Institute of Circular Economy (INCIEN)

Closing the loop on wood

Circular Bioeconomy Opportunities in the Value Chain for Forest Products and Wood in Czechia

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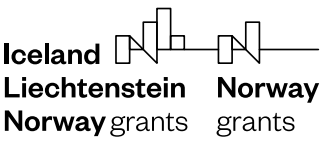
May 2023



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Executive Summary

Political context

The sustainable and strategic use of forest biomass resources has emerged as a major topic of debate in the context of the European Green Deal (EGD) and the transition to a climate neutral economy in the EU by 2050. This reflects the challenge of balancing diverse and sometimes conflicting economic, energy security, climate, biodiversity and other sustainability objectives for forests and forest-based value chains as well as the downstream consumption sectors for wood and wood-based products.

Multiple competing and increasing demands on forest biomass supply from the construction and energy sectors in particular underline the importance of maximising recovery and utilisation of secondary (processing) residues and tertiary (waste) streams through the development of a **circular bioeconomy**, in order to extend total biomass availability within the value chain. This concept comprises all activities that transform biomass (primary, secondary or tertiary) for use in materials, chemicals, energy production, and other product streams based on the principles of sustainable forest management (SFM), optimised cascading use of wood at each processing stage, material efficiency and ecodesign in manufacturing, and reuse, recycling or recovery of post-consumer (waste) wood at the end-of-life stage of products.

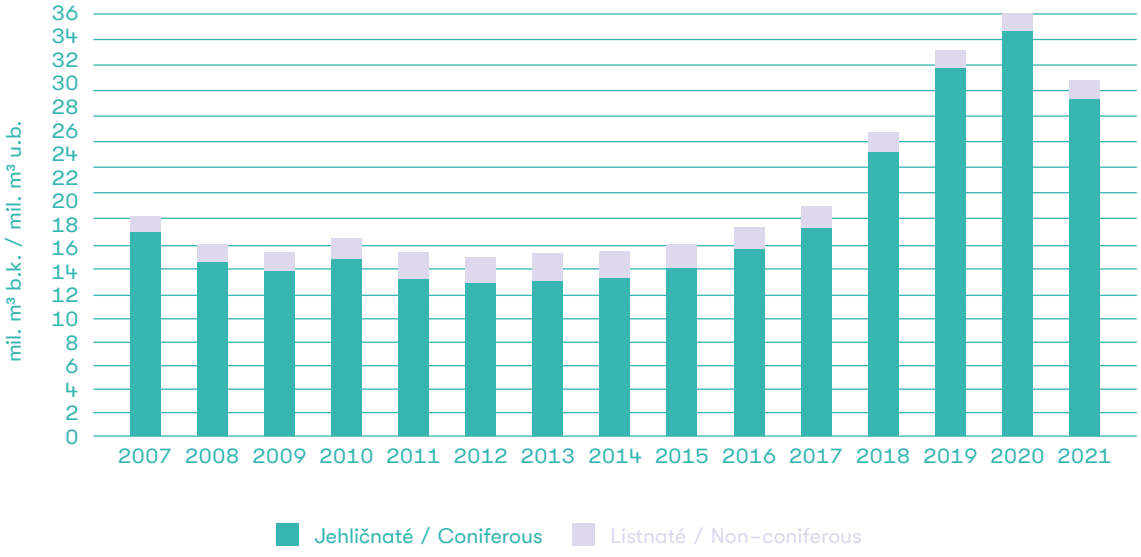
Material use of harvested wood as a renewable raw material is supported across multiple policy areas under the EGD. The EU Forestry Strategy and revised Renewable Energy Directive (RED III) formalise the **biomass cascading principle**, prioritising long-lasting wood products, reuse and recycling over bioenergy or

disposal except in specific cases. Strategies and policies for the buildings and construction sector are starting to address the **whole lifecycle carbon** footprint of buildings, including the embodied carbon in materials, favouring the adoption of timber structures as an alternative to cement and steel that can store carbon in long-lasting structures. In the coming years, EU **ecodesign rules** will also establish mandatory material efficiency and circularity criteria for key wood-based products including wooden furniture and paper and paperboard products. Circular design principles in all of these product areas are already supported through voluntary instruments including **green public procurement (GPP)** and the EU Ecolabel. From 2024, they will also be reflected in technical screening criteria for the Environmental Delegated Act of the EU Taxonomy for **sustainable activities**, as well as **sustainability reporting** requirements under the Corporate Sustainability Reporting Directive (CSRD).

