials if they meet strict quality and environmental criteria, preventing their further classification as waste.

  The waste hierarchy gives absolute priority to waste prevention, followed by reuse and recycling, while disposal is the last option. This hierarchy shapes business practices, encouraging furniture manufacturers to favor the utilization of by-products rather than their disposal.

  Furthermore, the implementation of Extended Producer Responsibility (EPR) introduces financial and managerial obligations for furniture producers and importers, strengthening recycling and reuse efforts. This means that companies must participate in systems for the collection, recovery, and management of waste generated from their activities.

- **Landfill Directive (1999/31/EC) and National Waste Management Plan (ESDA)**
  This Directive prohibits the disposal of untreated biodegradable and hazardous waste in landfills, protecting the environment from long-term harmful effects. In Greece, through the National Waste Management Plan, an ambitious target has been set to reduce landfill disposal to below 10% by 2030. Additionally, mandatory separate collection of bio-waste and recyclables was established by the end of 2022 to enhance the efficiency of waste stream management.

  These policies directly affect furniture producers, as wood waste can no longer be sent directly to landfills, forcing them to seek reuse, recycling, or energy recovery solutions.

- **EU Timber Regulation (EUTR 995/2010) and Its Greek Implementation**
  This Regulation serves as a tool to prevent the trade of illegal timber on the EU market. It requires producers and importers to implement due diligence systems to ensure the legality of the origin of timber and timber products. This applies to both domestic and imported timber, including by-products such as wood offcuts used in furniture production.

  Compliance with these rules necessitates transparency in sourcing and may limit or direct the selection of raw materials and by-products to those coming from legal sources, enhancing sustainability and adherence to European and national legal frameworks.

- **Industrial Emissions Directive (2010/75/EU) and Greek Pollution Control Legislation**
  Facilities applying chemical treatments to wood, such as preservation or production of composite wood products with chemical additives, must obtain Integrated Pollution Prevention and Control (IPPC) permits. The legislation also requires the application of Best Available Techniques (BAT) to reduce pollutant emissions, protecting human health and the environment.

  These restrictions impose strict controls and limits on the technologies and raw materials that can be used, affecting the types of by-products that may be incorporated into furniture products.

- **Packaging and Plastics Regulations (Law 2939/2001 & Directive 94/62/EC)**
  This legislation focuses on packaging waste management, promoting the use of recyclable and reusable materials, and integrates obligations for EPR systems. Furniture manufacturers are directly affected in the packaging and transportation of their products, as they must ensure that their packaging complies with new environmental standards, reducing waste and facilitating recycling.

- **Specific Waste Streams – Furniture, Wood, Construction and Demolition**
  The separate management of wood waste originating from construction and demolition is governed by specific Greek decisions (e.g., Joint Ministerial Decision 36259/2010, Laws 4030/2011, 4067/2012). Moreover, new EPR schemes related to furniture and wood waste are being developed to strengthen collection, recovery, and recycling of these streams.

  Compliance with these regulations shapes waste management strategies for wood and furniture industries, enforcing practices that incorporate sustainable circular economy solutions.

5.9.2. Italy

The use of wood in Italy's furniture industry is governed by a complex and evolving regulatory framework that combines European Union legislation, national standards, international certifications and regional policies. This system ensures legality, sustainability and traceability throughout the supply chain, significantly influencing the selection of wood species and sourcing practices in the sector.

EU Regulations: Legality and Sustainability First

At the European level, two key regulations shape the use of wood in furniture manufacturing:

- **EU Timber Regulation (EUTR – Reg. EU 995/2010)**
  Enforced since 2013, the EUTR prohibits the placement of illegally harvested timber on the EU market. It imposes a due diligence obligation on operators introducing wood products for the first time, requiring them to collect data on species, origin, suppliers, and quantities, assess risk, and implement mitigation measures. Mandatory traceability ensures transparency across the supply chain, and non-compliance can lead to sanctions.
- **EU Deforestation Regulation (EUDR – Reg. EU 2023/1115)**
  Entering into force in December 2024, the EUDR introduces stricter requirements, mandating that wood products must be deforestation-free (no deforestation or forest degradation after December 31, 2020) and legally produced in their country of origin. It also requires geolocation data of the wood source. SMEs have raised concerns about implementation, and calls for transitional support have been voiced by industry associations like FederlegnoArredo.

Italian National Framework: "Made in Italy" and Product Origin

- **UNI 11674:2017**
  This technical standard outlines the criteria for claiming a product as "Made in Italy", including full design and production within Italy and adherence to safety and durability norms.
- **Law 166/2009**
  This law legally protects the 100% Made in Italy label, imposing penalties on false claims. It incentivizes the use of local species and domestic production chains, reinforcing Italy's global reputation in craftsmanship and quality.

Regional Legislation: FVG as a Model for Local Wood Use

- **Friuli Venezia Giulia Regional Law 3/2021 – Article 79**
  This progressive regional law encourages the use of local wood, promoting sustainable forestry projects that include traceability systems, certified materials, ERP/MRP integration, and alignment with EU environmental regulations. It provides funding and incentives for innovation and sustainability in forestry and wood-based industries.

Italy's regulatory environment increasingly favors:

- The use of locally sourced, certified wood
- The avoidance of protected or non-traceable species
- The adoption of formal due diligence systems and certifications
- The alignment with regional incentives and EU green policies

5.9.3. Slovenia

The Forest Act is the fundamental legislation governing the management of forests in a sustainable and environmentally sound manner, including the protection of the environment and biodiversity. Under the Forest Act, forest management plans are prescribed, which, among other things, regulate permissible logging and provide guidelines for the management of specific tree species in designated areas. Through its defined restrictions and directives, the Forest Act directly impacts the availability of timber and the supply to the wood industry.

The Nature Conservation Act stipulates that timber must be sourced in a sustainable manner and that timber harvesting should not contribute to deforestation or the destruction of natural habitats. It provides for the protection of endangered tree species, prohibiting or strictly limiting their felling, thereby restricting the availability of certain wood species for the wood industry. The Nature Conservation Act also imposes restrictions on the use and management of non-native tree species if these species threaten biodiversity or the health of ecosystems.

In Slovenia, **EU Regulation No. 995/2010 (EU Timber Regulation – EUTR)** is applicable, requiring companies to fulfill prescribed obligations to ensure the legal sourcing of timber and timber products.

In accordance with **EU Regulation No. 305/2011**, it is mandatory in Slovenia to mark construction timber with the CE mark. When a manufacturer affixes or authorizes the affixing of the CE mark to a construction product, they thereby assume responsibility for the product's conformity with the specified properties and compliance with all applicable requirements set out in the regulation and other relevant harmonized EU legislation regarding the affixing of the mark. (www.les-gozd.com)

In Slovenia, the **EU Action Plan for Forest Law Enforcement, Governance and Trade (FLEGT)** is being implemented, which stipulates that the establishment of a licensing scheme is a measure to ensure that only timber products harvested in accordance with the legislation of the producing country can enter the EU. Under the licensing scheme, certain timber products imported into the EU from a partner country via any border crossing point for the release of goods into free circulation must have a license issued by the partner country, confirming that these timber products are made from domestically sourced, legally harvested timber or from timber legally imported into the partner country in accordance with national legislation[8].

The Regulation on Green Public Procurement governs the procurement of goods, services, or construction works that, compared to conventional goods, services, and construction works, have a lower environmental impact throughout their entire lifecycle, ensure savings in natural resources, materials, and energy, and offer equal or better functionality. Among other provisions, it stipulates that: a) the proportion of wood or wood-based materials in furniture must constitute at least 70% of the volume of materials used for the production of furniture, unless prohibited or made impossible by regulations or the intended use; b) the proportion of recycled or reused construction timber in wooden wall panels must be at least 10% and c) the proportion of wood or wood-based materials in building furniture must constitute at least 80% of the volume of installed materials (excluding glass and building hardware), unless prohibited or made impossible by regulations or the intended use.(https://pisrs.si/pregledPredpisa?id=URED7202)

[8] https://www.fu.gov.si/carina/prepovedi_in_omejitve/prepoved_trgovine_z_lesom_flegt#c4518

In Slovenia, the **PEFC certification scheme for forest management** applies nationwide, and interested owners can participate in it. According to data from 2021, 1,243 owners were included, representing only 0.3% of all owners; however, these owners managed 303,489 hectares of forest, which represents 26% of all Slovenian forests. (P.Bele;Trajnostna raba lesa, Certificiranje in standardi za dodano vrednost izdelka)

CoC certification means the monitoring of companies in the wood processing chain, from the felling of timber in certified or controlled forests, trading in wood, processing into semi-finished products, to the production of final products. If a manufacturer wants to promote a final product as certified, all companies in the supply chain must also be certified. In Slovenia, in 2021, 258 valid FSC CoC certificates were issued, involving 350 legal entities, and 80 valid PEFC CoC certificates were granted. (P.Bele;Trajnostna raba lesa, Certificiranje in standardi za dodano vrednost izdelka)

In summary, Slovenia's legal framework for the forest and wood processing industry is characterized by a strong emphasis on sustainability, legal compliance, and value chain integration. Through a combination of national legislation, strategic planning, and international cooperation, Slovenia aims to maximize the economic potential of its forests while preserving their ecological integrity for future generations.

In Slovenia, the use of by-products and waste in the production of furniture and wood products is legally regulated by several legislative acts, stemming from both national and European legislation. These regulations set out the conditions, limitations and possibilities for the integration of these materials into production processes, especially in the context of a circular economy.

Key legislative regulations and legal restrictions:

1. **Environmental Protection Act (ZVO-2)**
   The Environmental Protection Act (ZVO-2) is the fundamental environmental law in Slovenia, which sets out the principles, measures and instruments for preventing environmental pollution and promoting sustainable development. It sets out or regulates the conditions for waste management, including by-products, and also introduces the principle of "waste as a resource", which means that materials that are not hazardous and are properly treated can be reused in production. It sets out and regulates the conditions regarding emissions, natural resources and promotes a circular economy, and incorporates European environmental directives.

   The use of by-products is permitted if they do not pose a risk to the environment or human health.

2. **Waste Regulation**
   The Waste Regulation (Official Gazette of the Republic of Slovenia, No. 77/22, 113/23, 13/25) is the fundamental implementing regulation that regulates waste management in Slovenia. It was adopted with the aim of protecting the environment and human health and reducing the negative impacts of waste generation and management. The regulation is based on the European Directive 2008/98/EC on waste and sets out rules for the prevention, reduction, collection, processing and disposal of waste. The regulation applies to all types of waste, except for those that are specifically regulated by other regulations (e.g. radioactive waste, faecal matter, waste gases). It places special emphasis on the waste management hierarchy, which includes prevention of generation, preparation for reuse, recycling, other processing (e.g.

energy recovery) and only then disposal. Another important innovation is the definition of the conditions under which a material ceases to be waste and becomes a raw material (the so-called "end-of-waste" status), which is key to a circular economy.

The regulation sets out the obligations of waste producers, collectors, processors and municipalities. It also includes requirements for the separate collection, traceability, reporting and management of hazardous waste. It also pays particular attention to packaging, construction waste, textiles and bio-waste. For example, separate collection of textile waste is mandatory at national level from 1 January 2025.

For industry, including furniture and wood processing, the regulation means that companies must ensure the proper separation and management of by-products and waste, including hazardous ones (e.g. varnish residues, adhesives). The use of these materials in production is only permitted if they do not pose a threat to the environment or human health and if they meet the conditions for reuse or processing.

The regulation thus represents a key legal framework for the transition to a circular economy, as it promotes the reuse of materials, reduces the amount of waste and increases the responsibility of all stakeholders in the waste management chain.

3. **The Regulation on the Management of By-Products**
The Regulation on the Management of By-Products in Slovenia sets out the conditions under which materials that are generated as a by-product of the production process can be used as raw materials and not as waste. The purpose of the regulation is to promote a circular economy and reduce the amount of waste that ends up in landfills or incinerators. For material to be considered a by-product, it must meet four key conditions: it must be generated as a direct result of the production process, its further use must be ensured, and its use must be legal and safe for human health and the environment. If these conditions are not met, the material is considered waste and is subject to stricter management rules. The regulation is important for the wood and furniture industry, as it allows sawdust, chipboard residues, wood dust and other residues generated during production to be used as raw materials for new products – e.g. to produce pellets, composite panels or even furniture. This reduces the need for primary raw materials and promotes the sustainable use of resources. The regulation thus represents an important legal framework for companies that want to operate in accordance with the principles of the circular economy and sustainable development.

4. **Regulation on emissions of substances into the air from waste co-incineration plants**
The Regulation on emissions of substances into the air from waste co-incineration plants sets emission limit values and technical conditions for the operation of plants that co-incinerate waste in addition to the primary fuel. It was adopted on the basis of European Directive 2000/76/EC and is part of a broader environmental protection framework in Slovenia. The purpose of the regulation is to reduce the impact of emissions of harmful substances, such as nitrogen oxides (NO_x), sulfur dioxide (SO_2), dust, heavy metals and organic solvents, on air quality and human health. The regulation applies to all plants that co-incinerate waste – this also includes industrial furnaces, such as those in the wood and furniture industries, where wood residues containing adhesives, coatings or other chemicals can be used as fuel. In such cases, the plant must meet strict technical requirements regarding filtration, emission control and reporting. It is particularly important to determine the conditions under which certain wood residues can be used as fuel at

all. If they contain hazardous substances (e.g. formaldehyde, biocides), they may only be co-incinerated in plants that have the appropriate environmental permits and carry out continuous emission monitoring. The regulation thus has a significant impact on industrial practice, as it encourages the use of clean raw materials and at the same time restricts the use of contaminated residues if adequate environmental protection is not ensured.

5. **Regulation on packaging and packaging waste**
   The Regulation on Packaging and Packaging Waste is a key Slovenian regulation that regulates the management of packaging and packaging waste in accordance with European Directive 94/62/EC. The objective of the regulation is to reduce the environmental impact of packaging, encourage reuse, recycling and other forms of recovery, and thus contribute to the transition to a circular economy. The regulation sets out rules for placing packaging on the market, its labelling, collection, treatment and reporting. Special emphasis is placed on the extended responsibility of producers, who must ensure that packaging is properly collected and treated after use. It applies to all packaging, regardless of the material used in industry, trade, services and households. The regulation also includes obligations regarding separate collection and recycling targets that public service providers and producers must achieve. Sanctions are foreseen in case of failure to meet the obligations. The regulation is also important for the furniture industry, as it sets conditions for the use of packaging materials and their handling after use, which affects packaging design, logistics and the environmental responsibility of companies.

   In addition to basic legislation, such as the Environmental Protection Act (ZVO-2), the Waste Regulation and the By-Product Management Regulation, there are some additional regulations in Slovenia that are important for companies in the furniture and wood industry, especially if they want to incorporate by-products and waste into production. These regulations supplement the legal framework and set specific conditions, procedures or restrictions.

Important additional regulations include:

Waste Management Programme and Waste Prevention Programme
This is a strategic document that sets out objectives and measures to reduce waste, increase recycling and promote reuse. It also defines measures for the industry, including promoting the use of secondary raw materials.

Regulation on Emissions of Substances into the Air from Waste Co-Incineration Plants
It sets out the conditions under which certain wood residues (e.g. with residues of glues or varnishes) can be used as fuel. Use is only permitted in plants that meet strict environmental standards.

Chemical and product regulations
If materials containing hazardous substances (e.g. formaldehyde, solvents) are used in production, chemicals (REACH, CLP) and product safety legislation must be observed.

Regulation on packaging and packaging waste
Important for companies that use recycled or reused materials for packaging their products. It sets out obligations regarding the labelling, collection and recycling of packaging.

Regulations on the acquisition of secondary raw materials (SKD 38.210)

Regulates the conditions for activities related to the treatment and preparation of waste for reuse or processing into new products.

Together, these regulations form a comprehensive framework that enables companies to integrate circular practices while ensuring the protection of the environment and human health.

5.9.4. Bosnia and Herzegovina

Legal framework with regards to the application of procudures and activities in favour to the concept of circular economy is on the level of general recommendations, currently with no obligatory aspects for industrial actors.

Considering the complex administrative structure of Bosnia and Herzegovina (composed of two entities and one district), the forestry, wood processing, and furniture manufacturing sectors in Bosnia and Herzegovina operate within a complex legal framework. Bosnia and Herzegovina does not have a national (state-level) Forest Law that applies across the entire country. Instead, forest management is decentralized and takes place at the entity and cantonal levels, according to the competences defined by the Constitution of BiH and the constitutions of the entities.

The **Forest Law of the Republic of Srpska** (Official Gazette of RS no. 75/08, 60/13, and 70/20) defines the legal framework for the management, conservation, use, and protection of forests in the territory of the Republic of Srpska, regardless of ownership type (state or private forests). The goal of the law is sustainable forest management, protection, and improvement. According to the law, the management of state forests is carried out by the Public Enterprise "Forests of the Republic of Srpska" based on approved management plans. The Ministry of Agriculture, Forestry, and Water Management has supervisory and regulatory authority. The law mandates the preparation of a Forest Program, Forest Management Base (long-term plans), and annual forest management plans. Plans are adopted for each forest unit with the aim of sustainable resource use.

The law prescribes measures for protection against fires, diseases, and pests, forest regeneration and afforestation, biodiversity and genetic potential conservation, and the prevention of illegal logging. It also regulates the conditions for timber harvesting, utilization of wood and non-wood forest products, hunting, recreation, and more. The law also establishes a dedicated Forest Fund, which is used for forest protection and improvement, incentives for private forest owners, construction and maintenance of forest roads, and stipulates that forest users must pay certain fees for usage and concessions.

In the **Federation of Bosnia and Herzegovina**, there is currently no valid entity-level Forest Law. Seven out of ten cantons have adopted their own laws, except Sarajevo Canton, Herzegovina-Neretva Canton, and West Herzegovina Canton. These cantons rely on decisions, rulebooks, or draft laws.

Cantonal forest laws in the Federation of Bosnia and Herzegovina define the legal framework for the management, use, and protection of forests within individual cantons.

Although they differ in form and scope, all cantonal laws contain similar key provisions:

- Status and ownership of forests
- Management and forest governance (defining who manages the forests: typically the cantonal Ministry of Agriculture/Forestry and a public forest enterprise, along with the mandatory

preparation of 10-year forest management bases and annual plans – including logging and reforestation plans
- Use of forests and forest products
- Protection and preservation of forests – including protection from fires, diseases, and erosion; reforestation and forest regeneration after logging; and forest damage records
- Financing and fees – fees for forest use; concession royalties; funds for forest protection and development (with part of the funds going to local communities and part to cantonal budgets)

The **Brčko District** has its own regulations governing forest management (**Forest Law of Brčko District BiH**, "Official Gazette of Brčko District BiH", no. 14/10, 26/16).

The main objectives and principles of this law are to improve forest protection, ensure sustainable management and use of forests (both public and private), and emphasize biodiversity, fire protection, erosion and flood prevention, and preservation of the multifunctional value of forests.

The **Forest Law of Brčko District BiH** regulates in detail:
- sustainable forest management and protection,
- fire protection policy,
- public access and recreation,
- sanitary measures and planning,
- inspection, forest wardens' roles, and offenses with clearly defined financial penalties.

Restrictions arising from forest laws include:
- strictly regulated conditions for the use of forest resources (concessions, contracts, forest order).
- limited access to raw materials (especially for small and medium-sized processors) due to priority given to large concession holders.
- lack of transparent public tenders and irregular allocation of timber volumes.
- export restrictions on raw materials (in certain periods): bans or quotas on the export of logs are often considered in order to protect domestic wood processing.

Environmental Protection Regulation

Business entities in the wood processing sector must comply with environmental protection laws, particularly regarding waste disposal, dust emissions, and wastewater discharge.

These laws set limitations regarding the implementation of measures to reduce negative environmental impact (such as the use of filters, ventilation systems, and emissions monitoring), mandatory development of a waste management plan, obligations for sorting and proper disposal of wood waste, packaging, and hazardous waste (e.g., chemicals, varnishes, waste packaging), the requirement to cooperate with authorized waste collectors and to maintain waste disposal records, mandatory recycling of waste where technically feasible, restrictions on the use of hazardous substances (such as formaldehyde, toluene, phthalates), mandatory registration of chemicals, possession of safety data sheets, and labeling in accordance with CLP regulation, prohibition of using unregistered and unlabeled chemicals, limits on VOC emissions from paints, varnishes, and adhesives, and the obligation to install emission control devices (e.g., filtration systems, process encapsulation).

In accordance with these laws, obligations and restrictions by sector are as follows:

1. **For the forestry sector**
   An Environmental Impact Assessment (EIA) is mandatory for certain forestry exploitation activities (e.g., large-scale logging or construction of forest roads). Exploitation is prohibited in protected areas (national parks, nature reserves), and post-logging rehabilitation is obligatory (reforestation, erosion control).

2. **For the wood processing sector**
   It is mandatory to obtain an environmental permit for facilities (e.g., sawmills, board factories) and ecological permits for emissions into air, water, and soil (e.g., dust particles, wastewater). Waste management (dust, sawdust, wood protection chemicals) must be conducted in accordance with the Waste Management Law, and emissions of Volatile Organic Compounds (VOCs) during wood drying and gluing processes must be controlled.

3. **For the furniture manufacturing sector**
   For medium and large-capacity production facilities, an Environmental Impact Assessment and environmental permit are required. The use of paints, varnishes, and adhesives must comply with chemical and emissions regulations, while waste (wood residues, packaging, hazardous waste) must be sorted, stored, and disposed of according to regulations. Energy efficiency and the management of water and energy consumption are becoming increasingly important environmental standards (especially for export-oriented companies seeking ISO 14001 or EMAS certification).

Bosnia and Herzegovina is a signatory of the Stabilization and Association Agreement and is obligated to gradually harmonize with EU environmental directives. To access EU markets, export-oriented companies must comply with the following:

- REACH Regulation – registration and authorization for the use of substances.
- Ecolabel Criteria – limitations on the content of formaldehyde, toluene, xylene, etc.
- FSC/PEFC Certificates – although primarily focused on raw materials, they often include requirements for the use of non-hazardous coatings.

Considering the complex administrative structure of Bosnia and Herzegovina (composed of two entities and one district), the use of by-products and waste for the production of certain types of furniture or wood products is regulated by laws and other regulations at the entity level and in the Brčko District.

In the **Federation of Bosnia and Herzegovina**, the **Law on Waste Management** (“Official Gazette of FBiH” no. 33/03, 71/09, 92/17, and 72/24) establishes a general framework for solid waste management, including prevention, recycling, reuse, separation of secondary materials, energy recovery, and safe disposal.

Similarly, in the **Republika Srpska**, the **Law on Waste Management** (“Official Gazette of Republika Srpska nos. 111/2013, 106/2015, 2/2018 – Constitutional Court decision, 16/2018, 70/2020, 63/2021, and 65/2021 – correction) regulates types and classification of waste, waste management planning, waste management entities, responsibilities and obligations in waste management, organization of waste management, management of special waste streams, permit procedures, transboundary movement of waste, reporting and databases, financing of waste management, supervision, and other matters relevant to waste management.

In the **Brčko District**, the **Law on Waste Management** („Official Gazette of Brčko District BiH", no. 25/04, 1/05, 19/07, 2/08, 9/09) is in force, aiming to manage waste and encourage and ensure the main conditions for preventing waste generation, processing waste for reuse and recycling, extracting raw materials from waste for energy production, and safe disposal of waste.

The requirements of this law apply to municipal waste (household waste), commercial waste, and industrial waste.

Depending on the hazardous characteristics that affect human health and the environment, waste can be classified as inert, non-hazardous, or hazardous. Hazardous waste is classified according to its origin, characteristics, and composition that makes it hazardous. The owner of the waste, or the responsible person, is obliged to classify the waste in the prescribed manner, in accordance with this law. These requirements apply to urban, industrial, medical, and construction waste, among others.

The provisions of the law apply to all physical and legal persons, whether public or private, national or foreign, whose activities generate waste, as well as to those who hold waste or are engaged and licensed in the collection, storage, transport, recycling, processing, and disposal of waste. The law also applies to state institutions, civil society organizations, and individual citizens.

Although there is no specific law for wood waste, wood processing companies are subject to the general framework, where wood waste from production (sawdust, wood chips, excess wood) is defined as solid industrial waste.

In addition to the laws, there are numerous implementing acts (regulations, ordinances) issued by the entities, while cantons and local self-government units further regulate specifics such as issuing permits, calculating fees, maintaining waste registers, etc. Any use of wood waste, including activities related to waste management, such as collection and processing of wood production residues for recycling, production, or energy recovery, requires a permit for waste management.

5.9.5. Albania

Law No. 57/2020 "On Forests" is the fundamental law covering the entire forest management process, considering forests as assets of particular importance in climate protection, soil conservation, preservation and enhancement of productive potential, natural environmental balance, biodiversity, genetic resources, and the water regime. This law is partially aligned with:

- Council Regulation (EU) No. 2173/2005 "On the establishment of a FLEGT licensing scheme for imports of timber into the European Community";
- Regulation (EU) No. 995/2010 of the European Parliament and of the Council "Laying down the obligations of operators who place timber and timber products on the market";
- Commission Implementing Regulation (EU) No. 607/2012 "Laying down detailed rules concerning the due diligence system and the frequency and nature of checks on monitoring organizations as provided for in Regulation (EU) No. 995/2010 of the European Parliament and of the Council on the obligations of operators who place timber and timber products on the market."

The law aims to preserve, increase the area, and grow the total volume of the national forest fund and to establish a functional organization at all levels of governance for the sustainable exploitation and use

of forest resources. Its scope extends to all forests within the territory of the Republic of Albania, except for protected areas.

The Forest Policy Document of Albania, 2019–2030/2018, specifies the strategic objectives for the sustainable development of forests in Albania, as well as outlines the sectoral policies and measures that should be implemented to achieve these objectives.

Law 162/2020 "On Public Procurement" is applied by Local Government Units (LGUs) in tendering procedures for the use of forest areas under their administration.

Law 10448/2011 "On Environmental Permits" aims to prevent, reduce, and control pollution caused by certain categories of activities, in order to achieve a high level of environmental protection, human health, and quality of life. Among other things, this law defines the rules for permitting the activities that cause environmental pollution in the Republic of Albania, as well as the measures provided for preventing this pollution and, when prevention is not possible, measures for reducing their gaseous, liquid, and solid emissions into air, water, and soil. The law is fully aligned with the EU directive "Concerning integrated pollution prevention and control".

Strategic Policy Document for the Non-Food Industry (2016–2025)/2016, specifies the strategic objectives for the development of the non-food industry in Albania. For the wood, furniture, and paper industry, it aims to expand the range of solid wood products, which are highly demanded by foreign markets. Regarding the paper industry, the focus is on recycling waste to produce cardboard and certain products such as hygienic paper, packaging materials, etc.
Note: Currently, there is no legal framework for the certification of forests or the timber derived from them, nor for timber processed by Albanian wood processing companies.

Law No. 10463/2011 "On Integrated Waste Management" aims to ensure the protection of the environment and human health from pollution and harm caused by solid waste, through environmentally sound treatment at every stage: generation, collection, separation, storage, transportation, recycling, processing, and disposal, leading to waste reduction and minimizing their hazardous and dangerous impact. The law does not apply to hazardous, radioactive, nuclear, or explosive waste**.** The areas addressed by the law include:

- Reducing the amount of waste generated from production activities;
- Increasing the share of biodegradable, recyclable, and treatable waste in the total waste generated;
- Shortening the waste management cycle to reduce environmental exposure time;
- Sorting and treating waste separately at every stage of management to avoid mixing with hazardous and solid waste;
- Reducing transportation distances and ensuring disposal at the nearest waste treatment facility;
- Ensuring the safe incineration of residues following the final processing of waste.

The requirements of this law apply to urban, industrial, medical, and construction waste, among others.

Its provisions apply to all physical and legal persons, whether public or private, national or foreign, whose activities generate waste, as well as to those who hold waste or are engaged and licensed in the collection, storage, transport, recycling, processing, and disposal of waste. The law also applies to state institutions, civil society organizations, and individual citizens.

Among the methods foreseen for the treatment and disposal of urban waste, the law also includes recycling and reuse. With Amendment No. 156/2013, the law was supplemented with an article that strictly prohibits, in all cases, the import of hazardous and non-hazardous waste into the Republic of Albania.

Government DECISION No. 402/2021 "On the Approval of the Waste Catalogue", which lists the types of waste generated from various industrial activities, including those from wood processing. Below is the respective list as defined in the aforementioned decision:

03 – WASTES FROM WOOD PROCESSING AND THE PRODUCTION OF PANELS AND FURNITURE, PULP, PAPER, AND CARDBOARD
03 01 – Wastes from wood processing and the production of panels and furniture
- **03 01 01** Bark and cork waste
- **03 01 04** Sawdust, shavings, cuttings, particleboard and fiberboard containing hazardous **s**ubstances
- **03 01 05** Sawdust, shavings, cuttings, particleboard and fiberboard other than those mentioned in 03 01 04
- **03 01 99** Other unspecified waste

03 02 – Wastes from products used for wood preservation
- **03 02 01** Non-halogenated organic compounds used for wood preservation
- **03 02 02** Chlorinated organic compounds used for wood preservation
- **03 02 03** Organometallic compounds used for wood preservation
- **03 02 04** Inorganic compounds used for wood preservation
- **03 02 05** Other compounds containing hazardous substances used for wood preservation
- **03 02 99** Other unspecified preservatives

03 03 – Wastes from pulp, paper, and cardboard production and processing
- **03 03 01** Bark and wood waste
- **03 03 02** Green liquid sludge (from recovery of boiled liquids)
- **03 03 05** De-inking sludges from paper recycling
- **03 03 07** Mechanically separated rejects from pulping of waste paper and cardboard
- **03 03 08** Wastes from sorting of paper and cardboard destined for recycling
- **03 03 09** Lime mud waste
- **03 03 10** Fiber sludge, coating and filler sludges from mechanical separation
- **03 03 11** Wastes from on-site effluent treatment other than those mentioned in 03 03 10
- **03 03 99** Other unspecified waste

Old and unusable furniture, although not specifically listed, fall under Category 16: Unspecified Waste.

INSTRUCTION No. 1/2020 "On the Rules and Measures for the Treatment of Wooden Packaging and Pallets", which aims to define phytosanitary measures that reduce the risk of entry and spread of quarantine pests, associated with the movement of untreated wooden packaging materials in international trade. The instruction focuses on wooden packaging materials, including fixing materials, while excluding wood packaging made from processed wood that ensures cleanliness from pests — for example, plywood.

5.9.6. Serbia

Forestry Laws and Sustainable Wood Use: Serbia's primary legislation is the **Law on Forests** (Zakon o šumama), which governs how wood can be harvested and used. The law requires sustainable forest management plans, regeneration after felling, and measures against illegal logging. It mandates that all harvested timber be marked and accompanied by a prescribed transport document (consignment note). This legal framework effectively limits manufacturers to legally sourced wood species – timber acquired without proper marking or documentation cannot be used in production. In practice, furniture makers predominantly use domestic species like beech, oak, ash, and other legally harvested woods. Endangered native trees (e.g. the Serbian spruce *Picea omorika*) are strictly protected under nature conservation laws, so they are generally off-limits for commercial logging. The ***Law on Nature Protection*** reinforces this by forbidding the exploitation of protected wild flora and by requiring special permits for any exceptional use of protected species. Together, these laws ensure that only approved tree species from sustainable and legal origins enter the furniture and wood product supply chain.

National Certification Schemes (FSC & PEFC): While Serbia does not have a unique national certification, it participates in international schemes to promote sustainable wood sourcing. **The Forest Stewardship Council (FSC)** has a growing presence – Serbia published its first FSC Interim National Standard in 2023 to guide local forest managers. As of 2011, about 387,000 ha of forests (roughly 17% of Serbia's forest area) were FSC-certified, and a few dozen wood companies held chain-of-custody (CoC) certificates. Today, almost all state-owned forests are certified to FSC standards, indicating sustainable management. Forest governance and policy fall under the Forestry Directorate of the Ministry of Agriculture, Forestry and Water Management, which coordinates reforestation programs and enforces regulations. **The Programme for Endorsement of Forest Certification (PEFC)** is not widely implemented in Serbia. However, regional initiatives are underway to make certification more accessible to small forest owners. Importantly, certification is voluntary – Serbian law does not mandate FSC/PEFC certification, but it strongly incentivizes it via market access. Since the EU is the biggest buyer of Serbian wood products (Serbia exported $548 million in wood and furniture in 2020, mainly to EU countries), local companies adopt FSC/PEFC to meet buyer expectations of legality and sustainability. There are no explicit legal restrictions on using *uncertified* wood domestically, but uncertified timber may face hurdles in international markets and public procurement. In essence, certification schemes complement national laws by giving manufacturers a way to demonstrate compliance with sustainable and legal sourcing norms. There are over 330 companies from Serbia that are FSC-CoC certified. This means that they source forest materials from the FSC-certified forests and other controlled sources, thus ensuring responsible forest management and use of forest materials. More than half of the certified companies are processors (primary and secondary), while about a third primarily trade with FSC-certified materials and products. Considering a variety of forest-based materials, 4 out of 10 FSC-CoC-certified companies from Serbia process or sell solid wood (sawn, chipped, peeled), followed by 2 out of 10 FSC-CoC-certified companies processing or selling indoor furniture or rough wood.

Rules on Non-Native and Invasive Species: Serbia's forestry and environmental policies also affect which species can be planted or used. **The Law on Forests and related regulations** allow the use of fast-growing non-native trees (such as poplar hybrids or black locust *Robinia pseudoacacia*) in plantations, as these have long been part of Serbian forestry. However, invasive species are subject to strict controls. The **Law on Nature Protection** (articles 82–83) regulates introductions of *allochthonous* (non-native) species into the wild, providing a mechanism to declare certain species as invasive. Such rules ensure that wood processors rely on species that won't harm local ecosystems. While these

restrictions mainly target planting and habitat management, they indirectly influence manufacturing by limiting the availability of problematic non-native wood. In practice, Serbian furniture producers stick to established species – using imported exotics (e.g. tropical hardwoods) only when legally imported with proper permits. Serbia is a signatory to **CITES** (Convention on International Trade in Endangered Species), meaning that any use of endangered foreign wood (like mahogany or rosewood) requires CITES permits and is tightly regulated. Summarily, Serbia's policy balances openness to commercially valuable non-native timber (under controlled conditions) with a strong stance against invasive or illegally sourced species.

Alignment with EU Directives (Timber Trade and Forestry): Although Serbia is not an EU member, it has proactively aligned many forestry regulations with EU standards. Notably, Serbia's Law on Forests addresses the obligations of the **EU Timber Regulation (EUTR)** – a law that in the EU prohibits placing illegal timber on the market. A 2021 analysis found that Serbia's forest legislation already covers *all key EUTR requirements* (legality, documentation, due diligence), with only minor gaps in traceability systems. For instance, the Serbian law requires transparent forest management records and public availability of plans, supporting traceability of timber origin. However, being outside the EU, Serbia does not formally "implement" EUTR; instead, it uses domestic laws to mirror those principles. This alignment is crucial because a large share of Serbian wood exports go to EU countries, which demand proof of legal harvest. In addition, Serbia has updated its environmental laws to inch closer to EU forestry and biodiversity directives. Efforts are ongoing to fully harmonize rules on invasive species with EU Regulation 1143/2014, and the government continues to strengthen enforcement against illegal logging in line with **EU Forest Law Enforcement, Governance and Trade (FLEGT)** goals. Serbia also engages with international sustainability initiatives – for example, it participates in the Forest Europe process and periodic Ministerial Conferences on sustainable forestry.

