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Deliverable 2.2.1.

Scouting Report: Scouting cost-effective technologies for circular production

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Shaping new paths towards FUrniture circularity

Deliverable 2.2.1.

Scouting Report: Cost-effective technologies for circular production

Work package:	**2 - Preparatory work towards circular models integration in furniture**
Activity:	**2.2 - Scouting cost-effective technologies for circular production**
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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.

1. 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.

2. 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.

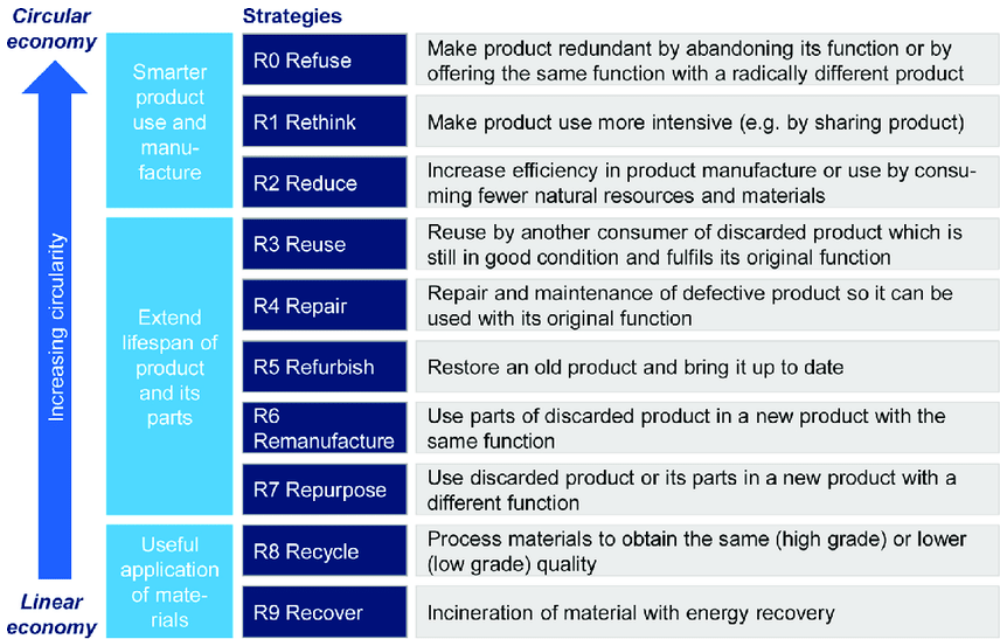
3. About the deliverable

The deliverable is the result of joint effort of FULAR partnership, design in order to present the research, which was focused on identification of technological, technical and marketing solutions with regards to the concept of circular economy applied in the furniture sector. Up-to-date and commercial solutions, as well as an innovative business models were also taken in consideration, providing provisional information on the physical and financial feasibility of developing circular economy business in the furniture sector. The deliverable is compiled upon the completion of number of tasks shared and coordinated by the project partners, including:

- Mapping Existing Technologies and Practices
- Engaging with Technology Suppliers and Providers (contribution of each partner expected)
- On-site Visits to Production Units or SMEs (contribution of each partner expected)
- Expert and Stakeholder Interviews
- Desk Research and Literature Review
- Collaboration with the furniture and interior designers, Design Schools and Fablabs
- Development of Evaluation Criteria
- Thematic Workshops and Validation Meetings on the partnership level

The results of the research are presented in line with the following illustration of 9R concept (in line with the review of existing literature performed by Julian Kirchherr, Denise Reike and Marko Hekkert).

FULAR



In response to the mounting environmental and economic challenges posed by the traditional "take-make-dispose" model, the circular economy offers a transformative alternative—one that prioritizes resource efficiency, product longevity, and systemic innovation. At the heart of this approach lies the 9R framework, a hierarchy of strategies designed to minimize waste and maximize value throughout the lifecycle of products and materials.

The 9R strategies—Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover—represent a continuum of interventions, from the most preventive to the least circular. They guide businesses, policymakers, and communities in reimagining production and consumption systems to align with ecological boundaries and societal needs.

- Refuse and Rethink challenge the necessity of products and promote alternative models such as sharing platforms and service-based solutions.
- Reduce, Reuse, and Repair focus on extending product life and minimizing resource input.
- Refurbish, Remanufacture, and Repurpose enable the regeneration and transformation of used goods into valuable assets.
- Recycle and Recover, while still important, are considered last-resort strategies due to their energy intensity and limited impact on upstream design.

Results of the research are structured to follow the concept of the project and rationale of the work package 2, where the 9R strategies are taken as the baseline for identification of potential behaviour and development directions for furniture sector in terms of the circular economy approach. Main findings of the research,

presented in the following sections, will be used as main inputs in the process of drafting of the "Practical guidelines for circular economy implementation in furniture sector", (within activity 2.3).

Findings for each strategy are presented in the way to present relevant technologies, techniques, digital tools, advanced concepts and study cases, as an exhaustive list of options to be considered for dissemination within the furniture sector or launch of innovative initiatives and ventures in Adriatic - Ionian region.

R0. Refuse

Encourages the elimination of unnecessary products or materials from the outset. This strategy challenges consumption habits and promotes conscious choices—such as refusing single-use plastics or declining promotional items that serve no long-term purpose. It's the first and most impactful step toward reducing environmental burden.

R1. Rethink

Promotes a fundamental shift in how products are designed, used, and accessed. It includes innovative business models like product-as-a-service (e.g., leasing instead of owning), and encourages systemic redesign to optimize resource use. Rethinking also involves questioning whether a product is needed at all or if a smarter alternative exists.

R2. Reduce

Focuses on minimizing resource input and waste generation throughout the product lifecycle. This includes designing for efficiency, using fewer materials, and streamlining production processes. It's about doing more with less—reducing energy, water, and raw material consumption while maintaining functionality.

R3. Reuse

Extends the life of products by using them again for the same purpose, often without significant modification. This strategy supports second-hand markets, sharing platforms, and repair cafés. Reuse reduces demand for new products and delays entry into the waste stream.

R4. Repair

Involves fixing broken or malfunctioning products to restore their original function. It supports local economies, preserves craftsmanship, and reduces the need for replacement. Repairability should be embedded in product design, with accessible parts and manuals to empower users and technicians.

R5. Refurbish

Refers to updating or restoring used products to a good working condition, often with cosmetic improvements. Common in electronics and furniture,

refurbishment gives products a second life and can be a cost-effective alternative to buying new, especially in institutional or commercial settings.

R6. Remanufacture

A more intensive process than refurbishment, remanufacturing involves disassembling a product and rebuilding it to meet original specifications using a mix of reused, repaired, and new components. It's common in industrial sectors like automotive and machinery, where precision and performance are critical.

R7. Repurpose

Transforms discarded products or components for a new use, different from their original function. For example, using old shipping containers as modular housing or turning textile scraps into insulation. Repurposing fosters creativity and reduces the need for virgin materials.

R8. Recycle

Processes materials to create new raw inputs for manufacturing. While widely practiced, recycling is energy-intensive and often downcycles materials into lower-quality outputs. It should be a last resort after higher-order strategies have been exhausted. Effective recycling requires clean material streams and robust infrastructure.

R9. Recover

Captures energy or residual value from waste that cannot be reused or recycled. This includes incineration with energy recovery or extracting biogas from organic waste. While better than landfilling, recovery is still a linear process and should be minimized in a truly circular system.

4. Materials and technologies for circular economy in furniture sector

In the transition toward a circular economy, the furniture industry is undergoing a profound transformation—shifting from linear production models to regenerative systems that prioritize sustainability, resource efficiency, and product longevity. This evolution is driven by the integration of innovative materials and enabling technologies that support whole range of strategies from least to most effective ones. FULAR consortium has made an effort to outline materials and technologies that underpin circular practices in furniture manufacturing, offering scalable solutions for reducing environmental impact while enhancing economic resilience. To that sense the purpose of the mapping process was to collect information on most relevant materials and technologies, in use or in the initial phase of commercial application. As the results of the mapping process are to be

considered as inputs for drafting of "Practical guidelines for circular economy implementation in furniture sector", the rationale behind the approach was to concentrate on relatively available and affordable solutions, feasible to be integrated in the furniture sector of targeted regions. In collaboration with the scientific partners, nominating materials and technologies in the experimental phase of development was avoided, in order to make the guidelines document as realistic and feasible for MSMEs active in the furniture sector.

Each identified material and technology are presented from the aspect of potential integration in the current or development of completely new business model of MSMEs active in the furniture sector.