Recent trends in forestry and wood-based industries in Czechia

The forestry and wood processing sectors in Czechia are currently recovering from a period of high instability resulting from climate change and the bark-beetle calamity, which at its peak in 2020 resulted in more than a doubling of the annual timber harvest relative to the preceding decade. As a result, Czech forests moved from being carbon sinks to becoming a significant source of CO_2 emissions. The calamity has led to opening of forest stands and the creation of large clearings that will need to be regenerated over many years, although a positive trend was already evident in 2021, with a strong rate of reafforestation. According to preliminary estimates, roundwood removals declined sharply again in 2022, towards 20 million m^3.

Roundwood removals in Czechia, 2007–2021



Source: Czech Statistical Office

The potential silver lining of the calamity was a large increase in raw timber supply, but the main effect was a corresponding surge in exports of roundwood without added value. The domestic wood processing sector has faced a number of chronic structural challenges including insufficient capacities, low operational efficiency, labour shortages and a lack of vertical integration into higher value-added semi-finished and finished product manufacturing. Despite significant investments in recent years, it remains a fragmented industry, with many micro and small enterprises. Domestic processors also operate within a regional and European supply chain and free market for sawn timber and other wood-based products in which there are long-term cross-border supply relationships with large-scale operators in neighbouring countries.

Limited domestic demand for harvested wood products, in part due to restrictive fire safety standards for timber construction, is another factor holding back development of value-added domestic processing. The calamity period has also seen increased consumption of fuel wood and other wood biomass streams for bioenergy, which will be difficult to sustain if harvesting volumes continue to stabilise, at least not without impacting material use of wood in other sectors.

Industry stakeholders emphasise the importance of a more stable outlook for future harvested timber supply, to support long-term investments in capacity expansion, state-of-the-art technologies and higher value-added production. However, a comprehensive policy framework to tackle the industry's structural weaknesses and support more efficient and value-added use of domestic timber as a strategic raw material has until now been missing. This gap is to be addressed by the end of 2023 with a new national **Raw Material Policy for Wood**, which has been under development since mid-2022.

The case for circularity

This study is intended to support the new policy by exploring how cascading use of wood and circular strategies in downstream sectors can optimise use of wood throughout the value chain, minimise waste, store carbon through material use of wood in long-lasting products and extend their useful life. Although wood is a renewable resource, major uncertainties remain around future supply of harvested timber, including the impacts of climate change and the exact implementation of EU policy and legislation related to biodiversity, deforestation and nature restoration. Circular bioeconomy approaches mitigate these risks by extending total biomass availability throughout the system while reducing CO_2 emissions from premature or avoidable incineration. The study reviews the state of play in the wood value chain in Czechia, identifies current barriers and highlights opportunities for greater circularity, including policy or technical solutions and examples of best practice.

The scope of circular strategies is not limited to domestic timber resources and wood processing industries. In most demand sectors for wood-based products, a significant or even dominant share of domestic consumption in Czechia is satisfied by imported products, whether it be structural building components, furniture, pallets or packaging paper and board. These products can be kept in use through reuse, repair and refurbishment and their waste streams collected for recycling by domestic processors. Conversely, many larger Czech wood processing facilities are export-oriented. By adopting circular

design principles and business models they can in the same way enable longer product life and higher material recovery from their products for reuse or recycling in international markets. Climate change mitigation, biodiversity protection and resource efficiency are not aims defined by national borders.

The case of Norway

Although not an EU Member State, Norway is an important actor in the European forest products economy, as highlighted by the pioneering research currently being undertaken on digital and circular wood value chains by NIBIO, the country's leading bioeconomy research institute. This bilateral cooperation project was supported by the EEA and Norway Grants and has provided an opportunity to draw inspiration from the latest Norwegian research and innovations focusing on high-value cascading of wood and greater circularity through the forest products sector.

Chapter 3 of the study describes three current research programmes that are of particular interest for the topic of the study:

- **SFI Smart Forest**, exploring the use of advanced digital technologies to transform forest data and information, and improve operational efficiency and transparency between forest operations and downstream processing.
- **SirkTRE**, a strategic national research programme aimed at establishing a holistic circular value chain for wood.
- **CircWood**, a sub-initiative of SirkTRE, focused on addressing knowledge gaps on availability and quality of recycled wood and investigating aspects of wood use in the Norwegian economy, including reuse of wood in construction, recycling of waste wood as a raw material in the wood processing industry and streamlining of processes through the use of digital tools and platforms.