Waste Management Law and Classification: The use of post-industrial wood waste in Serbia is governed by national waste management and environmental protection laws, which are increasingly harmonized with EU legislation. The cornerstone is the ***Law on Waste Management*** (Zakon o upravljanju otpadom), first adopted in 2009 (Off. Gazette No. 36/2009) and amended several times (notably in 2016) to align with EU standards. This law defines what constitutes waste, outlines responsibilities for waste generators, and sets rules for waste handling, treatment, and disposal. Under this law, most wood by-products from industry are considered "non-hazardous waste" – they fall into categories like *"waste from wood processing and the production of panels and furniture"* or *"wood packaging waste"*, analogous to **EU waste codes** (e.g. 03 01 in the European Waste Catalogue). Being non-hazardous means they are easier to reuse or recycle, but still the law requires proper management (e.g. storage, record-keeping, and transfer only to authorized facilities if leaving the factory). An important amendment in 2016 was the introduction of the **"by-product" concept**. This provision, mirroring the EU Waste Framework Directive, allows certain surplus materials to be legally *reclassified as by-products instead of waste* if they meet specific criteria (the material must be produced as an integral part of a production process, further use is certain, it is usable without additional processing, and it poses no greater risk to health/environment than a regular product). For wood industries, this is highly relevant – for example, sawdust sold to a pellet mill can be deemed a *by-product* rather than waste, simplifying its use. Serbia's recognition of wood residues as potential by-products facilitates circular reuse by removing regulatory hurdles (no waste permit needed to transfer a by-product). In essence, the Waste Management Law provides the framework ensuring that post-industrial wood waste is identified, handled safely, and preferably recovered or recycled rather than dumped, in line with the waste hierarchy principle.

Environmental Protection and Circular Economy Alignment: Complementing the waste law, the ***Environmental Protection Law*** (Zakon o zaštiti životne sredine) sets broader requirements that influence wood waste utilization. Amendments in 2016 to this law were made concurrently with the waste law changes, under the motive of opening EU accession Chapter 27 (Environment). The goal was twofold: to streamline procedures and **to harmonize Serbian regulations with EU waste and environmental standards**. Serbia also established **"Green Fund" incentives** to encourage businesses to invest in waste reuse and cleaner production. Wood processing companies can potentially access support for technologies that convert waste to new products (e.g. briquetting machines, recycling lines). Another legal aspect is **extended producer responsibility (EPR)**: while Serbia has EPR systems for packaging, electronics, etc., there isn't a specific EPR for furniture or wood products yet. But general obligations in the law push producers to take responsibility for waste generation and to minimize it. Overall, Serbia's alignment with EU circular economy policies means that **legally, reuse of wood waste is promoted** – regulations are moving away from just disposal towards facilitating recycling businesses and safe secondary material markets.

Regulations on Waste Processing and Safety: Post-industrial wood waste can be reused in various ways, but each route may trigger specific regulations. If wood waste is used as **fuel (biomass energy)**, Serbia's air protection and energy laws become relevant. Combusting wood waste on-site (in a factory boiler) must comply with emission limits under the **Law on Air Protection** and relevant bylaws; burning treated wood waste may require an *integrated permit* because it could classify as waste incineration. For example, a furniture plant wanting to burn lacquered scrap wood needs to ensure its boiler meets emission standards for pollutants. Serbia has transposed the EU Industrial Emissions Directive to some extent, meaning larger combustion of waste biomass falls under permitting. On the other hand, if wood waste is used to manufacture new products (like panels or children's toys), **then *product safety regulations*** and standards apply. All wood-based panels produced or sold in Serbia must meet the Serbian standards which align with European norms, particularly for formaldehyde emissions. Since 2010 Serbia has adopted the **EN standards for formaldehyde (class E1)** in wood panels, and a national Rulebook limits formaldehyde release in particleboard similar to EU requirements. This is relevant to using recycled wood in panels: even if made from waste, the final panel must not emit above E1 levels. Similarly, if post-industrial wood waste (like sawdust) is used in composite materials for toys, furniture, etc., the products must comply with **chemical safety rules** (no heavy metal contamination, safe levels of any adhesives, etc.). Thus, Serbian regulations ensure that circular use of wood waste does not compromise product safety or environmental health.

Alignment vs. Divergence from EU Framework: Broadly, Serbia's legal framework for wood waste is *converging* with that of the EU. **The Waste Management Law of 2009** was modeled on the **EU Waste Framework Directive 2008/98/EC**, and the 2016 amendments further brought in missing elements (like the by-product definition and clarifying certain duties). Serbia's laws now incorporate the **waste hierarchy** (prevention, reuse, recycling above disposal) as a guiding principle, matching EU law. There are also efforts to implement the **Circular Economy Package** – for example, draft amendments and by-laws are being prepared in line with newer EU directives (2018 revisions). One area where Serbia may still be catching up is setting ***quantitative* recycling targets** – the EU sets specific targets (e.g. recycling 55% of municipal waste by 2025, etc.), while Serbia's current waste legislation has fewer binding targets and more qualitative goals. Also, enforcement capacity is an ongoing challenge: aligning on paper doesn't always mean full implementation. But in terms of restrictions, Serbian law does not significantly diverge from EU rules.

5.9.7. Croatia

In Croatia, the selection and use of wood species for furniture and wood product manufacturing is regulated by several legal frameworks and strategic documents. These aim to promote sustainable forest management and ensure the responsible sourcing of wood materials.

Key Legislative and Regulatory Frameworks:

1. **Forest Act (Zakon o šumama)**
   - Governs forest management, utilization, protection, and regeneration
   - Encourages sustainable use of forest resources in line with ecological and economic principles
   - Determines which wood species and quantities may be harvested annually
1. **Nature Protection Act (Zakon o zaštiti prirode)**
   - Limits the exploitation of protected or rare tree species
   - Ensures biodiversity and conservation of native species in natural habitats
3. **Regulations on Protected Natural Values (Pravilnik o zaštićenim prirodnim vrijednostima)**
   - Restricts the use of endangered or strictly protected tree species in production processes
4. **Public Procurement Law**
   - In public projects, preference is given to products made from certified or sustainably sourced wood

Use of Certified Wood:

- FSC (Forest Stewardship Council) and PEFC (Programme for the Endorsement of Forest Certification) certificates are widely recognized and used in Croatia
- These certifications ensure that wood originates from responsibly managed forests that provide environmental, social, and economic benefits
- Increasingly required in both domestic and international markets, especially for export-oriented manufacturers

Impacts on Wood Species Selection:

- Priority is given to species from sustainably managed forests – primarily beech, oak, fir, and spruce
- Exotic or non-native species are used sparingly due to legal, ecological, and certification-related limitations
- Certified wood is often mandatory for international partnerships and eco-labeled products (e.g., EU Ecolabel)

Legal regulations in Croatia support sustainable forest management and encourage the use of certified wood. These frameworks not only limit irresponsible exploitation but also shape market behavior and influence the selection of wood species in the production of furniture and wood products.

In Croatia, the selection and use of by-products and waste materials for the production of furniture and other wood products are influenced by a number of legislative regulations at both national and EU levels. These regulations primarily address environmental protection, product safety, waste management, and the promotion of circular economy principles.

1. **Waste Management Act (Zakon o gospodarenju otpadom, NN 84/2021)**
   This law governs the classification, handling, and processing of waste, including wood waste. It defines conditions under which certain materials can be considered by-products instead of waste, enabling their further use in manufacturing processes. The Act promotes recycling and energy recovery from biomass waste, including wood residues, while imposing controls to prevent environmental pollution.

2. **Act on Sustainable Waste Management (Zakon o održivom gospodarenju otpadom)**
   This regulation emphasizes the waste hierarchy and encourages the reuse of materials such as sawdust, bark, and offcuts in industrial processes. The Act restricts the use of contaminated wood (e.g., wood treated with hazardous chemicals) for furniture production, due to risks related to health and environmental protection.

3. **EU REACH Regulation (EC 1907/2006)**
   Under REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals), materials used in furniture production must not contain hazardous substances above threshold levels. This regulation affects the selection of wood waste or by-products, particularly if these materials have been treated or exposed to chemicals during their previous use.

4. **Construction Products Regulation (EU) No 305/2011**
   In cases where wood by-products are used in building-related products (e.g., panels or composite materials used in furniture), CE marking and compliance with harmonized standards may be required.

5. **Forest Act (Zakon o šumama, NN 68/2018, 115/2018)**
   The Forest Act indirectly affects the availability and legal status of primary wood and by-products. It regulates forest management practices, harvesting rights, and the traceability of wood materials. This ensures that by-products and residues come from legal and sustainable sources.

6. **Eco-label and Circular Economy Promotion Policies**
   Voluntary but increasingly relevant, eco-label schemes (e.g., EU Ecolabel) and national circular economy strategies encourage the use of secondary raw materials, including wood by-products, under strict environmental and health safety criteria.

In summary, Croatian and EU legislation support the use of wood by-products and waste in the furniture industry, provided that the materials meet environmental and safety standards. Legal restrictions primarily apply to chemically treated or contaminated wood, which may be unsuitable for further use in consumer products. Companies are encouraged to prioritize clean, traceable, and recyclable materials to align with sustainability goals and regulatory compliance.

5.10. Conclusions

Legal frameworks across partner countries increasingly support sustainable forest management, legal timber sourcing, and responsible use of wood materials in the furniture industry. Common regulatory elements include controls on the legality and traceability of wood, restrictions on endangered or invasive species, and requirements related to environmental protection and chemical safety.

EU-level instruments such as the EU Timber Regulation, the upcoming Deforestation Regulation, and CITES provide a shared legal basis, while national and regional laws introduce additional rules concerning forest use, harvesting rights, and product safety. In some cases, regulations also promote the use of certified, local, or recycled materials - particularly through public procurement policies or targeted incentives.

Despite differing levels of implementation and enforcement, legislation in all countries determinates which wood species and material types are available for use. It also defines the conditions under which by-products or alternative raw materials can enter production. A clear understanding of these legal conditions is therefore essential for developing circular and sustainable practices in the wood and furniture sector.

6. Wood Species in the Furniture Industry

As part of the project's efforts to support more sustainable material use in the furniture and wood product sectors, project partners identified wood species most commonly used in their respective regions. The goal of this activity was to map species that currently play a key role in the industry and may hold further potential in the transition to circular and climate-resilient production models. The focus was on species relevant to both solid wood and upholstered furniture production, taking into account regional specificities, industrial relevance and product types.

In the context of sustainable forest management and circular economy principles, this task focused on identifying the most relevant wood species for furniture and wood product manufacturing within the project area. The analysis is based on species that grow within the regions of the project partners. These include both hardwood and softwood species currently present in national markets and industrial use.

To ensure consistency and reliability, all values for wood properties presented in the following section are based on recognized technical standards: 1ÖNORM B 3012, 2DIN 68364, and 3EN 350, depending on the property category and availability of data for each species.

All selected species are classified as Least Concern on the IUCN Red List, with population trends considered stable to slightly declining. None of the species are included in the CITES Appendices, which means that their use in manufacturing and international trade is currently unrestricted. This supports their continued use in wood-based industries without conflicting with biodiversity conservation or international legal frameworks.

The following section introduces the ten most commonly used wood species across the partner regions, along with essential information on their physical properties, typical applications and relevance for different furniture categories.

6.1. Overview of 10 Common used trees species in furniture industry

6.1.1. Europaean beech (*Fagus sylvatica L.*)

General information
European beech is widely distributed across Europe, from Sicily in the south to southern Norway in the north. Its distribution is limited by high summer temperatures, drought, and soil moisture availability, while in northwestern regions continental conditions also constrain its spread. Beech does not tolerate waterlogged or compacted soils and requires well-drained sites. It maintains relatively high growth rates even at mature ages. Climate change is expected to influence its future distribution: reduced competitiveness is predicted in the southern and eastern parts of its range due to increasing drought, whereas potential expansion is anticipated in Scandinavia and the Baltic region.

Wood characteristics
European beech is a diffuse-porous hardwood with small, evenly distributed vessels across the growth ring. Its narrow but visible medullary rays create a subtle sheen on radial surfaces. The freshly sawn wood is pale cream, turning light pinkish-brown upon exposure. Steaming results in a uniform reddish-brown colour, with prolonged steaming masking the darker areas of false heartwood. The grain is generally straight, with a fine and even texture. European beech shows faint growth rings and small, diffuse vessels on the cross-section. Radial surfaces display subtle ray fleck and fine striping, while tangential surfaces may feature a delicate flame figure.

Properties
European beech is a hard, medium-heavy to heavy hardwood with fine, even texture and consistent colour, making it ideal for smooth finishes and visually uniform surfaces. It has excellent steam-bending properties, allowing precise shaping of curved components. The wood machines and finishes cleanly and contains low levels of tannins, which minimises iron staining. However, it exhibits pronounced shrinkage and requires careful drying below 60 °C to prevent checks and deformations. Natural durability is poor (class 5, EN 350), but the wood is easy to impregnate, except in the case of false heartwood.

Uses
Due to its mechanical properties and appearance, European beech is widely used in furniture manufacturing. It is best suited for bentwood furniture (e.g. Thonet chairs), seating components, tables, tool handles, turned items, and both solid and modular furniture. It is sawn for solid-wood elements such as chair legs, rails, table tops, drawer sides, and carcass panels. The wood is also sliced or rotary-cut into veneer for plywood and decorative panels. Off-cuts, chips, and lower-quality wood are commonly processed into particleboard, MDF, and wood pellets.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties [1]	Density	Mean value	712 kg/m^3
		Limit values	650 ÷ 850 kg/m^3
	Shrinkage	Longitudinal	0.3 %
		Radial	5.8 %
		Tangential	11.2 %
	Swelling	Radial	
		Tangential	
Mechanical properties [2]	Strength	Bending	123 N/mm^2
		Tensile (‖ to the grain)	135 N/mm^2
		Compression (‖ to the grain)	62 N/mm^2
	Elastic properties	Modulus of elasticity (under bending)	16000 N/mm^2
	Hardness	Brinell (II to the grain)	
		Brinell (⊥ to the grain)	34 N/mm^2
Technological properties	Screw withdraw resistance	Transversal	4300 N
		Radial	5600 N
		Tangential	5400 N
	Thermal conductivity	Mean value	0.17 W/mK
	Equilibrium MC	Referring to 20°C, 37%	7.3 %
	Equilibrium MC	Referring to 20°C, 83%	15.7 %
Natural durability	Fungi[3]		Class 5 (not durable)
	Anobium[3]		Class S (sensitive)
	Color alteration due to UV radiation		Darkens to reddish brown
	Influence of UV radiation		Limited
Impregnability [3]	Heartwood		3, slightly impregnable
	Sapwood		1, impregnable

Source:
[1] According to the standard ÖNORM B 3012
[2] According to the standard ÖNORM B 3012 and DIN 68364
[3] Referred to the standard EN 350

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

6.1.2. Oak (*Quercus robur L., Quercus petraea Matt.*)

General Information
Pedunculate oak (*Quercus robur*) and sessile oak (*Quercus petraea*) are large, long-lived deciduous trees widely distributed across Europe, from southern Scandinavia to the Iberian Peninsula, Italy, the Balkans, Turkey and eastward to the Ural Mountains. They often grow together and hybridize, making species identification difficult. Ecologically, these oaks have a broad tolerance but thrive best on fertile, moist soils at low to mid elevations, where they can dominate forests in both number and size. Their large acorns enable them to establish as pioneer species by supporting early growth and the development of deep roots. Recently, increasing concern has arisen over Acute Oak Decline, a poorly understood syndrome threatening these key European hardwoods.

Wood Characteristics
Oak wood is a ring-porous hardwood distinguished by its large, prominent medullary rays, which are clearly visible on cross and radial sections. The heartwood is naturally light brown but tends to darken during drying, while the sapwood is white to light gray. In cross-section, the wood shows a pronounced flamed pattern in the latewood and conspicuous medullary rays. On radial surfaces, these rays appear as large speckles that create a striped figure, which continues as a flamed and striped texture on tangential sections. Freshly cut oak has a strong tannic odor that fades with time. It is a hard and durable wood, well-suited for demanding applications.

Properties
Oak is a hard, relatively heavy hardwood. It machines easily - saws, planes, drills and mills well. Drying requires expertise because of risks such as cracking, deformation, cell collapse and dark discolorations. The wood contains high tannin levels, which can cause dark stains when moist wood contacts metals but also support good surface treatments; lacquering requires pore fillers. Impregnation is difficult due to tyloses blocking vessels. Oak is strong, durable, has an attractive grain and steams well, making it ideal for bentwood applications. It resists wear and decay.

Uses
Oak is highly valued for solid wood furniture including tables, chairs, cabinets and dressers. It is also widely used for flooring, staircases, high-end furniture elements and veneers. Its strength, hardness, durability and attractive grain pattern contribute to its popularity in furniture production, interior finishes, façade construction and barrique barrels. Lower-grade wood often finds use in parquet flooring and other secondary products.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties [1]	Density	Mean value	702 kg/m^3
		Limit values	430 ÷ 960 kg/m^3
	Shrinkage	Longitudinal	0,4 %
		Radial	4,0 ÷ 4,6 %
		Tangential	7,8 ÷ 10 %
	Swelling	Radial	0,16 %%
		Tangential	0,36 %%
Mechanical properties [2]	Strength	Bending	88 (95) N/mm^2
		Longitudinal tensile	90 (110) N/mm^2
		Longitudinal compression	61 (52) N/mm^2
	Elastic properties	Modulus of elasticity (longitudinal)	13000 N/mm^2
	Hardness	Brinell (II to the grain)	66 N/mm^2
		Brinell (⊥ to the grain)	34 N/mm^2
Technological properties	Screw withdraw resistance[4]	Transversal	4780 N
		Radial	6400 N
		Tangential	6200 N
	Thermal conductivity[5]	Mean value	0,13 ÷ 0,20 W/mK
	Equilibrium MC[5]	Referring to 20°C, 37%	8,9 %
	Equilibrium MC[5]	Referring to 20°C, 83%	17,2 %
Natural durability	Fungi[3]		Class 2 (durable)
	Anobium[3]		Class S (sensitive)
	Color alteration due to UV radiation[5]		Brown
	Influence of UV radiation[5]		Limited
Impregnability [3]	Heartwood		4, extremely resistant
	Sapwood		1, impregnable

Source:
[1] According to the standard ÖNORM B 3012
[2] According to the standard ÖNORM B 3012 and DIN 68364
[3] Referred to the standard EN 350
[4] Kiliç M., Burdurlu E., Usta I., Berker U.Ö., Oduncu P. (2006). Comparative Analysis of the Nail and Screw Withdrawal Resistances of Fir (Abies Mill.), Cherry (Prunus Avium L.), Walnut (Juglans Regia L.) and Oak (Quercus L.) Wood. Düzce Üniversitesi Orman Fakültesi Ormancılık Dergisi, 2(2), 61-75.
[5] Alfred Teischinger, Anne Isopp, Josef Fellner. Wood species: Views, parameters and descriptions. pro:Holz publication; edition DETAIL, 2023, Austria. ISBN: 978-3-95553-619-0. https://www.detail.de/de_de/holzarten

6.1.3. Walnut (*Juglans regia L.*)

General information
The common walnut is a large, long-lived deciduous tree, typically reaching 25–35 m in height and occasionally up to 2 m in trunk diameter. Its native range is believed to include the Mediterranean region (Southern Europe and Western Asia) and Central Asia. The species has been widely cultivated throughout the northern hemisphere and is now present across most of Europe, except the northernmost areas. Common walnut is a demanding species that requires warm, sheltered sites with long growing seasons and thrives best on deep, fertile soils. It is often grown in pure stands or as isolated trees rather than in mixed forests.

Wood characteristics
Walnut wood is semi-porous, with diffusely arranged but large pores, especially prominent in spring wood, easily visible to the naked eye in longitudinal sections. The heartwood exhibits uneven brown stripes, often nearly black, which fade quickly under strong light. Color variation by origin is now uncommon in veneer markets. The sapwood ranges from white to pinkish grey, while the heartwood varies from light brown to grey-brown or red-brown with pronounced streaking. Steaming is commonly applied to reduce color contrast between sapwood and heartwood, producing a uniform dark brown tone.

In cross-section, annual rings are distinguished by larger spring pores. Radial sections show a smooth or lightly striated texture with subtle striping, and tangential sections reveal delicate flaming patterns with light stripes. The wood has little odor when dry but can smell unpleasant when wet.

Properties
Walnut wood is medium to heavy in weight. It dries slowly but well, requiring careful management to avoid defects. The wood is easy to process, varnish, and polish, offering a rich appearance, warm color and fine grain. Due to tannic acids, contact with iron can cause blue-black discoloration and corrosion, and tannin stains may appear during gluing with alkaline adhesives. Walnut has moderate natural durability (class 3) but is susceptible to damage from harmful insects. It is difficult to impregnate, limiting protection options.

Uses
Walnut has long been prized for its rich appearance and fine grain, making it one of the most sought-after woods for high-quality furniture and veneers. Its value is reflected in a higher price compared to other local hardwoods. Walnut is widely used for solid and modular furniture, including tables, stools, chairs, kitchens, wardrobes, and cabinetry. It is also favored for interior applications such as wall and ceiling paneling, flooring, doors, and luxury car dashboards featuring marbled veneers. Additionally, walnut is used in wood-based materials like sliced veneer and solid wood panels. Beyond furniture and interiors, walnut is a preferred material for artistic and decorative items, including sculptures and turned objects, as well as for musical instruments (notably backs and sides of stringed instruments) and luxury gunstocks.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties[1]	Density	Mean value	673 kg/m^3
		Limit values	570 ÷ 810 kg/m^3
	Shrinkage	Longitudinal	0,5 %
		Radial	5,4 %
		Tangential	7,5 %
	Swelling	Radial	0,18 %%
		Tangential	0,29 %%
Mechanical properties[2]	Strength	Bending	133 N/mm^2
		Longitudinal tensile	100 N/mm^2
		Longitudinal compression	58 ÷ 72 (65) N/mm^2
	Elastic properties	Modulus of elasticity (longitudinal)	11850 N/mm^2
	Hardness	Brinell (II to the grain)	26 ÷ 30 N/mm^2
		Brinell (⊥ to the grain)	-
Technological properties	Screw withdraw resistance[4]	Transversal	4250 N
		Radial	5760 N
		Tangential	5750 N
	Thermal conductivity[5]	Mean value	0,14 ÷ 0,15 W/mK
	Equilibrium MC[5]	Referring to 20°C, 37%	6,7 %
	Equilibrium MC[5]	Referring to 20°C, 83%	14,8 %
Natural durability	Fungi[3]		Class 3 (medium)
	Anobium[3]		Class S (sensitive)
	Color alteration due to UV radiation[5]		Dark brown
	Influence of UV radiation[5]		Limited
Impregnability[3]	Heartwood		3, slightly impregnable
	Sapwood		1, impregnable

Source:
[1] According to the standard ÖNORM B 3012
[2] According to the standard ÖNORM B 3012 and DIN 68364
[3] Referred to the standard EN 350
[4] Kiliç M., Burdurlu E., Usta I., Berker U.Ö., Oduncu P. (2006). Comparative Analysis of the Nail and Screw Withdrawal Resistances of Fir (Abies Mill.), Cherry (Prunus Avium L.), Walnut (Juglans Regia L.) and Oak (Quercus L.) Wood. Düzce Üniversitesi Orman Fakültesi Ormancılık Dergisi, 2(2), 61-75.
[5] Alfred Teischinger, Anne Isopp, Josef Fellner. Wood species: Views, parameters and descriptions. pro:Holz publication; edition DETAIL, 2023, Austria. ISBN: 978-3-95553-619-0. https://www.detail.de/de_de/holzarten

6.1.4. Common ash (*Fraxinus excelsior L.*)

General information
Common ash is a medium-sized deciduous tree native to the temperate zone of Europe. It is absent from the driest Mediterranean regions due to intolerance of prolonged summer drought and from northern boreal areas where seedlings are vulnerable to late spring frost. The species prefers fertile soils with a pH above 5.5 and typically grows in mixed stands or small groups rather than pure forests. Ash wood is valued for its combination of light weight, strength, and flexibility, historically used in agricultural tools and the construction of boat and car frames before widespread steel use. Future wood supply is seriously constrained by ash-dieback disease.

Wood characteristics
Ash is a ring-porous hardwood, with a distinct band of large earlywood vessels in each growth ring and dense, fibrous latewood. The sapwood is wide and creamy-white, while the heartwood ranges from light to medium brown and may feature darker olive-colored streaks, marketed as “Olive Ash.” Color transitions between sapwood and heartwood are often gradual and not sharply defined. The wood has a straight, regular grain with a medium to coarse texture, resembling oak. On flat-sawn surfaces, the growth rings produce a pronounced striped figure. Occasionally, boards may show curly or figured patterns. Rays are not visible, and when worked, ash emits a moderately unpleasant odor.

Properties
European ash is a medium-heavy, tough hardwood with good strength-to-weight ratio and excellent shock resistance. It exhibits moderate shrinkage, requiring controlled, low- to moderate-temperature drying to prevent surface checking and avoid the common “sandwich effect” (light surface, darker core). The wood has a coarse, open texture and a straight grain, which can raise under thin finishes. It machines and glues well, performs reliably with both hand and machine tools, and responds favorably to steam bending. The sapwood is easy to impregnate, while heartwood treatment is moderately effective. Natural durability is low, but the wood’s toughness, strong screw-holding, and resilience support repeated repair and reuse in demanding applications.

Uses
European ash is widely valued in applications where strength, elasticity, and shock resistance are essential. It is traditionally used for tool handles, sports equipment (such as bats, paddles, and gymnastic rings), and archery bows. In furniture and interior joinery, it is sawn for chair frames, table tops, stair treads, and flooring. Its light, uniform color accepts stains well, making it suitable for finishes that mimic other species like oak. Ash is also used for veneers and turned items, including various components in cabinetry and millwork. Lower-grade material and processing residues are utilized in moulded parts, particleboard production and bioenergy.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties [1]	Density	Mean value	680 kg/m^3
		Limit values	600 ÷ 820 kg/m^3
	Shrinkage	Longitudinal	0.2 %
		Radial	5.0 %
		Tangential	8.0 %
	Swelling	Radial	0.21 %%
		Tangential	0.38 %%
Mechanical properties [2]	Strength	Bending	120 N/mm^2
		Tensile (‖ to the grain)	165 N/mm^2
		Compression (‖ to the grain)	52 N/mm^2
	Elastic properties	Modulus of elasticity (under bending)	13400 N/mm^2
	Hardness	Brinell (II to the grain)	65 N/mm^2
		Brinell (⊥ to the grain)	41 N/mm^2
Technological properties	Screw withdraw resistance[4]	Transversal	-
		Radial	-
		Tangential	-
	Thermal conductivity[4]	Mean value	0.17 W/mK
	Equilibrium MC[4]	Referring to 20°C, 37%	7.3 %
	Equilibrium MC[4]	Referring to 20°C, 83%	16.5 %
Natural durability	Fungi[3]		Class 5 (not durable)
	Anobium[3]		Class S (sensitive)
	Color alteration due to UV radiation[4]		Light darkening
	Influence of UV radiation[4]		Limited
Impregnability [3]	Heartwood		2, moderatly impregnable
	Sapwood		2, moderatly impregnable

Source:
[1] According to the standard ÖNORM B 3012
[2] According to the standard ÖNORM B 3012 and DIN 68364
[3] Referred to the standard EN 350
[4] Alfred Teischinger, Anne Isopp, Josef Fellner. Wood species: Views, parameters and descriptions. pro:Holz publication; edition DETAIL, 2023, Austria. ISBN: 978-3-95553-619-0. https://www.detail.de/de_de/holzarten

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

6.1.5. Silver fir (*Abies alba Mill.*)

General information
Silver fir is one of the tallest European conifers, commonly found in montane regions of Central, Southern, and Eastern Europe at elevations between 500 and 2000 m. It prefers deep, moist, but well-drained soils though it does not thrive on compacted or waterlogged sites. As a key species in mixed forests, it plays an important ecological role in maintaining biodiversity and forest stability. The future distribution of silver fir is uncertain, with projections ranging from range contraction due to climate warming to potential stability or expansion depending on local conditions.

Wood characteristics
Silver fir wood is soft and light, with straight grain and a uniform, medium-coarse texture. Annual rings are clearly visible, with a gradual transition between earlywood and latewood. The wood is typically white-yellow, sometimes with gray or violet hues, and darkens with sun exposure. Sapwood and heartwood are similar in color, though heartwood can appear slightly reddish brown. Occasionally, "wet heart" may occur - zones of higher moisture content and discoloration - typically caused by bacterial activity or internal decay. The wood lacks resin canals. Radial sections often show a striped figure, while tangential sections reveal flame-like patterns. When fresh, the wood may emit a pungent odor.

Properties
Silver fir is a light, soft wood with good dimensional stability and moderate shrinkage. It is easy to work with and has a pleasant, light coloration, making it suitable for visible interior applications. The wood dries well and accepts all standard surface treatments. It has moderate impregnability and low natural durability (class 4, EN 350), similar to spruce. Though generally easy to machine, it can chip when cutting fine or sharp profiles. Silver fir splits easily, which can be advantageous or problematic depending on application. Its high resistance to acids and alkalis makes it suitable for specific technical uses. Due to the possible presence of wet heartwood, it is not recommended for use in glued load-bearing elements, especially in combination with spruce. Additionally, it has good acoustic properties, but its low hardness limits its use in high-wear furniture.

Uses
Silver fir is widely used across construction and woodworking sectors, often interchangeably with Norway spruce. It is suitable for structural applications such as beams, solid boards, windows, doors, stairs, flooring, facades and balconies. In interior architecture, it is commonly used for wall and ceiling paneling. The wood's low resin content makes it preferable over spruce for uses requiring odor neutrality or chemical resistance, such as containers for liquid chemicals. In furniture making, silver fir is well suited for lightweight furniture, drawer sides, back panels, and hidden structural elements. It is often processed into multilayer or joinery boards, with lower-quality material used for cores. Due to its good acoustic properties, it also serves in the manufacture of musical instruments, particularly soundboards for string instruments and pianos.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties [1]	Density	Mean value	441 kg/m^3
		Limit values	350 ÷ 750 kg/m^3
	Shrinkage	Longitudinal	0,1 %
		Radial	3,8 %
		Tangential	7,6 %
	Swelling	Radial	0,14 %%
		Tangential	0,28 %%
Mechanical properties [2]	Strength	Bending	73 (80) N/mm^2
		Longitudinal tensile	84 (95) N/mm^2
		Longitudinal compression	47 (45) N/mm^2
	Elastic properties	Modulus of elasticity (longitudinal)	11000 N/mm^2
	Hardness	Brinell (II to the grain)	30 N/mm^2
		Brinell (⊥ to the grain)	16 N/mm^2
Technological properties	Screw withdraw resistance[4]	Transversal	1430 N
		Radial	2120 N
		Tangential	2460 N
	Thermal conductivity[5]	Mean value	0.12 W/mK
	Equilibrium MC[5]	Referring to 20°C, 37%	7,1 %
	Equilibrium MC[5]	Referring to 20°C, 83%	16,9 %
Natural durability	Fungi[3]		Class 4 (slightly durable)
	Anobium[3]		Class SH (heartwood is vulnerable too)
	Hylotrupes[3]		Class SH (heartwood is vulnerable too)
	Color alteration due to UV radiation[5]		Honey brown
	Influence of UV radiation[5]		From moderate to strong
Impregnability [3]	Heartwood		3, slightly impregnable
	Sapwood		2, moderately impregnable

Source:
[1] According to the standard ÖNORM B 3012
[2] According to the standard ÖNORM B 3012 and DIN 68364
[3] Referred to the standard EN 350
[4] Kiliç M., Burdurlu E., Usta I., Berker U.Ö., Oduncu P. (2006). Comparative Analysis of the Nail and Screw Withdrawal Resistances of Fir (Abies Mill.), Cherry (Prunus Avium L.), Walnut (Juglans Regia L.) and Oak (Quercus L.) Wood. Düzce Üniversitesi Orman Fakültesi Ormancılık Dergisi, 2(2), 61-75.
[5] Alfred Teischinger, Anne Isopp, Josef Fellner. Wood species: Views, parameters and descriptions. pro:Holz publication; edition DETAIL, 2023, Austria. ISBN: 978-3-95553-619-0. https://www.detail.de/de_de/holzarten

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

6.1.6. Norvay spruce (*Picea abies Karst.*)

General information
Norway spruce is one of the most important coniferous species in Europe, valued for both its economic and ecological roles. Native to Boreal and subalpine forests from Central to Northern and Eastern Europe, it also thrives in mountainous regions. Its wide natural range has led to considerable variation within the species and norway spruce is now naturalised in many parts of Western Europe. Due to its adaptability and good growth performance, it has been widely cultivated across diverse sites, especially in lowlands and montane zones.

Wood characteristics
Spruce wood features non-colored heartwood, so sapwood and heartwood are visually similar. The wood is generally yellowish-white, turning yellowish-brown in older trees. Growth rings vary from narrow to wide and are clearly visible, with a gradual transition from light, whitish earlywood to reddish-yellow latewood. Planed surfaces display a silky sheen. Fresh spruce emits a characteristic resinous aroma and resin pockets are frequently present. The cross-section reveals distinct tree rings with darker latewood, while the radial section shows vertical ring boundaries. Tangential sections exhibit bands of latewood forming typical U- or V-shaped parabolic patterns. The wood has low hardness.

Properties
Spruce wood has low to medium density, moderate shrinkage and good elasticity and strength. It dries easily but splits readily and peels well. Light and soft, it's easy to work with and has good acoustic properties and a pleasant light color. Its closed pore structure can cause blotchy staining, so sanding sealers or gel stains are recommended. Spruce accepts common finishes, adhesives, nails, and screws well. Chemically stable due to low extractives, it resists discoloration from contact with water, acids and metals, though it may gray slightly near iron. It's moderately weather-resistant but vulnerable to insects and fungi, requiring proper treatment for outdoor use. Impregnation is less effective than in pine; freshly cut sapwood can be pressure-treated with water-based agents, while dry sapwood accepts oil-based treatments to improve durability. Its relatively low hardness and durability make it less suited for heavy-use furniture.

Uses
Spruce wood is widely used in the furniture industry and interior applications due to its light weight, workability and pleasant appearance. It is commonly processed into multi-layer and joinery boards, where lower-quality core wood can be utilized efficiently. Spruce is ideal for lightweight furniture and is frequently used for furniture components such as drawer sides and back panels. Its excellent acoustic properties make it a preferred material for soundboards in musical instruments like violins and pianos. Additionally, spruce is extensively applied in interior paneling, cladding, and hidden furniture frames, contributing to both aesthetic and functional elements of interior design. Beyond furniture, spruce also serves structural and construction roles, but its primary value lies in indoor use where its light color and ease of finishing are advantageous.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties[1]	Density	Mean value	441 kg/m^3
		Limit values	330 ÷ 680 kg/m^3
	Shrinkage	Longitudinal	0,3 %
		Radial	3,6 %
		Tangential	7,8 %
	Swelling	Radial	0,19 %%
		Tangential	0,33 %%
Mechanical properties[2]	Strength	Bending	95 N/mm^2
		Longitudinal tensile	77 (80) N/mm^2
		Longitudinal compression	44 (45) N/mm^2
	Elastic properties	Modulus of elasticity (longitudinal)	12500 (11000) N/mm^2
	Hardness	Brinell (II to the grain)	32 N/mm^2
		Brinell (⊥ to the grain)	12 N/mm^2
Technological properties	Screw withdraw resistance[4]	Transversal	-
		Radial	1820 N
		Tangential	1880 N
	Thermal conductivity[5]	Mean value	0,11 W/mK
	Equilibrium MC[5]	Referring to 20°C, 37%	7,0 %
	Equilibrium MC[5]	Referring to 20°C, 83%	16,4 %
Natural durability	Fungi[3]		Class 4 (slightly durable)
	Anobium[3]		Class SH (heartwood is vulnerable too)
	Hylotrupes[3]		Class SH (heartwood is vulnerable too)
	Color alteration due to UV radiation[5]		Brown honey
	Influence of UV radiation[5]		From moderate to strong
Impregnability[3]	Heartwood		3, difficult to treat
	Sapwood		2, moderately impregnable

Source:
https://treesplanet.blogspot.com/2016/05/picea-abies-norway-spruce.html
https://www.rona.ca/en/product/2-in-x-2-in-x-12-ft-spf-grade-3-better-lumber-ep2212-0971305

[1] According to the standard ÖNORM B 3012
[2] According to the standard ÖNORM B 3012 and DIN 68364
[3] Referred to the standard EN 350
[4] Miroslav Gašparík M., Karami E., Sethy A.K., Das S., Kytka T., Paukner F., Gaf M. (2021). Effect of freezing and heating on the screw withdrawal capacity of Norway spruce and European larch wood. Construction and Building Materials, 303(6). DOI: 10.1016/j.conbuildmat.2021.124457
[5] Alfred Teischinger, Anne Isopp, Josef Fellner. Wood species: Views, parameters and descriptions. pro:Holz publication; edition DETAIL, 2023, Austria. ISBN: 978-3-95553-619-0. https://www.detail.de/de_de/holzarten

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

6.1.7. Lime (*Tilia spp.*)

General information
Small-leaved lime (*Tilia cordata* Mill.), large-leaved lime (*Tilia platyphyllos* Scop.), silver lime (*Tilia tomentosa* Moench.) and Caucasian lime (*Tilia dasystyla* Stev.) are closely related species native to Europe, favoring warmer climates. They grow into large deciduous trees and are distributed from southern Finland to southern Italy, from the Caucasus to northwestern Spain and Wales. Limes generally prefer lowland sites over higher elevations and have been an integral part of European woodlands for at least six millennia. Traditionally, they were widely managed through coppicing, which provided long, straight poles and allowed trees to persist for over 2,000 years.