4.1. Chipboard (conventional and recycled)

The integration of recycled chipboards into furniture manufacturing represents a strategic advancement toward circular economy principles. As an engineered wood product composed of reclaimed wood particles, sawdust, and eco-friendly resins, recycled chipboard offers a compelling blend of environmental responsibility and functional performance.

Table 1. Chipboard (convenitional and recycled)

Material (furniture related)	**Circular economy action**
Chipboard (conventional and recycled)	Recycling
Technology	**Technology suppliers**
● Use of wood-based by-products and recycled wood - Collecting, sorting, pre-shredding at collection sites, transport to plant and processing into new chipboards. ● Use of waste wood from old furniture, pallets, and construction materials, which is mechanically cleaned, sorted, and shredded. After removing unwanted materials (metal, plastic, glass), the material is pressed with eco-friendly adhesives into new panels for furniture manufacturing.	● Komptech ● Dieffenbacher ● Siempelkamp
Material	**Material suppliers**
Chipboards panels: ● Dimensions (in mm) 2440 × 1220; 2800 × 2070; 3660 × 1830; 2750 × 1830; 2620 × 1830. ● Standard Thicknesses: 8 mm to 38 mm ● Density: Typically 600–750 kg/m³	● WINI ● Egger Group ● Kronospan ● Saviola ● Swiss Krono Group

●Surface Finish: Raw, sanded, melamine-faced, fire-retardant, or veneered ●Recycled Content: Often 60–100% of the wood particles are from recycled sources	• Akritas • Sonae Arauco • Finsa • Fantoni

Case study

"SARA" Chipboard made from 100% recycled waste wood by company WINI. Waste wood (classified according to the European Waste Catalogue, e.g. old furniture, pallets, construction timber, etc.) is chipped and processed into new, high-quality furniture boards. Adhering materials, such as Glass, steel or aluminium, are separated by type in the reconditioning process and sent for recycling. "SARA" is produced without the use of newly felled wood - that's hundreds of thousands of trees that don't have to be felled every year. No more forest has to be cleared for SARA, no habitat for Flora and fauna is destroyed and existing resources are used more efficiently. Thanks to the circular economy, carbon remains bound in the waste wood and our forests can absorb more CO2 for longer. "SARA" wood is PEFC and FSC-certified and less water is used in its production than with conventional chipboard. More info available on: https://www.wini.de/en/sara-chipboard/

Identified benefits

- **Resource Efficiency**: By repurposing wood waste from sawmills and post-consumer sources, recycled chipboards significantly reduce the demand for virgin timber, conserving forests and biodiversity.
- **Carbon Footprint Reduction**: The use of recycled materials helps retain the carbon stored in wood, extending its lifecycle and mitigating greenhouse gas emissions.
- **Cost-Effectiveness**: Compared to solid wood or MDF, recycled chipboards provide a more affordable alternative without compromising structural integrity, making sustainable design accessible across market segments.
- **Design Versatility**: Available in various grades and finishes—including melamine-coated or veneered surfaces—chipboards support modular, customizable, and aesthetic furniture solutions.
- **Circular Compatibility**: Their uniform composition and ease of disassembly make recycled chipboards ideal for reuse, remanufacturing, and end-of-life recovery strategies.

Potential circular economy strategy for SMEs

R7. Recycle (**high potential**)
R1. Rethink (**medium potential**)
R2. Reduce (**high potential**)

4.2. Recycled Medium Density Fiber (MDF) boards and elements

Recycled Medium-Density Fiberboard (MDF) is emerging as a pivotal material in sustainable furniture manufacturing, aligning with circular economy goals by repurposing wood fibres and minimizing resource extraction. Its engineered composition and adaptability make it a valuable alternative to virgin wood-based panels, especially in modular and mass-customized furniture systems. As sustainability becomes a core value in design and manufacturing, recycled MDF—especially in multi-layer configurations—offers a scalable, eco-conscious solution for the furniture industry's transition toward circularity.

Table 2. Recycled MDF boards and elements

Material (furniture related)	**Circular economy action**
Recycled (MDF) boards and elements	Recycling
Technologies	**Technology suppliers**
● Use of agricultural and wood waste to produce fully recyclable panels. ● Patented process to recover high-quality wood fibres from waste Medium Density Fibreboard (MDF), which is typically incinerated or landfilled. The recovered fibre can be reused in new MDF production or other fibreboard applications. ● An advanced plant integrating a three-layer production line is used to make MR panel. This system makes it possible to produce MDF with more than 50 percent recycled wood. To ensure the quality of the material, innovative technologies are used to purify the recycled wood, such as X-ray and infrared selectors, magnets and eddy current separators (ECS), which remove impurities such as glass, metals, stones and plastics, ensuring optimal performance in the middle layer of the panel. ● Lightweight wall panels grown by fungal mycelium that binds agro-industrial residues into a rigid, 100 % bio-based board; zero synthetic resin, VOC-free.	● n/a
Material	**Material suppliers**

●Resin-free panels from waste cellulose (ECOR) ●New MDF boards (recovered wood fibre) ●Three-layer MDF panel, designed to meet sustainability needs in the furniture and construction industries ●Mycelium acoustic panels	• ECOR Global Ldt. d.o.o. Kraljevo, Serbia • MDF Recovery Ltd, Unit 5, Sidcup Road, Manchester, UK • Fantoni • MOGU

Case study

ECOR converts agricultural and urban waste into sustainable building materials. ECOR's conversion process adds no urea formaldehyde or isocyanides. Precise amounts of heat, pressure and recycled water create a controlled chemical reaction to forge ECOR's FiberAlloy™ panels. ECOR is Nature's Composite. Independent analysis has confirmed that ECOR Technology is sound and commercially scalable. ECOR products meet or exceed all industry specifications for the wood composites they replace including HDF, MDF and Plywood. ECOR claims that it is the world's first commercially viable eco panel.
More info available on: https://ecorglobal.com/

Identified benefits

- **Waste Reduction & Resource Conservation** Recycled MDF utilizes post-industrial and post-consumer wood waste, diverting significant volumes from landfills and reducing the demand for fresh timber. This supports forest preservation and promotes responsible material cycles.
- **Enhanced Material Efficiency** Three-layer MDF panels—featuring a dense core flanked by finer outer layers—offer improved mechanical stability, smoother surfaces, and better edge retention. These attributes are ideal for high-precision furniture components and decorative finishes.
- **Design Flexibility & Surface Quality** The uniform texture and dimensional stability of recycled MDF allow for intricate shaping, veneering, and lamination. Three-layer variants further enhance surface quality, making them suitable for premium applications like cabinetry, shelving, and wall panels.
- **Environmental Performance** Advances in formaldehyde-free adhesives and emission-reduction technologies have made recycled MDF safer for indoor environments, addressing health concerns while maintaining structural integrity.
- **Circular Compatibility** Recycled MDF panels can be reprocessed into new boards or alternative wood products, supporting closed-loop manufacturing and reducing the environmental footprint of furniture production.

Potential circular economy strategy for SMEs

R8. Recycle (**high potential**)
R2. Reduce (**medium potential**)

4.3. Solid wood panels

Repurposing solid wood panels offers a compelling pathway toward sustainable innovation in furniture design. By extending the lifecycle of high-quality timber through creative reuse, manufacturers can reduce environmental impact while preserving the aesthetic and structural integrity of natural materials. The practice of repurposing solid wood exemplifies how sustainability and storytelling can converge in meaningful, market-ready furniture solutions.

Table 3. Solid wood panels

Material (furniture related)	**Circular economy action**
Solid wood panels	Repurpose
Technologies	**Technology suppliers**
●Hand-crafted furniture, floors, wall covers and accessories made from old wood elements (boards and beams) salvaged when traditional cottages are dismantled (specially in the area of Western Balkans) or old logs and timber (discovered in local rivers and lakes). Boards and beams are metal-detected, de-nailed, kiln-dried, planed and finished with natural oils, preserving historic patina. The process implies use of conventional machinery for wood processing (Sawing machines, planing machines, router machines, gluing machines, cnc machines, sanding machines, painting booths, etc.).	● SCM ● BIESSE ● HOMAG ● WEINIG ● FELDER ● HOLZHER ● MASTERWOOD
Material	**Material suppliers**
●Solid wood boards and elements refurbished and processed to be integrated in new product.	● Collection of the material is usually result of field researches and individual mapping performed by entrepreneurs.
Case study	
Flame Furniture Inc., based in Belgrade, Serbia, exemplifies a regenerative approach to furniture design. Operating within a region rich in cultural heritage and natural resources, the company leverages reclaimed wood from century-old Serbian cottages to craft bespoke furniture pieces that merge sustainability with artistry. The furniture industry faces increasing pressure to reduce its environmental footprint while maintaining aesthetic and functional value. Flame Furniture sought to:	

- Minimize reliance on virgin materials
- Preserve traditional craftsmanship
- Create globally appealing designs rooted in local identity

Flame Furniture implemented a circular production model centered on:

- **Material Recovery**: Sourcing reclaimed wood from deconstructed rural homes
- **Eco-Friendly Treatment**: Using only wax and natural oils to finish products
- **Collaborative Design**: Partnering with international artists to infuse cultural diversity into each piece
- **Fair Trade Principles**: Ensuring ethical labor practices and community engagement

More info available on: https://flamefurniture.rs/

Identified benefits

- **Material Preservation & Waste Minimization** Solid wood panels—often sourced from deconstructed furniture, architectural salvage, or industrial offcuts—retain their mechanical strength and visual appeal, making them ideal candidates for reuse. This approach diverts valuable hardwoods from landfills and reduces the need for virgin timber harvesting.