Brief snapshots of specific projects being undertaken within these programmes are included throughout the study as inspiration for further research and potential cooperation. All of these projects are multi-year programmes in progress. At this stage, the aim in featuring them in the study is not, therefore, to apply their final results, but to highlight the strategic approach adopted by the Norwegian research and innovation community to increasing efficiency of forest operations and circularity of wood value chains in a holistic way. It is also an outstanding example of collaboration between all key stakeholder groups in the forestry and wood sectors in Norway to develop systemic solutions to boost the long-term sustainability, resilience and competitiveness of the sector.

Closing the loop on wood in Czechia – current state of play and opportunities for greater circularity

The main chapters of the study provide a comprehensive overview of the value chain in Czechia, from forestry and processing to finished products manufacturing, waste wood and end-of-life products, including available data from public sources. Nevertheless, the main focus of the research is the demand side – wood processing industries and wood-based products – rather than supply-side dynamics in forestry operations. Key findings and

conclusions at each level of the value chain are highlighted below.

The forestry sector

- As forestry is the primary production sector for wood, cascading use and circularity at this level is not addressed in detail in the current study. Circular strategies in all downstream sectors serve to optimise demand for harvested wood products, by applying **ecodesign principles** in wood products manufacturing (material efficiency and use of by-products and waste streams in processing industries to the maximum extent), adopting **circular business models** for increased use and longer lifespans of wood based-products, and **reusing or recycling** wood waste streams in the end-of-life phase.
- A strategic economic objective for the forestry sector is to maximise efficient and value added use and processing of local harvested timber within domestic processing industries, by supporting sector employment, training and skills, boosting investment and innovation and minimising transport distances between forestry operations, processing facilities and final end use.
- Key challenges in Czechia continue to be low integration between forestry and downstream processing industries, weak marketing of wood products to boost domestic demand in end-use markets, regulatory restrictions on timber construction and a consequent lack of market incentives to maximise domestic processing of harvested timber from Czech forests.
- Also lacking in current EU and national policy frameworks is stronger support for the net expansion of forested areas to meet a range of ecosystem service needs, including an increased growing stock for industrial use. Emphasis remains on regulating market competition for a limited wood supply. A more **proactive reforestation policy** could relieve the intense competition for forest biomass resources that currently inhibits greater collaboration and integration in the sector.
- **Smart forestry** concepts to optimise the forest-wood-product value chain remain at a nascent stage in Czechia. There is a large opportunity for **technology transfer and adoption of best practice** from countries that have systematically explored and implemented smart forestry technologies and business models, especially in Scandinavia. NIBIO's **Smart Forest** project offers a state-of-the-art example of the benefits of collaboration across diverse industry stakeholders to boost **digitalisation**, operational efficiency, align timber supply with sawmill demand and deploy infrastructure to automate forthcoming requirements for traceability of forest biomass resources.

Sawmill production

- Sawmill capacities have increased in recent years, in response to a surge in harvested timber supply as well as government support. The 12 largest sawmills now account for close to 60% of production, but the industry remains highly fragmented, with at least another 600 operators comprising the balance.
- Development of the overall wood processing value chain has been hindered by a high share of exports during the calamity period for both roundwood

inputs and sawn timber outputs, although this share appears to have fallen in 2022.

- Cascading use of by-products and waste, whether for material use or energy recovery, is a well established practice in sawmill operations, with facilities aiming wherever possible for a "zero-waste" model. However, there continues to be limited vertical integration within facilities or companies from sawn timber to processed wood components and finished products. This results in lower value added and revenues for the domestic industry and a high level of export of sawn timber for processing outside Czechia.
- A more **stable outlook for harvested timber supply** as well as **stronger demand pull** from domestic end-use markets, especially for timber construction, are key prerequisites for sustained growth and investment in this segment. This will include adapting production technologies and equipment to a declining share of spruce in the harvested timber mix and to increased processing of other types of wood, such as pine, oak, beech, birch and Douglas tree.

Boards material production

- Czechia has significant production of OSB (11% share of European production), plywood (5%) and particleboard (3%). Notably, Czechia is the **4th largest producer of OSB in Europe**, after Romania, Germany and Poland.
- Particleboard and (since 2022) OSB production are the principal consumers of recycled waste wood in Czechia. Earlier research by the Czech University of Life Sciences Prague (ČZU LDF) has demonstrated a **wide range of benefits from using recycled wood**, including energy and operational efficiency, lower cost and carbon footprint and resource efficiency.
- Kronospan in Jihlava (and at one other European facility) is the only producer to date internationally with this patented technology. Its current ratio of recycled wood inputs to particleboard and OSB production is around 50% (totalling 600,000 tonnes of waste wood annually), but this can be increased to 80% or higher in future. More recent research by ČZU LDF has even developed products based on 100% recyclate.
- Due to lack of consistent waste wood collection in Czechia and specific targets or policy support for material recovery of this waste stream (instead of energy use), up to 50% of waste wood for domestic board production is still imported. Without additional measures, this level of import is likely to remain or increase in the coming years as a result of growth in demand for (and production of) these products and a progressive increase in recyclate content.