Wood characteristics
Limewood is a diffuse-porous species with a homogeneous, fine texture and generally non-decorative appearance. The wood is whitish to yellowish, often with reddish or light brown tones, and may occasionally show green streaks or cloudy patches. It has no distinct heartwood; however, mechanical damage can cause dark discoloration. Growth rings are only faintly visible. The pores are very small (typically less than 100 µm) and not visible to the naked eye in cross-section. Rays are fine and appear in radial sections as small, darker mirrors, usually visible only with a magnifying glass. Fresh limewood has a characteristic, pleasant scent.

Properties
All species of the genus *Tilia* work well mechanically and are particularly suitable for carving and turning. The wood is flexible and tough, with a very low modulus of elasticity and can be moderately bent. It has a strong tendency to shrink, but once dried it remains dimensionally stable under changing climatic conditions. Limewood splits, nails, and screws easily; it dries well though slowly and is prone to checking and discoloration. It glues and finishes effectively. However, it has very low natural durability and is not resistant to weather, fungi or insect attack.

Uses
Limewood is mainly sold as sawn timber and occasionally as rotary-cut veneer. It is widely used in joinery, as a core material for plywood, and especially for carving and turning. Due to its fine texture and workability, it is favored for pencils, packaging, matches, models, toys, drawing boards, frames and imitation ebony. The wood is also processed into fibreboard, paper, cellulose and wood wool. High-quality charcoal made from limewood is traditionally used for drawing. Its lightness and ease of carving have made it the preferred material for wooden sculptures and gilded altarpieces.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties [1]	Density	Mean value	553 kg/m^3
		Limit values	250 ÷ 600 kg/m^3
	Shrinkage	Longitudinal	0,3 %
		Radial	5,5 %
		Tangential	9,1 %
	Swelling	Radial	0,15 ÷ 0,23 %%
		Tangential	0,24 ÷ 0,32 %%
Mechanical properties [2]	Strength	Bending	98 N/mm^2
		Longitudinal tensile	85 N/mm^2
		Longitudinal compression	44 ÷ 52 N/mm^2
	Elastic properties	Modulus of elasticity (longitudinal)	9000 N/mm^2
	Hardness	Brinell (II to the grain)	39 N/mm^2
		Brinell (⊥ to the grain)	16 N/mm^2
Technological properties	Screw withdraw resistance[4]	Transversal	-
		Radial	-
		Tangential	-
	Thermal conductivity	Mean value	-
	Equilibrium MC	Referring to 20°C, 37%	-
	Equilibrium MC	Referring to 20°C, 83%	-
Natural durability	Fungi[3]		Class 5 (non durable)
	Anobium[3]		n/a, dati disponibili insufficienti
	Color alteration due to UV radiation		-
	Influence of UV radiation		-
Impregnability [3]	Heartwood		1, impregnable
	Sapwood		1, impregnable

Source:
[1] According to the standard ÖNORM B 3012
[2] According to the standard ÖNORM B 3012 and DIN 68364
[3] Referred to the standard EN 350

6.1.8. Chestnut (*Castanea sativa Mill.*)

General information
The sweet chestnut is a warm-temperate deciduous tree distributed from Southern Europe to North Africa, extending to Northwestern Europe and eastward to Western Asia. Its altitudinal range varies from 200 to 1,800 meters depending on latitude and site conditions. The majority of its distribution is concentrated in a few countries with a long history of cultivation, notably France, Italy, Spain, Portugal and Switzerland. The species is highly sensitive to summer droughts caused by the combination of high temperatures and low precipitation. In approximately 90% of its forests, sweet chestnut occurs as a pure or dominant species.

Wood characteristics
Chestnut wood is ring-porous, with a moderately visible earlywood vessel band and without distinct medullary rays visible to the naked eye-unlike oak, to which it is often compared. The heartwood is pale to dark brown, while the sapwood is whitish-brown and only slightly differentiated. The texture is medium-coarse, with a generally straight grain. On the cross-section, growth rings are visible with a delicate flame-like pattern. The radial surface reveals a fine, striped texture, while the tangential section shows a characteristic flamed figure. When freshly cut, the wood has a slightly acidic odor. It is classified as soft to medium-hard.

Properties
Chestnut is a moderately heavy wood with low shrinkage and good dimensional stability. However, it can be difficult to dry and is prone to cell collapse if not properly handled. It is easy to work with both hand and machine tools, though its coarse texture results in only moderate performance in turning. Gluing ranges from good to satisfactory, and the wood accepts stains and finishes well, polishing easily to a warm and attractive appearance. Chestnut splits readily, requiring care when nailing or screwing. Contact with iron may cause staining due to tannin content. Its natural durability is high - classified in durability class 2 - making it comparable to oak in resistance to decay and insects.

Uses
Chestnut wood is highly valued in the furniture industry and interior applications due to its durability, dimensional stability, and warm aesthetic. It is widely used for solid wood furniture such as tables, chairs and stools, as well as for modular elements including cabinet doors, wardrobe panels, and kitchen components. Its attractive grain and natural resistance to decay make it well-suited for interior joinery, including flooring, stairs, wall and ceiling cladding, doors and window frames. Chestnut also performs well in decorative applications such as turned components, sculptural elements and household items like bowls and utensils. While it can be used in structural and exterior settings, its primary appeal lies in interior design and high-quality furniture manufacturing.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties [1]	Density	Mean value	563 kg/m^3
		Limit values	-
	Shrinkage	Longitudinal	0,6 %
		Radial	4,3 %
		Tangential	6,4 %
	Swelling	Radial	0,14 %%
		Tangential	0,21 ÷ 0,26 %%
Mechanical properties [1]	Strength	Bending	80 N/mm^2
		Longitudinal tensile	135 N/mm^2
		Longitudinal compression	49 N/mm^2
	Elastic properties	Modulus of elasticity (longitudinal)	9000 N/mm^2
	Hardness	Brinell (II to the grain)	35 N/mm^2
		Brinell (⊥ to the grain)	18 N/mm^2
Technological properties	Screw withdraw resistance	Transversal	-
		Radial	-
		Tangential	-
	Thermal conductivity	Mean value	-
	Equilibrium MC[3]	Referring to 20°C, 37%	-
	Equilibrium MC[3]	Referring to 20°C, 83%	-
Natural durability	Fungi[2]		Class 2 (durable)
	Anobium[2]		Class S (sensitive)
	Color alteration due to UV radiation		-
	Influence of UV radiation		-
Impregnability [2]	Heartwood		4, extremely resistant
	Sapwood		2, moderately impregnable

Source:
[1] According to the standard ÖNORM B 301
[2] Referred to the standard EN 350
[3] Alfred Teischinger, Anne Isopp, Josef Fellner. Wood species: Views, parameters and descriptions. pro:Holz publication; edition DETAIL, 2023, Austria. ISBN: 978-3-95553-619-0. https://www.detail.de/de_de/holzarten

6.1.9. Poplar (*Populus spp.*)

General information
Poplars are fast-growing, light-demanding pioneer species with high ecological adaptability. They thrive in dynamic or disturbed environments and play an important role in early forest succession. Common traits include rapid juvenile growth, tolerance to a wide range of soil types and strong regenerative abilities. Black poplar (*P. nigra*) is native to lowland riparian zones and has a wide natural distribution across Europe, from the British Isles to the Mediterranean. Aspen (*P. tremula*) grows across a vast range, from boreal to temperate regions of Europe and Asia. It is highly adaptable and is especially common in regeneration stages following natural or human disturbance. White poplar (*P. alba*) occurs in warmer regions of central and southern Europe, especially along river valleys.

Wood characteristics
Poplar wood has a diffuse-porous structure with a light, uniform appearance. Its color ranges from white to pinkish-grey in the sapwood, while the heartwood may turn light brown to reddish-brown, often showing mild streaking. Growth rings are generally wide due to the tree's rapid diameter growth, with latewood forming narrow, denser bands. The transition between earlywood and latewood is subtle, resulting in a fine and homogeneous texture.
Poplar wood is medium hard and evenly porous, giving it a soft, fine, and non-patterned texture, suitable for applications where visual appearance is secondary.

Properties
Poplar wood is lightweight and generally easy to machine and glue. It works well with both hand and machine tools, but due to its softness and the frequent presence of reaction wood, sharp tools are essential during planing. Fine sanding is often required to achieve a smooth finish. It accepts paints, stains and varnishes wel. The wood dries reasonably well, but it has a tendency to warp or distort, especially if not properly conditioned. Poplar does not split easily but also has poor nail-holding strength. It is not durable, has limited resistance to wear and is highly susceptible to insect and fungal attack. Impregnation is generally ineffective, with only the sapwood being moderately treatable.

Uses
Poplar wood is a lightweight material commonly used in the furniture industry due to its ease of machining and good glueability. It works well with both hand and machine tools, but sharp tools and fine sanding are needed because of its softness and presence of reaction wood. Poplar accepts paints, stains and varnishes very well, making it ideal for painted furniture. It has limited durability, poor nail-holding strength and tends to warp if not properly conditioned, which limits its use to interior and protected environments. Poplar is best suited for plywood, composite and engineered wood products, decorative veneers (especially black poplar), pulp and paper, packaging, toys, kitchenware, upholstered furniture frames, painted furniture, and low-value cabinetry. Its combination of light weight, ease of processing, and finishing qualities make it a practical choice when durability is not a priority.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%*

Physical properties [1]	Density	Mean value	**441** / 482 kg/m^3
		Limit values	**410 ÷ 560** / 400 ÷ 600 kg/m^3
	Shrinkage	Longitudinal	**0,3** / - %
		Radial	**5,2** / 3,5 %
		Tangential	**8,3** / 8,5 %
	Swelling	Radial	**0,13** / 0,12 %%
		Tangential	**0,31** / 0,25 %%
Mechanical properties [1]	Strength	Bending	**60** / 56 N/mm^2
		Longitudinal tensile	**77** / 75 N/mm^2
		Longitudinal compression	**30 ÷ 35** / 25 ÷ 40 N/mm^2
	Elastic properties	Modulus of elasticity (longitudinal)	**8800** / 7800 N/mm^2
	Hardness	Brinell (II to the grain)	**30** / 22 N/mm^2
		Brinell (⊥ to the grain)	**10** /11 N/mm^2
Technological properties	Screw withdraw resistance	Transversal	**-**
		Radial	**-**
		Tangential	**-**
	Thermal conductivity[3]	Mean value	**0,12 ÷ 0,13** / 0,15 W/mK
	Equilibrium MC[3]	Referring to 20°C, 37%	**7,1** / - %
	Equilibrium MC[3]	Referring to 20°C, 83%	**16,7** / - %
Natural durability	Fungi[2]		**Class 5 (not durable)** / -
	Anobium[2]		**Class S (sensitive)** / -
	Color alteration due to UV radiation[3]		**Dark brown** / -
	Influence of UV radiation[3]		**Significant** / -
Impregnability [2]	Heartwood		**3v, slightly impregnable (high variability)** / -
	Sapwood		**1v, impregnable (high variability)** / -

Source:
* In bold, data for black and white poplar, in light, data for trembling poplar
[1] According to the standard ÖNORM B 301
[2] Referred to the standard EN 350
[3] Alfred Teischinger, Anne Isopp, Josef Fellner. Wood species: Views, parameters and descriptions. pro:Holz publication; edition DETAIL, 2023, Austria. ISBN: 978-3-95553-619-0. https://www.detail.de/de_de/holzarten

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

6.1.10. European larch (*Larix decidua Mill.*)

General information
European larch (Larix decidua) is discontinuously distributed across the mountainous regions of southern, central and eastern Europe. It occupies a broad altitudinal range, forming forests from approximately 180 m up to 2,500 m above sea level. At the upper limits of its range, it often grows in small groups or as solitary trees. It is a light-demanding, pioneer species and exhibits a wide ecological amplitude. Since larch occupies sensitive mountain habitats, its ecological role is also important - it helps protect the soil from erosion, prevents landslides, retains waterand provides green cover on steep rocky slopes with its extensive root system.

Wood characteristics
European larch wood is characterized by a distinct contrast between its heartwood and sapwood. The heartwood initially appears yellow to reddish-brown and darkens over time to a deep red-brown or dark brown shade. The sapwood is narrow, nearly white to yellowish, and clearly demarcated from the heartwood. Growth rings are very pronounced, with a sharp transition from lighter earlywood to darker, often wide, latewood. This contrast is especially evident in tangential and radial sections, where the alternating layers form a visible structure. Resin canals are small, solitary, and only visible under magnification. The wood has a strong, aromatic, resinous scent, particularly when freshly cut or worked. It has a medium density and good mechanical properties.

Properties
European larch wood is primarily available as sawn timber, with less frequent use as rotary-cut or sliced veneer. It is well-suited for various machining operations such as planing, drilling, milling, and sanding, provided the grain is straight and resin content is not excessive. Pre-drilling is advised for nailing to avoid splitting, and most hand and machine tools yield good results overall. Both natural and technical drying processes are efficient, although heartwood may develop cracks if not properly managed. Due to the contrast between soft earlywood and hard latewood, sanding can result in uneven surfaces. In furniture manufacturing, larch is valued for its strength, distinct texture and warm color tones. Its durability makes it particularly attractive for structural or visible components in furniture, while appropriate surface preparation ensures a smooth and aesthetically pleasing finish.

Uses
While European larch is commonly used as construction timber for structural elements under medium loads-both indoors and outdoors—it also holds significant potential in the furniture industry. Larch is particularly appreciated for solid wood furniture, stairs, and flooring, where durability and a natural look are desired. It is also used for fine finishes, especially in rustic or alpine-style interiors, and for outdoor furniture such as benches, tables, and gates, where its natural resistance to the elements is a key advantage. In addition to sawn timber, larch is used for sliced veneers and engineered wood products like fibreboard and particleboard.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%*

Physical properties [1]	Density	Mean value	583 kg/m^3
		Limit values	440 ÷ 850 kg/m^3
	Shrinkage	Longitudinal	0,3 / - %
		Radial	3,3 %
		Tangential	7,8 %
	Swelling	Radial	0,14 %%
		Tangential	0,30 %%
Mechanical properties [1]	Strength	Bending	99 N/mm^2
		Longitudinal tensile	107 N/mm^2
		Longitudinal compression	55 N/mm^2
	Elastic properties	Modulus of elasticity (longitudinal)	13800 N/mm^2
	Hardness	Brinell (II to the grain)	53 N/mm^2
		Brinell (⊥ to the grain)	19 N/mm^2
Technological properties	Screw withdraw resistance[3]	Transversal	-
		Radial	3110 N
		Tangential	3010 N
	Thermal conductivity	Mean value	-
	Equilibrium MC[4]	Referring to 20°C, 37%	8,4 %
	Equilibrium MC[4]	Referring to 20°C, 83%	17,1 %
Natural durability	Fungi[2]		Class 3-4 moderately/ slightly durable)
	Anobium[2]		Class D (durable)
	Color alteration due to UV radiation		-
	Influence of UV radiation		-
Impregnability [2]	Heartwood		4, extremely resistant
	Sapwood		2v, moderately impregnable, high variability

Source:
https://treesplanet.blogspot.com/2016/03/larix-decidua-european-larch.html
https://www.wooduchoose.com/wood-database/larch-siberian/

[1] According to the standard ÖNORM B 301

[2] Referred to the standard EN 350

[3] Miroslav Gašparík M., Karami E., Sethy A.K., Das S., Kytka T., Paukner F., Gaf M. (2021). Effect of freezing and heating on the screw withdrawal capacity of Norway spruce and European larch wood. Construction and Building Materials, 303(6). DOI: 10.1016/j.conbuildmat.2021.124457

[4] Alfred Teischinger, Anne Isopp, Josef Fellner. Wood species: Views, parameters and descriptions. pro:Holz publication; edition DETAIL, 2023, Austria. ISBN: 978-3-95553-619-0. https://www.detail.de/de_de/holzarten

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

6.2. Overwiev of 5 less common used and new wood species in furniture industry

6.2.1. Sycamore maple (*Acer pseudoplatanus L.*)

General information
The sycamore maple is a large, fast-growing deciduous tree with a broad, domed crown. Its native range extends across Central and Eastern Europe, the mountains of Southern Europe, the Caucasus and northern parts of Asia Minor, reaching as far north as southern Denmark. It grows best on nutrient-rich soils, often in cooler and more humid sites such as the bases of slopes and ravines, where it may dominate, although it rarely forms pure stands. Sycamore maple is tolerant of pollution, salt-laden winds and low summer temperatures, traits that, combined with its attractive appearance, have made it a favored ornamental species in urban and coastal environments.

Wood characteristics
Sycamore maple is a diffuse-porous hardwood with weakly marked growth rings. The vessels are extremely small and barely visible without magnification, and wood rays appear as a fine, silky sheen on quarter-sawn surfaces. The sapwood-most commonly used-is nearly white to light golden or slightly reddish-brown, while the heartwood is somewhat darker. The grain is usually straight but may also show wavy, curly, or quilted figures, giving the wood a decorative appearance. It has a fine, even texture, a smooth surface when worked and has no characteristic odor.

Properties
Sycamore maple is a moderately heavy and moderately hard wood with good strength, elasticity, and wear resistance. It dries easily, though boards can develop a “sandwich effect” with uneven color during drying. The wood is easy to machine with both hand and power tools, but it may burn when worked with high-speed cutters. It glues, turns and finishes well; however, staining can produce blotches, so the use of pre-conditioners or gel stains is recommended for an even finish. Sycamore maple is highly susceptible to discoloration, turning yellow with prolonged exposure to light and air. It has low natural durability (class 5, EN 350) but can be easily impregnated.

Uses
Sycamore maple wood is valued for its light color, fine texture, and workability, making it a preferred material for high-quality interior applications. It is widely used for sliced and rotary-cut veneers, particularly for decorative panels and composite boards, as well as for furniture, joinery, flooring and staircases. Due to its uniform appearance and absence of odor or taste, it is also used for kitchenware and culinary surfaces. The wood is popular for carving, turnery and the production of musical instruments. As one of the noble hardwoods, sycamore maple is increasingly sought after for its aesthetic and technical qualities. Premium logs are often sold at specialized timber auctions, where they achieve high prices for veneer production destined for high-value products.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties [1]	Density[1]	Mean value	630 kg/m^3
		Limit values	600 ÷ 660 kg/m^3
	Shrinkage	Longitudinal	0.5 %
		Radial[2]	4.5 %
		Tangential[2]	7.8 %
	Swelling	Radial	
		Tangential	
Mechanical properties	Strength	Bending[1]	98 N/mm^2
		Tensile (∥ to the grain)	82 N/mm^2
		Compression (∥ to the grain)	54 N/mm^2
	Elastic properties	Modulus of elasticity (under bending)[1]	9900 N/mm^2
	Hardness	Brinell (∥ to the grain)	62 N/mm^2
		Brinell (⊥ to the grain)	30 N/mm^2
Technological properties	Screw withdraw resistance	Transversal	3600 N
		Radial	5000 N
		Tangential	4900 N
	Thermal conductivity	Mean value	0.17 W/mK
	Equilibrium MC	Referring to 20°C, 35%	7 %
	Equilibrium MC	Referring to 20°C, 85%	17 %
Natural durability	Fungi[3]		Class 5 (not durable)
	Anobium[3]		Class S (sensitive)
	Color alteration due to UV radiation		Darkens to reddish brown
	Influence of UV radiation		Significant changes
Impregnability [3]	Heartwood		1, impregnable
	Sapwood		1, impregnable

Source:
[1] According to the standard ÖNORM B 3012
[2] According to the Wood-Database
[3] Referred to the standard EN 350

6.2.2. Scots pine (*Pinus sylvestris L.*)

General information
Scots pine) is a medium-sized, light-demanding conifer and the most widely distributed pine species in the world. Its natural range extends from Spain in the west to the Russian Far East, occurring from sea level in the north up to 2600 m in the Caucasus. In Europe, it represents over 20 % of the productive forest area. Scots pine is a pioneer species capable of colonizing recently disturbed sites. It thrives on sunny to partially shaded, nutrient-poor soils and tolerates both drought and frost, allowing it to grow even on poor sandy substrates. Under future climate change, its range is expected to expand northward while declining in the south.

Wood characteristics
Scots pine wood shows a distinct contrast between the pale yellow to whitish sapwood and the reddish-yellow heartwood, which darkens with age to a reddish-brown. The growth rings are clearly visible in cross-section, with a distinct boundary between earlywood and latewood. On radial sections, alternating layers of lighter earlywood and darker latewood are evident, while tangential sections display clear bands of these layers. The wood has a straight grain, a medium and even texture, and numerous resin canals, larger than those in spruce or larch. It emits a mild, resinous scent when fresh. Scots pine is soft to medium hard and moderately durable to non-durable, but its permeability makes it well suited for preservative treatments, which improve its use for exterior applications.

Properties
Scots pine exhibits moderate shrinkage and swelling, slightly higher than spruce, but it is less prone to warping and distortion. Its strength depends on wood density and under heavy load the wood emits characteristic warning sounds, which makes it valued for applications such as mining supports. Sapwood is vulnerable to blue-stain fungi, which increases moisture absorption and accelerates decay if left untreated. The wood is easy to machine with both hand and power tools. Sawing, planing, drilling and sanding generally produce good results, though the pronounced contrast between earlywood and latewood and its high resin content can occasionally cause surface irregularities and resin build-up on tools. Drying is straightforward, but should be done at lower temperatures to reduce resin-related defects. Before finishing, resin pockets must be cleaned. Scots pine bonds and finishes well and, once treated, provides good performance in structural and exterior applications.

Uses
Scots pine is widely used in interior joinery and furniture manufacturing. It is a common material for solid wood furniture, furniture components, and veneered panels, as well as for wall and ceiling paneling, flooring, and parquet. Thanks to its good workability and light color, it is suitable for both structural parts and visible surfaces that are later stained, painted, or varnished. Lower grades and residues are processed into plywood, particleboard, and fiberboard, providing material for furniture cores and composite panels. While Scots pine also serves in construction, packaging, and other industrial uses, its primary importance in the wood industry lies in interior applications and furniture production.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties [1]	Density	Mean value	543 kg/m^3
		Limit values	330 ÷ 890 kg/m^3
	Shrinkage	Longitudinal	0,4 %
		Radial	4,0 %
		Tangential	7,7 %
	Swelling	Radial	0,19 %%
		Tangential	0,36 %%
Mechanical properties [2]	Strength	Bending	100 N/mm^2
		Longitudinal tensile	104 (100) N/mm^2
		Longitudinal compression	55 (47) N/mm^2
	Elastic properties	Modulus of elasticity (longitudinal)	12000 (11000) N/mm^2
	Hardness	Brinell (II to the grain)	40 N/mm^2
		Brinell (⊥ to the grain)	19 N/mm^2
Technological properties	Screw withdraw resistance	Transversal	-
		Radial	-
		Tangential	-
	Thermal conductivity[4]	Mean value	0,14 W/mK
	Equilibrium MC[4]	Referring to 20°C, 37%	7 %
	Equilibrium MC	Referring to 20°C, 83%	15,3 %
Natural durability	Fungi[3]		Class 3-4 (moderate/slightly durable)
	Hylotrupes[3]		Class S (attackable)
	Anobium[3]		Class S (attackable)
	Color alteration due to UV radiation[4]		Dark brown-red
	Influence of UV radiation[4]		Strong
Impregnability [3]	Heartwood		4, extremely difficult to treat
	Sapwood		2v, moderately impregnable, high variability

Source:
https://www.lesprom.com/en/trade/Lumber_21/50_mm_x_150_mm_x_6000_mm_GR_S4S_Scots_Pine_Lumber_5983/
https://www.geograph.org.uk/photo/204608
[1] According to the standard ÖNORM B 3012
[2] According to the standard ÖNORM B 3012 and DIN 68364
[3] Referred to the standard EN 350
[4] Alfred Teischinger, Anne Isopp, Josef Fellner. Wood species: Views, parameters and descriptions. pro:Holz publication; edition DETAIL, 2023, Austria. ISBN: 978-3-95553-619-0. https://www.detail.de/de_de/holzarten

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

6.2.3. Black alder (*Alnus glutinosa (L.) Gaertn*)

General information
Common or black alde is a relatively small, fast-growing, short-lived broadleaved tree. It occurs from Scandinavia to the Mediterranean and parts of North Africa, generally below 1,000 m. Alder thrives in wet habitats and can grow on a wide variety of soils - including nutrient-poor sands and gravels - provided there is sufficient moisture. It tolerates a wide range of temperatures and is relatively frost-resistant. An unusual feature of alder is its ability to fix atmospheric nitrogen through root nodules, improving soil fertility. Climate change is expected to shift its range northwards, while populations in drier regions may decline.

Wood characteristics
Alder is a diffuse-porous hardwood with a fine, uniform texture and usually straight grain, occasionally showing a slightly irregular figure. Heartwood and sapwood are not clearly differentiated, both displaying a uniform pale yellow to light reddish-brown color that gradually darkens and reddens with age or exposure to light. On cross-sections, the fine vessels are evenly distributed across the growth rings. Radial surfaces may show a faint silky shimmer, while tangential sections are plain to slightly striped, sometimes with darker streaks or mineral lines. Large aggregate rays appear occasionally as fine lines on the surface. Freshly cut alder emits a mild, sweet, slightly spicy scent that disappears after drying. The low content of extractives makes alder easy to machine and a preferred material for joinery and turned items.

Properties
Alder is a light to medium-weight, moderately strong hardwood with good dimensional stability and low shrinkage. It dries quickly and evenly and is very easy to work with hand or machine tools. The wood is soft but tough, splits easily, and machines, sands, glues, stains, and polishes exceptionally well, making it well suited for joinery, cabinetry, turning, and carving. Its surface takes finishes evenly and is comparable in workability to cherry. Natural durability is low in outdoor conditions, but alder is easily impregnated with preservatives and becomes very durable when permanently submerged. The wood contains a relatively high tannin content and can occasionally cause skin irritation when handled. Growth defects such as crooked stems, discoloration, spiral grain, pith flecks, and insect galleries are common in logs.

Uses
Alder is widely valued in the furniture and joinery industry due to its uniform texture, ease of processing and excellent finishing properties. It is used for solid and modular furniture, cabinetry, interior joinery, veneer (both rotary-cut and sliced) and mouldings. Its even texture makes it ideal for stained or painted finishes, including imitation of more expensive woods such as mahogany. The wood is also popular for turned and carved elements, kitchen utensils, small wooden items, toys, handles and decorative objects. In addition, alder is used for musical instruments, wooden models and low-load interior components. While historically it was also employed for sewing machine tables and specialty items, today its primary value lies in high-quality interior applications and furniture manufacturing.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties[1]	Density[1]	Mean value	510 kg/m^3
		Limit values	450 ÷ 600 kg/m^3
	Shrinkage[2]	Longitudinal	0.4 %
		Radial	4.6 %
		Tangential	9.3 %
	Swelling	Radial	
		Tangential	
Mechanical properties[2]	Strength	Bending	75 N/mm^2
		Longitudinal tensile	80 N/mm^2
		Longitudinal compression	45 N/mm^2
	Elastic properties[1]	Modulus of elasticity (under bending)	10000 N/mm^2
	Hardness	Brinell (II to the grain)	44 N/mm^2
		Brinell (⊥ to the grain)[3]	22 N/mm^2
Technological properties	Screw withdraw resistance	Transversal	3800 N
		Radial	4400 N
		Tangential	4300 N
	Thermal conductivity	Mean value	0.14 W/mK
	Equilibrium MC[4]	Referring to 20°C, 35%	7.5 %
	Equilibrium MC[4]	Referring to 20°C, 85%	15.5 %
Natural durability	Fungi[5]		Class 4-5 (not durable)
	Anobium[5]		Class S (sensitive)
	Color alteration due to UV radiation		Slight darkening
	Influence of UV radiation		Limited
Impregnability[3]	Heartwood		2, moderately impregnatable
	Sapwood		1, impregnable

Source:
[1] According to the standard ÖNORM B 3012
[2] According to the standard ÖNORM B 3012 and DIN 68364
[3] Referred to the standard EN 350

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

6.2.4. Cherry (*Prunus avium L.*)

General Information
Wild cherry is a medium-sized, fast-growing but short-lived deciduous tree native to temperate regions of Europe, Anatolia, parts of the North African Maghreb, and western Asia. Its natural range extends from the Mediterranean northwards to the British Isles and southern Scandinavia. It typically grows as a scattered pioneer species in semi-shaded deciduous woodlands, forest edges, glades, and clearings. Wild cherry favors sites with adequate summer rainfall and is limited in the south by drought and in the north and east by colder conditions. Thanks to rapid juvenile growth and its ability to regenerate through coppicing and root suckers, it competes successfully in early successional stages but is gradually replaced by climax species over time.

Wood Characteristics
Cherry is a semi-ring-porous hardwood with distinct growth rings marked by a concentration of small earlywood vessels. The heartwood is light pinkish-brown when freshly cut and gradually darkens to a golden or reddish-brown tone with age and light exposure, while the sapwood is pale yellowish. Occasionally, greenish streaks or gum deposits may appear. The wood has a fine to medium texture, with generally straight or slightly wavy grain.On radial sections, medullary rays form a decorative, shimmering pattern, while tangential sections show a subtle flamed figure. Cross-sections highlight the ring of earlywood pores. The wood is medium hard, has no distinct odor, and can develop a warm, mahogany-like tone when treated with steam or alkalis.

Properties
Cherry is a moderately heavy, moderately hard to hard hardwood with good elasticity and strength. It has a fine, uniform structure that allows excellent machining with both hand and machine tools, producing smooth surfaces suitable for turning, carving and bending. The wood glues, stains and polishes well, though staining can be blotchy, so the use of sanding sealers or gel stains is recommended. Drying is generally fast and uncomplicated when properly controlled, but the wood is prone to end checking, warping in smaller pieces and moderate shrinkage. Steaming improves dimensional stability. The heartwood offers moderate natural durability, while the sapwood is perishable and susceptible to fungal decay and insect attack. Cherry wood discolors on contact with metals and may darken slightly when exposed to alkaline conditions.

Uses
Cherry wood is a classic material for high-end furniture and interior joinery, prized for its warm color, fine texture, and excellent workability. It is used both as solid wood and as sliced veneer for luxury furniture, cabinets, and seating, particularly for curved elements. In interior design, it is applied for wall and ceiling paneling, flooring, and decorative components. Cherry is also valued for fine joinery, inlays, musical instruments, and small wooden accessories. Most of the timber is marketed as veneer, with sawn wood used for solid elements. It is considered a traditional furniture wood and was particularly favored during the Biedermeier period.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties [1]	Density	Mean value	603 kg/m^3
		Limit values	520 ÷ 700 kg/m^3
	Shrinkage	Longitudinal	-
		Radial	5,0 %
		Tangential	8,7 %
	Swelling	Radial	0,16 ÷ 0,18 %%
		Tangential	0,26 ÷ 0,30 %%
Mechanical properties [2]	Strength	Bending	98 N/mm^2
		Longitudinal tensile	98 N/mm^2
		Longitudinal compression	45 ÷ 55 (50) N/mm^2
	Elastic properties	Modulus of elasticity (longitudinal)	10250 N/mm^2
	Hardness	Brinell (II to the grain)	55 N/mm^2
		Brinell (⊥ to the grain)	31 N/mm^2
Technological properties	Screw withdraw resistance[4]	Transversal	3085 N
		Radial	4895 N
		Tangential	4705 N
	Thermal conductivity[5]	Mean value	-
	Equilibrium MC[5]	Referring to 20°C, 37%	-
	Equilibrium MC[5]	Referring to 20°C, 83%	-
Natural durability	Fungi[3]		Class 3 (medium)
	Anobium[3]		Class S (sensitive)
	Color alteration due to UV radiation[5]		Dark reddish brown
	Influence of UV radiation[5]		Medium to strong
Impregnability [3]	Heartwood		-
	Sapwood		-

Source:
[1] According to the standard ÖNORM B 3012
[2] According to the standard ÖNORM B 3012 and DIN 68364
[3] Referred to the standard EN 350
[4] Kiliç M., Burdurlu E., Usta I., Berker U.Ö., Oduncu P. (2006). Comparative Analysis of the Nail and Screw Withdrawal Resistances of Fir (Abies Mill.), Cherry (Prunus Avium L.), Walnut (Juglans Regia L.) and Oak (Quercus L.) Wood. Düzce Üniversitesi Orman Fakültesi Ormancılık Dergisi, 2(2), 61-75.
[5] Alfred Teischinger, Anne Isopp, Josef Fellner. Wood species: Views, parameters and descriptions. pro:Holz publication; edition DETAIL, 2023, Austria. ISBN: 978-3-95553-619-0. https://www.detail.de/de_de/holzarten

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

6.2.5. Olive (*Olea europaea L.*)

General information
The olive (*Olea europaea* L.) is a small, slow-growing evergreen tree. Native to the eastern Mediterranean, it was domesticated from the wild oleaster and has been cultivated for millennia. Today, it is widespread throughout the Mediterranean basin and has been introduced to other regions with similar climates, such as California, Chile, South Africa, Australia and New Zealand. The olive is well adapted to drought, poor soils and salinity. Typically, it is found in coastal areas, although its cultivation now extends across all Mediterranean-type climates worldwide. It is one of the most important agricultural species in the region, producing over 70 % of the world's olive oil. Beyond its economic role, the olive is a cultural symbol of peace, fertility, resilience, and prosperity, deeply embedded in the history and identity of Mediterranean civilizations.

Wood characteristics
Olive wood is a diffuse-porous hardwood with fine growth rings that are visible but not strongly marked. The sapwood is light brown and darkens with age, while the heartwood is distinctly darker, ranging from brown with reddish tones to irregular dark brown streaks, creating a highly decorative appearance. The grain is generally straight but may be slightly twisted in larger trees. Pores are very small, visible only with a lens and unevenly distributed across growth rings. Rays are fine, heterogeneous and also visible only under magnification. Parenchyma is abundant, typically arranged in circular patterns around groups of pores. Root wood is especially prized for its striking, richly figured texture. Olive wood has no characteristic odor and is valued for its dense, patterned appearance.