- **Aesthetic & Historical Value** Reclaimed wood often carries unique grain patterns, patinas, and historical character that enrich the narrative of new furniture pieces. Whether sourced from old barns, ships, or urban renovations, each panel contributes to a design language rooted in authenticity and craftsmanship.

- **Versatility in Design Applications** Repurposed solid wood panels can be reconfigured into tabletops, shelving units, cabinetry, or decorative wall cladding. Their dimensional stability and workability allow for both traditional joinery and modern CNC-based fabrication.

- **Environmental Performance** Compared to energy-intensive recycling processes, direct reuse of solid wood panels requires minimal processing, resulting in lower carbon emissions and reduced resource consumption.

- **Circular Compatibility** Products made from repurposed wood panels can themselves be designed for future reuse or disassembly, reinforcing circularity across multiple life cycles. This supports modular design strategies and aligns with eco-certification frameworks such as Cradle to Cradle or FSC Recycled.

Potential circular economy strategy for SMEs

R7. Repurpose (**high potential**)
R6. Remanufacture (**high potential**)
R1. Rethink (**medium potential**)
R5. Refurbish (**medium potential**)

4.4. Cross-laminated timber panels

Cross-Laminated Timber (CLT), traditionally used in construction projects, is gaining traction as a repurposed material for furniture production—offering both mechanical robustness and sustainability. By reclaiming CLT panels from deconstructed buildings or surplus construction stock, manufacturers can unlock new value streams while advancing circular economy goals. CLT panels fabricated from appropriate reclaimed wooden-based products can match the mechanical performance of new panels, showcasing the viability of upcycled timber in both construction and furniture applications.

Table 4. Cross-laminated timber

Material (furniture related)	**Circular economy action**
Cross-laminated timber panels	Recycling/Repurposing
Technologies	**Technology suppliers**
●Grinding into wood fibres for the production of insulation materials or wood composites (shredders) ●Conventional wood-processing (Sawing, planning, drilling, gluing, sanding, painting, etc.) and CLT production lines.	● SCM ● BIESSE ● HOMAG ● WEINIG ● FELDER ● HOLZHER ● MASTERWOOD
Material	**Material suppliers**
●Collection of furniture pieces made from reused exhaust CNC milled laminated wood panels ●Cross-laminated boards and elements refurbished and processed to be integrated in new product	● Collection of the material is usually result of field researches and individual mapping performed by entrepreneurs.
Case study	
Slovenia's forestry and woodworking sectors have long been central to its cultural and economic identity. Yet, the challenge of wood waste and underutilized timber persists. The "Lesni Feniks" project was launched to address this gap by transforming discarded wood into valuable community assets, facing the challenges: ● Large volumes of wood waste from construction and deconstruction ● Limited public awareness of material reuse and circular design ● Fragmented collaboration between industry, education, and local communities Lesni Feniks created a multi-stakeholder platform to:	

- **Reclaim and Repurpose**: Salvage wood remnants and used timber destined for disposal
- **Design for Community Use**: Convert recovered materials into functional products for local institutions
- **Educate and Inspire**: Host lectures, exhibitions, and films to promote circular practices
- **Foster Collaboration**: Unite businesses, schools, and municipalities under a shared sustainability mission

More info available on: https://www.lesnifeniks.si/

Identified benefits

- **Structural Integrity & Dimensional Stability** CLT panels consist of multiple layers of solid-sawn lumber glued crosswise, providing exceptional strength and rigidity. When repurposed, these panels retain their load-bearing capacity, making them suitable for durable furniture components such as tabletops, benches, and shelving systems.
- **Material Efficiency & Waste Reduction** Reusing CLT from construction waste or offcuts minimizes landfill contributions and extends the lifecycle of high-quality timber. This approach supports resource conservation and reduces the carbon footprint associated with new material production.
- **Design Versatility** The layered composition of CLT allows for creative reconfiguration into modular furniture elements. Panels can be cut, shaped, and finished to meet diverse aesthetic and functional requirements, including minimalist, industrial, or rustic styles.
- **Environmental Performance** Repurposed CLT retains its carbon storage properties, contributing to climate mitigation. When sourced from certified sustainable origins, it aligns with eco-labelling standards and green building certifications.
- **Circular Compatibility** Furniture made from reclaimed CLT can be designed for future disassembly and reuse, reinforcing circularity across multiple product lifecycles. This supports regenerative design strategies and aligns with Living Lab and Smart Factory principles.

Potential circular economy strategy for SMEs

R7. Repurpose (**high potential**)
R8. Recycle (**high potential**)
R6. Remanufacture (**high potential**)

4.5. Plastics – Recycling for furniture and components

The recycling of plastics into furniture and interior components represents a transformative approach to sustainable design—diverting waste from landfills and oceans while unlocking new possibilities for durable, low-maintenance, and aesthetically versatile products. As circular economy models gain traction, recycled plastics are becoming essential materials in both industrial and consumer furniture applications. From outdoor benches and patio sets to modular cabinetry and decorative panels, recycled plastics are reshaping the furniture industry—merging environmental responsibility with functional innovation.

Table 5. Plastics

Material (furniture related)	**Circular economy action**
Plastics	Recycling
Technologies	**Technology suppliers**
●Custom-built recycling presses, shredders and flakers, cleaning and drying systems (sorters, washers, dryers), CNC equipment for finishing. ●Plastic shredders, Extrusion lines, Injection moulding machines, Washing units.	● The Good Plastic Company ● EREMA ● Lindner ● Vecoplan
Material	**Material suppliers**
●High-quality panels made from recycled plastic are used for furniture production. ●Recycled plastic components for furniture ●Furniture (final products – chairs)	● Collectors of plastic waste, e-waste and other type of waste. ● Collectors of specific materials and products (fishing nets and pharmaceutical packaging waste (insulin pins) and recycled steel). ● Distributors of plastic granules (recycled).
Case study	
Smile Plastics is a UK-based materials design studio and manufacturer that transforms post-consumer plastic waste into high-end, supersized panels for commercial interiors and product design. With over 30 years of experience, the company exemplifies how circularity can be both scalable and beautiful. Plastic waste remains one of the most pressing environmental issues, with millions of tonnes discarded annually. Smile Plastics set out to: • Divert plastic waste from landfills and oceans • Create visually compelling materials from recycled content • Scale production without compromising sustainability or aesthetics Smile Plastics developed a closed-loop system centred on:	

- **Material Recovery**: Sourcing waste streams like yoghurt pots, chopping boards, cosmetics bottles, and e-waste

- **Design Transparency**: Each panel visually reflects its origin—barcode fragments, foil glimmers, and color washes narrate the material's lifecycle
- **Custom Blending**: Designers can co-create bespoke panels from specific waste types and color palettes
- **Scalable Production**: Operating 24/7, the facility can divert up to 3,000 tonnes of plastic waste annually

Smile Plastics transforms 100% recycled and recyclable plastic waste into high-end design panels, combining sustainability with aesthetics. Their materials come with verified Environmental Product Declarations (EPDs) and contain virtually no VOCs, ensuring safety and transparency.
Economically, they've carved out a premium niche for architects and designers seeking sustainable surfaces. Socially, their panels tell the story of their origins—barcode fragments, foil glimmers—raising awareness of reuse and circularity.
Industrial impact is backed by ISO 9001 and ISO 14001 certifications, with 24/7 production capacity capable of diverting up to 3,000 tonnes of plastic waste annually. It's circularity at scale—with beauty built in.
More info available on: https://smile-plastics.com/