Pulp production and biorefinery products

- There are two main pulp mills in Czechia, for paper pulp (Mondi Štětí) and dissolving pulp (Lenzing Biocel Paskov). Both mills generate process by-products based on their respective pulping processes. For Mondi, this includes crude sulphate turpentine, crude tall oil and derivatives, and lignin. Lenzing utilises 7.5% of pulp inputs for production of biorefinery products including soda ash and Magnesium-Lignosulfonate Biobased.
- **Lignin** in particular is typically used for heat recovery and regeneration of pulping chemicals but has a wide variety of potential **alternative uses**

in high-value biochemicals and biomaterials, as illustrated in the product portfolio of the Norwegian biorefinery Borregaard. This has also been a focus of recent research by ČZU LDF, including the development of a pelletisation method for powdered lignin for use in production of resins, adhesives and other materials.

Biomass energy production

- Growing demand from industry for bioenergy in order to meet renewable energy targets at an EU and national level (in energy sector policy) as well as at a company level (in ESG strategies and corporate sustainability reporting) has resulted in a high current share of bioenergy (80–85%) in total renewable energy production in Czechia.
- Based on the biomass cascading principle, harvested wood biomass and residues should be used for bioenergy only in specific cases where viable options for its material use in products, reuse or recycling are not available.
- Research by Mendel University in Brno has concluded that use of wood biomass for energy production in Czechia based on reported figures (2020 basis) has already reached its maximum available limit in line with sustainable forestry principles and will be insufficient to meet even current 2030 targets for renewable energy in the energy mix, not to mention the increased ambition proposed in the update of the EU Renewable Energy Directive (RED III). Higher bioenergy use will also negatively impact material use of wood in sawmill, pulp and paper and board production and downstream manufacturing sectors.
- Analysts also point to a significant gap in national statistics between the reported supply of wood biomass for energy production and higher actual consumption based on energy production figures, suggesting that supply of wood into the energy sector is significantly underreported.
- Kronospan CR, the leading processor of waste wood in Czechia (for board production), has found it increasingly difficult to compete with the energy sector in securing supplies of waste wood in the domestic market. In an environment of growing demand (as well as rising prices and subsidies) for biomass for energy, even waste streams that are suitable for recycling in board production, and should therefore be recycled in accordance with the waste hierarchy, are increasingly diverted for energy use.
- The role of bioenergy needs to be carefully formulated in forthcoming updates to energy policy, including the National Energy and Climate Plan (NECP) and the State Energy Concept, to ensure **sustainable and high value use of forest biomass in line with the biomass cascading principle**.
- Sector experts point to Finland and Austria as examples of countries with policy environments where material flows and pricing mechanisms for forest biomass are clearly defined and separated for energy production versus material use, to avoid market competition for wood supply that subverts the biomass cascading principle and waste hierarchy.

Wood construction

- Wood is a renewable material that can store carbon in long-lasting products and structures, and construction

represents by far the leading opportunity and source of demand growth for wood products in the coming years. Aside from its function as a carbon sink, wood has many benefits in construction in terms of technical properties, flexibility and recyclability, speed, precision and efficiency in manufacturing and assembly as well as positive impacts on buildings' interior environment quality and energy efficiency. Increased use of wood in construction is currently supported through multiple EU policy and legislative initiatives, as outlined in Chapter 2 of the study.