Properties
Olive wood is very hard, heavy and dense. It has a fine texture and distinctive, often interlocked grain that gives it a highly decorative appearance but can also make machining moderately difficult. Sharp tools and slower feed rates are recommended to avoid tear-out, though the wood planes and sands to a smooth, lustrous surface. It turns exceptionally well, producing excellent results in small furniture components, decorative objects and turned items. Drying is particularly slow and the wood is prone to end checks, warping and high movement in service, especially when branch wood is used. It glues and finishes well, though its natural oils may require careful surface preparation for even adhesion. Olive wood is moderately durable, showing good resistance to fungi but limited resistance to insect attack. Its combination of hardness, density and aesthetic appeal makes it a valued specialty wood.

Uses
Olive wood is prized for its hardness, density, and striking decorative grain, making it a sought-after material despite its limited availability, which usually comes from orchard trimmings, pruned branches, or storm-damaged trees. It is used for high-end furniture in small dimensions, inlays, carving, and artisanal crafts. The wood is especially valued for turned objects, decorative pieces, and small household items such as cutting boards, bowls, spoons, and handles. It is also employed for walking sticks, umbrella handles, and smaller artistic works, while in some regions it is made into charcoal or appreciated as high-quality firewood. Due to its rarity and demand, olive wood is considered an expensive specialty hardwood.

FULAR

Properties values referred to test samples with moisture content (MC) of 12%

Physical properties [1]	Density	Mean value	850 kg/m^3
		Limit values	750 ÷ 1100 kg/m^3
	Shrinkage	Longitudinal	0.3 ÷ 0.4 %
		Radial	4.6 %
		Tangential	8.5 %
	Swelling	Radial	0.23 %%
		Tangential	0.38 %%
Mechanical properties [2]	Strength	Bending	118 N/mm^2
		Longitudinal tensile	130 N/mm^2
		Longitudinal compression	65 N/mm^2
	Elastic properties	Modulus of elasticity (longitudinal)	14500 N/mm^2
	Hardness	Brinell (II to the grain)	70 N/mm^2
		Brinell (⊥ to the grain)	37 N/mm^2
Technological properties	Screw withdraw resistance	Transversal	3700 N
		Radial	3700 N
		Tangential	3800 N
	Thermal conductivity	Mean value	0.2 – 0.22 W/mK
	Equilibrium MC	Referring to 20°C. 37%	6.5 %
	Equilibrium MC	Referring to 20°C. 83%	15 %
Natural durability	Fungi[3]		Class 2–3 (durable to moderately durable; heartwood significantly better than sapwood)
	Anobium[3]		Class S (sapwood very susceptible, heartwood more resistant)
	Color alteration due to UV radiation		Dark Brown with strong contrast
	Influence of UV radiation		Moderate
Impregnability [3]	Heartwood		4 (extremely difficult to treat)
	Sapwood		1–2 (easy to moderately easy to impregnate)

Source:
Kollmann, F. F. P., & Côté, W. A. (1968). *Principles of Wood Science and Technology. Vol. I: Solid Wood*. Springer-Verlag, Berlin.
EN 350 (2016). *Durability of wood and wood-based products – Testing and classification of the durability to biological agents of wood and wood-based materials*. CEN, Brussels.
The Wood Database (2024 update). *Olive (Olea europaea)*.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

6.3. Overview of potential future local and non-native wood species for furniture industry

There is growing interest in which tree species will shape the forests of the future and what types of wood will be available for the wood-processing industry. Studies and climate models for Europe indicate that drought-tolerant and thermophilic species will gain importance under warmer and drier conditions. Among the most relevant candidates are *Quercus frainetto, Q. pubescens, Q. ilex, Q. macrolepis* and oriental beech (*Fagus orientalis*), all native to the Mediterranean–southeastern European region.

These species share a high degree of ecological adaptability, thriving in warm, drought-prone climates and often on nutrient-poor soils. Their resilience to heat and water stress positions them as particularly relevant under ongoing climate change, as rising temperatures and increasing drought frequency are expected to challenge the persistence of more temperate, less drought-tolerant species. With climate warming, their potential ranges are likely to shift northwards, allowing them to spread into areas where central European broadleaves may decline, thus maintaining forest stability and ecosystem functions.

Ecologically, they act as keystone species by providing habitat and food resources, enhancing soil protection and sustaining biodiversity. Culturally and economically, they have long supported rural communities and they continue to represent valuable resources for sustainable forestry. From the perspective of the wood and furniture industries, their timber, which is ranging from the hard, durable oaks to the fine-grained oriental beech, may become highly valued for furniture, flooring and high-quality interior applications. This combination of ecological resilience and economic utility highlights their role as “species of the future,” able to contribute both to climate adaptation strategies and to the sustainable supply of raw materials for bio-based industries.

Hungarian oak (*Quercus frainetto*)
Native to the Balkans and southeastern Europe, Hungarian oak grows best on deep fertile soils. Its wood is heavy, hard and coarse-grained, with strength comparable to other white oaks but somewhat lower natural durability. It machines and finishes reasonably well, though careful slow drying is necessary to avoid cracking and warping. Once seasoned, it offers good dimensional stability and attractive textured surfaces for furniture. Large straight stems allow production of wide planks and long boards suitable for flooring and interior joinery. With climate warming, it may expand northwards into central Europe where mesic oaks decline.

Holm oak (*Quercus ilex*)
Holm oak is an evergreen oak native to the Mediterranean basin, adapted to shallow dry soils and summer drought. Its wood is very dense, extremely hard and durable, making it suitable for specialty furniture, flooring and decorative uses requiring high wear resistance. Workability is difficult due to its toughness and cutting tools dull quickly, while drying must be done slowly to reduce checking. The dark fine texture gives high aesthetic value in interior applications. Its range is projected to extend northwards and to higher altitudes as temperatures rise, filling ecological niches unsuitable for deciduous oaks. Its evergreen character makes it a key candidate for maintaining canopy cover in future drought-prone forests.

Turkey oak (*Quercus cerris*)
Turkey oak is widespread in southeastern and central Europe, growing even on poorer soils. Its wood is heavy and hard, with coarse texture and irregular tyloses that limit use in high-end furniture. It is suitable for construction timber, interior joinery and lower- to mid-range furniture products when carefully

processed. Drying is slow and prone to deformation, yet the species provides large logs and abundant raw material. It has been historically used as fuelwood and for structural applications. Projections suggest expansion into central and western Europe in warmer lowlands, offering potential as a volume hardwood supplier.

Downy oak (*Quercus pubescens*)
Downy oak is native to southern and central Europe where it thrives on dry shallow calcareous soils. Its wood is dense, strong and durable, suitable for quality flooring, furniture and cooperage when tyloses are present. It machines well but must be dried carefully to avoid cracks and distortion. The medium texture and appealing grain make it attractive for visible furniture elements. Today it is widespread in Mediterranean and sub-Mediterranean regions. Future range shifts are expected northwards and upslope into drier niches where mesic species decline.

Valonia oak (*Quercus ithaburensis subsp. macrolepis*)
Valonia oak is a large deciduous species native to the eastern Mediterranean, especially Greece and the Aegean. Its wood is hard, heavy and durable, but has been less commercially exploited due to limited availability. It can be processed for flooring, furniture and construction where strength and stability are required. Historically it was valued more for its tannin-rich acorn cups than for timber. Processing is moderately easy with good finishing properties. With warming climates, it may expand into drier lowlands of southeastern and central Europe, offering untapped potential for quality hardwood production.

Oriental beech (*Fagus orientalis*)
Oriental beech is distributed from the Balkans through Turkey to the Caucasus, dominating moist montane forests. Its wood is light-colored, fine-textured, hard and moderately heavy, used in furniture, flooring and plywood. It machines and finishes very well, with excellent bending properties, though it lacks natural durability outdoors. Large straight stems allow production of wide boards and veneers highly valued in the furniture industry. Today it is one of the most important hardwoods of southeastern Europe and western Asia. With climate change it is expected to persist in cooler moist habitats while retreating from drier lowlands and shifting upslope and northwards.

6.4. Potential non-native wood species that are imported and used for furniture and wood product manufacturing

Although most raw material for furniture manufacturing in the project region is domestically sourced, several non-native species are imported because of their distinctive mechanical, aesthetic and processing properties. Imports come mainly from North America and tropical regions of Africa and Asia, supplying species that are highly appreciated by the furniture and wood product industries.

From North America, widely traded species include **white oak (*Quercus alba*)**, **red oak (*Quercus rubra*)**, **black walnut (*Juglans nigra*)**, **sugar maple (*Acer saccharum*)** and **black cherry (*Prunus serotina*)**. These wood species are valued for their good strength, uniformity and workability combined with attractive grain and color. White oak is durable and widely used for furniture, flooring and veneers, red oak is popular for interior joinery and mass furniture, black walnut is prized for its dark color and stability in high-end furniture and veneers, sugar maple is appreciated for its hardness and light appearance in flooring and cabinetry, while black cherry is used for fine furniture and decorative

veneers. In general, North American hardwoods come from well-managed forests, their main sustainability issue relates to transport distances and carbon footprint.

From tropical regions, imported woods include **teak (*Tectona grandis*)**, **mahogany (various *Swietenia* and *Khaya* species)**, **sapele (*Entandrophragma cylindricum*)**, **iroko (*Milicia excelsa*)**, **okoumé (*Aucoumea klaineana*)**, **ayous (*Triplochiton scleroxylon*)** and highly decorative **tropical veneers** such as **wenge (*Millettia laurentii*)**, **zebrano (*Microberlinia brazzavillensis*)** and **ebony (*Diospyros* spp.)**. Teak is highly durable and dimensionally stable, making it sought after for premium indoor and outdoor furniture. Mahogany, sapele and khaya are valued for their rich color and easy workability in high-quality furniture and veneers. Iroko serves as a substitute for teak in both furniture and joinery. Okoumé and ayous provide lightweight timber and veneers widely used in plywood, panels and interior furniture components. Wenge, zebrano and ebony are imported mainly for decorative veneers, adding exotic textures and color contrasts to fine furniture and interior design. These species are technically and aesthetically highly desirable, but they are also more problematic from a sustainability perspective, as many originate from regions with weaker governance, higher risks of illegal logging and deforestation and limited availability of certified timber.

Regulations such as the EU Timber Regulation (EUTR) and the new EU Deforestation Regulation (EUDR) apply to all imported wood species and require proof of legality and sustainability. This increases the administrative burden and costs for manufacturers and supply can be affected by certification constraints or trade restrictions. Therefore, while imported non-native species significantly contribute to the diversity and quality of furniture and wood products, their long-term role in the region depends on balancing market demand with sustainability concerns, regulatory compliance and the growing shift toward local or climate-resilient alternatives.

7. By-Products and Waste Streams in Wood Processing and Furniture Production

7.1. Sources, availability and characteristics

In industrial processes within the wood industry, furniture manufacturing, and wood product production, certain by-products and waste are generated. Consequently, the wood and furniture manufacturing industry seeks to maximize the utilization of by-products and waste generated during production processes, with the aim of enhancing overall production efficiency and sustainable development. Also, the environmental impact of this sector is substantial, mainly due to the fact that furniture uses a large volume of virgin material, adhesives, dyes and coating, which can lead to a large amount of waste and volatile organic compounds.

In industrial processes within the wood industry, furniture manufacturing, and wood product production, the project partners have identified 10 different applications during which certain by-products and waste that may arise.

That identified by-products and waste are listed in the following table:

Processing	Application	Products	By-products	Residues/waste
Primary processing	Production of sawn timber *(seasoned or kiln dried)*	Rough sawn timber - Boards, construction timber *(different shapes and sizes)*	Fuel wood *(regular edges, well stockpiled)*	• Bark (from debarking, is used mainly for heating) • Slabs • Edges • Off-cuts • Saw dust *(all the quantity can be used for production of particleboards, fiberboards, pellets or briquettes)* **Notes:** Nowdays, most of this material is used for energy production. The bark is used in the same companies as it is produced, in case they have drying kilns in addition to the sawmill. The other residues are mainly sold on the market for energy production and a smaller part for particleboard or fibreboard production.
Primary processing	Production of veneer *(sliced one)*	Sliced veneer (decorative veneer)	Ripped board/back board *(good quality material which remains at the end of slicing the flitch; can be used in furniture production etc.)*	• Bark (from debarking, is used mainly for heating) • Slabs & Saw dust (from sawing process for preparation of flitch) • Veneer pieces residues (from cutting processes in guillotine as well as from repairing processes) *(all the quantity can be used for production of particleboards, fiberboards, pellets or briquettes)*

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

Primary processing	Production of rotary veneer and plywood	• Rotary veneer *(used as raw material for plywood, boxes for carrying and storing fruits and vegetables, flame match etc.)* • Plywood	Peeler core *(the central part of the log which remains at the end of peeling; can be used for production of fences, small dimensions sawn timber, fuel wood etc.; depends by the wood species)*	• Bark (from debarking, is used mainly for heating) • Log ends (in cases where the length of the log must be adjusted to the space of the veneer lathe) • Veneer pieces (from cutting processes in clipper as well as from repairing processes) • (all the quantity can be used for production of particleboards, fiberboards, pellets or briquettes) • Trimmed plywood edges (from sizing process in circular saw) (can be used for production of particleboards) • Sanding dust (during sanding of plywood trimmed boards) (can be used as fuel or as raw material for wood-plastic composite WPC)
Primary processing	Production of particleboards and fiberboards	Different types of: • Particleboards • Fiberboards		• Bark (from debarking in case of unprocessed forest products such as round wood from thinnings, branches are used as raw material; is used mainly for heating) • Sanding dust (from calibration and sanding processes) (can be used as fuel or as raw material for WPC) • Metal accessories and fasteners (bolts, nails, screws etc.) (the case of recycling used particleboard, old furniture, pallets etc.) • Pieces of overlaying materials (the case of application of overlaying added value process) • Trimmed fiberboards edges (from sizing process in circular saw) (up to now their destination is incineration for heating (but there is always the issue of toxic gases) and in some cases landfill)

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

Primary processing	Production of pulp and paper	• Pulp • Paper • Cartoon		• Bark (from debarking of logs, is used mainly for heating) • Wastewaters, such as pulp sludge and liquors (black, brown, green, white); (from pulping process; can be used for extraction of chemicals or biofuel, but the process is expensive. They are pollutants for aquatic fauna)
Primary processing	Production of sandwich and solid wood-based panels	Panel		• Wood shavings/chips, • Off-cuts • Trimmed edges *(all above from technological processes applied on sawn timber; can be used for production of particleboards, fiberboards, pellets or briquettes)* • Sanding dust (from calibration and sanding processes) (can be used as fuel or as raw material for WPC) • Fiberboards/plywood trimmed edges and paper residues (from sizing process in circular saw of honeycomb core sandwich composites)
Primary processing	Production of engineered wood-based materials	• Glulam beams • Cross Laminated Timber (CLT) • Nailed Laminated Timber (NLT)		• Wood shavings/chips (wood shavings can be used for insulation of timber frame buildings; example https://www.sciencedirect.com/science/article/pii/S0360132324002130) • Off-cuts (both from technological processes applied on sawn timber for production of Glulam, CLT, NLT and DWL; can be used for production of particleboards, fiberboards, pellets or briquettes)

		• Dowel Laminated Timber (DLT) • Laminated Veneer Lumber (LVL) • Structural Composite Lumber (SCL) • WPC		• Trimmed edges (from sizing process in circular saw of all listed products, except of WPC) (can be used for production of particleboards) • Sanding dust (from calibration and sanding processes of all listed products, except of WPC) (can be used as fuel or as raw material for WPC) • Bark (from debarking, is used mainly for heating; LVL & SCL) • Veneer pieces (from cutting processes in clipper; LVL & SCL) (all the quantity can be used for production of particleboards, fiberboards, pellets or briquettes)
Secondary processing – from solid wood	Production of high end furniture and joinery	• Different types of furniture • Different interiors components • Different wooden joinery		• Wood shavings, particles and chips • Wood pieces, off cuts and edges • Overlaying veneer pieces (all above from technological processes applied on solid wood timber; can be used for production of particleboards, fiberboards, pellets or briquettes) • Saw and sanding dust (can be used as fuel or as raw material for wood based composites as well as for WPC) • Plywood, particleboards pieces (can be used as raw material for particleboards) • Glass, aluminium, different fire treated boards for fire safety doors. Can be collected and recycled
Secondary processing – wood	Production of furniture from wood	• Different types of furniture		• Plywood, particleboards pieces (can be used as raw material for particleboards)

based composites	based composites furniture	• Different interiors components shelves, tables, all indoor furniture		• Fiberboards pieces (up to now their destination is incineration for heating or landfill) • Wastewaters (from lacquering & coating processes; are pollutants; can be cleaned but the process is expensive) • Non wood waste (plastic, metal, foam, upholstery fabrics, leather components etc.; some of them (plastic and metal) can be easily recycled. The sorting of materials is important
Other	Paper processing and printing	• Books • Notebooks • Journals • Packing etc.		• Paper pieces • Cartoon pieces *(can be easily recycled)*

Interpreting the identified residues/waste as following:

1. **Bark:** Bark is stripped from logs at sawmills before further cutting (many mills use debarking machines). Bark is a significant by-product, often comprising ~10% of the log volume.

   Key findings: Bark is typically used as a biofuel or soil product. Its high energy content means many sawmills simply burn bark in furnaces to produce heat or steam (sometimes combined with sawdust). Alternatively, bark is processed into mulch for landscaping. Although mulch from pure bark decomposes slowly, it is valued for gardening; some forestry enterprises supply bark mulch to garden centers. In a circular economy sense, bark contributes to both renewable energy (replacing fossil fuels in heat generation) and to organic soil improvement. It generally does not enter furniture production, but efficient use of bark can improve the overall resource efficiency of the wood industry.

2. **Sawdust:** This fine particulate residue is produced in large quantities whenever wood is sawed, milled, or sanded. In practice, sawdust is far from “waste” – it’s a valuable by-product. Sawdust is primarily generated as a byproduct from several key wood-processing and wood construction-related industries.

   Sawmills are the largest producers of sawdust. Larger sawmills are equipped with drying chambers and use its sawdust for energy production for drying and heating of the production during winter. And others sell for production of particle boards or farmers. For smaller sawmills are usually located in rural areas, they mostly sell their sawdust to the farmers. This value for sawmills process softwoods and hardwoods. Sawdust from sawmills has high moisture content usually >40 %. But it is clean and homogeneous, small in size without other materials and impurity.

   Possible future use: We assume that in the future, the use of sawdust will remain similar to the current situation. Some additional material could be utilized in the production of boards; however, due to the low market price, transportation costs play a significant role. Therefore, this is an economically viable option near production facilities, but much less so in remote areas.

   Wood construction companies and joinery Workshops poducest consturction product form coniferous wood mostly spruce and fir. Sawdust is primarily generated during the preparation and cutting of construction elements, as well as during the shaping of components for windows and doors. In the production of structural timber, in addition to sawing, there is also a significant amount of planing. The same applies to the production of window profiles, where square profiles are transformed into complex window shapes. The cut-off parts are entirely converted into wood shavings.

   Properties of sawdust from Wood construction and joinery Workshops:
   There is a mix of sawdust and shavings. This means that is more inhomogeneous structure, but the moisture content is low, usually below 15 %. Sawdust and shavings are without other materials and impurity. In the mixture approximately 80 % of shavings.

Wood construction companies and joinery workshops use sawdust and shavings for their own energy production, primarily for heating production facilities and offices. A smaller portion is sold to farmers, and a limited amount is also used as raw material for the production of wood fibre boards and production of pellets.

Possible future use: If the companies can separate sawdust and shavings. Shavings can be used for insulation of timber (frame or CLT) buildings.

Numerous small to medium-sized furniture manufacturers generate sawdust during cutting, sanding, and shaping processes. Most of the furniture companies work with massive wood and also with wood based composites (particle boards, decorative wood-based panels). In most cases, companies do not separate the collection of sawdust and shavings from solid wood from that produced during the cutting of wood composites. This means that the resulting sawdust is mixed and contains not only wood but also a small proportion of adhesives and other components found in wood-based panels. As a result, such sawdust and shavings can no longer be used universally.

Properties of sawdust and shavings from furniture production:
There is a mix of sawdust and shavings. They have low moisture content around 10 %. The shape and size of the sawdust are consistent, but its composition can vary significantly between companies and through the year, depending on the type of material they process and the proportion of solid wood versus wood composites. In the case of wood composites - especially particle boards - it is important to note that these can be produced from reclaimed wood. As a result, despite various regulations, there is still a possibility that contaminants may be present in boards and later in the sawdust. Due to increasingly optimized production processes and tooling, the amount of such sawdust is relatively small. Therefore, it is most economically sensible to use it directly at the site where it is generated

Today, they are primarily used for energy recovery, usually directly by the companies that produce them.

Above mentioned are the main places where can we found sawdust. In all other companies where sawdust is still being produced, the quantities are small and, from the perspective of future use, insignificant.

Key findings: Many wood companies collect sawdust and reuse it as fuel. It is common for furniture makers to have biomass boilers that turn sawdust into heat for wood drying kilns or factory heating. On a larger scale, sawdust is the primary feedstock for booming wood pellet industry. This is a concrete circular economy pathway – converting sawdust “waste” into a renewable fuel. Additionally, sawdust can be used in making wood-based panels (like particleboard and MDF) by mixing it with resins. Some panel manufacturers source sawdust and fine wood dust from furniture workshops to supplement their raw material.

3. **Wood Off-cuts and Edgings:** These are solid wood scraps cut away from timber during processing. In sawmills, off-cuts include slab pieces (the outer parts of a log with bark), trim ends, and pieces removed when sizing lumber. In furniture and cabinetry factories, off-cuts arise when panels or boards are cut to shape, leaving strips or chunks.

   As with sawdust, sawmills are also the largest producers of wood off-cuts and edgings. Modern sawmills equipped with advanced technology immediately grind all off-cuts and convert them into wood chips. As a result, no off-cuts or end Edgings are produced in these modern sawmilling operations. However, there are still relatively few such sawmills. Therefore, in most cases, off-cuts and edgings are still generated.

   Moisture content is high > 40 %. Off-cuts can vary greatly in size. At sawmills, they are often up to 4 meters long, although their cross-sections are usually much smaller. However, in most cases, the size of the off-cuts is too small to be used for manufacturing solid wood products. Among the off-cuts, especially on the surface, there may be various contaminants such as stones and soil that adhere to the wood during forest harvesting. Other types of contamination are not expected.

   Approximately 20% of the gross sawn coniferous logs result in off-cuts, while for deciduous logs this share ranges between 30% and 35%, depending on the quality of the logs, the sawing technology, and the type of products being manufactured.

   As mentioned earlier, in larger operations, off-cuts are processed into wood chips. These chips are then sold either for the production of particleboard and fiberboard or for energy generation in large boiler systems located near the facility. In contrast, most smaller operations sell all their off-cuts on the market—also for the production of particleboard or fiberboard, as well as for energy purposes. These chips become also raw material for pulp.

   Possible future use: A potential future use could be in fibre production, for example, for manufacturing wood fibre insulation boards. However, most of this material already has a certain market value today, so in order to redirect it toward the production of new products, it would be necessary to offer a higher value than what companies currently receive for it.

   In wood construction companies and joinery workshops, only end cuts are typically produced. Since these companies receive most of the wood already partially cut and optimize their cutting processes, very few off-cuts are generated. Most of the resulting material is used for energy purposes. In some cases, the off-cuts are first ground into chips before being used.

   The off-cuts are clean and free from any contaminants. Their moisture content is low, below 15%. While there is some variability in their dimensions, they are still too small to be used for manufacturing any products.

   The quantities of this type of residue are very small, so large-scale utilization is not practical. Today, most companies use these off-cuts for their own energy needs.

Today, most companies use these off-cuts for their own energy needs.

Possible future use: Due to the small quantities, utilization in other facilities is not practical - transportation is too expensive.

Key findings: Sawmill residues consist largely of “bark, woodchips, and sawdust” while furniture and carpentry shops generate off-cuts and “stubs” (blocky leftovers). Rather than landfilling these, companies find various reuses. Larger off-cuts can be reprocessed – for example, cut into smaller components for other products (legs, spindles, etc.) or glued into panels (finger-jointed boards). Smaller off-cuts and wood edgings are frequently chipped to produce wood chips. These chips become raw material for pulp, particleboard, or are used as biomass fuel. In some regions, local firms have arrangements where sawmills send wood chips and off-cut scraps to panel factories or paper mills. Off-cuts with high calorific value are also used directly as firewood by communities or in industrial biomass boilers.

4. **Wood Shavings:** These thin curls or flakes are generated by planing, turning, or routing wood. In furniture production, processes like carving, lathe turning (for chair legs, etc.), and surface planing produce shavings. Shavings are generally dry and clean (especially from planing untreated wood), making them suitable for reuse.

   Key findings: Sood shavings are commonly reused as animal bedding, especially in rural areas for horse stables or poultry farms. They are absorbent and soft, providing a useful agricultural by-product. Shavings can also be compacted into briquettes for fuel. Some woodshops briquette their planer shavings mixed with sawdust to create densified biofuel logs for local use. Like other biomass, shavings can go into particleboard manufacturing as well.

5. **Veneer and Plywood Residues:** The production of veneers (thin wood sheets) and plywood panels yields specific waste types such as veneer off-cuts, trimmings, and cores.

   Key findings: The trimmings – narrow strips and end pieces – are usually dry and can be shredded. These, along with plywood edge scraps, are recycled into particleboard or used as fuel. Veneer mills often send their dry wood scraps to pellet or briquette producers.

6. **Sanding Dust and Treated Wood Waste:** In later stages of furniture making, very fine dust is produced from sanding, and there may be waste pieces that have paint, varnish, or glue (for example, cut-offs of laminated particleboard or an old batch of varnished chair parts). These materials are more challenging to reuse because of chemical contamination (the “biomass wastes containing toxic components” noted in industry reports refers to wood waste with finishes or adhesives).

   Key findings: This treated wood waste is typically handled under waste management rules: larger companies segregate it and may send it to licensed facilities. Some of it can be used as fuel in industrial boilers that have appropriate emission controls (burning lacquered wood releases chemicals, so it must be done in regulated

conditions). This is an area identified for improvement as region moves toward circular economy practices.

7. **Wastewaters:** Wastewaters from the pulping process are among the most environmentally challenging by-products in the wood industry. Generated during the chemical or mechanical separation of wood fibers, these effluents are typically rich in organic pollutants, including lignin residues, carbohydrates, and process chemicals such as sodium hydroxide and sulfides (in chemical pulping). These wastewaters require complex multi-stage treatment involving biological degradation, sedimentation, and chemical neutralization before being safely discharged or reused. Their proper management is essential to mitigate the ecological footprint of fiberboard and paper production.

   Wastewaters from hydrothermal processes, especially from wood steaming, represent a lesser-known but increasingly relevant source of environmental concern. Large volumes of condensate are produced daily during steaming operations. This condensate, though technically a wastewater, is notable for its high content of polyphenolic compounds with antioxidant properties. Its composition varies depending on the wood species and steaming parameters. While there is currently no established industrial application, emerging research suggests potential for reuse in textile dyeing, biopesticide development, or as a substitute fluid in wood bonding processes, opening the door for future valorization strategies.

8. **Non-wood waste materials:** Besides wood, furniture manufacturing generates a variety of non-wood waste materials. These mostly consist of: Foam offcuts, Fabric trimmings, Leather and faux leather scraps, Batting and padding (polyester, wool, or natural fiber padding), and primarily come from upholstered furniture manufacturing. Among the less prevalent types of non-wood waste are: Finishing and coating waste (Paint and lacquer residues, Solvent containers, Used brushes and rags), Fasteners and fittings waste (metal and plastic pieces, adhesive residues), Packaging waste (Cardboard and paper, plastic wrapping film, Polystyrene blocks) and other.

In the wood and furniture industry, waste and scrap are generated at different stages of the production process. These materials vary in type, quantity and potential for reuse or recycling. Here is an overview of the main points where waste is generated.

1. **Raw material extraction and preparation**
   - **Bark, branches and leaves:** are produced during logging and rough processing of logs
   - **Unusable parts of logs:** include rotten, damaged or undersized parts of wood
   - **Residues from cutting logs:** sawdust, irregularly shaped pieces of wood

   Sources: forestry operations and logging companies (NACE code A02)
   Availability: In project region, the availability of wood residues and waste is relatively high, mainly due to the country's high forest cover and the developed wood processing industry. It is estimated that approximately 30–40% of the input raw material is generated in the wood processing industry as residues or waste, which, however, has great potential for further use.

2. **Primary wood processing (sawing, drying, gluing)**
   - **Sawdust and wood dust:** generated during sawing, sanding and drilling
   - **Board and beam waste:** pieces that do not meet the dimensions or quality
   - **Waste due to material defects:** cracks, knots, resins

   Sources: sawmills, furniture factories, flooring production units (NACE codes C16, C31)
   Availability: A significant amount of wood residues and waste is generated during the primary wood processing phase – i.e. sawing, drying and basic processing of logs.

   It is estimated that approximately 30–40% is generated as residues of wood annually by wood was processed

3. **Secondary processing (production of semi-finished and finished products)**
   - **Veneer, particleboard and MDF board waste:** from cutting and shaping
   - **Adhesive residues and waste from adhesives, varnishes and paints:** often hazardous waste
   - **Discarded semi-finished products:** due to dimensional errors, surface defects or damage
   - **Textile waste:** furniture upholstery

   Sources: Production of wood and wood-based products (NACE code C16)
   Availability: Secondary wood processing, which includes the production of semi-finished and finished products (e.g. furniture, interior design, wooden structures), generates a significant amount of wood waste in project region. According to estimates from experts and industry sources such as Lesoteka, approximately 10–20% of the input material is generated as residue or waste during this processing phase.

4. **Textile waste at furniture upholstery**
   - **Furniture upholstery** (e.g. sofas, chairs, beds)
   - **Textile coverings** (e.g. interior walls, decorative elements)
   - **Technical textiles** (e.g. protective covers, felts, mats)

   Sources: Production of wood and wood-based products (NACE code C16)
   Availability: In the furniture industry, textile waste is generated mainly as: fabric scraps from tailoring and upholstery, discarded pieces due to errors (e.g. stains, incorrect dimensions), and foam and textile filler residues.

   It is estimated that in the furniture industry, textile waste represents 2–5% of the total mass of input materials in upholstery and upholstery programs. For larger manufacturers (e.g. companies that produce sofas), this can mean several hundred tonnes of textile waste annually.

5. **Furniture assembly and installation**
   - **Remains of fittings, screws, adhesives:** packaging, damaged or unused materials
   - **Packaging waste:** cardboard, plastic, protective foam

Sources: furniture production (NACE C31)
Availability: Furniture assembly and installation generates a relatively small but still significant amount of wood residues and waste. It is estimated that approximately 5–10% of the input material is generated as residue or waste at this stage. These residues are often a mixture of wood and unwanted materials (e.g. metal, plastic), which makes their reuse or recycling more challenging. A large part of these residues is still used for energy purposes (burning), especially if they do not contain hazardous substances (e.g. varnishes or adhesives).

6. **Surface treatment (varnishing, painting, oiling)**
   - **Remains of varnishes, paints, solvents:** often hazardous waste that requires special handling
   - **Filters and cloths soaked in chemicals:** also, hazardous waste

   Sources: industrial paint shops, systems for surface treatment of wood, metals and plastics, painting lines within production plants
   Availability: In the surface protection of wood – i.e. varnishing, painting, oiling or impregnation – mainly hazardous and mixed waste is generated, the availability of which is lower compared to residues from primary and secondary processing, but they have a significant impact on the environment and their management requires special attention. Residues of varnishes, paints and solvents represent hazardous waste that must be collected separately and handed over to authorized collectors. Their quantity depends on the volume of production but usually represents 1-3% of the input materials in this phase. This waste is mostly not recycled but is used for energy recovery (co-incineration) or taken to specialized hazardous waste disposal plants.

7. **Final inspection and packaging**
   - **Discarded products:** due to inadequate quality or damage
   - **Packaging materials:** cardboard, foils, wooden boxes

   Sources: companies, paper and pulp production
   Availability: Final inspection and packaging in the wood and furniture industry mainly generates mixed municipal and industrial waste, although the amount is smaller than in the wood processing stages, but it is important from the perspective of material handling and sustainability. Based on industry estimates and data from environmental reports, it is estimated that approximately 3-5% of all industrial waste in the wood industry is generated in this phase. A large part of this waste is recyclable (e.g. cardboard, plastic), but the efficiency of recycling depends on source separation and the purity of the materials.

In conclusion, forestry and wood processing sectors generate a wide range of by-products and waste materials. The consistent annual wood harvest and the high number of enterprises in related industries ensure the continuous availability of these materials. This creates a strong foundation for circular economy initiatives, particularly in material reuse and bioenergy applications.

7.2. A summary of the process where by-products and waste materials generated in the wood procssing and furniture manufacturing sectors with description of by-product/waste

The following table outlines major by-products and waste materials generated from wood processing and furniture manufacturing. In sawmilling, common by-products include sawdust, wood chips, bark, slabs, offcuts, and shavings, all resulting from the cutting and shaping of logs. During cutting and assembly, waste mainly arises from MDF/particleboard scraps, solid wood offcuts, and veneer trimmings. Sanding produces fine dust, which poses health risks and requires proper dust control measures. Gluing and painting processes generate chemical residues from adhesives and coatings, while packaging contributes additional non-wood waste such as cardboard and plastics. Overall, the table highlights how each stage of production contributes different and distinct waste streams, ranging from wood residues to chemical and packaging waste.

Process	By-product/waste	Description of by-product/waste
Sawmilling	Sawdust	Fine particles from cutting logs
Sawmilling	Wood chips	From debarking and trimming
Sawmilling	Bark	Removed before milling
Sawmilling	Slabs & offcuts	Outer parts of logs
Sawmilling	Wood shavings	From planing, shaping
Cutting/Assembly	MDF/particleboard scraps	Irregular pieces, often glued
Cutting/Assembly	Solid wood offcuts	Small trimmings
Cutting/Assembly	Veneer waste	Trimmed from decorative panels
Sanding	Fine dust	Health hazard, needs control
Gluing/Painting	Chemical residues	Adhesives, coatings
Packaging	Cardboard, plastics	Non-wood waste but significant

7.3. Summary of by-products and waste materials that can be found generated in the wood processing and furniture manufacturing sectors with the potential for further use

The table highlights the availability and potential uses of by-products and waste materials from wood processing and furniture manufacturing. Sawdust is abundant and has high reuse potential in products like pellets and panels. Bark is commonly utilized for bioenergy or as mulch in landscaping. Wood chips are often repurposed in particleboard production or used as fuel. Offcuts and slabs can be reused as firewood or reprocessed into new products. In contrast, MDF and panel scraps are harder to recycle, though some are used in refuse-derived fuel, while furniture packaging waste is usually landfilled or locally recycled.

By-product/waste material	Notes on by-product/waste material
Sawdust	High reuse potential (pellets, panels)
Bark	Often used for bioenergy or as a material applied to the surface of soil (mulch)
Wood chips	Used in particleboard or fuel
Offcuts & slabs	Often used for firewood or reprocessing
MDF & panel scraps	Difficult to recycle, some used in Refuse-derived fuel (RDF)
Furniture packaging waste	Often landfilled or recycled locally

7.4. Overview of the physical and technical properties of identified post-industrial wood raw material

1. Solid Wood Residues

The following table provides an overview of the physical and technical properties of solid wood residues generated as post-industrial raw materials. Offcuts from joinery and furniture are generally uniform in shape, consisting of slabs or strips, and are relatively clean, with minor contaminants such as adhesives, surface finishes, or minimal metal. Reclaimed wood, such as from pallets, is more irregular, with weathered surfaces, lower cleanliness, and frequent contaminants like nails, staples, paint, dirt, and oils. Trim waste, including long strips or blocks from beams and edges, has medium cleanliness but often contains adhesives, coatings, and occasional fasteners. These differences highlight how the origin of the material influences both its physical characteristics and contamination levels. Such properties are important for determining suitable reuse or recycling pathways.