Identified benefits

- **Waste Reduction & Resource Conservation**
  By repurposing post-consumer and post-industrial plastic waste—such as HDPE, LDPE, and polypropylene—manufacturers reduce environmental pollution and conserve fossil-based raw materials. This contributes to cleaner ecosystems and supports global sustainability targets.
- **Durability & Weather Resistance**
  Recycled plastic furniture exhibits high resistance to moisture, UV radiation, and chemical wear, making it ideal for outdoor settings, public spaces, and high-traffic environments. Reinforced variants with fiber additives or UV stabilizers further enhance performance.
- **Design Flexibility & Aesthetic Appeal**
  Advanced processing techniques allow recycled plastics to mimic traditional materials like wood, stone, or terrazzo. Sheet press and extrusion technologies enable the creation of beams, panels, and molded components with customizable colours and textures.
- **Cost Efficiency & Market Differentiation**
  Recycled plastics offer a cost-effective alternative to virgin polymers, helping manufacturers reduce production costs while appealing to eco-conscious consumers. This opens new market segments and strengthens brand positioning as a sustainability leader.
- **Circular Compatibility**
  Furniture made from recycled plastics can be designed for future recycling or modular disassembly, reinforcing closed-loop systems. This aligns with

regenerative design principles and supports certifications such as Global Recycled Standard or Blue Angel.
Potential circular economy strategy for SMEs
R8. Recycle (**high potential**)

4.6. Wood plastic composites (WPC)

Wood Plastic Composites (WPCs) are gaining traction in the furniture industry for good reason—they blend the aesthetics of wood with the durability of plastic, offering a smart alternative to traditional materials. WPCs are especially promising for circular furniture strategies. Integrating recycled plastics into furniture production enables manufacturers to meet sustainability targets, enhance product resilience, and lead in circular innovation.

Table 6. Wood plastic composites

Material (furniture related)	**Circular economy action**
WPC (Wood plastic composites)	Recycling
Technologies	**Technology suppliers**
● Produced through advanced industrial processes, including extrusion and co-extrusion, which allow for products with different finishes and technical characteristics. The workability of the material is similar to that of wood, allowing operations such as cutting, milling, sanding, and insertion of inserts, rivets, and screws.	● The Good Plastic Company ● EREMA ● Lindner ● Vecoplan
Material	**Material suppliers**
● New generation wood composite, also known as WPC (Wood Plastic Composite)	● Collectors of plastic waste, e-waste and other type of waste. ● Collectors of specific materials and products (fishing nets and pharmaceutical packaging waste (insulin pins) and recycled steel). ● Distributors of plastic granules (recycled).
Case study	
Inocram is a young yet technically seasoned company based in Friuli Venezia Giulia, Italy. With deep expertise in composite materials, recycling, and green economy principles, it has developed GAR_deck—a next-generation Wood-Plastic Composite (WPC) that exemplifies sustainable innovation in design and construction. The	

construction and furniture industries face increasing pressure to reduce environmental impact, improve material longevity, and comply with public procurement sustainability standards. Traditional wood and imported composites often fall short in recyclability, durability, and ecological performance.
Inocram introduced GAR_deck, a 100% Italian-made WPC that is:

- Fully recycled in both its wood and plastic components
- Infinitely recyclable, enabling closed-loop production
- Recognized by the Italian Ministry of Environment and listed in the Official Gazette as a certified material for Green Public Procurement (PANGPP)

GAR_deck combines high-quality eco-compatible inputs with advanced processing, merging tradition with innovation to meet modern sustainability demands.
Impact is multidimensional.
Environmentally, GAR_deck supports the 3R principle—Recycle, Reuse, Repurpose—by transforming waste into durable, versatile products. Its infinite recyclability reduces landfill dependency and conserves virgin resources.
Economically, as a certified material for public procurement, GAR_deck opens access to institutional markets and green construction projects. Its durability and low maintenance reduce lifecycle costs.
Socially, Inocram's commitment to sustainability reflects growing public demand for environmentally responsible products. The company's ethos resonates with communities and institutions seeking ethical sourcing.
Industrially, GAR_deck is applicable across a wide range of sectors, including:

- Public and private construction
- Interior and exterior flooring
- Wall cladding, partitions, and facades
- Furniture components, platforms, and event structures

More info available on: www.inocram.it

Identified benefits

- **Waste Reduction & Resource Conservation** By combining recycled wood fibers with thermoplastics such as polyethylene (PE), polypropylene (PP), or PVC, WPCs reduce the need for virgin timber and fossil-based plastics. This approach diverts wood and plastic waste from landfills, conserves natural resources, and supports circular economy goals.
- **Durability & Weather Resistance** WPC furniture offers excellent resistance to moisture, rot, insects, and UV radiation, making it suitable for outdoor use, public spaces, and humid environments. Reinforced variants with additives or stabilizers further enhance mechanical strength and longevity.
- **Design Flexibility & Aesthetic Appeal** WPCs can be molded, extruded, or pressed into a wide range of shapes and finishes. They can replicate the look of natural wood, stone, or terrazzo, and support customized textures, colors, and surface treatments—ideal for both functional and decorative furniture components.

• **Cost Efficiency & Market Differentiation** WPCs provide a cost-effective alternative to solid wood and virgin polymers. Their durability reduces maintenance and replacement costs, while their eco-friendly profile appeals to sustainability-conscious consumers and institutional buyers. • **Circular Compatibility** Furniture made from WPCs can be designed for modular disassembly and future recycling. This reinforces closed-loop production systems and supports certifications such as FSC Recycled, Global Recycled Standard, or Blue Angel—enhancing credibility in green procurement channels.
Potential circular economy strategy for SMEs
R8. Recycle (**high potential**)

4.7. Textile/sponges/upholstery

The furniture industry is undergoing a transformative shift toward circularity, and the recycling of textiles, sponges, and upholstery materials presents a significant opportunity for sustainable innovation. These components—often overlooked in end-of-life strategies—hold untapped value when recovered, reprocessed, and reintegrated into new furniture production or refurbishment cycles. Post-consumer and post-industrial furniture waste typically includes complex blends of synthetic fabrics, foams, and laminated textiles. Through advanced sorting, cleaning, and mechanical or chemical recycling techniques, these materials can be transformed into regenerated fibres, eco-sponges, and reupholstery inputs. This not only reduces landfill dependency and raw material consumption but also supports carbon reduction targets and green procurement policies. As textile recycling infrastructure expands and modular furniture design becomes mainstream, the integration of recycled soft materials will play a vital role in building resilient, low-impact furniture systems for the future.

Table 7. Textile/sponges/upholstery

Material (furniture related)	**Circular economy action**
Textile, sponge, upholstery	Recycling
Technologies	**Technology suppliers**
•Upholstery textile woven from 100 % recycled PET yarn containing post-consumer bottles and marine-litter plastics. Each linear metre re-uses ≈ 26 plastic bottles, diverts ocean waste, and offers commercial-grade abrasion resistance for sofas and task chairs •Mechanical technology: shredded sponge pieces are glued together and compressed to form new foam-based products. Chemical technology: polymer foam broken into its chemical	• BeA • Rapid Tools • Juki • Durkopp Adler • Gerber • Zünd • Savio • Halco

components for reuse in new foam production. ● Mainly hand-craft labour, where are included different operations, such as disassembly of old sofas, replacement of old materials (foam, springs etc.) and application of new polyester recycled upholstery. ● The leftover textiles generated during furniture production are reused for the restoration of worn or damaged furniture (reupholstering furniture with new fabric).	
Material	**Material suppliers**
● Various upholstered furniture. ● Oceanic recycled-PET fabric ● Recycled matrasses & sofas ● Recycled sofas	● Collectors and distributors of relevant materials
Case study	
Plastic pollution in oceans is one of the most pressing environmental challenges of our time. SEAQUAL Initiative addresses this issue by recovering marine litter and transforming it into high-quality textile materials. SEAQUAL YARN is the result of this process—a sustainable, traceable yarn made from upcycled marine plastic. The textile industry faces growing scrutiny over its environmental impact, particularly regarding synthetic fibers and ocean-bound plastic waste. Brands and manufacturers need innovative materials that combine sustainability, performance, and transparency. SEAQUAL YARN is produced through a vertically integrated process: • Marine litter is collected from coastal regions including Tunisia, Egypt, Vietnam, Mexico, and Brazil • Recovered plastics are cleaned and transformed into SEAQUAL MARINE POLYMER pellets • These pellets are spun into SEAQUAL YARN in facilities located in Spain and Mexico, in partnership with ANTEX and VICA SEAQUAL YARN is available in polyester filament, staple fiber, and nylon (from PA6 fishing nets), offering versatility across textile applications, including the production of upholstery furniture. More info available on: https://www.seaqual.org/seaqual-yarn/	
Identified benefits	
● **Waste Reduction & Resource Efficiency -** Recycling upholstery materials and refurbishing furniture diverts bulky waste from landfills and incineration. It	