- According to national building fire safety standards, the height of timber structure buildings that fall within standard permitting procedures is currently capped at 12 metres above ground, imposing an effective limit of four to five storeys, putting Czechia far behind international practice in large-scale mass timber construction (MTC). As a result, wood construction in Czechia is found primarily in family houses, where it has grown to around 15% share of the market since 2015. Long-called-for changes to fire safety standards to facilitate construction of taller MTC buildings are now finally in prospect as the Czech Standardisation Agency has commissioned a review to update current norms to this end. However, it is likely to be at least five years until revisions from this review come into effect.
- Developers such as Skanska and UBM are already planning larger MTC residential development projects within existing fire safety standards. Regional production of cross-laminated timber (CLT), the key technology used in MTC, has also been growing rapidly over the last several years, including the launch of Stora Enso's new CLT production line in Ždírec nad Doubravou in Q3 2023. As such, the commercial and technical preconditions for an expansion in timber construction are already in place, pending regulatory changes.
- Expansion of timber construction will ultimately be driven by increased demand from property developers and end-users. Key mechanisms to support demand include **timely implementation of the Environmental Delegated Act of the EU Taxonomy**; promotion of good practice for timber construction in **public procurement** guidelines; and accelerated development and adoption of national methodologies and policies to **measure and set targets for reduction of Whole Life Carbon** (or Global Warming Potential) of buildings ahead of EU mandatory requirements under the recast of the Energy Performance of Buildings Directive (EPBD). This will allow timber construction to benefit from its advantages as a carbon sink in competition with other materials as developers and investors pursue strategies to decarbonise building portfolios and reduce Scope 3 GHG emissions.
- Industry stakeholders also emphasise a continuing need to **raise public awareness** and expand **professional education and qualifications** in timber construction, which still suffers from misconceptions regarding fire safety and other functional properties.
- With strong growth potential for timber construction in Czechia, **circularity principles** should be evaluated and embedded in sectoral policy, decarbonisation roadmaps and industry practice at all levels of the value

chain, from **design for adaptability, renovation, deconstruction, reuse and recycling** of timber structures to requirements for **pre-demolition audits** of end-of-life buildings, followed by **selective demolition and disassembly**, in order to support repurposing of buildings and structures for longer life spans and maximum recovery of wood components for reuse or recycling.

- Norway's current **SirkTRE** and **CircWood** programmes represent a strategic and holistic national initiative to map, develop and implement a wide range of circular wood technologies, processes, business models and policies across the wood value chain and industry stakeholders. These projects are still in progress, but offer inspiration and sources of **best practice and knowledge transfer**, including through potential bilateral cooperation in circular strategies for timber construction.

Wooden furniture

- The furniture industry has been a focus for development of circular business models and procurement practices for many years, from circular design for modularity, reuse, repair and recycling to rental and sharing business models and extended producer responsibility for collection and recycling or repair of waste furniture. Despite this, furniture still comprises a major wood waste stream that is not separately tracked in the waste management system of most EU countries.
- Czech furniture production is export-oriented and comprises only a minor share of domestic furniture sales in volume terms. Apart from intense price competition from imported furniture, the very low share of Czech forests with **FSC certification** is a barrier to greater local procurement by leading furniture retailers, such as IKEA and XXX Lutz, that require this certification. The Czech market is dominated by low-cost imported furniture, most of which is not currently designed for dismantling or recycling.
- Circular strategies for wooden furniture should focus on supporting **demand for furniture made according to ecodesign and circular design criteria** (whether Czech-made or imported), **resale of used furniture** and **sharing and rental services** for temporary furniture needs. These practices will be addressed in both the EU Taxonomy Environmental Delegated Act from 2024 and the Ecodesign for Sustainable Products Regulation (ESPR). At a national level, existing **public procurement** guidelines for furniture should be promoted and widely adopted in practice. IKEA is a leading example of good practice in sustainable furniture design, procurement and retail, with initiatives to collect and repair used furniture, supply spare parts and trial furniture rental services.

Wooden pallets

- The wooden pallet market consists of both returnable/reusable pallets (especially Euro pallets, a classic example of a circular business model) and non-standard one-way pallets for more complex supply chains such as automotive components. It has experienced high volatility in the last three years, including from supply chain disruptions related to the war in Ukraine, underlining the need to make efficient use of the existing pallet

pool, pallet components and waste streams for material recovery.

- One-way pallets are a particular focus for additional recovery of waste wood for material use. This is not currently a transparent market in terms of material flows and waste management. In addition, there has been a growing practice of companies selling off used pallets to their employees, which likely burn the pallets for heating purposes.
- Circular solutions for non-contaminated one-way pallets include applying to regional authorities for exemption from the waste regime to allow **further operational use or refurbishment for reuse**, separate collection in the waste treatment system for processing and **recycling in particleboard and OSB production**, or even **upcycling** of pallet components for furniture and interior design. There are also local projects to produce technically certified pallets from sawmill residues and waste streams.