Material	Particle Size & Shape	Cleanliness	Contaminants
Offcuts (Joinery, Furniture)	Uniform slabs, strips; medium to large pieces	High	Adhesives (possible), surface finishes (occasional), minimal metal
Reclaimed Wood (e.g., pallets)	Irregular boards, weathered surfaces	Medium to Low	Metal (nails, staples), paint, dirt, oils
Trim Waste (Beams, Edges)	Long narrow strips, blocks	Medium	Adhesives (common in engineered wood), coatings, occasional fasteners

2. Panel and Engineered Wood Residues

This table outlines the physical and technical properties of panel and engineered wood residues as post-industrial raw materials. Materials like MDF, particleboard, and HDF trimmings are irregular in shape, have medium to low cleanliness, and contain high

levels of adhesives and surface coatings. Plywood waste generally appears as thin layered pieces, with moderate cleanliness but possible formaldehyde-based adhesives and occasional coatings. Laminated panel scraps consist of composite blocks with smooth surfaces, but they have low cleanliness due to high adhesive and coating content along with occasional metal fittings. Edge banding waste occurs as thin, flexible strips, typically containing adhesives and plastics from PVC or ABS edges. These characteristics show that engineered residues often carry higher levels of adhesives and coatings compared to solid wood residues, affecting their reuse potential.

Material	Particle Size & Shape	Cleanliness	Contaminants
MDF/PB/HDF Trimmings	Irregular flakes or blocks	Medium to Low	High adhesive content (UF, MUF), paint or laminate coatings
Plywood Waste	Thin layered boards or pieces	Medium	Formaldehyde-based adhesives, occasional coatings, rare metal
Laminated Panel Scrap	Composite blocks with smooth faces	Low	High in adhesives and coatings, occasional metal fittings
Edge Banding Waste	Thin, flexible strips	Medium	Adhesives (hot melt/glue), plastic content (for PVC/ABS edges)

3. **Particulate By-products (Fine Materials)**
The table presents the physical and technical properties of fine particulate by-products from wood processing. Sawdust is a fine, powdery material with generally high cleanliness if sourced from raw wood, though it may contain adhesives when derived from panels. Wood shavings are light, curled flakes with high cleanliness and few contaminants unless mixed with treated or coated wood. Sanding dust, by contrast, is an ultra-fine powder with low cleanliness, often carrying residues of paint, varnish, or lacquer. CNC router dust consists of fine, uniform particles, usually with medium to high cleanliness but potential adhesive or laminate contaminants. Overall, the properties and contamination levels of these fine materials depend strongly on their source and processing method, influencing their reuse potential.

Material	Particle Size & Shape	Cleanliness	Contaminants
Sawdust	Fine granular or powdery; typically <1mm	High (if clean source)	Rare (can contain adhesives if from processed panels)
Wood Shavings	Thin curls, light flakes (1–5 mm)	High	Rare, unless mixed with coated/treated wood

Sanding Dust	Ultra-fine powder; <0.1 mm	Low	High in paint, varnish, or lacquer residues
CNC Router Dust	Fine, consistent particle size	Medium to High	May contain adhesive residues or laminate particles

4. **Specialty Wood Waste**
   The table provides an overview of the physical and technical properties of specialty wood waste materials. Veneer offcuts are thin sheet-like residues, usually clean but often containing adhesives and occasional coatings. Bark appears as irregular chunks or fibrous material, with medium to low cleanliness and possible contamination from soil or organic debris. Wood chips, produced by chipping, are medium-sized flakes or chunks that are generally clean unless mixed with treated or coated wood. Wood ash, a fine powder or granular material from combustion, is highly clean but consists of inorganic matter that may contain trace metals. These specialty wastes vary widely in form and cleanliness, which affects how they can be reused or processed further.

Material	**Particle Size & Shape**	**Cleanliness**	**Contaminants**
Veneer Offcuts	Thin sheets, sometimes curled	High	Adhesives (common), rare coatings
Bark	Irregular chunks or fibrous	Medium to Low	Low (if untreated), but can contain soil or organic debris
Wood Chips (from chipping)	Chunks or flakes (10–50 mm)	Medium	Low, unless mixed with coated/treated wood
Wood Ash (from combustion)	Fine powder or granular	High	Inorganic; may contain trace metals from combustion residues

Reference of contaminant levels and meaning
The table defines reference levels used to describe the presence of contaminants in different wood residues. This classification helps assess material quality and suitability for reuse or recycling.

Level	**Meaning**
High	Frequently present and inherent in the material (e.g., adhesives in MDF)

Medium	Present occasionally, or depends on the source (e.g., nails in pallets)
Low	Rare or minimal presence
None	Not typically present

7.5. Overview of the potential for re-use in new materials or products

Based on the identified generated by-products and waste materials, there is a strong potential for usability in producing materials/products for furniture and wood product manufacturing (e.g., conversion into composite materials, briquettes, OSB boards, new innovative materials, composite panels, or insulation materials).

The following table provides an overview of how different wood by-products and residues can be repurposed into new materials or products. It shows that fine residues like sawdust, wood shavings, and sanding dust can be reused in composite panels, fillers, or bio-based composites. Larger residues such as wood chips, offcuts, and trim waste are suitable for engineered boards, furniture components, or structural applications. Reclaimed wood and veneer offcuts offer value in rustic furniture, decorative inlays, or resurfacing panels. Engineered panel waste like MDF, plywood, and laminated scraps can be recycled into composite boards, cores, or reinforced products. Even specialty wastes such as bark and wood ash have applications in adhesives, insulation, or bio-cementitious composites, highlighting the broad reuse potential across waste streams.

Material	**Potential Usability in Furniture & Wood Product Manufacturing**
Sawdust	- MDF, particleboard, fiberboard - Bio-composites and wood-plastic composites (WPCs) - Briquettes or pellets - Wood filler or putty
Wood Shavings	- Lightweight particleboard - Wood wool boards (insulation, acoustics) - Briquettes or bedding - Mulch or decorative filler
Wood Chips	- OSB boards, chipboard - Bio-composites - Wood cement boards, insulating panels
Bark	- Filler in composites - Insulation material - Natural adhesives (tannin-based)
Offcuts (Solid Wood)	- Finger-jointed panels, blockboards - Furniture frames, legs, drawers - Composite panel core
Trim Waste (Edges, Beams)	- Laminated panels - Small wood components - Chipboard or OSB feedstock
Reclaimed Wood	- Rustic-style furniture - Reprocessed flooring, paneling - Low-grade particleboard
MDF/HDF/PB Trimmings	- Recycled composite boards - Core for laminated panels - Furniture drawer bottoms, backs
Plywood Waste	- Furniture frames, drawers - Plywood-reinforced composites - Engineered panel feedstock

Laminated Panel Scrap	- Reconstituted particleboard core - Laminated sandwich panels - Mosaic or accent tiles
Edge Banding Waste	- Re-extruded edge banding - Filler in WPCs - Decorative trims or inlays
Veneer Offcuts	- Inlays, marquetry - Veneered surface panels - Composite facing layers
Sanding Dust	- Filler in adhesives, wood putties - Lightweight panels - Surface coatings, fire-resistant boards
CNC Router Dust	- Precision bio-composites - Bio-resin or WPC injection molding - Fuel pellets
Wood Ash	- Cement-bonded particleboards - Bio-cementitious composites - (Non-furniture: soil amendment)

The next table highlights emerging and creative uses of wood residues in sustainable manufacturing. Sawdust and fine dust can be transformed into 3D-printed biomaterials, bio-resins, or low-carbon building panels. Bark finds new life as a source of tannin-based adhesives or carbonized panels for interior decoration. Veneer waste can be repurposed into laser-cut decorative panels or eco-friendly product packaging. Edge banding scrap is being recycled into thermoplastic furniture edging or wood-plastic composite (WPC) cladding. These examples demonstrate the potential of wood by-products to contribute to innovative, sustainable materials beyond traditional recycling pathways.

Material	**Innovative Uses**
Sawdust, Dust	3D printed bio-materials, bio-resins, low-carbon building panels
Bark	Tannin-based adhesives, carbonized bark panels for interior decor
Veneer Waste	Laser-cut decor panels, sustainable product packaging
Edge Banding Scrap	Recycled thermoplastic furniture edging or WPC cladding

7.6. Overview of the by-product and waste material and potential their usability in producing materials/products for furniture and wood product manufacturing with sources

The following table provides an overview of different wood by-products and waste streams, their sources, and potential applications in manufacturing. Fine materials such as sawdust, wood dust, and sanding dust can be used in MDF, particleboard, fiberboard, composites, or as fillers in adhesives and finishes. Larger residues like wood shavings, chips, offcuts, and trimmings are suitable for lightweight boards, blockboards, OSB, and solid furniture components. Veneer waste, edge banding scraps, and laminated panel residues can be reprocessed into decorative inlays, re-extruded trims, or recycled cores for engineered boards. Reclaimed wood and painted or coated wood, once treated, can serve in rustic furniture, paneling, or low-grade composites. Even specialty waste like bark and wood ash can be used as bio-resin fillers, surface materials, or mineral additives, demonstrating wide reuse potential across the furniture and wood product industries.

Material Type	Source	Potential Uses in Furniture/Wood Product Manufacturing
Sawdust	Milling, sawing, turning	- Raw material for **MDF, particleboard, and fiberboard** - **Wood-plastic composites** - **Bio-binders** or **fillers** in engineered panels
Wood Shavings	Planing, turning	- Lightweight **particleboard** - Animal bedding (possible pre-use step before bio-based panels) - **Wood wool boards** (insulation and acoustic panels)
Wood Chips	Chipping operations, logging residue	- Feedstock for **chipboard** and **OSB (Oriented Strand Board)** - **Decorative panel inlays** after processing
Bark	Debarking of logs	- Used as **bio-based resin filler** - Surface material for **decorative panels or rustic finishes** after treatment
Offcuts & Trimmings	Joinery, panel sizing	- Finger-jointed **laminated wood boards** - **Blockboards** - **Solid wood furniture components** (especially from hardwood trimmings)
Veneer Waste	Plywood and veneer sheet production	- Decorative **inlays** or **marquetry** - **Laminated surface layers** for low-cost panels
Edge Banding Scrap	Panel edging lines	- Can be re-extruded into new edge banding - Ground into filler for **composite materials**
Sanding Dust	Surface preparation	- Fine filler for **composite boards** or **adhesive systems** - **Wood filler paste** for repair and finishing
Laminated Panel Waste (MDF, HDF, particleboard)	Panel processing	- Re-milled into raw material for **recycled particleboard** - Use in **laminated sandwich panels** with recycled cores
Plywood Waste	Trimming and cutting defects	- Smaller **cabinet components**, drawers - Used in **pallets**, **crate panels**, or **composite core layers**
Painted or Coated Wood	Rejects, old furniture	- After decontamination, can be used in **low-grade panels** or **compressed board products**
Reclaimed Wood (pallets, floors, crates)	Post-use recovery	- **Rustic-style furniture**, reclaimed wood panels - **Decorative paneling**, shelving, frames
Wood Ash *(from combustion of wood waste)*	Energy recovery plants	- Can be used as a **mineral filler** in composite materials or cement-bonded wood products
Wood Dust from CNC Routers	Furniture panel machining	- High-precision dust usable in **injection-molded wood composites** - Can be pelletized or used in **bio-binders**

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

7.7. Case studies of by-product utilization (Circular Economy Practices) in IPA ADRION region

7.7.1. Study case 1: Alfa Wood Group (Greece)

Basic Information

Alfa Wood Group is one of Greece's leading manufacturers of melamine-faced chipboards and decorative surfaces for the furniture and interior design industries. With over 400 employees, Alfa Wood Group operates modern production facilities equipped with advanced machinery for particleboard and melamine panel manufacturing. Its product range includes:

- Melamine panels
- MDF and particleboards
- Laminates and decorative surfaces

The company serves both domestic and international markets, exporting across Europe and the Mediterranean region.

Circular Economy Business Model: Use of Post-Industrial Wood Raw Materials

Alfawood has adopted a circular approach by sourcing and utilizing post-industrial wood waste, including:

- Offcuts and residues from sawmills
- Shavings and chips from furniture manufacturers
- End-of-life wooden furniture, properly treated and cleaned

Instead of using only virgin timber, these by-products are collected and processed into high-quality particleboards, fiberboard panels (MDF), wood pellets & briquettes and biomass electricity generation (On-site electricity generation).

1. **Types of products and services:** ALFAPAN 5+ an advanced five-layer chipboard

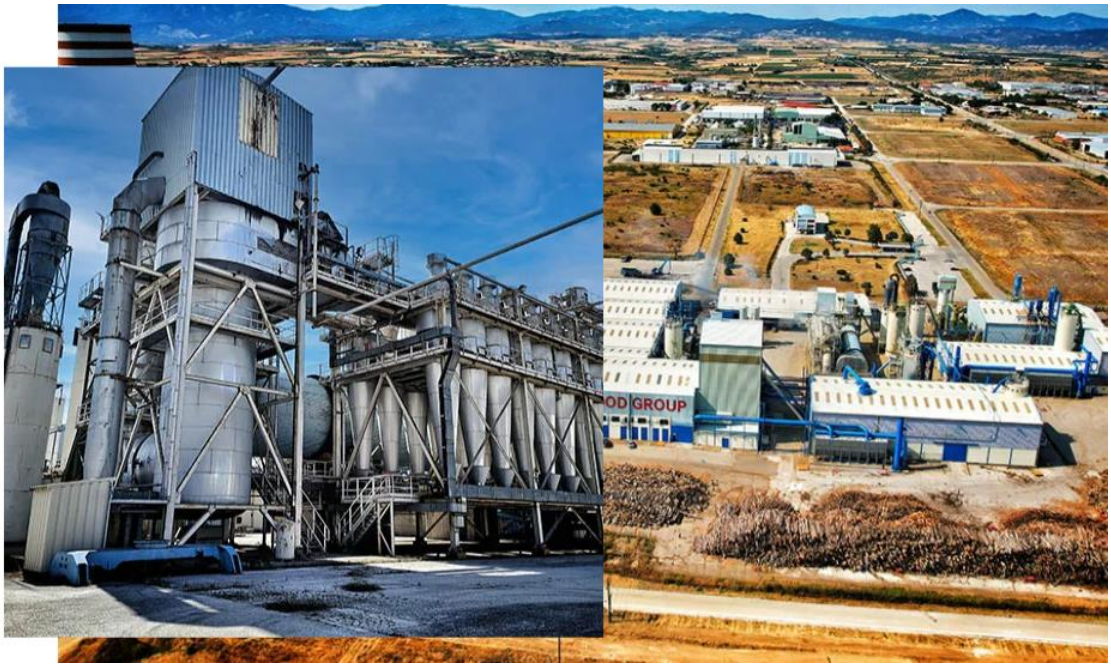
- **Headquarters:** Larisa, Greece
- **Production Facilities**:
  - Komotini factory:
    - Total site area: 297,000 m²
    - Covered (building) area: 58,615 m²
  - Production lines include:
    - Five-layer chipboard manufacturing
    - Grinding line for high surface accuracy
    - Melamine veneer impregnation
    - Two-stage decorative paper impregnation
    - Quality control laboratory (in-house chemical lab)
    - Modern logistics for storage & distribution

Raw Materials & Quality:

- Uses pine, beech, poplar, and pure recycled raw material
- No bark, stones, or metal contaminants
- Layer-specific flake sizes (fine flakers for the core)

FULAR

- Carefully engineered wood composition for high mechanical performance



The industrial facilities of Alfa Wood Group in Komotini

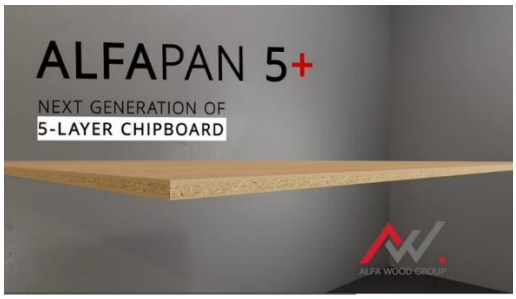
The raw materials and wood quality classification of Alfa Wood Group in Komotini

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

FULAR

Technical Properties of ALFAPAN 5+:

- 5-layer structure
- Internal Bond (tensile): > 4.5 kg/cm²
- Screw holding: > 70 kg (socket), > 90 kg (surface)
- Thickness variation: < 0.10 mm
- Formaldehyde emission: E1
- High stability and machinability - compatible with CNC, lamination, etc.
- Dimensions produced include: 3.66 × 1.83 m, 4.20 × 2.07 m, 2.80 × 2.07 m, 3.05 × 1.85 m.
- Benefits: excellent uniform cladding surface, high tensile strength, excellent screw retention, tight core, mechanical property uniformity, low formaldehyde, CNC compatibility.



The **ALFAPAN 5+**, the advanced five-layer chipboard produced in the factory of Alfa Wood Group in Komotini.

Markets & Distribution:

- Strong presence in Greece and beyond— Alfa Wood Group operates a network of partners domestically and internationally.
- Over 40% of its production is exported to 39 countries.

Mission & Identity

Alfa Wood Group is a family-owned business rooted in human-centered values, sustainability, innovation, and a commitment to people and the environment. They aim to shape a better future through dynamic growth, responsible operations, and trust-based collaboration.

Their production of ALFAPAN 5+ exemplifies these values: it pairs advanced five-layer engineering, strict quality control, eco-conscious materials, and modern production techniques to deliver a high-performance, low-formaldehyde panel—ideal for demanding furniture and interior design applications.

2. **Types of products and services:** Fiberboard Panels (MDF)

- **Production Facilities**:
  - Grevena factory:
    - Site area: ~107,000 m², with ~27,200 m² covered
    - Production includes:
      - Standard MDF
      - Fire-retardant MDF

- Moisture-resistant MDF
- Veneer-coated MDF
- Lacquered MDF
- Laminate flooring

- Larissa factory:
  - Site area: ~73,000 m², with ~35,500 m² covered.
  - Produces panels including raw MDF sheets (fiberboard) and melamine-coated chipboard, melamine-faced panels, interior doors, kitchen/work counters, acoustic panels, and more.

The industrial facilities of Alfa Wood Group in Grevena

Raw Materials & Production Technologies

- Alfa Wood sources wood from Greek forests along with sawmill residues for its MDF production, ensuring high quality and resource efficiency Wood Based Panels.
- Historically, the Grevena plant (Alfa Wood Pindos) was fully refurbished, incorporating a modern continuous press line, veneer and melamine finishing lines and refiners - raising annual MDF capacity from 90,000 m³ to around 130,000 m³.

Markets Exports

- Exports: Over 40% of production is exported to 39 countries across Eastern Europe, the Middle East, North Africa, and Australia.

Mission & Identity

- Alfa Wood Group is family-owned, driven by core values of sustainability, innovation, trust, and environmental consciousness. Their MDF production reflects these values - leveraging advanced technology, high-performance materials, and strict quality standards to deliver durable, versatile, and environmentally sound fibreboard solutions.

3. **Types of products and services:** Wood pellets and briquettes

Wood Pellets (ENplus A1 certified) – high calorific value, low ash content, moisture-controlled, suitable for residential and industrial heating systems

FULAR

Wood Briquettes – compressed from pure sawdust and residues, delivering long-lasting, eco-friendly energy for stoves and boilers

- **Production Facilities**:
  - Alfa Pellet Plant (Nevrokopi-Drama):
    - Annual capacity: Over 80,000 tons of pellets and briquettes
    - Technology: Fully automated production lines with strict quality controls
    - Energy efficiency: Utilizes residues and by-products from the group's panel production, ensuring a zero-waste philosophy
    - Sustainability: Biomass energy self-generation supports greener industrial operations

Raw Materials & Quality

- Produced exclusively from natural wood residues (beech, pine, poplar, and other Greek woods) without chemical additives, adhesives, or contaminants
- Certified according to ENplus A1 European standards
- Consistent pellet size, high mechanical durability, low ash, and moisture levels
- 100% eco-friendly and carbon-neutral energy source

Technical Properties of Alfa Pellet Products

- **Wood Pellets:**
  - Calorific value: ~4.8–5.0 kWh/kg
  - Diameter: 6–8 mm
  - Ash content: <0.7%
  - Moisture: <10%

- **Wood Briquettes:**
  - High compression density for long burn time
  - Low moisture and ash content
  - Easy storage and handling

Markets & Distribution

- Alfa Pellet has a strong presence in Greece and exports extensively across Europe (including Italy, Germany, Austria, and Balkan countries).
- Distribution networks cover both residential consumers (households, small businesses) and industrial clients (district heating, energy plants).

Mission & Identity

Alfa Wood Group is a family-owned company rooted in values of sustainability, innovation, and responsibility toward people and the environment. Its production of wood pellets and briquettes reflects these principles by:

- Converting wood residues into clean, renewable energy
- Reducing dependence on fossil fuels
- Supporting a circular economy model with zero waste
- Providing affordable, eco-friendly heating solutions

Through Alfa Pellet, the company contributes to both energy independence and environmental protection, positioning itself as a leader in Greece's green energy transition.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

The industrial facilities of Alfa Wood Group in Nevrokopi-Drama

5. **Types of Products and Services:** Power generation

Renewable Power Generation – biomass-based electricity produced from wood residues and by-products

Heat and energy recovery systems – maximizing energy efficiency and supporting industrial operations

- **Production Facilities**
  - **Biomass Power Plants:**
    - Total installed capacity
      - Grevena site:1MWH electricity production using biomass
      - Nevrokopi site: 2MW electricity production using biomass
      - Larisa site: 1MWH power generation using biomass
    - Technology: Modern biomass combustion and cogeneration units
    - Fuel source: Wood residues, sawdust, and by-products from Alfa Wood's panel and furniture production lines
    - Contribution: Supplies renewable electricity to the national grid and supports in-house energy needs
    - Sustainability impact: Reduces CO_2 emissions and closes the loop in the company's circular economy model

Raw Materials & Quality

- 100% use of wood residues and sawmill by-products (pine, beech, poplar, etc.)
- No external chemical additives—fuel is purely natural biomass
- Meets EU renewable energy and emission standards

- Supports resource efficiency by valorizing production waste

Technical Properties of Energy Production

- Installed capacity: 4 MW
- Fuel efficiency: Optimized combustion of wood residues with high calorific value
- Grid connection: Integrated into the Greek national energy network
- Environmental performance: Significant reduction in fossil fuel dependence; carbon-neutral energy source

Markets & Distribution

- Power supplied to the domestic Greek electricity grid under renewable energy regulations
- Internal use of heat and electricity across Alfa Wood Group's facilities, lowering energy costs and environmental footprint
- Strengthens Greece's renewable energy mix and supports EU climate goals

Mission & Identity

Alfa Wood Group is a family-owned company rooted in values of sustainability, innovation, and responsibility toward people and the environment. Its 4 MW power generation initiative embodies these principles by:

- Transforming wood-processing residues into renewable energy
- Enhancing national energy security
- Supporting the transition to a circular, low-carbon economy
- Demonstrating leadership in combining industrial production with environmental stewardship

Through its bioenergy operations, Alfa Wood Group positions itself not only as a leader in wood products but also as a pioneer in green energy production in Greece and the wider Balkan region.

7.7.2. Study case 2: Slovenia - KNOF

Basic information

- **Headquarters**: Krško, Slovenia
- **Number of employees:** exact number not publicly listed, but as a registered social enterprise, KNOF operates with a core team and a broad network of collaborators, including local craftsmen, designers, and vulnerable groups (e.g., long-term unemployed, people with disabilities).
- **Types of products and services:**
  - **furniture and interior products** made from recycled wood and plastic
  - **semi-products** for the furniture and construction industries
  - **custom-made items** from reused materials (e.g., office furniture, home decor)
  - **reuse boutiques** (under the brand Stara Šola) offering second-hand furniture, clothing, and household items
  - **consulting and development** of circular business models and sustainability strategies

  - **workshops and education** on reuse, recycling, and circular design
- **Facilities:**
  - **Circular Lab in Krško** (3,000 m²): includes carpentry, sewing workshop, FabLab, and testing facilities
  - **Circular Factory in Skopice:** industrial-level production of recycled materials and furniture components
- **Markets**
  - **Domestic market (Slovenia):** through physical stores in Krško, Sevnica, Brežice, Litija, and Novo mesto
  - **Online sales**: via collection.knof.si
  - **B2B collaborations:** with companies like Kostak d.d. and Beti d.d., as well as municipalities and public institutions

Mission: To reduce waste and promote sustainable living through reuse, recycling, and social innovation.

KNOF, a Slovenian social enterprise, exemplifies a robust circular economy model by transforming post-industrial wood residues and other waste materials into high-quality furniture and interior products. Their approach is rooted in sustainability, social inclusion, and innovation, making them a leading example of circular business practices in the region.

Material Sourcing and Waste Utilization

KNOF sources its raw materials primarily from:
- Post-industrial wood waste from carpentry workshops, construction sites, and furniture manufacturers (e.g., solid wood, plywood, particleboard).
- Discarded furniture, which is disassembled and sorted for reusable components.
- Plastic and textile waste, which is repurposed into acoustic panels, decorative items, and accessories.

These materials are diverted from landfills and incineration, significantly reducing environmental impact while preserving the embedded value of high-quality wood.
Processing Technologies and Facilities

KNOF operates a 3.000 m² Circular Lab in Krško, equipped with:
- a woodworking workshop for cutting, sanding, gluing, and assembling components.
- a FabLab with CNC machines, laser cutters, and 3D printers for precision work and prototyping.
- manual and semi-automated tools for processing both wood and plastic materials.

This infrastructure enables the transformation of heterogeneous waste streams into standardized, modular components suitable for new product development.

Conversion Costs and Economic Efficiency
The cost of converting waste into usable materials is relatively low due to:
- Free or low-cost sourcing of raw materials (via donations or collection partnerships).
- Labor-intensive processes managed through social employment programs, involving vulnerable groups and volunteers.

- Design strategies that emphasize modularity and simplicity, reducing the need for complex processing.

This model not only minimizes production costs but also maximizes social and environmental value.

Material Properties and Product Quality

The reclaimed materials exhibit the following characteristics:

- Mechanical properties: Solid wood retains good structural integrity and load-bearing capacity; engineered wood (e.g., particleboard) is used for non-structural elements.
- Aesthetic qualities: Natural wear, patina, and imperfections are often preserved to enhance the product's uniqueness and authenticity.
- Workability:
  - *Cutting:* Easily performed with standard woodworking tools.
  - *Gluing:* Effective with proper surface preparation and standard adhesives.
  - *Sanding and finishing:* Feasible, though care is needed with thin veneers or laminated surfaces.
  - *Polishing:* Primarily applied to solid wood and plastic surfaces for a refined finish.

These materials are generally easy to process and integrate into new designs, supporting efficient and flexible production workflows.

Final Products and Structural Integrity

KNOF produces a wide range of items, including:

- Office and home furniture (e.g., desks, benches, drawers).
- Interior elements (e.g., acoustic panels, modular walls, decorative features).
- Gift and promotional items made from upcycled materials.

All products are designed for durability, reparability, and modularity, ensuring long life cycles and ease of maintenance. Structural integrity is verified through in-house testing, particularly for load-bearing components.

Renovation and upholstery

7.7.3. Study case 3: Agroflora ltd (Bosnia and Herzegovina)

In Bosnia and Herzegovina, the idea of a circular economy is still new and underdeveloped. In recent years, the circular economy has started to gain recognition both as a concept and as a practice, but it is still applied to an insufficient extent. The economy in Bosnia and Herzegovina is primarily based on the model of a linear, extractive economy – the depletion of natural resources, the increasing problem of waste generation, and leaving a high carbon footprint in the country.

With the adoption of the Green Agenda for the Western Balkans in 2020, the Western Balkan countries accepted the European Green Deal (or its key elements), committing themselves to the implementation and compliance with measures in five areas, one of which is the circular economy. The first priority of the Green Agenda for the Western Balkans is that „the value of materials is preserved for as long as possible, and waste generation is minimized".

As a resource-intensive economy, Bosnia and Herzegovina has the potential to achieve significant economic benefits by applying the circular economy model. This means increasing resource productivity in the economy, making the best possible use of raw materials extracted domestically, keeping them in circulation for as long as possible, maximizing their value, and minimizing waste.

Although Bosnia and Herzegovina has not yet adopted a Circular Economy Roadmap as a necessary framework for a faster transition, some companies in the country have begun applying circular economy models in their operations. This is particularly evident in the wood processing and furniture manufacturing sector, where residues and production waste are most commonly used for pellet production or for heating their own facilities.

However, only a very small number of companies in this sector use production residues and waste to create new products. The main reasons are the high initial investments required, compounded by the challenges of finding a skilled workforce, as well as the insufficient

quantities of production waste and residues needed to produce new value-added products that would justify the investment.

Nevertheless, there are still certain examples in Bosnia and Herzegovina where companies from this sector are striving to integrate circular economy models into their operations with the goal of utilizing the highest possible percentage of raw materials (wood).

One such example is the company „Agroflora" ltd. from Kozarska Dubica.

"Agroflora" ltd. from Kozarska Dubica was founded in 1989, and since 1996 it has been engaged in wood processing. The company's core activities are primary wood processing and the production of final wood products, including oak, beech, ash, linden, acacia, elm, etc. It employs around 80 workers.

The company has strong technological capacities that cover all key stages of both primary and final wood processing, ensuring a fully integrated production process. The annual wood processing capacity is around 13.000 m³. More than 80% of production is exported to EU countries (Austria, Slovenia, Italy, Spain, Belgium, Croatia, Serbia, etc.), as well as to other countries worldwide.

The company holds ISO 9001, FSC CoC certification, and the CE mark for laminated beams and sawn timber (EN 14080 and EN 14080-1). In addition, the CE mark for multilayer flooring is in preparation, confirming the company's compliance with ecological sustainability standards and responsible management of wood resources.
The main products are:

- Sawn timber (raw, dried, steamed, and thermo-treated from oak, beech, ash, linden, acacia, elm, etc.)
- Glued laminated and solid wood (boards and beams) (with the option of thermo-treatment)
- Flooring – solid, multilayer, and parquet (with the option of thermo-treatment)
- Decking (with the option of thermo-treatment)
- Wooden wall claddings
- Solid wood table tops
- Children's cribs and cradles
- Pellets
- Small household items and decorative objects

It is equipped with:

- Sawmill capacities (annual processing capacity of 13.000 m³)
- Drying capacities for raw sawn timber, ensuring proper and stable wood processing (capacity 1.000 m³)
- Wood steaming capacities, improving dimensional stability, color, and workability of wood (capacity 60 m³)
- Thermo-treatment capacities – TERMO WOOD system, one of the most modern and technologically advanced methods in the wood industry, where the high-temperature process significantly improves wood resistance to moisture and pests, reduces moisture content below 1%, evens out the color (giving a darker, "exotic" appearance), and increases durability, stability, and insulation properties (capacity 20 m³)

- Capacities for cutting and processing wooden elements
- Capacities for wood and beam gluing (laminated and solid), enabling lengthwise and widthwise gluing of sawn timber suitable for the production of laminated beams, glued beams, and solid panels, including processed variants (thermo-treated). This contributes to the production of stable and dimensionally precise structural elements
- Capacities for UV varnishing of products
- Capacities for the production of pellets and wood chips
- Biomass boilers for heating the company's facilities and powering the thermo-treatment process – ensuring high technological self-sufficiency and an environmentally efficient model
- Transport equipment – the company owns transport vehicles for internal and external needs, enabling efficient management of raw materials, materials, and product distribution

Agroflora ltd, in all its processes of primary and final wood processing, strives for maximum utilization of raw materials. However, certain types of by-products and wood waste still appear, which do not meet the required quality and dimensions, namely:

- Unusable parts of logs: include rotten, damaged or undersized parts of wood
- Bark
- Wood pieces, off cuts and edges
- Trimeed edges
- Sawdust
- Wood Shavings/Chips
- Sanding Dus

These residues are generated in the following production processes:

- production of raw boards of natur and rustic quality (surpluses that do not correspond in length, width, or appearance as required by that quality standard),
- glued laminated beams made of dried fir/spruce (surpluses generated during formatting and removal of products of undesired quality),
- length-and-width jointed panels (elements smaller than the required dimensions or not meeting the required quality),
- width-jointed panels (strips that do not correspond in quality or thickness).

Ultimately, Agroflora ltd utilizes all types of wood by-products and waste for the production of pellets and wood chips, as well as for fuel to heat boilers used for its own heating, drying, steaming, and thermo-treatment processes. In this way, the value of wood by-products and waste generated during primary and final production is increased, leading to waste minimization, efficient use of resources, and support for a renewable future. This principle is also embedded in the company's marketing strategy to build a strong reputation for entering demanding markets.

The pellets are produced exclusively from the company's own waste, coming from both primary and final processing. Bark is separated in every process, and the clean wood material is ground to obtain a pure mass for pellet production. This mass is then further dried and pressed, resulting in the finished pellet material, which is automatically packed into bags. The pellets consist mainly of oak and beech, with a smaller proportion of fir.

FULAR

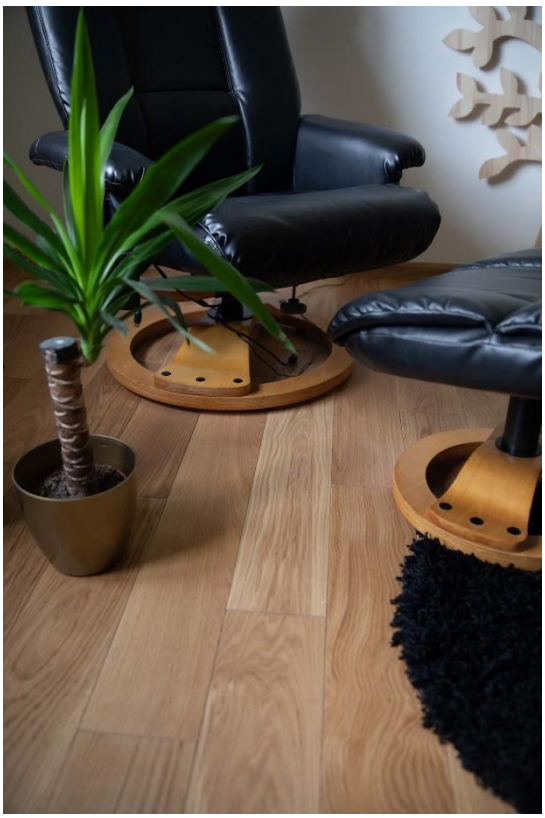
Other waste not suitable for pellet production, such as bark, decayed wood, contaminated material, or wood that does not meet pellet production standards, is also ground and used in the company's own heating systems. With the help of a moving grate boiler, 99% of this mass is combusted, leaving only a very small percentage of ash.

However, Agroflora d.o.o. has set itself the goal of maximizing the use of wood by-products and waste for the production of final products. In this way, a significant portion of the by-products and wood waste is used to produce multilayer flooring, thermo decking boards, length-and-width jointed panels, rustic width-jointed panels, and small household items (such as cutting boards).

The thermo decking boards are made from smaller elements (short, narrow, and thin) of beech, ash, pine, Douglas fir, and larch. These elements are generated as waste during the production of panels due to their unsuitable dimensions. They are then resized into uniform smaller dimensions, subjected to thermal treatment, profiled, and pressed onto plastic supports.

Decking

Cutting boards



Multilayer flooring (Natural Oak)

Multilayer floors are produced as two-layer and three-layer products. The upper part (the main part) is the walking surface, most often made of laminated oak panels (rustic and natur), ash (thermo, white, and core), and fir. These laminated panels are frequently produced from boards that do not meet the required quality and dimensions for sale. Such boards are dried and prepared specifically for the production of these flooring elements. The lower or middle parts of the floors are made from fir slats, cross-glued to the upper laminated panel. For the production of these lower layers, wood residues generated in the process of laminated beam production are used. In addition, the bottom layer of the three-layer flooring is made of fir or oak veneer, produced from raw boards of lower quality.

Length-and-width jointed panels are produced from elements (of all types of wood) generated as waste in the production of raw boards (which do not meet the required quality or dimensions). These elements undergo a selection process and are then cut to uniform dimensions, after which they are jointed lengthwise to form strips used for making the finished panel. The quality of the panel depends on the quality of the input material. Elements that do not meet the required dimensions or quality are used as raw material for pellet production.