reduces demand for virgin textiles, foams, and wood, conserving energy and raw materials across the supply chain. • **Extended Product Lifespan -** Repairing and reupholstering used furniture extends its functional life by years or even decades. This slows down the consumption cycle and reduces the environmental impact associated with frequent replacements. • **Material Recovery & Reuse -** Post-consumer textiles, foams, and padding can be cleaned, shredded, and reprocessed into new upholstery, insulation, or cushioning. This supports closed-loop systems and reduces reliance on fossil-based inputs. • **Local Job Creation & Skills Development -** Furniture repair, reupholstery, and refurbishment services foster local employment, especially in craft, design, and technical roles. They also support vocational training and community-based circular initiatives. • **Design for Disassembly & Modularity -** Circular furniture strategies promote modular construction, allowing components to be easily replaced, upgraded, or recycled. This enhances adaptability and supports future reuse. • **Compliance & Certification Opportunities -** Using recycled textiles and refurbishing furniture aligns with green procurement policies and sustainability certifications such as EU Ecolabel, Global Recycled Standard, and Blue Angel—strengthening institutional credibility.
Potential circular economy strategy for SMEs
R8. Recycle (**high potential**)

4.8. Bio-based auxiliary products (Adhesives/glues, Varnishes and paints)

As the furniture industry transitions toward circular economy principles, the adoption of bio-based products—such as glues, adhesives, varnishes, and paints—has emerged as a strategic enabler of sustainable innovation. These materials, derived from renewable resources like plant oils, natural resins, and agricultural by-products, offer a compelling alternative to fossil-based chemicals traditionally used in surface finishing and bonding.

By integrating bio-based formulations, manufacturers can reduce environmental impact, improve indoor air quality, and enhance the recyclability of furniture components. Unlike conventional systems that often hinder material recovery due to toxic residues or irreversible bonds, bio-based adhesives and coatings support disassembly, reuse, and safe end-of-life processing.

Moreover, these products align with evolving regulatory frameworks and consumer demand for healthier, low-emission interiors. Their use contributes to

resource efficiency, supports regional bioeconomy development, and reinforces the industry's commitment to climate-positive design.

In essence, bio-based glues, varnishes, and paints are not just technical upgrades—they are foundational elements in building a regenerative, circular furniture ecosystem.

Table 8. Bio-based auxiliary products

Material (furniture related)	**Circular economy action**
Adhesives/glues, Varnishes and paints	Recycling/Reduce
Technologies	**Technology suppliers**
● Bio-based coatings - Bio-based raw materials are often chemically modified (e.g. epoxidation, esterification) to acquire desired properties such as water resistance, adhesion or elasticity. ● Bio-based linoleum ("furniture linoleum") surfacing sheet (linseed oil, wood flour, jute) that offers natural, self-healing finish for desks/cabinets; replaces petro-based laminates or PVC foils ● Bio-based adhesives-glues - Liquefied wood, derived from wood waste, can be used as a bio-based adhesive in the wood sector (e.g. in particleboard production and parquet installation), as a renewable fuel and as a base material for the production of polyurethane foams.	● Helios ● FORBO, Assendelft ● Mitol ● GGP Postojna
Material	**Material suppliers**
● Various upholstered furniture. ● Oceanic recycled-PET fabric ● Recycled matrasses & sofas ● Recycled sofas	● Collectors and distributors of relevant materials
Case study	
Furniture Linoleum is a high-quality, climate positive and natural surface material that emphasizes elegance and sustainability. With its matte finish and soft texture, Furniture Linoleum transforms any surface – furniture, kitchen cabinetry, doors and much more - into a refined and durable design element. Most important features of the material:	

- Sustainable: Removes more CO_2 than it emits during production
- Durable: Resists fingerprints, easy to clean, Low maintenance and long-lasting
- Beautiful: Warm texture, muted colours, complements wood and stone
- Award-winning design (Red Dot: Best of the Best 2025)

Application of the material:

- Furniture surfaces (tables, cabinets, doors)
- Works on MDF, chipboard, plywood, and metal
- Suitable for flat and curved designs
- Ideal for circular design initiatives

More info available on: https://www.forbo.com/flooring/en-gl/products/linoleum/furniture-linoleum/bonogj#panel_100

Identified benefits

- **Health & Indoor Air Quality -** Bio-based formulations are typically free from formaldehyde, VOCs, and other toxic emissions—creating safer environments for workers and end users, especially in schools, homes, and healthcare settings.
- **Climate & Environmental Impact -** Derived from renewable resources such as plant oils, natural resins, and starches, these products reduce dependence on fossil-based chemicals and often result in lower carbon footprints across the product lifecycle.
- **Performance & Durability -** Modern bio-based coatings offer excellent resistance to abrasion, moisture, and UV exposure. Many match or exceed the performance of synthetic alternatives, with added benefits like non-yellowing finishes and fast drying times.
- **Circular Economy Compatibility -** Bio-based systems support circular design principles by enabling recyclability, compost ability, and integration of agricultural or forestry by-products—strengthening regional bioeconomy strategies.

Potential circular economy strategy for SMEs

R2. Reduce (**high potential**)
R4. Repair (**high potential**)
R5. Refurbish (**high potential**)

5. Digital tech&tools for circular economy in furniture sector

The furniture industry, traditionally reliant on resource-intensive production processes, is undergoing a significant transformation through the adoption of digital software, devices, and platforms. These technological solutions are not only improving efficiency and competitiveness but also supporting the shift towards a circular economy model. Digital design and simulation tools enable companies to optimize material use, reduce waste, and create products designed for durability, repair, and recycling. Advanced manufacturing technologies, such as CNC machining, robotics, and additive manufacturing, facilitate precision production with minimal resource consumption. At the same time, digital platforms for product lifecycle management, material tracking, and reverse logistics strengthen circular practices by extending product life and encouraging reuse. Emerging devices, including sensors and IoT-enabled solutions, provide real-time data on product performance, enabling predictive maintenance and more sustainable consumption patterns. By integrating these digital innovations, the furniture industry can enhance resource efficiency, minimize environmental impact, and align more closely with circular economy principles, paving the way for a more sustainable future of production and consumption.

5.1. Software supporting circularity of furniture sector

The adoption of specialized software is transforming how the furniture industry approaches circularity. From parametric design tools that enable modularity and disassembly, to lifecycle assessment (LCA) software that quantifies environmental impact, these digital solutions empower manufacturers to embed sustainability into every stage of production. Material tracking systems, waste analytics, and repair optimization software further support closed-loop strategies by enhancing resource efficiency and enabling data-driven decision-making. By integrating these tools into design, manufacturing, and post-use phases, companies can accelerate their shift toward regenerative models while meeting evolving regulatory and market demands.

Throughout the mapping process, FULAR partnership has identified and structured following types of software applicable in furniture industry, contributing to the concept of circular economy – Design&Optimization, Lifecycle Transparency Product Traceability; Reuse, Repair & Modular Assembly; and Lifecycle Assessment & Decision Support.

5.1.1. Design and optimization

Software dedicated to design optimization, minimization of waste reduction, supporting modularity and enabling furniture disassembly. These software features directly reduce resource consumption and enable circular-ready furniture through modularity and precision.

Table 9. Design and optimization software

Software	Circular Actions	Key Capabilities	Strategic Impact
IMOS iCAD	Redesign, Optimization	CNC integration, panel utilization planning	Reduces offcuts, improves material yield
Optimik	Reduce	Cutting plan generation for sheet materials	Supports SMEs in reducing chipboard/MDF waste
Deepnest	Redesign, Reduce	Nesting optimization for CNC milling	Maximizes material usage, lowers scrap rates
Maestro Nesting / Cut / CNC / 3D	Redesign, Reduce	SCM Group's suite for CNC programming and cutting optimization	Enables precise, low-waste production workflows
Spazio3D	Redesign, Reduce	Modular CAD/CAM for furniture design and CNC file generation	Supports custom furniture with efficient material use
CAD/CAM + SWOOD	Redesign, Repair	Parametric modelling, BOM generation, nesting	Facilitates modular, repairable furniture design

5.1.2. Lifecycle Transparency Product Traceability

Software features enabling tracking of materials and components across the product lifecycle to support reuse, repair, and recycling. These systems build transparency, support compliance, and enable circular business models through data-driven lifecycle management.