Paper and paperboard products

- Circularity initiatives in the paper industry focus on packaging paper and board, which account for 60% of European paper and board consumption and 65% in Czechia. Through the 4evergreen alliance, the European fibre-based packaging industry has committed itself to a 90% recycling rate by 2030, exceeding the 85% target in the European Commission's proposed Packaging and Packaging Waste Regulation (PPWR).
- Czechia has a relatively small paper industry in the European context, with an above-average (80%+) focus on packaging paper and board, most of which is exported across the EU. Domestic collection of waste paper (1 million tonnes per annum) currently exceeds domestic paper production. Due to the focus of operating paper machines in Czechia on processing of primary softwood pulp, "paper for recycling" (collected waste paper) accounts for less than a quarter of paper mill raw material inputs, and 80% is exported.
- Although use of paper for recycling is a function of each mill's production capabilities and product mix, such a high rate of export is a clear opportunity to better utilise **abundant local waste paper** volumes and reduce relative consumption of harvested pulpwood. Significant **(re)investment in new recycling capacities** to process this raw material will be needed in the next five years to support the European fibre-based packaging industry's ambitious recycling targets.

Waste wood and end-of-life products

- Main sources of waste wood streams are wood processing industries (including production of boards and furniture), pulp and paperboard production, construction and demolition activities, one-way wood packaging, waste treatment facilities and municipal waste collection. Total separately recorded wood waste from all these sources in official statistics was approximately 430,000 tonnes in 2021, excluding hazardous waste.
- Most **industrial process waste** generated in mills and manufacturing facilities is either reprocessed in production, used or sold into other processes or burned for energy. Primary sources of waste wood for potential recycling (mainly in particleboard and OSB production) are one-way packaging (including crates and pallets), used furniture and boards, and

non-contaminated timber components and flooring from construction and demolition sites.

- According to MoE statistics for **wood packaging waste** (over 220,000 tonnes in 2021), 39% was recycled and 4% used for energy. This already exceeds 2030 EU and national targets for wood packaging recycling (30%), which is the lowest target among all packaging materials. The majority of wooden packaging waste that is not recovered is either burned, reused or repurposed by households and businesses (including reusable pallets) or disposed of in mixed municipal waste and landfilled.
- **Wooden furniture waste** is currently a major gap in waste wood statistics. Most of this waste, estimated at up to 300,000 tonnes, is "hidden" in the category of municipal "bulky waste". Additional waste furniture may be disposed of in illegal or unmanaged landfills or burnt by households for heating. This reflects inadequate furniture design for disassembly and recycling, the absence of an **Extended Producer Responsibility (EPR) system** for furniture, such as that operating in France since 2013, and lack of separate **reporting, collection and sorting infrastructure** for this substantial municipal waste stream. This could be enabled, for example, by the addition of a subcode of bulky waste in the waste catalogue, to motivate separate collection.
- Other blind spots in waste statistics include sell-off of unused wooden pallets and crates by companies to employees (as mentioned above), lack of **selective demolition practices in construction** to properly separate waste streams on site and limit contamination, and informal flows of recovered waste construction timber that are not reported in the system.
- Due to current data limitations, the total potential volume of waste wood for material recovery is not known, nor how much is too contaminated to be suitable for recycling. However, based on the above considerations it could be in the order of 1 million tonnes per annum. This would be in line with the potential total volume of wood waste required for domestic particleboard and OSB production within the next several years based on current production trends and technologies to increase the rate of recyclate use in these products.
- Given its status both as a biodegradable material and fuel source for energy production, wood waste has received limited attention in EU and national waste management policy to date. Rising landfill fees under Czechia's Waste Act towards the 2030 landfill phaseout provide some motivation to increase recovery of recyclable waste, but **more proactive policy measures** should be evaluated to achieve transparent, separate and effective collection and reporting of waste wood flows for material use. This could include setting **specific targets for wood collection and recycling** in the national and regional Waste Management Plans and supporting associated investments to improve collection infrastructure. Germany and Belgium are examples of countries that have already achieved high levels of waste wood recovery, and equivalent reductions in harvested timber consumption, through special regulations, including early landfill bans for wood waste.

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Introduction

Background

The sustainable use of forest biomass resources has emerged as a major topic of debate in the context of the European Green Deal. This has been driven by the challenge of reconciling different economic and climate objectives across the EU Taxonomy, the proposed revision of the Renewable Energy Directive, the New Circular Economy Action Plan and the New EU Biodiversity and Forestry Strategies for 2030, amongst others. Multiple competing and increasing demands on primary forest biomass supply from the construction and energy sectors in particular underline the importance of maximising recovery and utilisation of secondary (processing) residues and tertiary (waste) streams through the development of a circular bioeconomy, specifically the cascading and circular use of wood biomass focusing on material efficiency, reuse, recycling and recovery for material or, in specific circumstances, energy use.