Rustic width-jointed panels are made from boards that do not meet quality standards. Such boards are cut into several strips, which are resized and glued into a panel. Knotholes and cracks are filled, and after drilling, a rustic width-jointed panel is obtained.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

7.7.4. Study case 4: DAFINOR (Albania)

Below is an expanded case study, in simple language, on how **DAFINOR,** in the city of Shkodra, North Albania, applies circular economy principles by reusing post-industrial wood residues in furniture and wooden products manufacturing.

Basic overview:

- **Name:** Dafinor sh.p.k.
- **Location:** Shkodër, Albania.
- **Factory size:** Around 14000 m², divided into two main sectors.
- **Ownership:** Family-run/Private, since the mid-1990s.
- **Employees:** Approximately 100 workers.
- www.dafinor.com

What they produce:

- Industrial wood panels via finger-joint technology.
- Furniture and interior design items, such as doors, flooring, kitchens, bedrooms, studios and individual art pieces.
- Kitchen cutting boards (and more) and wood pellets, as by-products.

Markets served:

- Local and international clients, including Italy, France, Romania, Montenegro, Russia, Germany, Greece, Canada, Azerbajxhani.
- Projects range from apartments and villas to state institutions, religious buildings, hotels, bars and restaurants.

Technology and Process Details

1. **Primary processing/Sawing of logs**
   - Timber logs are sawn into rough boards (unedged and not dried) applying band saw technology, leaving approximately 20 ÷ 25 % of material as slab and sawdust (referring beech logs). This technological process takes place in Montenegro, where the company relocated its sawmilling facility a few years ago. The move was prompted by the Montenegrin government's ban on log exports. Additionally, the export of wood processing residues is also prohibited by the Montenegrin government, as they are in high demand by the pellet production domestic industry.
   - The boards are subsequently transported to Albania for further processing.

2. **Primary processing/Panel production**
   - In one sector, Dafinor manufactures finger-joint panels. These use short, defect-free blocks that are end-jointed with D3/D4 vinyl glue to form longer strips. The blocks are produced by kiln dried boards of 8 ÷ 10 % moisture content. The company owns two middle size drying kilns for the boards it produces in Montenegro, as well as a steaming smaller one. The average yield from cutting boards into blocks is approximately 40 ÷ 45% (referring dried beech boards). Quite often, the company also purchases boards, whether dried or not, from third-party suppliers.

FULAR

Dried beech boards inside the kiln

Defect-free beech blocks

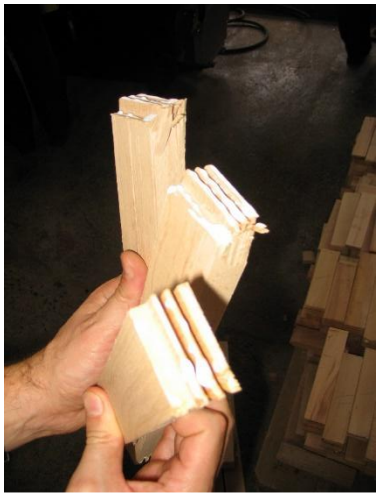
Finger-joint profile machine

Finger-joint ends

- Then, the strips are four sided planed and are joined edge to edge with D3/D4 vinyl glue, forming panels with dimensions up to 4.500 mm long, 1.220 mm wide and the thickness ranging from 19 to 62 mm. The company applies high-frequency electric pressing technology. However, depending on the workload, pressing is often carried out at room temperature as well.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

FULAR



Applied glue to the blocks

Joined blocks into the strips

Four side planed strips

Pressing process

High frequency power press

- Finally, the panels are trimmed to exact dimensions and then go through a calibration and sanding process, using 80 to 150 grit sandpaper. A portion of the finished panels is used for the company's own needs, while the rest is sold on the market as raw material.

The panel after pressing

Piled trimmed panels in front of sanding machine

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

3. **Furniture & Interiors**
   - The second sector uses above mentioned panels to make custom luxury furniture. This includes designs for living rooms, kitchens, bedrooms, studios, doors and decorative flooring.
   - Aesthetic appeal is high: natural wood grains and mixed-colour patterns are embraced, often left visible or enhanced by finishes.
   - Panels are easy to machine—cut, drill, polish—and finish using PVA/PUR glue and standard oils or lacquers.
   - The application of CNC technology ensures the production of high quality furniture with a variety of finishes.


Furniture and interior elements produced using finger-joint panels


Furniture and interior elements produced using finger-joint panels

4. **Kitchen cutting boards and other wooden items**
   - Cutting boards are made as by-products from blocks too short or with quality not suitable for panels. These are processed and glued to create stable, decorative

boards. Depending on the boards model and the dimensions of available material, finger jointing can also be applied.

- Just like in the case of furniture, here too, the application of CNC technology enables the creation of various finishes.

Different models of cutting boards

Puros tray and brandy glass holders

5. **Pellets production as by-product**
   - Dafinor convert around 50 ÷ 60% (even more; depending by the season) of the amount of sawdust, shavings, chips and small wood pieces into wood pellets, a renewable biomass fuel. The rest is burned in the boiler to produce heat and steam for the drying kilns and the evaporation one.
   - A few years ago, the company purchased a new line for pellet production (as by-product), consisting of 2 mill dies, each with a capacity of about 300 kg/hour.
   - The pellets are packaged in plastic bags with a capacity of 15 kg. Since all the material used is properly dry, the quality of the pellets is very satisfactory.
   - Pellets are primarily sold in the Italian market.

Pellets production line

FULAR

Material Properties & Workability

1. **Panels**
   - Finger-jointing reconnects short wooden blocks via interlocking “fingers” and strong adhesives (vinyl D3/D4), making possible formation of longer boards with mechanical properties similar to solid wood and good surface quality.
   - The physical and mechanical properties of these panels depend on the properties of the wood material from which they are produced, but the finger-joint connection gives them an advantage in terms of stability and durability.
   - The ability to maintain high mechanical properties and stability has made this material a preferred choice for all types of non-structural interior applications that require high quality standards. It offers greater dimensional and deformation stability than solid wood, high durability, and a very positive environmental profile.
   - The company produces mainly panels of beech, oak and walnut wood (grades A and B), used for furniture of rustic style. These panels offer good strength, consistent moisture content, flatness and are easy to work with (cutting, milling, gluing), meeting industrial standards.

Property	**Description**
Mechanical strength	Finger-joint panels match solid wood in bending and internal bond strength
Moisture & stability	Dried to 10 ± 2 % moisture; stable with minimal warping
Workability	Clean cuts, smooth drilling and milling with standard tools
Gluing & finishing	Excellent adhesion with PVA or PUR; well-sanded for oils/lacquers
Aesthetics	Natural grains/art patterns: visually pleasing and unique
Structural integrity	Panels demonstrate flatness and strength via cross-joint techniques

2. **Pellets**
   - Off-cuts, chips, sawduast and shavings from panel-making feed into pellet production areas.

Technical specification

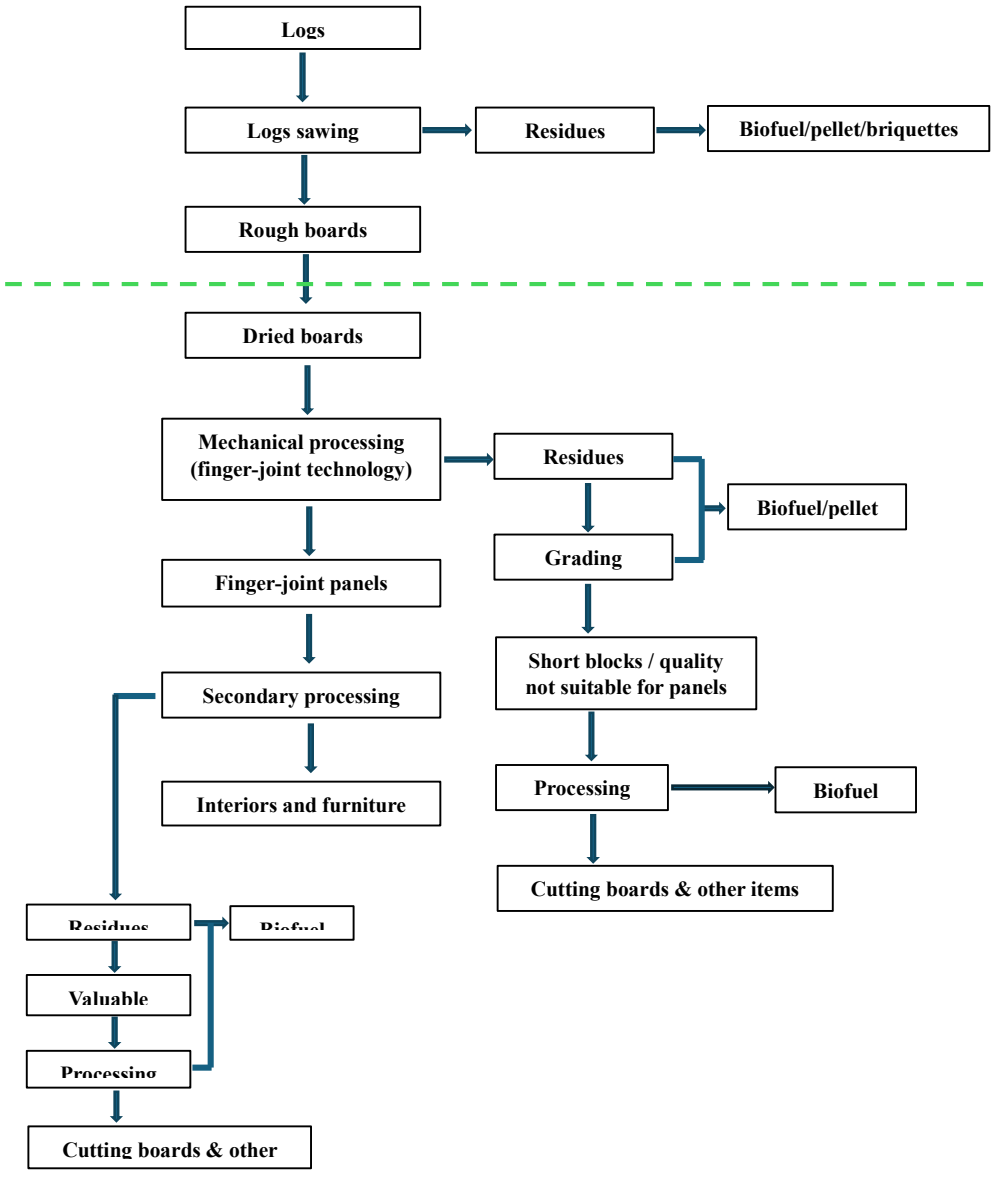
Specific weight	1.12 kg/dm^3
Diameter	6 mm
Length	1÷3 cm
Calorific power	18.76 ÷ 19.95 MJ/kg
Ash	≤ 0.7 %
Fines	≤ 0.5 %
Mechanical durability	≥ 98 %
Moisture content	7 ÷ 8 %
Content of Metanal	1.3 mg HCHO/100 gr
Bulk density	600 ÷ 750 kg/m^3
Energitical value	98 %
Binding agent	Not present
Packaging	15 kg

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

FULAR

Circular Economy in Action

- Dafinor has developed a circular production system. Rather than discarding leftovers, they reuse them creatively and effectively. All shavings, off-cuts, sawdust, low graded blocks are not discarded. This material is rechanneled into production of by-products, such as cutting boards and biofuels (pellets).
- Almost all the entire amount of wood material that enters the factory is transformed into value-added products and by-products as well as into bioenergy.
- By using everything, Dafinor reduces waste to almost zero, supporting a true circular economy model.
- Below is presented the material flow diagram according to the technological process applied by DAFINOR.



The project is co-funded by the European Union through the Interreg IPA Adrion programme.

Economic & Environmental Benefits

Economic advantages

- Below is a detailed consumption of raw material in %, according to the technological process.

The presented values may vary within a ± 2% range, even more.

Logs	**100.0 %**
● slabs	12.0 %
● sawdust	10.0 %
Rough boards	**78.0 %**
● drying loss	8.0 %
Dried boards	**70.0 %**
● sawn dust	8.0 %
● residues* (off-cuts, edges etc.)	31.5 %
○ usable blocks/pieces	15.0 %
❖ cutting boards	8.0 %
Blocks	**30.5 %**
● residues (chips, shavings, edges, sanding dust)	5.5 %
Panel	**25.0 %**
● residues**	5.0 %
○ cutting boards	2.5 %
Furniture	**20.0 %**

* The residues are subjected to a selection process in which pieces and blocks of appropriate size and quality are selected, and these are used to produce cutting boards or other wooden items.
** These are residues consisting mainly of cut panel pieces. The pieces with suitable dimensions are used as raw material for cutting board production.

- The yield at each stage of processing is presented in the table below, according to the raw material consumption values mentioned above.

Processing stages	Logs %	Rough boards %	Dried boards %	Blocks %	Panel + Boards %	Furniture %
Logs	100					
Rough boards	78	100				
Dried boards	70	90	100			
Blocks	30.5 + 15[1]	58	65	100		
Panel	25	32	36	82	100	
Furniture + boards	20 + 10.5[2]	26 (39)[4]	29 (44)	66[3] (67)	80[3] (-)	100 (100)

[1] The amount of recovered waste used for cutting boards production.
[2] The quantity of raw material recovered into value-added products.
[3] The value refers to the line: Blocks-Panel-Furniture/30.5-25-20.
[4] The values in brackets refer to the total quantity of product (Furniture + boards = 30.5%) aswell as to the total quantity of blocks produced, which is 45.5%.

- By reusing about one-fifth of residues for value-add products, their material efficiency increases by more than 10%.
- This value increases even further during periods when the demand for pellets and their price decreases.
- Less raw timber is needed, cutting costs and reducing reliance on forest resources.
- Cutting boards and pellets bring in extra sales, diversifying income and stabilizing cash flow.

Environmental impact

- The positive environmental impact of producing finger-joint panels lies in the fact that they enhance the value of low-quality wood by turning it into high-performance, long-lasting solid wood products. This leads to an increased the yield of the wood material, meaning more efficient use of wood.
- Efficient use of wood also implies better management of forest resources.
- Using wooden residues for pellets, sequesters carbon and reduces fossil fuel dependence.
- Nearly zero wood waste, reducing landfill and environmental harm.
- Encourages sustainable forestry by valuing all wood resource parts.

Business Scale & Impact

- Over the years, Dafinor has grown beyond the local market and now operates in several European and overseas markets.
- Its projects include high-profile interior work in government buildings (e.g., Prime Minister's office, ministry offices), religious institutions (cathedrals), hotels, restaurants.
- This mix of industrial panel production and fine furniture/interior design makes the business diversified and resilient.

Summary and Lessons Learned

1. Circular design thinking; from the start, Dafinor designed its factory to handle raw materials and residues in two balanced sectors.
2. Technology matched to sustainability; finger-joint panels allow the use of offcuts with no compromise in quality. With their CNC, that are a state of art production of BIESSE company, they can afford to realise every design they are asked for.
3. Value diversity; from panels to furniture, cutting boards, and pellets, by-products are turned into products with real market demand.
4. Quality maintained; despite using residues, products are mechanically strong, stable, and visually appealing.
5. Environmental responsibility; minimal waste, efficient resource use, and renewable material practices all support a sustainable future.

Conclusion

Dafinor in Shkodër shows how a family-run medium enterprise can successfully implement circular economy principles in wood production:

- Efficiently recover material through finger-jointing.
- Offer diverse products from residues, adding economic value.
- Maintain product quality and aesthetic appeal.
- Export to demanding markets, building a strong reputation.

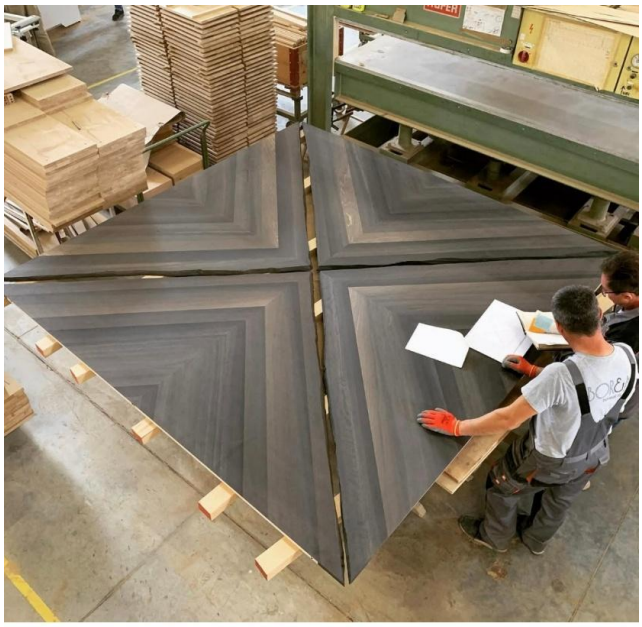
7.7.5. Case study 5: Boreal ltd (Serbia)

Basic information

Boreal is a design-driven Serbian manufacturer that puts *value before volume*. With 55 employees, it produces custom solid-wood interiors and furniture from local oak, walnut and sub-fossil “bog oak” salvaged from riverbeds. Their clients are premium buyers worldwide, including luxury lounge projects at the airports in Zurich, Geneva and New York. Production, CNC machining, finishing and assembly all take place on the same campus, and even the smallest off-cuts are turned into high-end accessories.

Application of circular-economy principles

To embed circularity in its business model, the company has turned a difficult material stream – centuries-old river oak that would otherwise decay in situ – into a signature resource. Divers bring up roughly 25 m³ of bog-oak logs each year. After gentle kiln-drying and defect mapping, these irregular blanks are CNC-machined into tabletops, counters and wall cladding whose dark, mineral-stained grain commands premium prices. In order to minimize waste, Boreal converts the remaining off-cuts into smaller lifestyle products – bowls, lamp bases, serving boards – using five-axis routing and hand finishing. Fine dust and shavings are used on-site to fuel the biomass boiler that heats the production halls and offices, while any surplus fuel is sold to neighbouring households, closing the loop and sending zero wood waste to landfill.



"Bog oak" table and wall panelling

Study case: Euro Spin d.o.o.

Basic information

Euro Spin is a micro-enterprise founded in 2017 in Vranje that manufactures and sells regenerated polyurethane ("re-bonded") foam blocks and sheets to small and mid-size upholstery shops across Serbia and North Macedonia.

Application of circular-economy principles

Furniture factories and mattress makers deliver PU-foam off-cuts that would otherwise be land-filled. Euro Spin shreds the scrap into flakes, mixes them with an MDI binder and presses the mixture into blocks, then slices these into cushions and sheet stock. The re-bonded foam matches the compression performance of medium-firm virgin foam and can be cut, glued and upholstered with standard equipment. By turning an unavoidable post-industrial residue into a saleable intermediate, Euro Spin keeps polyurethane in circulation for an additional five-to-seven-year product life and prevents thousands of cubic metres of foam from entering Serbia's municipal-waste stream.

Re-bonded foam block ready for further processing

7.7.6. Case Study 6: Bjelin ltd – Woodura Technology as an example of circular economy in practice (Croatia)

Basic information about the business entity

Bjelin d.o.o. is a Croatian company operating as part of the Swedish-Croatian Pervanovo Group, with production facilities in Ogulin, Bjelovar, Spačva and Otok. The company employs several hundred workers, and its core activity is focused on the production of flooring, boards, panels, and veneers. Bjelin markets its products across European, American, and other international markets, placing special emphasis on quality and sustainability, confirmed by FSC, CE and ISO certifications.

Application of circular economy in the business model

The central element of Bjelin's business model is the application of circular economy principles through the innovative Woodura technology. This technology ensures that post-industrial by-products such as sawdust, wood dust, and veneer residues are not treated as waste but as valuable raw material. These by-products are transformed into wood powder, which is used in

the fusion process with an ultra-thin layer of noble wood. Under high pressure, the veneer is bonded with a core made of HDF and wood powder, creating a flooring board that fully retains the natural appearance of solid wood while achieving greater resistance and stability. In this way, up to ten times more flooring can be produced from a single tree compared to traditional manufacturing, significantly reducing raw material consumption and providing an excellent example of resource management.

Technology and material properties

The Woodura process offers numerous advantages. The mechanical properties of the material far surpass those of traditional parquet, as Woodura floors are up to three times more resistant to impacts and deformations, while also being significantly more stable against moisture and temperature changes. Aesthetically, the floors preserve the natural beauty of wood, and thanks to technological processing, a wide range of surface finishes and colors can be achieved. The material is suitable for further processing – it can be easily cut, polished, sanded, and glued – while the finished products retain high structural strength and long service life, making them suitable for both residential and commercial use. Although currently used primarily for flooring production, this technology is expected to be applied in the future to the manufacturing of panels and furniture components as well.

In Woodura technology, saws and mills are used for veneer and powder production, dosing systems, high-pressure presses, CNC machines for processing, and finishing and joining lines. The most important part of the process is the patented press for the fusion of veneer and wood powder, which creates a composite far more durable than traditional parquet.

Benefits, challenges, and conclusions

The implementation of this business model brings multiple benefits. Economically, Bjelin achieves lower raw material costs and produces high value-added products that are successfully marketed internationally. Environmentally, the impact is equally important since waste is reduced to nearly zero, trees are utilized to their maximum, and pressure on forest resources is significantly reduced. In addition, the company generates social benefits by creating jobs in rural areas and positioning Croatia as a leader in innovative wood industry solutions.

Despite the many advantages, the introduction of Woodura technology also posed certain challenges. It required significant investments in development and patents, as well as continuous market education to communicate the advantages over traditional parquet to customers. It was also necessary to ensure consistent quality of by-products used as raw material for wood powder. Nevertheless, Bjelin successfully met these challenges and has demonstrated how innovative technology and circular economy principles can operate in perfect synergy.

This example shows that post-industrial wood waste can become the foundation for high-value products. Bjelin and its Woodura technology represent best practice in the region, proving that with a smart approach it is possible to achieve near-total utilization of raw material, ensure premium product quality, increase international competitiveness, and at the same time make a strong contribution to sustainability.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

FULAR

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

8. Mapping furniture parts of end life items

8.1. Typology of furniture and their respective functional elements

Currently, there are many types of furniture in use and their number has increased significantly over time. This diversity ensures that every space and activity to have the most suitable furniture for specific needs (eg. dining tables, coffee tables, side tables, kitchen islands, bar counters, picnic tables etc.). The development of new materials has enabled the creation of furniture with forms and functions that were not possible before (eg. smart furniture, modular furniture that changes easily etc.). Likewise, the furniture industry encourages diversity to increase sales by creating products for every possible need. This diversity can be a benefit (more choices for specific needs), but also a challenge (more decision making and costs for consumers).

Although there are dozens of different types of furniture for each specific need, they can still be grouped into several main types, based on their use and basic function. Below is a list of the main types of furniture, as well as their components and respective functional description.

1. **Sofa**
   - Frame
     Description**:** *Main structural base of the sofa*
   - Suspension
     Description**:** *Internal support system (springs or webbing)*
   - Cushioning
     Description**:** *Soft padding for comfort*
   - Upholstery
     Description**:** *Outer textile or leather cover*
   - Legs
     Description**:** *Bottom supports for structure*

2. **Table (Dining or Coffee Table)**
   - Top
     Description**:** *Usable flat surface*
   - Legs/Base
     Description**:** *Structural support under the top*

3. **Bed**
   - Slats
     Description**:** *Supports the mattress*
   - Frame
     Description**:** *Holds all parts of the bed*

4. **Wardrobe / Cabinet**
   - Panels (Carcass)
     Description**:** *Structural sides, top, bottom*
   - Back Panel
     Description**:** *Stabilizing back section*

- Drawer Runners
  Description**:** *Mechanism to slide drawers*

5. **Office Chair**
   - Base
     Description**:** *Bottom part with wheels*
   - Seat & Backrest
     Description**:** *Main support for user*

6. **Outdoor Chair / Table**
   - Frame
     Description**:** *Outdoor-graded structure*
   - Cushions
     Description**:** *Soft, outdoor-ready pads*

7. **Kitchen Cabinet**
   - Countertop
     Description**:** *Work surface for cooking*
   - Carcass
     Description**:** *Box structure of cabinet*
   - Handles/Knobs
     Description**:** *Opening/closing accessories*

8.2. Mapping furniture types and material composition of their components

The importance of materials for furniture components lies in several key factors that affect the functionality, durability, appearance and sustainability of the final product. Choosing the right materials for furniture components is essential to achieve the desired balance between these factors and the furniture's cost. It impacts not only the product's performance and lifespan, but also how it fits into users' lifestyles and values. Below is presented a list of main types of furniture (see 4.1), along with the **components** that make up each piece and the **materials** commonly used for those components.

Sofas / Seating

1. **Sofa / Couch**
   Frame: Usually hardwood (eg. beech, oak) or metal (steel, aluminum)
   Suspension: Webbing (elastic belts), sinuous springs (steel)
   Cushioning: Foam (polyurethane), down/feather, polyester fiberfill
   Upholstery: Fabric (cotton, linen, polyester), leather (genuine or synthetic)
   Legs: Wood, metal or plastic

2. **Armchair**
   Similar components as sofa, usually in a single-seating format
   Frame: Usually hardwood (eg. beech, oak) or metal (steel, aluminum)
   Suspension: Webbing (elastic belts), sinuous springs (steel)
   Cushioning: Foam (polyurethane), down/feather, polyester fiberfill

Upholstery: Fabric (cotton, linen, polyester), leather (genuine or synthetic)
Legs: Wood, metal or plastic

3. **Recliner**
   Reclining mechanism (metal, plastic gears), **motor** for electric versions

4. **Dining Chair / Side Chair**
   Frame: Wood, metal, plastic.
   Seat: Upholstered (fabric/leather), wood, plastic.
   Backrest: Solid or upholstered.

Tables

1. **Dining Table**
   Top: Solid wood, veneer overlayed engineered wood, glass, marble or laminate
   Legs/Base: Solid wood, metal, engineered wood

2. **Coffee Table**
   Same as dining tables but smaller and lower
   Top: Solid wood, veneer overlayed engineered wood, glass, marble or laminate
   Legs/Base: Solid wood, metal, engineered wood
   Often includes **shelves or drawers** (plywood, coated MDF or veneer overlayed MDF)

3. **Side/End Table**
   Small accent tables; same material as above
   Top: Solid wood, veneer overlayed engineered wood, glass, marble or laminate
   Legs/Base: Solid wood, metal, engineered wood
   Often includes **shelves or drawers** (plywood, coated MDF or veneer overlayed MDF)

4. **Console Table**
   Top: Solid wood, veneer overlayed engineered wood, glass, marble or laminate
   Legs/Base: Solid wood, metal, engineered wood
   Often includes **shelves or drawers** (plywood, coated MDF or veneer overlayed MDF)
   Narrow, used in hallways; often features **drawers or shelves**

Beds

1. **Bed Frame**
   Headboard/Footboard: Wood, upholstered (foam and fabric), metal
   Side Rails & Slats: Solid wood, engineered wood, metal
   Legs: Wood or metal

2. **Mattress Base (Box Spring / Foundation)**
   Structure: Wood frame with metal springs (box spring) or solid base (foundation)
   Covering: Fabric

3. **Bunk Bed / Loft Bed**
   Structure: Mostly metal or solid wood, with guardrails and ladders

FULAR

Storage Units

1. **Wardrobe**
   Panels: Solid wood, MDF/particleboard with veneer or laminate
   Back Panel: Plywood or thin hardboard
   Doors: Hinged or sliding; same as panels or MDF
   Shelves: Engineered wood, particle board or glass
   Hinges/Rails: Steel or aluminum

2. **Cabinet**
   Similar to wardrobes but smaller; kitchen or living room use
   Panels: Solid wood, MDF/particleboard with veneer or laminate
   Back Panel: Plywood or thin hardboard
   Doors: Hinged or sliding; same as panels or MDF
   Shelves: Engineered wood, particle board or glass
   Hinges/Rails: Steel or aluminum

3. **Chest of Drawers**
   Carcass: Solid or engineered wood
   Drawer Runners: Metal or plastic
   Knobs/Pulls: Metal, wood, ceramic, plastic

4. **Bookshelf**
   Open frame: Wood, metal or glass shelves

Office / Commercial Furniture

1. **Office Desk**
   Top: Solid wood, MDF or particleboard with laminate or veneer
   Frame/Legs: Metal or wood
   Drawers: Same as home storage

2. **Office Chair**
   Base: Nylon, aluminum or steel with casters
   Seat & Backrest: Foam with mesh, leather or fabric cover
   Mechanism: Gas lift, tilt and height adjustment (metal/plastic)

3. **Reception Desk / Counter**
   Larger, often custom made; wood or composite with laminate, metal details

Outdoor Furniture

1. **Patio Chair / Lounge**
   Frame: Aluminum, steel (often powder coated), teak, plastic (polypropylene)
   Seating Surface: Mesh fabric (textilene), plastic slats, wood slats or cushions
   Cushions: Outdoor rated fabric (acrylic, polyester), quick-dry foam

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

2. **Outdoor Table**
   Top: Glass, wood (teak, eucalyptus), metal or HDPE
   Frame: Same as above

3. **Bench / Swing / Hammock Stand**
   Often wood (treated), metal or synthetic rattan

Kitchen Furniture

1. **Kitchen Cabinets**
   Carcass: Plywood, particleboard or MDF with melamine/laminate
   Fronts: Solid wood, coated/veneered/thermofoiled MDF
   Countertop: Laminate, solid wood, stone (granite, quartz), composite (Corian)
   Handles/Hinges: Metal (stainless steel, zinc alloy)

2. **Kitchen Island**
   Same as cabinets, may include seating**,** drawers**,** sinks**,** electrical accessories
   Carcass: Plywood, particleboard or MDF with melamine/laminate
   Fronts: Solid wood, coated/veneered/thermofoiled MDF
   Countertop: Laminate, solid wood, stone (granite, quartz), composite (Corian)
   Handles/Hinges: Metal (stainless steel, zinc alloy)

3. **Pantry Units**
   Tall cabinet-style storage; made like regular kitchen cabinets
   Carcass: Plywood, particleboard or MDF with melamine/laminate
   Fronts: Solid wood, coated/veneered/thermofoiled MDF
   Countertop: Laminate, solid wood, stone (granite, quartz), composite (Corian)
   Handles/Hinges: Metal (stainless steel, zinc alloy)

8.3. Damage and repair of furniture

During daily use, and/or due to external factors, furniture can be damaged physically and/or aesthetically. This leads to the need for their repair. The damage and repair of furniture are two important aspects related to their maintenance and longevity. Below (Table 4.1.), is a summary of the most common types of damage, as well as the repair methods for each case.

Furniture damages and respective repair methods

Furniture Component	Material	Possible Damage	Cause of Damage	Replacement or Fix
Sofa Frame	Wood/Metal	Cracks, warping, rust	Moisture, overload, age	Replace damaged frame section or reinforce
Sofa Suspension	Springs/Webbing	Sagging, breakage	Wear and tear, heavy use	Replace springs or webbing
Sofa Cushioning	Foam	Compression, deformation	Long-term use	Replace cushion inserts
Sofa Upholstery	Fabric/Leather	Tears, stains, fading	Pets, spills, sunlight	Reupholster or replace covers
Sofa Legs	Wood/Metal/Plastic	Breakage, wobbling	Impact, overload	Replace legs or tighten screws
Dining Table Top	Wood/Glass/Marble	Scratches, stains, cracks	Heat, impact, moisture	Sand and refinish, replace top
Table Legs	Wood/Metal	Loose joints, bending	Frequent movement, heavy load	Reinforce or replace legs
Bed Frame	Wood/Metal	Creaking, structural damage	Weight stress, age	Reinforce joints or replace frame
Slats	Wood/Metal	Breaking, bending	Jumping, overload	Replace individual slats
Headboard	Wood/Upholstered	Loosening, fabric wear	Leaning, friction	Tighten bolts, reupholster
Wardrobe Panel	Wood/MDF	Warping, delamination	Humidity, poor construction	Replace panel or cover with laminate
Drawer Runners	Metal/Plastic	Jamming, breakage	Overloading, dirt	Clean, lubricate or replace runners
Back Panel	Hardboard	Detachment, bending	Movement, poor fastening	Nail or screw in place or replace
Desk Top	Wood/Laminate	Scratches, swelling	Water, wear	Refinish or replace top
Office Chair Base	Metal/Plastic	Wheel breakage, cracks	Rolling fatigue, impact	Replace base or casters
Chair Upholstery	Mesh/Fabric	Tears, sagging	Prolonged use	Replace fabric or mesh
Patio Frame	Metal/Wood/Plastic	Rust, rot, cracking	Weather exposure	Treat rust, seal wood, replace parts
Cushions	Outdoor Fabric	Fading, mildew	Sunlight, rain	Replace with weather-resistant material
Table Top	Glass/Wood	Shattering, staining	Impact, weather	Replace top
Cabinet Carcass	MDF/Particleboard	Swelling, delamination	Moisture, leaks	Replace carcass or panels
Countertop	Laminate/Stone	Burns, chipping	Hot pans, impact	Resurface or replace
Drawer Handles	Metal/Plastic	Loosening, breakage	Frequent use	Tighten or replace handles

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

In the table below (Table 4.2.) are listed some proposals about the material that can be used to produce the components that need to be replaced, or is damaged.

Materials for replacement of damaged furniture's components

Furniture Component	Best Ecological Replacement
Sofa Frame	FSC-certified hardwood or recycled steel
Sofa Suspension	Natural jute webbing or recycled steel springs
Sofa Cushioning	Natural latex foam or recycled cotton batting
Sofa Upholstery	Organic cotton, hemp, or eco-leather
Sofa Legs	Sustainably sourced wood or recycled metal
Dining Table Top	Reclaimed wood, bamboo, or recycled glass
Table Legs	Reclaimed wood or bamboo
Bed Frame	FSC-certified wood or recycled metal
Slats	Bamboo or recycled steel slats
Headboard	Recycled wood or organic upholstered materials
Wardrobe Panel	Formaldehyde-free MDF or solid reclaimed wood
Drawer Runners	Recycled metal runners
Back Panel	Recycled hardboard or plywood
Desk Top	Bamboo or eco-laminate over formaldehyde-free plywood
Office Chair Base	Recycled aluminum or bio-based reinforced plastic
Chair Upholstery	Recycled mesh or natural wool fabrics
Patio Frame	Recycled plastic lumber or FSC-certified teak
Cushions	Recycled PET fabric or natural latex foam
Outdoor Table Top	Recycled glass or sealed reclaimed wood
Cabinet Carcass	FSC-certified plywood or formaldehyde-free particleboard
Countertop	Recycled glass composite or sustainably harvested wood
Drawer Handles	Recycled metal or bamboo

8.4. Best practices in furniture reuse and recycling in IPA ADRION region

The practices of furniture reuse and recycling include reusing, restoring or dismantling old furniture to create new products or reduce waste. These practices involve renovating damaged parts, using materials from old furniture for new projects or donating them for further use. In the partner countries of the FULAR Project, several business models related to furniture reuse or recycling have been identified, which are presented below, respectively for each country.

8.4.1. Best practice 1: Greece - Restoration of furniture for its reuse

With this model, the conventional linear "take-make-dispose" furniture industry is changed into a closed-loop system in which furniture is collected, repaired, restored, reupholstered, and then sold or reused instead of being discarded. Its main objectives are extending product life cycles, reducing waste, and recovering materials to create new products. Through this sustainable practice, this model not only minimizes environmental impact but also creates new business opportunities.