Table 10. Lifecycle Transparency Product Traceability software

Software	Circular Actions	Key Capabilities	Strategic Impact
Empower DPP / DPP ID	Rethink, Reuse, Recycle	QR-linked material passports, blockchain backend	Supports EU Ecodesign, enables take-back and reuse
BIM (Autodesk, Graphisoft, etc.)	Redesign, Reuse	Intelligent 3D models with lifecycle data	Facilitates disassembly, facility management, and circular planning

Digital Twin (DOME)	Redesign, Rethink	Virtual replicas for lifecycle management	Enhances customization, reduces errors, supports reuse
Material Optimization ERP (Monitor G5, SoftOne Series 5)	Reduce, Recycle	Tracks material flow, supplier reliability, remanufacturing logistics	Enables circular supply chain coordination

5.1.3. Reuse, Repair & Modular Assembly

Software that supports tool-less assembly, disassembly, and reuse of furniture components. These software features promote reuse and refurbishment by enabling flexible, modular construction and simplified disassembly.

Table 11. Software for Reuse, Repair & Modular Assembly

Software	Circular Actions	Key Capabilities	Strategic Impact
Lamello Cabineo CNC Library	Rethink, Refurbish	Macro generation for knock-down joints	Enables fast, tool-less furniture assembly and reuse
Palette CAD	Redesign	Integrated design-to-production workflow	Supports modular design and efficient production
SolidWorks + SWOOD	Redesign, Optimization	Modular furniture modelling, connector libraries	Facilitates repairable and upgradeable furniture systems

5.1.4. Lifecycle Assessment & Decision Support

Software that helps quantify environmental impact and guide sustainable material/process choices. These software features guide strategic decisions, helping manufacturers align with climate goals and circular economy metrics.

Table 12. Software for Lifecycle Assessment & Decision Support

Software	Circular Actions	Key Capabilities	Strategic Impact
LCA Tools (SimaPro, GaBi, OpenLCA, One Click LCA)	Optimization	Lifecycle impact analysis, carbon footprint tracking	Supports eco-design and material selection
ERP Systems (SoftOne, Monitor G5)	Optimization	Warehouse and logistics management for remanufacturing	Enables resource-efficient operations and circular logistics

5.2. Digital devices and tools supporting circularity of furniture sector

The transition to a circular economy in the furniture industry is increasingly supported by the integration of specialized devices across production and post-use phases. Technologies such as 3D printers, IoT-enabled smart sensors, wood scanning and sorting systems, and ERP-integrated monitoring tools provide manufacturers with enhanced control over material efficiency, product lifecycle management, and waste reduction. These devices enable precision in design, real-time data collection, and automated decision-making, all of which contribute to more sustainable, traceable, and regenerative production models. By embedding intelligence and adaptability into manufacturing processes, the industry can move beyond linear consumption toward resilient circular systems. Throughout the mapping process performed by FULAR partnership, following digital devices&tools (technologies) have been identified: Additive manufacturing (3D printers), IoT and smart sensors, Wood scanning and sorting systems and ERP-integrated monitoring systems.

5.2.1. Additive manufacturing (3D printers)

Additive manufacturing, particularly through 3D printing, offers transformative potential for circularity in the furniture sector. By enabling precise, low-waste production and the use of recycled or bio-based materials, it supports sustainable design and resource efficiency. Customization, modularity, and repairability become more accessible, extending product lifecycles and reducing environmental impact. On-demand fabrication also minimizes overproduction and logistics-related emissions. As a flexible and scalable technology, 3D printing empowers manufacturers to rethink traditional processes and embrace regenerative, circular models of production. Additive manufacturing enables production of customized furniture parts using recycled materials and thermoplastics.

Table 13. Additive manufacturing devices

Device	Description	Benefits
BigRep Studio G2	Large-format 3D printer using recycled PETG/PLA	Reduces virgin material use, supports prototyping and part replacement
3D Systems Pellet Extrusion	Produces functional furniture from recycled plastics	Enables modular, low-waste production
CEAD + Polymaker	Industrial 3D printing of benches and tables	Combines design freedom with sustainability
RapidTech 3D	Precision printing for complex furniture forms	Minimizes waste, supports on-demand manufacturing

5.2.2. IoT and smart sensors

Smart sensors and Internet of Things (IoT) technologies are key enablers of circularity in the furniture sector. By providing real-time data on material usage, energy consumption, and product performance, these devices support predictive maintenance, lifecycle tracking, and resource optimization. Embedded sensors allow furniture components to communicate wear, usage patterns, and environmental conditions, facilitating repair, reuse, and extended lifespans. IoT connectivity also enhances transparency across supply chains, enabling manufacturers to monitor circular metrics and automate decision-making. Together, these technologies transform static products into dynamic systems, accelerating the shift toward regenerative, data-driven manufacturing models. Their application might enable extension of the product life through predictive maintenance and real-time usage tracking.

Table 14. Smart sensor and IoT devices

Device	Description	Benefits
Arduino Nano, BLE Sensors, RFID Tags	Embedded in furniture to monitor wear and usage	Enables predictive maintenance, reduces premature disposal
Kontakt.io, Libelium	IoT platforms for space optimization and inventory tracking	Supports refurbishment and efficient resource use
Herman Miller Sensor-Equipped Furniture	Commercial application of smart monitoring	Enhances customer experience and lifecycle transparency
Arduino Nano, BLE Sensors, RFID Tags	Embedded in furniture to monitor wear and usage	Enables predictive maintenance, reduces premature disposal

5.2.3. Wood scanning and sorting systems

Wood scanning and sorting systems are vital enablers of circularity in the furniture sector. These technologies use advanced sensors, AI, and machine vision to detect defects, classify wood types, and separate reclaimed materials with high accuracy. By distinguishing between untreated and engineered wood fractions, they ensure quality inputs for reuse, remanufacturing, or cascading applications. Automated grading and impurity removal reduce waste and optimize yield, supporting sustainable resource management. As precision tools, these systems help manufacturers close material loops and elevate the consistency and value of circular outputs. Their application enhance the value of secondary raw materials and supports industrial-scale circular wood processing.

Table 15. Identified wood scanning and sorting systems

Device	Description	Benefits
Smarti Lumber Scanners	AI-powered defect detection in wood	Increases yield, reduces waste, improves sorting accuracy
Fantoni Group's Recy Plant	Cleans and processes recycled wood for MDF production	Enables high-quality recycled panels, diverts wood waste from landfill

5.2.4. ERP-integrated monitoring systems

ERP-integrated monitoring systems are essential for embedding circular principles into the operational framework of the furniture industry. By consolidating data across procurement, production, inventory, and post-use phases, these systems enable manufacturers to track material flows, optimize resource use, and monitor sustainability metrics in real time. When enhanced with circular modules—such as Digital Product Passports and lifecycle analytics—they support traceability, repair documentation, and take-back coordination. This integration empowers companies to align production with circular goals, improve compliance, and transition toward regenerative business models. ERP systems might be the baseline feature for circular operations, ensuring transparency and efficiency across production cycles.

Table 16. Identified ERP monitoring systems

Device	Description	Benefits
SoftOne Series 5 Cloud ERP	Warehouse and logistics management	Supports remanufacturing, reduces inventory waste
Monitor G5 ERP	Tracks supplier reliability and delivery performance	Enables circular supply chain coordination

5.3. Specialized platforms supporting circularity of furniture sector

Specialized digital platforms are central to advancing circularity in the furniture industry. These platforms facilitate data exchange, lifecycle transparency, and stakeholder coordination across design, production, and post-use phases. By hosting tools such as Digital Product Passports, circularity dashboards, and material traceability modules, they enable manufacturers to document sustainability metrics, verify compliance, and support repair, reuse, and recycling strategies. Interoperable and scalable, these platforms foster cross-sector collaboration and help align business models with emerging circular economy standards and legislation. Throughout the mapping process related to digital platforms fostering circularity in furniture sector, following type of platform have been identified: Product Traceability & Lifecycle Transparency; Reuse & Second-Life Channels; and Industrial Symbiosis & Resource Matching.

5.3.1. Product Traceability & Lifecycle Transparency

In the transition toward a circular furniture economy, platforms for product traceability and lifecycle transparency are becoming indispensable. These digital systems—such as Digital Product Passports (DPPs)—enable manufacturers, suppliers, and consumers to track materials, processes, and environmental impacts across the entire lifecycle of furniture products. By capturing data on sourcing, design, usage, and end-of-life pathways, such platforms support ethical sourcing, facilitate reuse and recycling, and ensure compliance with emerging sustainability regulations. As the EU mandates DPPs for furniture by 2030, early adoption offers a strategic edge for organizations aiming to future-proof operations and foster closed-loop value chains. These platforms might play foundational role for circular business models, enabling data-driven decisions, product-as-a-service models, and regulatory alignment.