Within the forestry products value chain, a key focus area is the use of wood-based construction products, such as timber components, glulam and cross-laminated timber (CLT), as low-carbon alternatives to traditional building materials including steel and cement. This reflects the increasing focus on the Whole Life Carbon (WLC) of buildings in the construction sector, and the prospect of incorporation of embodied carbon emissions in building materials into future climate legislation and carbon accounting mechanisms in the coming years. An increased uptake of wood-based construction also represents a key opportunity to stimulate development of wood processing industries. Other important product value chains include furniture, logistics and

transport packaging, paper and paperboard, fibres and biorefinery products.

The aforementioned sustainability challenges are fully reflected in the forestry and wood processing sectors in Czechia. In addition, these sectors have been heavily impacted by a sharp increase in logging rates between 2018 and 2021 relative to the preceding period due to the bark-beetle calamity. Despite this massive (temporary) increase in wood supply, approximately half was exported as roundwood in recent years, resulting in a domestic shortage of timber products and high prices of timber for domestic processing industries. Contributing factors to this were low operating rates of domestic sawmills driven by labour shortages, a lack of sawmill and value-added processing capacity per se, and continuing cross-border supply arrangements with buyers in neighbouring countries. As a result of these trends, the Czech forestry sector shifted from being a long-term carbon sink to becoming a net carbon emitter from 2019 onwards.

A much needed national policy to set a sustainable long-term direction for the forestry sector and wood-processing industries and provide a strategic framework for necessary investments in these sectors has been missing until now. This situation is expected to change in the near future with the development of a national raw material policy for wood, due to be adopted by the end of 2023. The authors hope that this study provides a valuable input for the finalisation of a national policy framework based on the biomass cascading principle, focusing on pathways to maximise value added in wood processing industries and pursue opportunities for greater circularity in the use of wood at each step in the value chain.

In addition, almost all organisations and companies contacted in connection with this study in multiple sectors have highlighted the importance of greater education at all levels (among experts, professionals, students and the general public) on the suitability of, and applications for, wood and wood-based products.

Research objectives

The primary objective of this study is to identify and characterise key opportunities for the development of a circular bioeconomy in the value chain for forest products and wood in Czechia, while drawing inspiration from relevant knowledge, expertise and best practice of the Norwegian forest products industry and its ongoing research programmes.

Forestry and forest products are among the most traditional sectors of the Czech economy, with a long history both in forest management and wood processing industries, as well as in academic research and development. In the last several years, following international trends, the sector has received increasing attention in the national media and in policy-making discussions in connection with both decarbonisation of industry and construction, as well as the broader sustainability, climate change and biodiversity agenda. While there are many past and present projects and initiatives in Czechia related to specific aspects of the wood industry, no comprehensive overview has thus far been developed on the application of circular economy principles to this value chain across major product types and end-use markets. Both harvested wood products, wood by-products and waste streams have a critical role to play in reconciling the strategic environmental (biodiversity protection, decarbonisation), economic

(capital investment, growth in value added, job creation, energy and material efficiency and security) and social (rural employment, training and skills) challenges of Czechia's transition to a climate neutral economy.

This study summarises the current state of play in Czechia, provides an overview of key domestic actors, projects and initiatives related to cascading use of wood, and highlights the opportunities and benefits of applying circular economy principles throughout this value chain as a strategic raw material base for a low-carbon future.

Partnership with Norway

As an initiative of the Fund for Bilateral Relations under the EEA and Norway Grants, the research has been undertaken in cooperation with the **Norwegian Institute of Bioeconomy Research (NIBIO)**. The ambition is to identify specific follow-up activities between Norway and Czechia that could strengthen this collaboration and create opportunities for future research as well as for capacity building activities. INCIEN intends that this initial study be the starting point for long-term cooperation between NIBIO and INCIEN and, by extension, the wider community for sustainability and innovation in the forest products and wood value chain in Norway and Czechia on the development of circular strategies and initiatives for the sector.

The mission of NIBIO is to contribute to food security and safety, sustainable resource management, innovation and value creation through research and knowledge production within food, forestry and other biobased industries. In cooperation with Innovation Norway and the National Research Council, NIBIO has undertaken or is currently undertaking various pioneering research activities and development programmes for the forest products and wood processing industries. These projects are described in further detail in Chapter 3.