FULAR

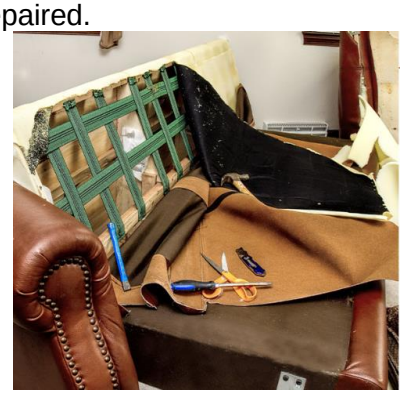
Key components:

- structural repairs: fix broken frames, legs, and joints.
- surface restoration: sanding, refinishing, painting, or staining.
- reupholstery: replace fabrics, foam, and cushions with sustainable materials.
- upcycling: transform outdated furniture into new, functional, or artistic design.
- promote designs that allow easy disassembly and reupholstery.
- implement zero-to-landfill policy for discarded furniture parts.
- waste minimization: reclaim wood scraps for small furniture or home accessories.

Advantages:

- natural resources conservation by reusing wood, metals, and textiles.
- reducing waste generation by diverting furniture from landfills.
- reduction of CO_2 emissions from manufacturing and raw material extraction.
- lowering costs of materials through component reuse and donations.
- creating new revenue streams from refurbished sales, upholstery services, and leasing.
- promotes sustainable consumption and eco-conscious behavior.
- supports local artisans and small businesses in the repair industry.

User of this business model is Furniture repair-restoration & manufacturing company Kourogenis Bros. The company has been operating since 1965, in Athens. A traditional workshop that undertakes restorations, changes of fabrics on sofas, painting and varnishing of furniture. Also restores used pieces for reuse. Its main focus is furniture repairs & restorations as well as the creation of handmade furniture (bedrooms, living rooms, dining rooms) according to the preferences and needs of the costumers. All of their constructions can be made in various styles (classical, neoclassical, modern) & in various sizes. Due to their experience and their knowledge, thanks to their constant updating on construction materials and more, the company can undertake services such as, living room repairs, sofa repairs, dining room chair repairs, chair repairs, furniture restorations, furniture upholstery and furniture polishing. The company is also able to manufacture any special construction and give advice on customers on how any detail can be repaired.



Living room repairs

Chair repairs[9]

[9] https://episkeves-epiplon.gr/epidiorthoseis

8.4.2. Best practice 2: Greece - Product upcycling

This is a sustainable production and consumption model where discarded, unused, or end-of-life products are transformed into new, higher-value products without breaking them down into raw materials. Upcycling preserves and enhances material value, reduces waste, and prolongs product lifecycles in contrast to traditional recycling, which frequently downgrades material quality. This circular approach promotes a closed-loop system in which resources continuously return back into production, thus minimizing negative effects on the environment.

Key components:
- creating value out of waste: materials that would otherwise be discarded are turned into something new and desirable.
- creative reuse: using creativity and innovation to repurpose objects that have been thrown away.
- improvement of value and quality: upcycled products of higher quality, functionality, and aesthetic appeal than the originals.
- promotes sustainability by minimizing the negative effects of production on the environment, conserving resources, and reducing waste.
- circularity: by extending the useful life of materials upcycling promotes a more circular economy.

Advantages:
- reduced waste: keeps materials out of incinerators and landfills.
- resource conservation: reduces the demand for new raw materials.
- creative expression: promotes innovation and unique design.
- unique products: produces items that are unique and one-of-a-kind.
- cost-effectiveness: can be a more affordable way to develop new products.

User of this business model is Furniture and decorations manufacturing company EchoDeco Professional. The company has been operating since 2012, in Athens. It is focused in upcycled furniture and decorations as well as in furniture and decorations made from recycled materials. Their collection is based on selected, recycled or refurbished furniture, and they propose solutions on product manufacturing and also add product's value. Through the process of upcycling, the company transforms old object into furniture and decor and creates some of the most impressive and unique pieces of interior design. The objects that emerge through this process bear the marks of their old identity, but appear in a completely new perspective. By incorporating upcycling into the decor, the company is expressing their environmental awareness. The company uses the term "One of a Kind" to describe unique products that produce (e.g. old furniture, vintage decorations, handmade flower pots, etc.) with special charm and character. A critical stage of the production process where the company keeps particular diligence is the selection of materials used for its wooden creations, that are not coming from recycled wood, emphasizing the sustainable approach to wood.

Bench made of recycled wood

Furniture made of solid recycled wood[10]

8.4.3. Best practice 3: Greece - Shared furniture-social contribution

Within the framework of the circular economy, this model is a cooperative, community-driven approach that emphasizes the collective ownership, sharing, and redistribution of furniture in order to maximize resource use, reduce waste, and create social and economic value. Unused, excess, or pre-owned furniture is gathered, restored, and re-distributed among people, homes, or organizations through cooperatives, social enterprises, and community platforms. This strategy encourages economic inclusion, environmental sustainability, and social solidarity by promoting shared access to resources rather than private ownership. Particularly, shared furniture when donated or collectively used, can significantly contribute to social well-being and community building, especially in challenging situations.

Key components:

- network for collection and donations: partnerships with households, offices, hotels, and institutions to gather unwanted furniture.
- sorting and evaluating quality: specialized facilities where furniture is inspected, categorized, and given a repair, refurbishing, or direct redistribution priority.
- facilities for repair and renovation: skilled workshops that guarantee beneficiaries' safety, durability, and usage through the restoration, painting, upholstery, or upcycling of furniture.
- channels of redistribution: free gifts to NGOs, shelters, families, and refugees.
- social inclusion and employment: participation of unemployed in logistics and furniture restoration, offering them jobs, training, and reintegration routes.
- material recovery and recycling: disassembling non-repairable things responsibly in order to recover fabric, metal, and wood for recycling.

Advantages:

- environmental sustainability: prevents the depletion of resources and carbon impact by diverting furniture trash from landfills.
- impact on society: provides essential furniture to low-income households, charities, and community projects.
- financial gains: saves money for recipients and raises money for social projects by selling reconditioned goods.

[10] https://www.echodecoprofessional.gr/re-living

- creating jobs and developing skills through the employment opportunities in distribution, logistics, restoration, and collection.
- encourages the practice of giving and consuming responsibly.

User of this business model is RETO Hellas Association – Challenge of Hope (Ρέτο Ελλάς - Πρόκληση της Ελπίδας). The RETO Hellas Association – Challenge of Hope is a non-profit NGO with a social mission that focuses on the psychological and professional reintegration of people who have overcome addiction but still face social exclusion. This association, which was legally established in 2003, has headquarters in Athens, but also operates multiple stores in different Greek cities. Its mission is to collect all types of items, functional or non-functional, including furniture, electrical/electronic appliances, clothing, toys, etc. The furniture restoration and upcycling workshops are performed by different teams of former addicts, trained in repair, restoration, and upcycling, who work to rehabilitate collected items in RETO's workshops. They are specialized in refurbishment tasks such as reconstruction, painting, polishing, and transforming furniture to give them a unique character and new aesthetics. The association is capable to restore and upcycle old wooden furniture (vintage, retro, antique pieces), functional everyday furniture (chairs, tables, wardrobes, sofas), and decorative items (lighting fixtures, art frames, small household furniture). This company profile of RETO encourages social inclusion by hiring and training former addicts and offers customers high-quality, reasonably priced furniture while promoting socially responsible cause.

Shared furniture-social contribution[11]

8.4.4. Best practice 4: Italy - Closed-Loop Furniture Design (CALLIGARIS)

Calligaris is a long-established design and furniture manufacturer based in Friuli Venezia Giulia. Founded in 1923 in Manzano, in the province of Udine, the company has grown into one of Italy's most

[11] https://www.retohellas.com/magazia-reto

prominent players in the sector, employing between 500 and 1,000 people worldwide. Over the past decades, Calligaris has expanded its reach beyond Italy, now distributing its products in more than 90 countries and managing a network of flagship stores, concessions, and shop-in-shops. Its portfolio spans a wide range of products, including chairs, tables, sofas, beds, cabinetry, lighting, and accessories, sold under brands such as Calligaris, Connubia, Ditre Italia, and Luceplan, as well as through partnerships with other design companies like Fatboy.

Traditionally positioned as a global mid-to-high-end brand, Calligaris combines Italian “smart design” with artisanal heritage, appealing to both retail consumers and the contract sector, particularly in hospitality and horeca. In recent years, however, the company has increasingly aligned its operations with sustainability principles, embracing ideas of circularity and longevity in its design philosophy. This shift is evident in Calligaris’ emphasis on creating products that last over time, thanks to the use of durable materials and a focus on repairability. The company has also moved toward modular and configurable designs, such as extendable tables or stackable chairs, allowing pieces to adapt to different spaces and uses instead of being discarded.

Central to this commitment is the Greenbow sustainability agenda, a structured program that frames Calligaris’ efforts across both product design and organizational practices. Greenbow introduces a measurable sustainability index - known as the “I am green” indicator - which evaluates each product on several key factors: the use of natural and responsibly sourced materials, such as FSC-certified wood; the proportion of recycled or recyclable materials incorporated; the ease of disassembly and potential for reusability; and compliance with stringent safety criteria for chemicals in finishes and fabrics. Products meeting these criteria earn the “I am green” label, signaling to customers that they adhere to Calligaris’ sustainability standards.

Material innovation is a major element of the company’s strategy. Since 2006, Calligaris has sourced FSC®-certified wood for its furniture, winning multiple FSC Furniture Awards for its commitment to traceable and sustainable timber. Starting in 2019, the company began producing pieces like the Skin and Liberty chairs using 100% post-industrial recycled plastic, significantly reducing CO_2 emissions compared to virgin plastic. The Vela chair is made from sugarcane-derived bioplastic, cutting emissions by around 70% compared to standard polypropylene. Other product lines feature recycled glass and metal, while ceramic and tempered-glass tabletops offer long-lasting resistance to scratches, stains, and chemicals. Even finishes and fabrics reflect this ethos: Teflon™-treated textiles and silver-ion antimicrobial treatments prolong product life while reducing cleaning impact and solvent use.

Calligaris also plays an active role in the wider furniture industry’s sustainability movement, particularly in relation to Extended Producer Responsibility (EPR). As a member of FederlegnoArredo, the company is supporting the development of frameworks for furniture take-back, refurbishment, and remanufacturing systems. While these programs are still emerging in Italy, Calligaris is designing its products with the future in mind - ensuring they can be easily disassembled, safely recycled, and comply with forthcoming EU regulations such as the Ecodesign for Sustainable Products Regulation.

The impact of this approach is evident across several dimensions. In terms of longevity, Calligaris’ use of high-quality materials and modular solutions means products stay in use longer, reducing waste. From a resource use perspective, FSC wood, recycled plastic, and recycled glass demonstrate a shift toward more responsible sourcing. On the design front, the focus on repairability, disassembly, and the “I am green” label helps embed circular principles into every stage of product development. And from a

strategic viewpoint, the company is aligning itself with upcoming EPR and ecodesign requirements, ensuring it is ready to meet the demands of future legislation and consumer expectations.

In summary, Calligaris demonstrates how a traditional, large-scale furniture manufacturer can evolve into a leader in sustainable design. By measuring and communicating its progress through Greenbow, innovating with materials like bioplastics and recycled glass, and creating furniture that is modular, repairable, and durable, Calligaris is helping shift the industry toward a more circular model. Its proactive stance on EPR and readiness for EU regulatory changes position it not only as a heritage brand with deep Italian roots but also as a frontrunner in the transition to a more sustainable future for furniture.

8.4.5. Best practice 5: Italy - Reuse, Recycle, Rebuild (R3B – Reuse, Recycle, Rebuild)

R3B – short for Reuse, Recycle, Rebuild – is a small but innovative artisan enterprise based in Venice, in the Marghera area. Born out of the ReBiennale initiative, it operates as a socially engaged workshop that blends carpentry, logistics, and design with a mission to reduce waste and promote sustainable reuse of materials. Rather than functioning as a traditional furniture manufacturer, R3B positions itself as a niche, hands-on service provider dedicated to deconstruction, upcycling, and community-oriented design.

The company's core philosophy is summed up in its own words: "We were born to fight against all this waste and transform into resources and projects what others see as useless garbage." This ethos is evident in every aspect of its operations, which focus on the careful dismantling of exhibition installations, pavilions, and temporary structures - notably from major cultural events like the Venice Biennale. By disassembling these structures selectively, R3B preserves wood, polystyrene, drywall, and other materials that would otherwise be discarded. These reclaimed materials are then stored and given a second life, either in bespoke furniture, installations, or broader creative projects.

R3B's work can be understood through its three-phase circular strategy. The first phase, Reuse, centers on selective dismantling, which reduces the volume of waste sent to landfills and keeps materials intact for future use. The second phase, Recycle, comes into play when direct reuse isn't possible: R3B collaborates with local recycling networks to divert non-reusable materials - such as EPS polystyrene or plasterboard - away from landfill. A notable example of this is its work on the Dorte Mandrup pavilion, where 200 cubic meters of polystyrene were processed through a partner company, Politop S.R.L. in Treviso. The third phase, Rebuild, is the creative heart of the operation: salvaged materials are transformed into art installations, furniture, and interiors, often through partnerships with universities, associations, non-profits, and local communities.

What makes R3B distinctive is not only its commitment to circularity but also its deeply social dimension. The company integrates volunteer networks and engages with educational institutions and civic groups, turning its projects into collaborative ventures rather than purely commercial operations. Initiatives like the Giudecca social housing restoration and self-build projects with IUAV University reflect this participatory spirit.

From a practical standpoint, R3B also brings serious logistical capacity to its work. The team manages complex dismantling operations with cranes, platforms, and coordinated transport - on land and on Venice's waterways - allowing them to operate in sensitive cultural contexts such as Biennale installations. This technical expertise is matched by an infrastructure for material preservation: the

workshop maintains a warehouse of reclaimed wood, metals, and other materials, which serves as a repository for designers, artists, and social projects. Even materials that cannot be repurposed are directed thoughtfully into recycling pipelines, ensuring that virtually nothing ends up as unmanaged waste.

R3B's impact extends well beyond the workshop walls. By turning dismantled materials into custom furniture, community-built interiors, and public artworks, the company demonstrates how discarded objects can gain new cultural and functional value. It also shows how circular design practices can intersect with social engagement, education, and local identity.

In essence, R3B is more than just an upcycling workshop - it is a working model of how the EU's circular economy principles can come to life at a local level. Its entire process, from dismantling to recycling to rebuilding, closes material loops, reduces environmental impact, and involves the community in reimagining waste as a resource. This model, while modest in scale, offers a powerful template for integrating sustainability, craftsmanship, and social value in the worlds of furniture, architecture, and beyond.

8.4.6. Best practice 6: Slovenia - Closed-Loop Furniture Design

This model is based on the principles of the circular economy, where the company takes responsibility for the entire life cycle of furniture – from design to reuse. The goal is to create a system where old furniture pieces are collected, dismantled, evaluated and reused in new products.

The closed-loop manufacturing process starts with the design phase, where the product is designed with sustainability in mind. The production phase involves using the most efficient processes and technologies to manufacture the product while minimizing waste and emissions. Once the product is used and reaches the end of its life, it is recycled, and the materials are reused in the production of new products.
The closed-loop manufacturing approach is an essential component of the circular economy, which aims to minimize waste and promote the sustainable use of resources.

By implementing closed-loop manufacturing, companies can reduce their environmental impact, increase resource efficiency, and create more sustainable products. Additionally, closed-loop manufacturing can result in cost savings by reducing waste and optimizing the use of resources.

Key components:
- collection and return: users can return old furniture in exchange for a discount on the purchase of a new one;
- modular design: new furniture is designed to allow easy disassembly and reuse of parts;
- material tracking: each piece has a digital identity (e.g. QR code) that allows tracking of materials and their history;
- in-house production: The company has a workshop where parts are recycled and assembled into new products.

Advantages:
- reduction of waste and raw material costs;
- increased customer loyalty with a return system;

- possibility of marketing as a sustainable brand.

User of this business model is KNOF – Social Enterprise for Circular Economy. KNOF is a Slovenian social enterprise that operates according to the principles of a circular economy and implements a closed-loop model. It focuses on the collection, processing and reuse of waste materials, especially wood and plastic, to produce new furniture and other useful products. The company involves local communities, creates green jobs and promotes sustainable consumption. Their business model also includes consulting, education and the development of modular products that enable easy recycling. KNOF is an example of good practice that combines environmental responsibility, social inclusion and innovative production.

8.4.7. Best practice 7: Slovenia - Platform Model: "Craftsmen-as-a-Service"

This model is based on a digital platform that connects owners of old furniture with local craftsmen and designers who create new custom products from these pieces. The company does not manufacture the products itself, but rather provides services and logistics.

Key components:
- digital platform: users upload images of old furniture and select a designer or craftsman;
- logistics and pickup: the platform organizes the pickup, delivery and return of the refurbished product;
- marketplace for sale: users can sell refurbished products through the platform;
- ratings and certificates: each product receives a recycling certificate and a quality rating.

Advantages:
- low initial costs (no need to manufacture in-house);
- promotion of local economy and crafts;
- high level of personalization and uniqueness of products.

User of this business model is BETI d.o.o. – Textile industry with upcycling projects. BETI d.o.o., a traditional textile company, has in recent years become involved in sustainable projects based on upcycling and reuse of materials. In collaboration with social enterprises and designers, they develop new products from waste materials, including wooden components of old furniture. Their model is based on a platform approach, where the company acts as a connector between industry, designers and contractors. This enables the development of unique, sustainable products and encourages local creativity. With this approach, BETI strengthens its role in the circular economy and contributes to reducing the industrial environmental footprint.

8.4.8. Best practice 8: Slovenia - Furniture Recycling / Upcycling / Reuse

Below we present a case study of the Reuse Center (CPU) from Slovenia, which applies the principles of the circular economy by recycling and/or reprocessing furniture. It is a pioneering social enterprise founded in 2010. CPU was the first reuse center in Slovenia and has since developed into a network of social enterprises dedicated to reducing waste, promoting reuse, and supporting social inclusion. Since 2025, CPU has been operating several centers throughout Slovenia and is part of a six-member consortium of social and non-profit organizations.

FULAR

General informations:
CPU locations in Slovenia include:

- Ljubljana (largest center)
- Rogaška Slatina
- Vojnik
- Slovenske Konjice
- Ormož
- Kočevje
- Trebnje

In Rogaška Slatina, they particularly emphasize the manufacture of custom-made wooden products and the restoration of wooden furniture, which is directly related to wood recycling and its incorporation into new production.

Key features of the CPU

- Collection and restoration: They accept old but still usable pieces of furniture, which they then restore or rework.
- Sale at a symbolic price: The products are sold in so-called "green shops," which makes them accessible to the wider public.
- Local production: Some units, such as CPU Rogaška Slatina, also manufacture new custom-made products from recycled wood.
- Environmental and social impact: They reduce waste, create jobs for vulnerable groups, and raise public awareness of sustainable consumption.

Core Activities
The Reuse Centres (CPU) in Slovenia operate as social enterprises focused on collecting, refurbishing, and reselling used items, particularly furniture. They accept donations of functional second-hand goods, which are then cleaned, repaired, or creatively transformed into new products. A special emphasis is placed on wooden furniture, which is often restored or repurposed into custom-made items. These products are sold in so-called “green stores” at affordable prices, promoting sustainable consumption. In addition to resale, some centres offer repair services and organize workshops that encourage community participation and skill development. Through these activities, CPUs not only reduce waste and extend product lifecycles but also create employment opportunities for vulnerable groups and raise awareness about the circular economy.

Environmental & Social Impact
The Reuse Centres in Slovenia have a significant positive impact on both the environment and society. Environmentally, they help reduce waste by diverting large quantities of used items—especially furniture—from landfills, while also cutting down on CO_2 emissions and conserving natural resources. Socially, CPUs create meaningful employment opportunities for vulnerable groups, including people with disabilities and the long-term unemployed. They also foster community engagement through educational activities and promote a culture of sustainability and responsible consumption.

Business Model Highlights
The business model of the Reuse Centres is built on the principles of the circular economy and social entrepreneurship. They operate without using new raw materials, relying entirely on donated or discarded items that are refurbished or repurposed. What cannot be reused is either recycled or

redirected to appropriate waste streams. The centres generate revenue through the sale of restored products in their green stores, while also receiving support through partnerships with municipalities and public institutions. Importantly, they prioritize social impact by employing individuals from vulnerable groups and reinvesting profits into community-based sustainability initiatives.

Employees and Social Inclusion
- CPU employs 34 full-time staff, of which 85% are individuals with special needs
- In addition to core staff, the broader reuse network involves 15 full-time employees and 30 additional workers in the social economy sector
- Through social activation programs, CPU has supported 75 long-term unemployed individuals, with 67% successfully reintegrated into the labor market

Scale and Reach
- Over 100,000 reused items are sold annually.
- Around 5,000 new products are created each year from discarded materials.
- The centres attract over 300,000 visitors and host dozens of community events and workshops

Processing Technologies
At the Reuse Centre in Rogaška Slatina, the focus is on manual and carpentry-based techniques for restoring and repurposing old furniture, with an emphasis on sustainable wood processing and the creation of custom-made products. While they do not rely on high-tech industrial recycling systems, they use a range of practical and accessible tools and methods.

The centre includes a carpentry workshop, where skilled workers and craftspeople repair damaged wooden parts, sand surfaces, repaint or refinish furniture, and assemble new items from reclaimed wood. They also creatively upcycle materials to produce unique, functional products.

In addition, the centre features a repair space open to the public, where individuals can use basic tools—such as saws, drills, screwdrivers, and clamps - with professional guidance to fix or modify their own items. This promotes community engagement and hands-on learning.

Rather than focusing on industrial-scale recycling, CPU Rogaška Slatina emphasizes local, low-energy, and circular practices, ensuring that every piece of wood is treated as a valuable resource that can be reused, transformed, or integrated into new products.

Recycling
The recycling and reuse process at CPU Rogaška Slatina follows a sustainable, hands-on approach rooted in circular economy principles. It begins with the collection of donated items, including furniture, wooden objects, electronics, books, clothing, and more. These items are inspected by staff to assess their condition and potential for reuse. Those suitable for restoration are selected, while others are either recycled or redirected to appropriate waste streams.

In the carpentry workshop, skilled workers use techniques such as sanding, painting, varnishing, upholstering, and assembling new products from old parts. Special attention is given to wooden furniture, which is often transformed into custom-made pieces. The restored items are then sold at symbolic prices in the centre’s green store, promoting affordable and sustainable consumption.

Additionally, the centre features a community repair space, where visitors can fix their own items using available tools and guidance from mentors. This encourages public involvement and supports knowledge-sharing.

Rather than relying on industrial recycling, CPU Rogaška Slatina emphasizes manual craftsmanship, local expertise, and low-energy practices, ensuring that each item is treated as a valuable resource with the potential for a second life.


CPU Rogaška Slatina[12]

8.4.9. Best practice 9: Bosnia and Herzegovina - Furniture restoration for reuse

Furniture restoration involves the process of renewing and enhancing old pieces of furniture, bringing back their original beauty and functionality. It allows a part of history and tradition to be preserved. The process of furniture restoration may include repairing damage, replacing parts, restoring the finish, and other steps that allow old furniture to shine again.

One of the main reasons why furniture restoration is a good option is its sustainability. Restoring old furniture offers an environmentally friendly solution that contributes to the preservation of natural resources and the reduction of negative impacts on the environment.

Instead of discarding old pieces and replacing them with new ones, restoring existing furniture extends its lifespan and reduces the need for new raw materials.
One of the most important aspects of the sustainability of furniture restoration is the reduction of waste ending up in landfills. Additionally, the restoration process requires far fewer chemicals and other harmful substances (such as varnishes, adhesives, paints, and other materials that often contain volatile organic compounds – VOCs – which contribute to air pollution), or it uses environmentally friendly alternatives instead.

Furniture restoration also enables creativity to be expressed through the use of different techniques, styles, and combinations, resulting in personalized and more functional furniture pieces, at a lower cost than purchasing new items of similar quality.

[12] https://www.youtube.com/watch?v=FHFYhtoPQl0

FULAR

Through this sustainable practice, the model not only minimizes environmental impact but also creates new business opportunities.

An example of such a business model is the workshop for repair, restoration, and redesign of old furniture „WOOD SURGERY/LEJLINA RADIONICA“, which restores and saves old furniture pieces. In this workshop, neglected old chairs, dressers, tables, and other items are given new life – sometimes by renewing them in their original design, and sometimes by adding creative elements that ultimately find their place in modern interiors. Worn-out furniture is transformed into unique, chic wooden pieces with a special story. In this way, the workshop restores authentic furniture, as well as home decorations designed and created with love, carrying an irresistible handmade, retro, and chic touch.

This practice gives a second chance to a piece of furniture – an old chair or a dresser that was meant to be discarded. From the choice of materials to finishing details and decorations, every part of the furniture carries its own special story. The pieces restored in this workshop now decorate homes across Europe.

The main customers are people who do not prefer classic interior design for their living or working spaces – people who have traveled and know that furnishing spaces with restored pieces has long been a global trend. What attracts them the most is timeless design, especially restored pieces designed in the 1970s and 1980s, as well as items over a hundred years old.

Photo: Una Kulenović (WOOD SURGERY/LEJLINA RADIONICA)

The business concept is strongly based on recycling and environmental preservation, since the majority of pieces that leave the workshop are exactly those whose final destination would otherwise have been bulky waste or firewood. A huge potential has been recognized in furniture pieces that most people consider to be waste. Many of these pieces are acquired precisely when people decide to throw them out of their homes. These are items that have been collecting dust in basements, garages, attics, and cottages, which people sell for symbolic prices – and very often even give away for free.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

Photo: Una Kulenović (WOOD SURGERY/LEJLINA RADIONICA)

8.4.10. Best practice 10: Bosnia and Herzegovina - Wood Repurpose

Repurposing furniture and wood is a strategy that incorporates discarded components into entirely different products for unique use or alternative purposes. This strategy encourages innovation and can lead to the creation of unique products with added value.
Repurposed furniture retains its original material composition, while reworked pieces are transformed to serve different functions or to improve their visual appeal.

The goal is to reduce the impact of the built environment on climate change – which is responsible for global emissions – by minimizing waste, keeping materials in circulation longer in higher-value forms, and preserving natural resources.

FULAR

Choosing reclaimed wood in furniture production reduces the need for cutting new timber. Every plank of reclaimed wood carries its own narrative, often showcasing depth of color and texture that freshly cut wood simply cannot match. This gives furniture a unique charm, and certain types also promise both longevity and visual appeal.

An example of such a business model is the company „Truago drvo“ ltd. from Prijedor.

„Truago drvo“ ltd. was founded in 2022 through the lease of the former company „Prozori Potkozarje“ ltd. and by taking over its workers with many years of experience in a carpentry workshop. It is a startup company that introduced complete innovation – refining and combining rustic wood with wood waste to create unique products: custom-made floors, wall claddings, furniture, carpentry, and other products from reclaimed wood. The company has successfully merged refined Italian design with Bosnia and Herzegovina's tradition of wood craftsmanship, creating unique interiors for customers seeking a personalized approach – in other words, it „transfers its magic“ onto wood, giving it new life and value.

This is a manual carpentry workshop (traditional processing), with a complete production process, woodworking technology, and small-scale production, which provides exceptional flexibility. Its products are made according to specialized design solutions. It offers a distinctive value proposition in the form of high-quality products from aged wood with patina. These are premium handcrafted products that are unique, refined, and sustainable.

The value proposition lies not only in the high-quality handmade product but also in the reuse (revival) of wood that has already „fulfilled its purpose“. Old wood carries with it former owners, past uses, and achievements – it has its own story. Thanks to „Truago drvo“ ltd., that story continues.

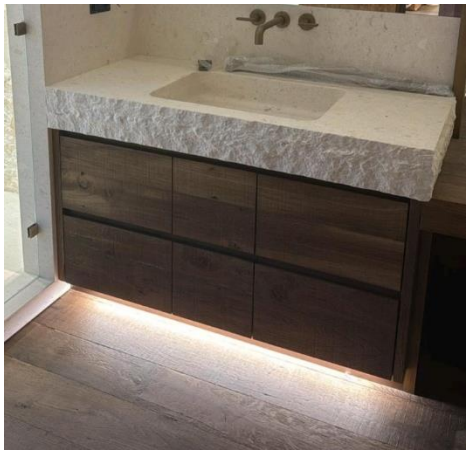
Through its refinement techniques, the company achieves multiple effects: it gives „new life“ to naturally aged wood, makes use of wood residues, and contributes to sustainable management of wood resources. These products are highly valued on foreign markets, and „Truago drvo“ ltd. bases most of its operations in Austria, Italy, and Switzerland, while only a smaller share is sold on the domestic market. Its customers are sophisticated buyers who demand a special value proposition in the form of premium products made from old wood with patina – products that are handcrafted, unique, refined, and sustainable.

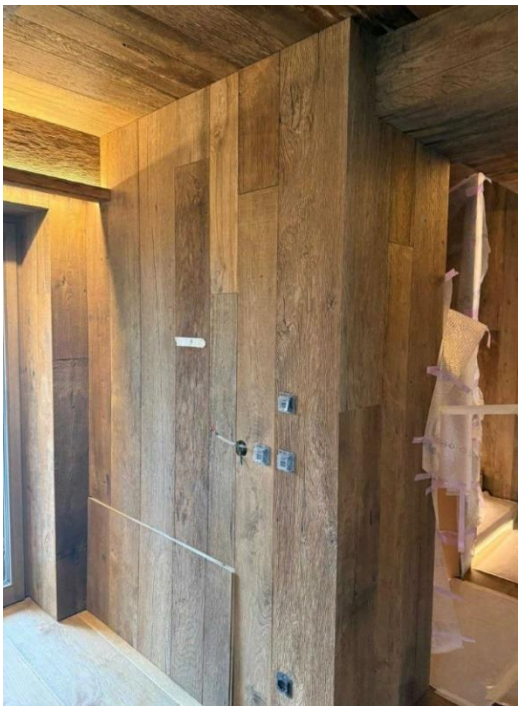
Most of its raw material is sourced by purchasing old barns, stables, bridges, or driftwood extracted from riverbeds, as well as reclaimed wood from large pieces of furniture, which it buys across the wider region – Bosnia and Herzegovina, Croatia, and Serbia.

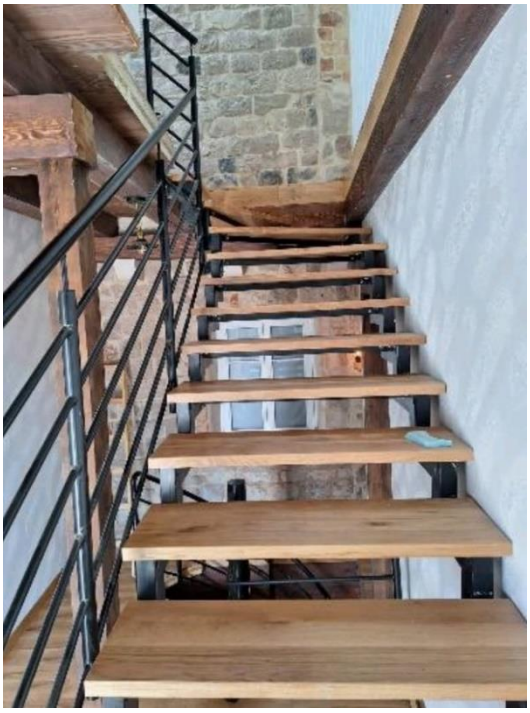
The project is co-funded by the European Union through the Interreg IPA Adrion programme.

FULAR

FULAR







8.4.11. Best practice 11: Albania - Reuse platform

This business model is based on "buying and selling with maximum profit" philosophy. It exemplifies circular economy principles, where furniture continues to be used by different consumers instead of becoming waste after first use. The target customers are individuals wanting to sell used items without handling resale logistics themselves. The model optimally combines economic and indirect environmental benefits through reuse and extended lifecycle of furniture. This is a business concept that is adapting well to the Albanian market. Notably, it serves an educational function, raising consumer awareness about reuse and recycling benefits while fostering more sustainable consumption patterns and environmental consciousness.

Key components:
- free furniture valuation services from professional staff;
- free disassembly of furniture;
- free transport;
- free display of items at on-line platform and to shopping facilities.

Advantages:
- it significantly reduces the amount of waste that ends up in landfills or is burned inappropriately;
- by providing people the opportunity to buy used furniture in good condition, the need for producing new items is reduced;
- it reduces the consumption of raw materials;
- it reduces the energy needed for production;
- it reduces greenhouse gas emissions from manufacturing processes.

User of this business model is "Shtëpia e Ofertave sh.p.k." (House of Offers). This is a service business that operates primarily as a commission agency specializing in the valuation and resale of second-hand goods, mainly furniture. Established in 2020, the company operates as an intermediary, earning commission on successful sales rather than purchasing items directly. In addition to its online platform, the company maintains two storefronts in Tirana where goods are displayed and sold, making the process accessible to both sellers and buyers. A wide variety of furniture is accepted, such as couches, sofas, bedroom sets, kitchens, wardrobes, tables, chairs and more. This approach holds particular significance in Albania's current context, where developing waste management infrastructure makes reuse initiatives especially impactful for environmental sustainability.

8.4.12. Best practice 12: Albania - Material recycling

This business model reflects a hybrid model of customer service and sustainable production, where aftersales maintenance is combined with internal recycling material processes, reinforcing so the company's commitment to resource efficiency and environmental responsibility. It integrates material recovered from used furniture into the new or refurbished ones. This model is applied mainly by companies which have established a well structured practice in managing postsales relationships with their customers, particularly through maintenance and refurbishment services. This activity is focused mainly on upholstered furniture, such as sofas and armchairs, which are periodically returned to the companies facilities for repair or partial remanufacturing before being delivered back to clients.

Key components: The intervention process typically involves the replacement of worn components, including cushions, seating pads and certain structural elements, ensuring that the furniture regains both its functional and aesthetic qualities. Usually, the main steps include:

- foam extration from old armchairs and sofas;
- shredding of extracted foam;
- reuse shredded foam as filling material in new cushions or seating components.

Advantages:

- optimization of resource utilization by the economical viewpoint, but also aligns with principles of material circularity;
- reducing waste generation;
- extending the lifecycle of both new and refurbished products.

User of this business model is Mobileri Korça (Korça Furniture). The company is established in 1995, in Durrës. It stands as one of the well-established businesses of the Albanian upholstered furniture industry. As a small company, it combines a long experience with a consistent and trustworthy image within the local community. Its good quality products, their reasonable price and good relationships with their customers, demonstrates a continuous engagement and a transparent approach to showcasing its products and services. The company's strategy is founded on the application of optimal quality-price relation to create products with clean lines and timeless aesthetics, reflecting a clear orientation towards durability and long-term functional performance. The frequent use of modular systems, especially corner sofas and seating units with integrated mechanisms, highlights an understanding of adaptability to modern living spaces. This approach extends the functional lifecycle of its products by allowing them to adjust to changing spatial and household needs, as well as to be refurbished according to the needs or preferences of the customers.

8.4.13. Best practice 13: Albania - Product repair/upcycling

This business model represents a contemporary approach to the furniture industry, integrating the principles of the circular economy across its entire value chain. At the core of its philosophy lies the principle of product longevity. An essential aspect of this approach is repairability and modularity. Products are engineered so that individual components can be easily replaced or repaired without destructive interventions. Simple structures and mechanical connections facilitate efficient maintenance, significantly extending the product's life cycle and reducing the need for premature replacement. Aligned with the principles of a closed-loop system, this model has developed processes that enable product return, renewal and material recovery. Furniture that has reached the end of its primary life cycle can be returned to the factory, where it undergoes refurbishment, partial remanufacturing or substitution of elements or material recycling. Referring to Albanian economy, furniture repair and upcycling are particularly valuable as they provide affordable access to quality furnishings while building local economic capacity and reducing environmental pressures from waste management challenges.

Key components:
- assessment; inspection of the furniture for structural integrity, damage extent and material quality, to determine feasibility and approach;
- planning; development of a clear plan for the final outcome, whether maintaining original style or creating something entirely new;
- furniture transport to the repair facilities;
- disassembly; documentation of pieces and taking apart when necessary;
- cleaning; remove of dirt, old finishes, overlays, upholster;
- repair structural issues, replacing damaged components or upholster, reinforcing weak areas;
- finishing; applying new paints or protective coating;
- reassembly with improved joints and other accessories.