Table 17. Platforms for Product Traceability & Lifecycle Transparency

Platform	Circular Actions	Key Capabilities	Strategic Impact
Empower Digital Product Passport (DPP)	Rethink, Reuse, Recycle	QR-linked material passports, blockchain backend	Supports EU Ecodesign, enables take-back schemes, boosts consumer trust
DPP ID – Digital Passport	Recycle, Repair, Refurbish, Remanufacture	Lifecycle data, repairability scores, origin verification	Enhances transparency, supports EMFF compliance, enables competitive differentiation
Digital Twin Platform (DOME)	Redesign, Rethink, Repurpose	360° visualization, customization, order tracking	Improves customer engagement, reduces production errors, supports modularity

5.3.2. Reuse & Second-Life Channels

As the furniture industry shifts from linear consumption to circular value creation, reuse and second-life platforms are emerging as vital enablers. These digital and physical channels—ranging from peer-to-peer resale apps to manufacturer-led buy-back schemes—extend product lifespans, reduce waste, and unlock new business models. By facilitating refurbishment, redistribution, and repurposing, they help divert furniture from landfills and support resource-efficient design. Leading examples like IKEA's Buy Back & Resell program demonstrate how second-life strategies can scale circularity while meeting consumer demand for affordable, sustainable options. These platforms activate circular loops at the consumer and community level, making reuse accessible and economically viable.

Table 18. Identified Reuse & Second-Life Channels

Platform	Circular Actions	Key Capabilities	Strategic Impact
Network of Reuse Centres (Slovenia)	Reuse	Drop-off, repair, resale at symbolic prices	Diverts furniture from landfill, supports social inclusion
IKEA Buy-Back Estimator	Reuse	Online valuation, in-store resale via Circular Hub	Engages consumers, extends product life, supports brand circularity
Nonsibuttavianiente (Italy)	Reuse	Sharing and reuse of museum exhibits	Demonstrates cross-sector circularity, adaptable to furniture reuse models
PERMA Platform	Reuse, Recycling	Stakeholder coordination across lifecycle stages	Enables industrial symbiosis, promotes knowledge exchange

5.3.3. Industrial Symbiosis & Resource Matching

Platforms that connect producers, recyclers, and users to optimize resource flows and reduce waste. Industrial symbiosis and resource matching platforms offer transformative potential for circularity in the furniture industry. By connecting manufacturers, recyclers, and material processors across sectors, these platforms enable the exchange of by-products, surplus materials, and underutilized resources—turning waste into value. In furniture production, this means sourcing reclaimed wood, repurposing textile offcuts, and sharing logistics infrastructure to reduce environmental impact and operational costs. Digital matchmaking tools and regional symbiosis networks foster collaboration, transparency, and innovation, aligning with EU circular economy goals and unlocking new pathways for sustainable growth.

Table 19. Identified Industrial Symbiosis & Resource Matching platforms

Platform	Circular Actions	Key Capabilities	Strategic Impact
Digital Platform for Circular Economy (Serbia)	Recycling, Upcycling	Interactive map, by-product listings, email alerts	Diverts waste from landfill, feeds secondary raw materials into new production

Cloudwood	Recycle	Blockchain traceability of timber supply chains	Promotes sustainable sourcing, supports local bioeconomy

6. Advanced concepts fostering circularity of furniture sector

The transition to circular practices in the furniture industry is being accelerated by innovative marketing strategies that emphasize sustainability, transparency, and user engagement. Through the mapping exercise performed by FULAR consortium, range of innovative marketing concepts and approaches has been identified. As expected, actual business models which are based on circular economy marketing concepts are still far from becoming dominant or having significant share in the furniture industry. However, their relevance in global terms increases constantly, as the consumers are becoming more aware of the environmental issues and the need to neutralize negative impact of the society.

Identified key concepts include service-based models like Furniture-as-a-Service, which replace ownership with flexible access, and Design for Disassembly, which enables easy repair and recycling through modular construction.

Refurbishment Networks and Recommerce Platforms foster reuse and local economic development by restoring and reselling furniture through digital and community channels. Digital Lifecycle Tools enhance product transparency and customer loyalty by tracking usage and material origins, while Eco-Materials Promotion highlights sustainable sourcing and certified components to differentiate brands.

Take-Back and Modular Programs extend product life and encourage customer retention through upgrade kits and buy-back schemes. Finally, Local Circular Craftsmanship celebrates regional identity and sustainability by promoting handmade furniture from reclaimed or natural materials, reinforcing cultural and environmental values.

Together, these concepts form a robust framework for circular innovation—blending design, technology, and storytelling to reshape how furniture is produced, marketed, and consumed.

Results of the mapping process are presented below (one table per identified concept).

6.1. Furniture-as-a-Service

Table 20. Description of Furniture-as-a-Service concept

Concept	Circular Actions	Marketing Strategy	Key Enablers	Case Examples
Furniture-as-a-Service	Reuse, Refurbish	Subscription models, ESG branding, flexible ownership	Web platforms, logistics systems	Enky, IKEA Preowned
Furniture-as-a-Service represents a shift from traditional ownership models to service-based access. Instead of purchasing furniture outright, customers subscribe to usage plans that include delivery, maintenance, and eventual replacement or recovery. This approach encourages longer product lifecycles and supports circular principles by keeping materials in circulation and reducing waste. It's particularly effective in dynamic environments like offices, co-working spaces, and hospitality sectors where flexibility and sustainability are increasingly valued.				
Furniture-as-a-Service - **Case study** Enky is a European platform offering flexible furniture solutions for hospitality, living, and workspaces. Through subscription, circular purchase, and leaseback models, Enky enables users to access high-quality, sustainable furniture without the burden of ownership. Its Furniture-as-a-Service approach keeps products in circulation longer, supports reuse and resale, and reduces waste. Customers can subscribe monthly, buy second-hand, or sell back furniture when needs change. Enky also buys existing furniture and leases it back, unlocking capital while maintaining usability. With design-led, eco-conscious collections and digital lifecycle support, Enky exemplifies how circular economy principles can be embedded in everyday furnishing. The model is highly replicable for regional initiatives—especially in co-working hubs, Living Labs, and serviced apartments—where adaptability and sustainability are key. More info available on www.enky.com				

6.2. Design for Disassembly

Table 21. Description of Design for Disassembly concept

Concept	Circular Actions	Marketing Strategy	Key Enablers	Case Examples
Design for Disassembly	Redesign, Remanufacture	Eco-design storytelling, modularity campaigns	CAD tools, modular construction kits	Wehlers, Herman Miller
Design for Disassembly focuses on creating furniture that can be easily taken apart and reassembled. This design philosophy enables straightforward repair, upgrading, and recycling of individual components. By simplifying the disassembly process, manufacturers can reduce the environmental impact of their products and extend their usability. It also opens the door for modular marketing strategies, where adaptability and personalization become key selling points.				
Design for Disassembly - **Case study**				

Herman Miller is a global furniture brand recognized for embedding sustainability into every aspect of its operations. From pioneering **Design for Environment (DfE)** principles to achieving **Cradle to Cradle** certifications, the company has consistently led the way in circular innovation.
Its initiatives include the use of **ocean-bound plastics** in iconic products like the Aeron and Sayl chairs, a **rePurpose program** that diverts up to 98% of used furniture from landfills, and a commitment to **100% renewable electricity** across global facilities. Herman Miller also promotes material transparency through tools like the **European Declare Label**, helping customers understand product origins and end-of-life pathways.
As a founding member of the **US Green Building Council** and **NextWave Plastics**, Herman Miller exemplifies how large-scale operations can drive systemic change. Its model offers replicable strategies for regional ecosystems—combining eco-design, lifecycle engagement, and responsible sourcing to create a better world through better furniture.
More info available on https://www.hermanmiller.com/en_eur/better-world/sustainability/

6.3. Refurbishment Networks

Table 22. Descrition of Refurbishment Networks concept

Concept	Circular Actions	Marketing Strategy	Key Enablers	Case Examples
Refurbishment Networks	Repair, Refurbish	Local craftsmanship promotion, community engagement	Workshops, repair kits, digital guides	Relieve Furniture, Lejlina radionica
Refurbishment Networks involve coordinated efforts among local artisans, workshops, and SMEs to restore used furniture to a functional or aesthetic standard. These networks support circular goals by breathing new life into discarded items, reducing the need for new production, and preserving craftsmanship. They also foster community engagement and can be promoted through storytelling that highlights heritage, skill, and sustainability.				
Refurbishment Networks – Case study Relieve Furniture is a Belgium-based platform transforming office furnishing through circular practices. It offers reused furniture, zero-waste removals, and redistribution programs that extend product lifecycles while supporting social impact. Their model combines space planning, flexible furnishing, and digital catalogues to help businesses transition to sustainable workspaces. With over 145,000 items rehoused, 450+ charities and schools supported, and 1 million tons of CO_2 saved, Relieve demonstrates how circularity can be both environmentally and economically effective. Their Solidarity™ program redistributes furniture to underserved communities, while clients benefit from cost savings, reduced emissions, and enhanced ESG performance.				

Relieve's approach is highly replicable for regional initiatives—especially in public administration, co-working hubs, and educational institutions—where sustainability, affordability, and social value intersect. More info available on: https://www.relievefurniture.com/

6.4. Recommerce Platforms

Table 23. Description of Recommerce Platforms concept

Concept	Circular Actions	Marketing Strategy	Key Enablers	Case Examples
Recommerce Platforms	Reuse, Repair	End-to-end B2B logistics, resale marketing	E-commerce backend, cleaning & repair systems	Mjuk.com, Sajkla
Recommerce Platforms are digital marketplaces that facilitate the buying and selling of second-hand or refurbished furniture. These platforms often integrate logistics, cleaning, and repair services to ensure quality and convenience. By enabling reuse and resale, recommerce reduces landfill contributions and makes sustainable furniture more accessible to a broader audience. It's a scalable model that can serve both individual consumers and businesses.				
Recommerce Platforms – Case study Mjuk is a leading Nordic recommerce platform that simplifies the resale of second-hand furniture for both individuals and businesses. Specializing in overstock, returns, and showroom pieces, Mjuk handles the entire process—from quality control and storage to marketing, delivery, and payment—offering a seamless circular solution. By transforming excess inventory into new revenue streams, Mjuk helps partners reduce waste, cut costs, and meet sustainability goals without major infrastructure investments. Its model supports reuse, redistribution, and lifecycle extension, making it a scalable tool for circular transition in the furniture sector. With success stories from brands like Sofacompany, Layered, and Trademax, Mjuk demonstrates how digital platforms can turn problematic products into profitable, sustainable outcomes. The approach is highly replicable for regional initiatives, especially in public procurement, retail, and co-working environments. More info available on: www.mjuk.com				

6.5. Digital Lifecycle Tools

Table 24. Description of concept based on Digital Lifecycle Tools

Concept	Circular Actions	Marketing Strategy	Key Enablers	Case Examples
Digital Lifecycle Tools	Reuse, Remanufacture	QR/NFC-enabled storytelling, traceability marketing	Digital twins, mobile apps	Steelcase, IKEA Circular Hub

Digital Lifecycle Tools use technologies like QR codes, NFC tags, and digital twins to track the history, usage, and material composition of furniture items. These tools enhance transparency and allow users to engage with products throughout their lifecycle—from purchase to maintenance to end-of-life decisions. They also support predictive maintenance and data-driven circular strategies, strengthening brand trust and customer loyalty.
Digital Lifecycle Tools – Case study IKEA Circular Hub is a global initiative designed to extend the life of furniture through resale, repair, and reuse. Originally launched as "Bargain Corner," the program now offers ex-display items, discontinued products, and gently used furniture a second chance—diverting them from landfill and into new homes. Customers can resell their used IKEA furniture back to the company, contributing to a dynamic inventory of circular goods. IKEA also supports repairs through its spare parts program, enabling owners to maintain and restore items rather than discard them. To ease logistics, IKEA partners with Hertz 24/7, offering hourly van rentals for transporting larger pieces. The Circular Hub exemplifies how large-scale retail can embed circularity into everyday consumer behavior—making sustainability accessible, affordable, and practical. It's a replicable model for regional initiatives, especially in retail, public procurement, and educational outreach. More info available at: https://www.ikea.com/es/en/offers/circular-hub-pub2eab7840/?msockid=3c227aef69dc65b433426bf3684064eb

6.6. Eco-materials promotion

Table 25. Concept based on promotion of Eco-materials

Concept	Circular Actions	Marketing Strategy	Key Enablers	Case Examples
Eco-Materials Promotion	Recycle, Upcycle	Material transparency, certification-based branding	Bio-based adhesives, reclaimed wood, recycled textiles	ECOR, Seaqual, MOGU
Eco-Materials Promotion centres on highlighting the use of sustainable, recycled, or bio-based materials in furniture production. This concept leverages certifications and transparency to differentiate products in the marketplace. By showcasing the environmental benefits of material choices, companies can appeal to conscious consumers and align their branding with broader sustainability goals.				
Eco-Materials Promotion – Case study MOGU is an Italian design and materials company pioneering the use of mycelium—the root structure of fungi—to create fully circular interior products. Their collections include acoustic panels, wall coverings, and resilient flooring, all made from upcycled textile residues and agro-industrial waste. MOGU's acoustic panels are the first commercially available products of their kind, combining high sound absorption with radically sustainable aesthetics. Their flooring solutions replace traditional pigments with bio-based inputs like rice straw, coffee grounds, and seaweed, offering durability with a soft, natural touch.				

Through iterative R&D and cross-industry collaboration, MOGU transforms low-value biomass into high-performance design materials. Their model exemplifies regenerative production and is highly replicable for regional initiatives focused on sustainable architecture, circular design labs, and eco-material innovation. More info available on: https://mogu.bio/

6.7. Take-Back & Modular Programs

Table 26. Concept based on Take-Back & Modular Programs

Concept	Circular Actions	Marketing Strategy	Key Enablers	Case Examples
Take-Back & Modular Programs	Recycle, Refurbish	Buy-back guarantees, modular upgrade kits	CNC machines, pellet presses, disassembly tools	Casala, Vepa–Plastic Whale
Take-Back and Modular Programs offer customers the opportunity to return used furniture or upgrade existing pieces through modular components. These programs encourage recycling and remanufacturing while building long-term relationships with customers. They can be tied to loyalty schemes or ESG reporting, reinforcing a company's commitment to circular practices and customer satisfaction.				
Take-Back and Modular Programs – Case study Casala is a Dutch furniture manufacturer specializing in stylish, functional contract furniture for offices, education, hospitality, and public spaces. With over a century of experience, Casala integrates circularity into its design DNA—combining modularity, recycled materials, and lifecycle responsibility. Their award-winning Omega seating range, for example, features a slim felt shell made from recycled PET and a lightweight steel frame, showcasing how high design can meet low environmental impact. Casala also promotes modular systems like Riva, enabling flexible layouts and easy reconfiguration for dynamic workspaces. Through initiatives like Circular Refurniture, Casala refurbishes and redistributes used furniture, extending product life and reducing waste. Their approach is highly replicable for regional innovation hubs, co-working spaces, and public procurement—where durability, adaptability, and sustainability are key. More information available on: https://www.casala.com/				

6.8. Local Circular Craftsmanship

Table 27. Local Circular Craftsmanship concept

Concept	Circular Actions	Marketing Strategy	Key Enablers	Case Examples
Local Circular Craftsmanship	Reuse, Repurpose	Heritage branding, artisanal storytelling	Manual tools, natural oils, reclaimed materials	Flame Furniture, Hardstuff.eu
Local Circular Craftsmanship celebrates regionally sourced, handcrafted furniture made from reclaimed or natural materials. This concept supports cultural				

preservation, reduces transportation emissions, and strengthens community resilience. It's particularly effective in storytelling campaigns that emphasize authenticity, tradition, and environmental responsibility.
Local Circular Craftsmanship – Case study Hardstuff is a Slovenia–Serbia-based furniture brand that blends industrial aesthetics with handcrafted sustainability. Specializing in dining tables, stools, and coffee tables, Hardstuff uses raw materials like reclaimed wood, steel, glass, and concrete to create durable, timeless pieces. Each item is handcrafted, emphasizing longevity, repairability, and emotional value. With over a decade of experience, Hardstuff promotes local production, minimal waste, and material authenticity. Their approach supports circular principles by prioritizing reuse, artisanal restoration, and modular design. The brand's identity—"Handcrafted with love"—underscores its commitment to quality and sustainability. Hardstuff's model is highly replicable for regional initiatives focused on circular design labs, co-working spaces, and heritage-based innovation. It offers a compelling narrative for promoting local craftsmanship, reducing material throughput, and elevating sustainable aesthetics. More information available on: https://hardstuff.eu/