Advantages:
- waste reduction; repairing and upcycling furniture reduces considerably the volume of bulky waste sent to landfills;
- resource conservation; extending the life of existing furniture reduces the demand for raw materials;
- carbon footprint reduction; manufacturing new furniture requires more energy and generates substantial greenhouse gas emissions comparing to repair and upcycling of the old ones;
- chemical reduction; new furniture often contain much more volatile organic compounds (VOCs) and formaldehyde comparing to the older ones;
- extending the lifecycle of repaired/upcycled products; these practices contribute to a circular economy model where materials stay in use longer, reducing the overall environmental impact of our consumption patterns;
- education value; these practices help shift consumer mindset from disposable to durable goods, promoting more sustainable lifestyle choices;
- skill development; learning repair and upcycling skills can become a source of income or cost-saving hobby.

User of this business model is “Erald Furniture sh.p.k.” With more than 25 years of experience in the market, this company has established a sustainable model of design and production that combines aesthetics, functionality and environmental responsibility. Erald carefully selects high-quality materials

such as wood and wood composites as well as natural textiles to ensure long-term durability and optimal performance. Its design strategy avoids short-lived trends and ensures that products maintain both their visual and functional value over an extended period of use.

The company does not position furniture repair as a standalone commercial service; rather, it is an exclusive after-sales activity dedicated to extending the lifespan of its own products. The company provides repair, refurbishment and partial remanufacturing only for restorants and coffee-bars furniture and doors originally manufactured by itself, ensuring that these interventions meet the same quality standards as the initial production. This approach reflects a commitment to product stewardship and circularity, focusing on supporting customers who have previously purchased Erald furniture and now require professional maintenance or restoration to prolong its functional and aesthetic value. In this way, Erald Furniture not only contributes to waste reduction and natural resource conservation, but also establishes a sustainable and innovative business model that aligns with the highest standards of the circular economy. Its furniture is no longer seen as a short-lived product but as a long-term, renewable asset, integrated into a responsible production and consumption ecosystem.

Below is a case study referring to ERALD FURNITURE, in the suburbs of Tirana, applies circular economy principles by recycling and/or upcycling furniture. It is one of the most established companies in Albania's furniture industry, with a history spanning over a quarter of a century. The company began as a modest family-run business operating in a 2,000 m² facility with only 10 employees. Today, after years of significant investment and steady growth, it operates in a modern complex facility. The company employs highly skilled furniture craftsmen, technicians and experienced managerial personnel.

General information

Basic overview
- Name: ERALD FURNITURE SH.P.K.
- Location: Tirana, Albania.
- Factory size: Over 15000 m², divided into three main sectors:
  - 5500 m^2 dedicated to production (cover area);
  - 1500 m^2 products exhibition;
  - 8000 m^2 raw material warehouse and yard.
- Ownership: Family-run/Private, since 1997.
- Employees: Approximately 50 workers.
- Web: www.eraldfurniture.com

What they produce?
The company manufactures a wide range of custom-made furniture, including:
- armchairs, lounge chairs, wooden and metal chairs, desks and benches for offices and schools;
- furniture and interior design items, such as doors, flooring, kitchens, bedrooms and studios;
- institutional furnishings.

The company has built a reputation for quality and product customization, with every item crafted according to specific client requirements. One of its main strengths is its focus on institutional projects, supplying furniture for schools, public offices, hotels and other organizations. This strategic orientation has enabled Erald to expand its operations beyond Albania.

FULAR

Markets served:

- Local and regional clients, including mainly Kosovo, Montenegro and Greece.
- Projects range from apartments and villas to hotels, bars and restaurants.

Technology and Process Details

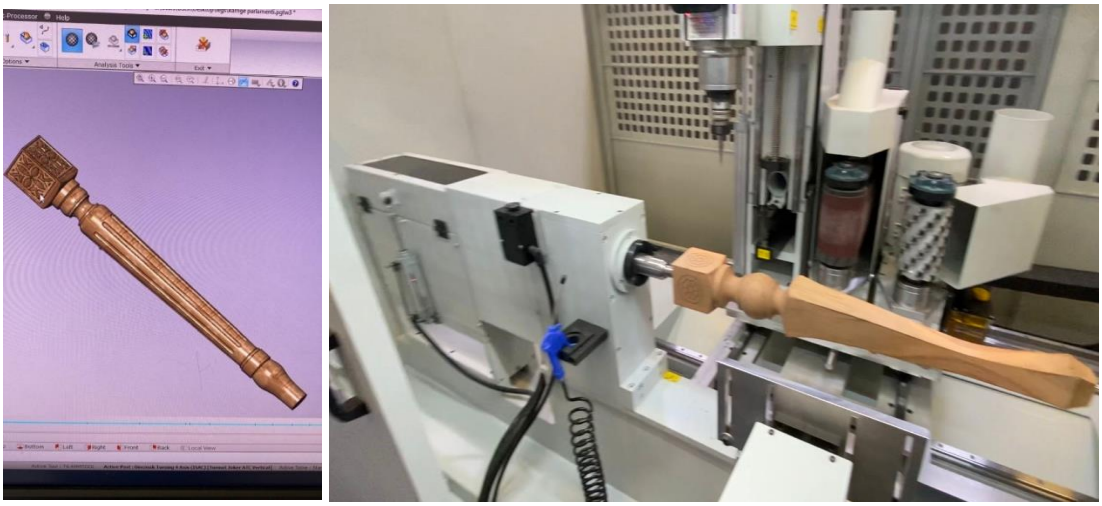
A key factor in the company's success lies in its investments in modern technology and CNC machinery**,** which have significantly improved precision and production quality. Additionally, Erald carefully selects its raw materials, using certified wood and high-quality auxiliary components to ensure both durability and refined aesthetics.

It has also begun integrating sustainability practices aligned with the "green" business philosophy. Special attention is given to sourcing certified and recyclable materials, thereby reducing the environmental footprint and meeting the growing demands of local and regional markets for sustainably produced furniture. The optimization of technological processes, particularly through CNC equipment, minimizes production waste, while small wood fragments and secondary materials are repurposed for auxiliary uses within the production lines.

CNC machine for hinges, locks and handles of doors

CNC milling & drilling machine

4-axis CNC wood lathe machine



4-axis CNC wood lathe machine

Furniture recycling activity

An interesting and distinctive aspect of Erald Furniture's business philosophy lies in its furniture repair and restoration services, which, although not a core activity, demonstrate the company's responsible approach toward both its products and its clients. These services are primarily focused on providing functional and aesthetic solutions for furniture manufactured by the company itself, including chairs, armchairs, lounge chairs and, in certain cases, doors or larger furniture pieces.

For chairs and benches, the repairs typically involve replacing damaged upholstery, restoring seat padding to improve comfort and reinforcing or replacing wooden or metal legs and other components that may have weakened over time. Additionally, the company undertakes re-tightening mechanical joints and restoring scratched or worn wooden surfaces, ensuring that the furniture maintains not only its functionality, but also its original appearance or even better.

Restoration of chairs

In the case of armchairs and lounge chairs, the interventions are often more extensive, including replacing deformed foam padding, repairing internal springs and mechanisms and restoring upholstery with either identical materials or new alternatives, according to customer preferences. Exposed wooden elements undergo surface treatment and aesthetic restoration to recover their original shine and colour.

Although less frequently, the company also offers repairs for doors and larger furniture items, such as adjusting hinges and opening mechanisms, replacing damaged handles and restoring exterior finishes to their original condition.

FULAR

Restoration of doors

As a matter of fact, the company does not currently implement a business plan for recycling used furniture. However, as one of the largest suppliers in the country of furniture for restaurants and coffee-bars, it is compelled for marketing reasons to offer these clients the service of furniture repair. Considering the very large number of restaurants and bars in the country (Albania ranks among the top countries in the world for the number of restaurants and coffee-bars per capita), as well as the frequent renovations that restaurants and bars undertake for marketing purposes, this activity is gradually increasing day by day. While this service is not a major source of revenue, it serves two strategic purposes. First, it extends the lifespan of the products, contributing to reduced waste generation and avoiding unnecessary consumption, aligning with the company's sustainability-oriented philosophy. Second, it strengthens relationships with loyal customers, who view this service as a sign of Erald Furniture's reliability and responsibility for the products it manufactures. In doing so, the company not only increases its brand value but also positions itself as a strong regional example of combining product quality, customer care and environmental responsibility.

Thanks to its strategy of focusing on custom made furniture and large institutional projects, Erald Furniture has maintained a stable and distinctive market position. Over the years, Erald Furniture has grown into one of the most trusted companies in Albania and the region, successfully combining artisanal craftsmanship with modern technology. This balanced approach has established the company as a positive example of growth and sustainability in Albania's furniture industry.

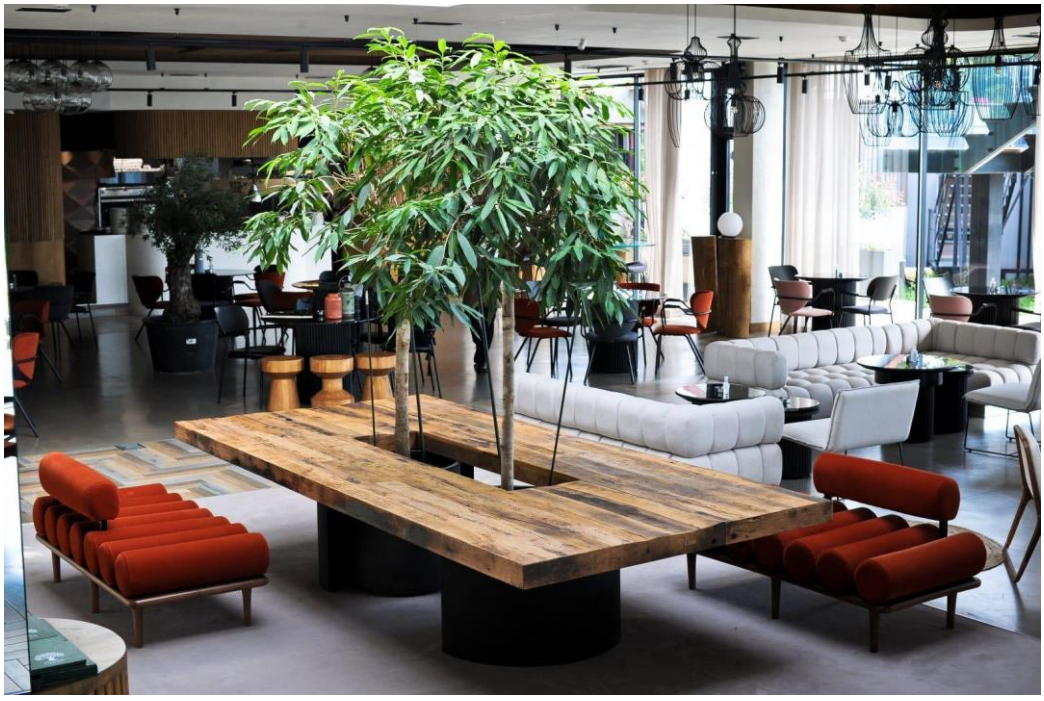
8.4.14. Best practice 14: Serbia - Furniture recycling

Basic information:

Flame Furniture is a small, design-led collective based in Belgrade that specializes in up-cycling heritage timber. The company has only three permanent employees, yet it cooperates closely with a network of independent craft-workers and designers to build bespoke dining tables, benches and shelving from century-old oak beams and floorboards salvaged during the dismantling of mountain cottages in western Serbia. Finished pieces are marketed to premium customers in Serbia and neighboring EU markets.

Application of circular-economy principles:

Flame's value proposition centers on direct material reuse. Demolition crews and local brokers supply the company with reclaimed oak. After metal-detection and slow kiln-drying, beams are re-sawn and jointed into wide table tops that retain original mortise holes and weathered faces - features that command a higher price than new oak. Shorter off-cuts are laminated into stair treads or cheese-board blanks, while sawdust and fines are collected and sent to a nearby pellet plant, achieving very high material recovery. By combining carefully documented provenance with design storytelling, Flame Furniture keeps historic oak in circulation for another 30+ years and diverts what would otherwise be construction waste from landfill or low-grade combustion.



Dining table (350 × 160 × 75 cm) from reclaimed oak (100+ years old) and steel

8.4.15. Best practice 15: Serbia - Furniture recycling

Basic information:

Fragment d.o.o. is a start-up housed in the Čačak Science-Technology Park. The firm employs twelve people – materials engineers, designers and machine operators – and has perfected the production of 20 mm and 30 mm panels made from 100 % recycled glass cullet bound with cement and proprietary additives. The panels are marketed to architects, interior designers and furniture makers in Serbia, Scandinavia, Austria and Germany.

Application of circular-economy principles:

Fragment collects discarded glass from nearby sorting plants, crushes and cleans it, then presses the grains with a cement-based binder to form terrazzo-like slabs (the glass content in the products is 73%). Off-cuts generated during cutting are returned to the crusher, so the process cycles virtually all incoming material back into production. By turning an abundant secondary raw material into a high-value décor product that slots straight into furniture production, Fragment demonstrates how circular design can extend beyond wood residues and still fit within broader material-efficiency goals.

Oak bench with Fragment top

8.4.16. Best practice 16: Croatia - Reuse business models: Prostoria d.o.o. – Sustainable use of textile waste through the "Štof by Prostoria" project

General information

- **Name:** Prostoria d.o.o.
- **Location:** Sveti Križ Začretje, Croatia

FULAR

- **Year of establishment:** 2011
- **Employees:** more than 200
- **Main products:** designer upholstered and wooden furniture (sofas, armchairs, chairs, tables)
- **Markets:** European and global market (export to more than 60 countries)
- **Certificates:** FSC®, ISO 9001, ISO 14001

Application of circular economy in the business model

In a relatively short time since its establishment, Prostoria has grown into an internationally recognized furniture manufacturer with a strong focus on sustainability. As a producer of upholstered furniture, Prostoria consumes large amounts of textiles, and inevitably surplus material and waste are generated during production. This became the starting point for developing the internal project "Štof by Prostoria", whose aim is to ensure that all textile offcuts created in the production process are used for new products instead of ending up as waste.

Through this project, the company has established a system for collecting, sorting, and processing textile remnants. The material is first selected according to dimensions and quality: larger pieces can be directly used for new products such as pillowcases or bags, while smaller pieces are cut and stitched into patchwork items or serve as a base for decorative elements. This creates a double benefit – on one hand, the amount of waste that would otherwise burden the environment is reduced, and on the other hand, new products with added market value are created.

The business model also integrates the use of wooden and metal by-products. Sawdust and wood chips generated during production are sold to the pellet industry or used for energy within the company's own facilities, while metal scraps are sent to recycling centers. In this way, Prostoria closes the loop in almost all phases of production, ensuring that no part of the material remains unused.

Furniture parts and materials that can be reused

The particularity of Prostoria's model lies in the ability to use textile remnants without additional processing, for example larger fabric pieces that can be directly sewn into covers or cushions. Smaller pieces, although requiring additional processing and sewing, also become valuable raw material because when combined they provide a unique visual identity for the products. Wood offcuts can be used in the experimental phase of prototyping, while metal elements such as screws or smaller frames can be reprocessed and reused in structural solutions.

Technology and material properties

The processing of textile waste is based on traditional tailoring and sewing techniques, but it requires careful selection of materials because they often consist of different types of fabrics that vary in thickness, elasticity, and surface finish. For this reason, Prostoria has developed specific internal procedures for sorting and combining fabrics so that the final product maintains consistent aesthetic and functional properties.

Textile remnants retain all the aesthetic and mechanical properties of the original materials – colors remain vibrant, and strength and durability are not diminished. Their workability allows cutting, sewing, and combining into different forms, while the patchwork approach further emphasizes the uniqueness and aesthetic value of the final products.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

FULAR

Possibilities and costs of recycling

Industrial recycling of textiles is a complex and costly process, especially due to the fact that fabrics often have mixed compositions and finishing treatments. Prostoria therefore opted for a solution that is both economically and environmentally more efficient – repurposing remnants into new products. This reduces waste disposal costs and creates a new product line that carries added value due to its sustainability label.

The costs of processing textile remnants mainly relate to the additional work of employees in the sorting and cutting stages. However, the value of products such as unique cushions or bags more than compensates for these costs, since customers appreciate the fact that they are limited editions made from remnants.

Benefits, challenges and conclusions

The implementation of this business model brings multiple benefits. From an environmental perspective, the amount of waste is significantly reduced and the use of raw materials is optimized. Economically, Prostoria generates additional revenue through the new product line and reduces disposal costs. Socially, the company raises awareness among its customers about the importance of sustainability and recycling, and positions Croatia as a good practice example in the furniture industry.

The biggest challenge in implementing the model is the logistics of collecting and sorting textile remnants, which requires additional organization and resources. Also, creating new products from diverse and sometimes inconsistent materials requires additional effort from designers to achieve both aesthetic and functional balance.

Despite these challenges, Prostoria demonstrates that even in a design- and luxury-oriented industry the concept of the circular economy can be successfully applied. The “Štof by Prostoria” project proves that textile waste can become a valuable resource rather than a problem, and that through an innovative business model approach both market and social benefits can be achieved.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

8.4.17. Best practice 17: Serbia - Upcycling and reuse business models: Royal Oak – furniture made from old wood

Basic information about the business entity

Royal Oak is a Croatian company based in Samobor, specialized in the production of furniture and decorative products made from old wood. In addition to production, the company is engaged in the purchase and sale of old wood (most often oak aged between 50 and 200 years) obtained from dilapidated rural houses, barns, and other old buildings. Royal Oak manufactures tables, chairs, beds, lighting fixtures, and decorative elements, and markets its products both domestically and internationally.

Application of circular economy in the business model

The entire Royal Oak business model is based on the reuse of old wood, which would otherwise end up as waste or fuel. The company collaborates with local communities and families in rural areas to purchase old wood from buildings that are being demolished or renovated. In this way, resources that would otherwise be lost are returned to the production cycle and become the basis for unique pieces of furniture.

Technology and material properties

Old wood requires special treatment. After purchase, each beam or plank undergoes a process of selection, cleaning, drying, and stabilization. If necessary, metal fasteners and irregularities are removed, and then the wood is planed, sanded, and joined. A distinctive feature of Royal Oak products is that natural cracks, patina, and imperfections are often preserved, which become an aesthetic value and set them apart from mass-produced furniture.

The mechanical properties of old oak remain excellent—the wood is already dry, stable, and extremely durable. It can be easily processed with standard tools, and the products have a long service life. The aesthetic value is particularly emphasized, as the material carries history and authenticity.

Benefits, challenges and conclusions

This business model brings multiple benefits. Environmentally, the amount of waste is reduced, and the lifespan of materials is extended, reducing the need for felling new trees. Economically, Royal Oak products belong to the premium segment with high added value, as customers pay for uniqueness and authenticity. Socially, the company contributes to the preservation of local heritage by salvaging wood from old rural houses and buildings.

The main challenges lie in procurement—it is necessary to constantly secure sufficient quantities of quality old wood, which depends on the renovation and demolition of buildings. Additionally, working with old material requires extra expertise and manual work, which increases costs.

In conclusion, Royal Oak represents a best practice example of upcycling and reuse business models in Croatia. The company shows how old resources can become the foundation for luxury products of high aesthetic and market value, while at the same time significantly contributing to sustainability and resource conservation.

The project is co-funded by the European Union through the Interreg IPA Adrion programme.

9. Individuation of 3 different types of sustainable materials to use

Through a structured scouting process, three types of materials were analyzed:

1. Wood species – locally relevant species suitable for recycling, reuse, or improved circular use,
2. Post-industrial wood raw materials – side-streams and by-products from industrial processing that can be reintroduced into production, and
3. Reused components from end-of-life furniture – material parts or assemblies that retain functional or structural value.

The aim was to identify the most suitable sustainable material solutions for circular furniture production where the findings will feed directly into the development of practical guidelines for companies, especially SMEs, supporting them in the transition toward more circular, resource-efficient furniture design and production.

In order to perform joint and coordinated review of findings of this study and clearly stipulate the final selection of materials to be recommended for regional furniture industry in the following stages of FULAR – the validation workshop was held on 26th August 2025, where each partner proposed one type of material for each analyzed category.

An overview of the proposals by partners is presented in the following table:

No PPs	Partner	Wood species	Post-industrial wood raw materials	Reused components from end-of-life furniture
LP	University of Thessaly – Special account of research grants, Department of Forestry, Wood sciences & Design	European beech	• Wood shavings/chips • Solid wood off-cuts	• Sofa frame • Bed frame
PP1	Wood Furniture Home Cluster FVG			
PP3	Wood Industry Cluster	Oak (*Quercus robur*)	Sawdust	Furniture frame made of solid wood
PP4	Development agency of City of Prijedor „PREDA“	European beech	Solid wood off-cuts and edgings	Top by dining table made of solid wood
PP5	Slovenian Forestry Institute	European beech	Sawdust	Furniture frame made of solid wood
PP6	Wood Industry Cluster Albania	• Oak (Quercus spp.) • Cherry (Prunus avium)	• Off-cuts • Sawdust and shavings	Frames, table legs, or structural panels of solid oak and cherry wood
PP7	University of Belgrade – Faculty of Forestry	European beech	Solid wood and panel off-cuts	Solid wood furniture parts (e.g., table tops, frames, and structural elements)
PP8	Croatian Wood Cluster			

PP9	Competence Centre Ltd. for research and development	Oak (Quercus robur)	Wood off-cuts and edgings	Furniture frames made of solid wood
PP10	Universita' IUAV di Venezia			

Partner proposals:

LP - University of Thessaly – Special account of research grants, Department of Forestry, Wood sciences & Design

1. Wood species
   European beech is a regional hardwood with a high share in forest resources, easy to work and widely applicable in furniture production.
2. By-products and waste
   Wood shavings/chips - Wood shavings/chips can go into particleboard manufacturing as well
   Solid wood off-cuts - Larger off-cuts can be reprocessed – for example, cut into smaller components for other products. Smaller off-cuts and wood edgings can be chipped to produce wood chips
3. Furniture parts of end-of-life items
   Sofa frame and Bed frame, as they retain material quality and structural integrity, can be easily repaired or reshaped, and are straightforward to process for reuse

PP3 - Wood Industry Cluster

1. Wood species
2. **Oak (*Quercus spp.*)** is hardwood with a high share in forest resources, easy to work and widely applicable in furniture production
3. By-products and waste
   Sawdust is produced in large amounts during processing and is an important clean raw material for particleboard, MDF and biocomposites, which are widely used in furniture making.
4. Furniture parts of end-of-life items
   Furniture frame made of solid wood, as they retain material quality and structural integrity, can be easily repaired or reshaped, and are straightforward to process for reuse

PP4 - Development agency of City of Prijedor „PREDA“

1. Wood species
   European beech is a regional hardwood with a high share in forest resources, easy to work and widely applicable in furniture production.
2. By-products and waste
   Solid wood off-cuts and edgings can be reintroduced into the production cycle as raw materials. Larger off-cuts can be reprocessed – for example, cut into smaller components for other products (legs, spindles, etc.) or glued into panels (finger-jointed boards). Smaller off-cuts and wood edgings can be chipped to produce wood chips. These chips become raw material for pulp, particleboard, or are used as biomass fuel.
3. Furniture parts of end-of-life items
   Top by dining table made of solid wood, as they retain material quality and structural integrity, can be easily repaired or reshaped, and are straightforward to process for reuse

PP5 - Slovenian Forestry Institute

5. Wood species
   European beech is a regional hardwood with a high share in forest resources, easy to work and widely applicable in furniture production.
6. By-products and waste
   Sawdust is produced in large amounts during processing and is an important clean raw material for particleboard, MDF and biocomposites, which are widely used in furniture making.
7. Furniture parts of end-of-life items
   Furniture frame made of solid wood, as they retain material quality and structural integrity, can be easily repaired or reshaped, and are straightforward to process for reuse

PP6 - Wood Industry Cluster Albania

1. Wood species
   Oak (*Quercus spp.*) is one of the most important hardwood resources in the region, naturally present in lowland and hilly forests across the country. Oak wood is strong, durable, and highly valued for its decorative grain. It is widely used in furniture, flooring, interior elements, and traditional carpentry.
   Cherry (*Prunus avium*) Wild cherry is a native hardwood species in Albania, found in scattered stands across mountainous and hilly regions. Cherry wood is appreciated for its warm reddish color, fine texture, and good workability, making it suitable for decorative and high-value applications.
2. By-products and waste
   Off-cuts - Industrial processing of oak generates significant off-cuts and residues. Larger off-cuts can be reused for smaller structural elements, glued boards, or parquet components, decorative and artistic objects and artifacts. Smaller pieces are often chipped for particleboard or used as biofuel. Processing cherry wood produces off-cuts that can be reused for small decorative items, panels, or glued boards. Smaller residues, such as veneer rejects, can be repurposed in decorative composites.
   Sawdust and shavings are suitable for energy production or composite manufacturing.
3. Furniture parts of end-of-life items
   Frames, table legs, or structural panels of solid oak components from discarded furniture ntain excellent mechanical performance and can be directly reused, reshaped, or integrated into new furniture products. Their durability also makes them ideal for restoration projects and reclaimed wood applications. Also, Cherry wood parts from end-of-life furniture (such as table tops, cabinet doors, and decorative frames) retain their aesthetic qualities and can be directly reused in new designs, reshaped for smaller applications, or restored for artisanal furniture, ensuring the preservation of their natural beauty.

PP7 - University of Belgrade – Faculty of Forestry Wood species

1. Wood species
   European beech is the most significant hardwood resource in Serbia, accounting for a substantial share of the country's forests. It is easy to process, has good mechanical properties, and is widely used in furniture and interior elements
2. By-products and waste
   Off-cuts (solid wood and panels) can be directly reintroduced into production or processed into secondary products. Larger cut-offs may be used for smaller components or glued panels, while smaller pieces can be chipped for particleboard or energy use.
3. Furniture parts of end-of-life items

Solid wood furniture parts (e.g., table tops, frames, and structural elements) retain their material quality and can be repaired, reshaped, or directly reused in new products.

PP9 - Competence Centre Ltd. for research and development

1. Wood species
   Oak (Quercus robur) is a regional hardwood suitable for demanding applications, with a high share in forest resources. It is easy to process and widely used in furniture production.
2. By-products and waste
   Wood off-cuts and edgings can be reintroduced into the production cycle as raw material and reprocessed – for example, cut into smaller elements for other products (glued components, veneers, connecting elements, legs, etc.). Smaller waste pieces can be chipped into wood chips, while sawdust and shavings generated throughout the entire processing cycle are used for the production of particleboards and other types of boards.
3. Furniture parts of end-of-life items
   Furniture frames made of solid wood retain material quality and structural integrity, and can be easily repaired and restored (through sanding, re-lacquering, oiling, staining, etc.) for reuse.

Based on the above listed proposals, in line with the challenge accepted in project application, FULAR consortium has provisionally defined materials as the ones with highest potentials for circular economy. However, it should be primarily emphasized, that the performed research has strongly confirmed high "circularity" of the wood-based materials and products, labeling this great material as point of interest not only for industrial actors, but also policy makers at all governance levels.

Traditional deciduos tree species are recognized by the most of the partners as most relevant materials to be used for the development and promotion of circular economy in furniture industry. Among them, various types of beech and oak are underlined.

In the category of "post-industrial wood raw materials", solid wood off-cuts are identified as the material to be strongly considered for processing in line with the circular economy strategies (9R approach).

Within the category of "reused components from end-of-life furniture", various components and surfaces of solid wood furniture, including the structural elements and wooden frames (e.g. from upholstery furniture), are identified as the high potential materials to be used (processed) in line with the circular economy strategies (9R approach).

Presented findings will be used for the following stages of FULAR project. Provisional list will be used as the initial proposal for selection of materials to be exploited within the pilot actions. However, FULAR consortium might adopt the approach to the specifics, potentials and capacities of each locations participating in planned pilot actions.

References

Gozd in gozdarstvo v Sloveniji. 2021. https://www.zgs.si/assets/uploads/files/vsebine/1/8/3/zgs_gozd_in_gozdarstvo_v_sloveniji_zlo_a4_press-compressed.pdf

Statistical Office of the Republic of Slovenia. 2025. https://pxweb.stat.si/sistat/sl/Podrocja/Index/85/kmetijstvo,-gozdarstvo-in-ribi%C5%A1tvo

Slovenia Forestry Service. 2025. https://www.zgs.si/gozdovi-slovenije/

Informacija o poslovanju lesne in pohištvene industrije v letu 2024. Gospodarska zbornica Slovenije (GZS), Združenje lesne in pohištvene industrije. 42 p.

Identification of Value Chains in the Slovenian Forest and Wood Bioeconomy. A. Straže, D. Gornik Bučar, J. Kropivšek. 2023. Les/Wood, 33Les/Wood. https://doi.org/10.26614/les-wood.2023.v72n01a03

Hoadley, R. B. (2000). Understanding wood: A craftsman's guide to wood technology. Taunton Press.

Ross, R. J. (Ed.). (2010). Wood handbook: Wood as an engineering material. USDA Forest Service, Forest Products Laboratory.

Uzielli, L. (Ed.). (2009). Wood science for conservation of cultural heritage: Florence 2007. Firenze University Press.

Niemz, P., & Sonderegger, W. (Eds.). (2023). Springer handbook of wood science and technology. Springer.

Tsoumis, G. (1991). Science and technology of wood: Structure, properties, utilization. New York: Van Nostrand Reinhold.

Hellenic Statistical Authority (ELSTAT)

Ministry of Environment and Energy. (2024). National energy and climate plan of Greece. Hellenic Republic. https://ypen.gov.gr

Wagenführ, R. (2007). *Holzatlas*. 6th ed. Leipzig: Fachbuchverlag
– Comprehensive atlas of European and tropical wood species, with density, shrinkage, mechanical, and technological properties

Kollmann, F. F. P., & Côté, W. A. (1968). *Principles of Wood Science and Technology. Vol. I: Solid Wood*. Springer-Verlag, Berlin
– Classical reference on solid wood anatomy, physics, mechanics, and thermal/moisture behavior

Forest Products Laboratory (2010). *Wood Handbook – Wood as an Engineering Material*. General Technical Report FPL-GTR-190. Madison, WI: USDA

– Standard U.S. reference covering wood properties, moisture relations, mechanical performance, and durability

DIN 68364 (1979). *Kennwerte von Holzarten – Rohdichte, mechanische Eigenschaften, Zuordnung zu Festigkeitsklassen*. Beuth Verlag, Berlin
– German standard for characteristic values of wood species and strength class allocation

ÖNORM B 3012 (2015). *Characteristics of wood and wood-based materials – Determination of density*. Austrian Standards Institute

EN 350 (2016). *Durability of wood and wood-based products – Testing and classification of the durability to biological agents of wood and wood-based materials*. CEN, Brussels

Sell, J. (1997). *Eigenschaften und Kenngrößen von Holzarten*. Zürich: Baufachverlag
– Detailed handbook on technological properties, including screw withdrawal, thermal conductivity, and processing behavior

Salem, M. Z. M., Böhm, M., Srba, J., & Beránková, J. (2013). *Norway Spruce Wood: Properties and Suitability for Panels and Boards*. *BioResources*, 8(1), 1199–1214
– Scientific study of Norway spruce variability in density and strength across Central Europe

The Wood Database (2024 update). *Wood Species Profiles*:
- Norway Spruce (*Picea abies*): https://www.wood-database.com/norway-spruce/
- European Larch (*Larix decidua*): https://www.wood-database.com/european-larch/
- Scots Pine (*Pinus sylvestris*): https://www.wood-database.com/scots-pine/
- Olive (*Olea europaea*): https://www.wood-database.com/olive/

ANFI - Albanian National Forest Inventory Project, Final Report, 2021. National Forest Agency, Republic of Albania.

INSTAT – Institute of Statistics, Forestry and Biodiversity Statistics, 2023. https://www.instat.gov.al/en/themes/agriculture-and-fishery/forests/#tab2

INSTAT – Institute of Statistics, Business Registers, 2024. https://www.instat.gov.al/en/publications/books/2025/business-registers-2024

UDA Consulting (Turkey), DIAVA Consulting (Albania), 2018, Report on Albanian Fuelwood Demand Assessment and Analysis. Funded by the World Bank.

Kiliç M., Burdurlu E., Usta I., Berker U.Ö., Oduncu P. (2006). Comparative Analysis of the Nail and Screw Withdrawal Resistances of Fir (*Abies Mill.*), Cherry (*Prunus Avium L.*), Walnut (*Juglans Regia L.*) and Oak (*Quercus L.*) Wood. Düzce Üniversitesi Orman Fakültesi Ormancılık Dergisi, 2(2), 61-75.

Alfred Teischinger, Anne Isopp, Josef Fellner. Wood species: Views, parameters and descriptions. pro:Holz publication; edition DETAIL, 2023, Austria. ISBN: 978-3-95553-619-0. https://www.detail.de/de_de/holzarten.

Miroslav Gašparík M., Karami E., Sethy A.K., Das S., Kytka T., Paukner F., Gaf M. (2021). Effect of freezing and heating on the screw withdrawal capacity of Norway spruce and European larch wood. Construction and Building Materials, 303(6). DOI: 10.1016/j.conbuildmat.2021.124457

Ministry of Foreign Affairs of Bosnia and Herzegovina, https://www.mvteo.gov.ba/Content/Read/sumarstvo?lang=en

Ministry of Foreign Affairs of Bosnia and Herzegovina, https://www.mvteo.gov.ba/Content/Read/sumarstvo

Report on the Implementation of the Production and Financial Plan for the Year 2022, Public forestry company „Šume Republike Srpske“ a.d. Sokolac

Information on Forest Management in the Federation of Bosnia and Herzegovina in 2021 and Forest Management Plans for 2022, Federal Ministry of Agriculture, Water Management and Forestry

Strategic Plan for Rural Development of Bosnia and Herzegovina for the Period 2023–2027 – Framework Document (Draft)

Report on the Implementation of the Production and Financial Plan for the Year 2022, Public forestry company „Šume Republike Srpske“ a.d. Sokolac

Strategic Plan for Rural Development of Bosnia and Herzegovina for the Period 2023–2027 – Framework Document (Draft)

Cadastre of forests and forest land in the Republic of Srpska as of December 31, 2024. year, Public forestry company „Šume Republike Srpske“ a.d. Sokolac

Association of Forestry Engineers and Technicians of Bosnia and Herzegovina – UŠIT FBiH, https://usitfbih.ba/sumarstvo/

Statistical Bulletin 389 - Forestry 2023, Federal Statistical Office of the Federation of Bosnia and Herzegovina

CompanyWall ltd, https://www.companywall.ba/

Foreign Trade Exchange of Bosnia and Herzegovina with the World, ANALYSIS – Trends in Bosnia and Herzegovina’s Foreign Trade Exchange with the World in 2023 (Wood Industry), Infocom (Bulletin of the Foreign Trade Chamber of Bosnia and Herzegovina, Issue No. 89, February 2024)

Production, Sales, and Stocks of Forest Assortments in Bosnia and Herzegovina by Assortment in 2023, Agency for Statistics of Bosnia and Herzegovina, Report, Agriculture and Forestry, No. 3

Forests of the Republic of Srpska JSC Sokolac, https://sumerepublikesrpske.org/index.php/strana-1/rg-niz-ci

Report on sustainable business - Project "Mapping sustainable development goals in relation to value chains in the furniture and car parts production sector in Bosnia and Herzegovina

FULAR

Study of the development of the wood processing industry and the furniture industry in Bosnia and Herzegovina, prof. Ph.D. Eng. Th. Stautmeister INNOTECH Holztechnologien GmbH Berlin by order of Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ) GmbH, November 2001

Report on sustainable business - Project "Mapping sustainable development goals in relation to value chains in the furniture and car parts production sector in Bosnia and Herzegovina

The project is co-funded by the European Union through the Interreg IPA Adrion programme.