Through the partnership developed in this initiative, the Czech forestry and bioeconomy sectors can also benefit from Norway's experience and technical expertise in forestry and wood processing in addressing sustainability challenges and unlocking opportunities for greater circularity. In turn, NIBIO will expand its active knowledge network in Czechia and Central Europe to increase the international impact of its research and innovation activities in forestry and forest products.

Research approach

This study has been developed through a combination of secondary research, an online survey among relevant sector organisations and interviews with selected key stakeholders from academia, government and the private sector.

First, comprehensive **desk research** was conducted to review past research and analysis, industry data as well as recent media coverage to map the current situation in the forest products and wood processing sector both in an EU and Czechia context. This included review and analysis of relevant EU and Czech national policies, regulations, strategies and action plans, research papers, articles in professional journals, presentations from industry workshops, press releases of sector institutions and organisations and other public information from key value chain participants.

A **working group** of member organisations related to the use of wood was set up within the **Czech Circular Hotspot**, a circular economy acceleration platform of approximately 60 members coordinated by INCIEN. Working group members included Atelier Paletky, Balance is Motion, Nema, Progresus, Škoda Auto, the Timber Institute and ZERO Architecture. These organisations responded to an online survey and/or participated in two online discussions. An additional online survey was conducted among sector organisations, research institutes, associations and societies relevant to the sector.

Furthermore, INCIEN conducted **project reviews** with project partner NIBIO and consultations with selected stakeholders in the forest products, wood processing and related end-use markets in Czechia. Two consultations were conducted with NIBIO in the course of the project. A first in-person meeting (October 2022) provided an overview of current trends in the Norwegian forestry sector and the wood processing industry, with a focus on the projects described in Chapter 3, introduction of NIBIO's ongoing research activities related to these sectors and potential focus areas for this project. A second online consultation addressed important trends in circular and cascading use of wood and examples of good practice from Norway. A NIBIO representative also attended the project's final presentation event in Prague in May 2023, including a presentation on relevant NIBIO projects and participation in a discussion panel. Other stakeholder interviews focused on important trends at different levels of the wood value chain, current barriers, challenges and opportunities to cascading and circular use of wood, relevant research projects, product innovations and business models.

Finally, the Hotspot working group and selected organisations had the opportunity to **review the draft** of the study prior to its publication. Their feedback was incorporated to the extent possible wherever relevant to the study's scope and objectives. However, INCIEN is solely responsible for the content of the report, the interpretation of data and sources used and the conclusions and recommendations contained herein.

Scope and definitions

Forestry and wood products

The forest products sector represents a highly complex value chain that produces a wide range of both conventional and emerging (innovative) products for use in a diverse range of end-use markets. To illustrate this complexity, the most recent Classification of Forest Products 2022 from the Food and Agriculture Organisation of the United Nations (FAO) runs to 178 pages. It has been updated to include many new products, including high-value engineered wood products and increasingly diverse end-uses resulting from ongoing technological improvements and innovation.[1]

1 FAO, 2022. Classification of forest products 2022. Rome.

The classification includes the following wood and wood-based product forms across 14 main sections:

01. Wood in the rough (roundwood)[2]
02. Wood simply worked or processed
03. Wood chips and particles, residues and recoverable wood products
04. Wood pellets and other agglomerates
05. Sawnwood
06. Veneer sheets
07. Wood-based panels (including panels from other ligno-cellulosic materials)
08. Wood pulp
09. Other pulp
10. Recovered paper
11. Paper and paperboard
12. Cork
13. Secondary wood products
14. Secondary paper products

These product forms are in turn consumed in a wide range of end-use applications. The FAO's 2022 analysis of substitution opportunities for forest products in the global bioeconomy focuses on the following major product categories:

- Conventional products: graphic paper, traditional wrapping and packaging, wood products for construction, cellulosic fibres for textiles, resin and its chemical derivatives.
- Emerging products with innovation potential: engineered wood products, wood foam, bioplastics, wood-based composites and wood-based fibres for textiles.[3]

It is beyond the scope of this overview study to address the full range of wood and wood-based products. The study scope is therefore limited to selected major applications for harvested and secondary wood products in the context of Czechia, with a focus on ecodesign of manufactured articles, cascaded use and waste management of wood based on the principles of a circular wood-based bioeconomy.

What is a circular bioeconomy for wood?

As described in a joint 2021 study by the FAO and the UN Economic Commission for Europe (UNECE), the forest products value chain operates within both biological and technical material cycles, at the intersection of the circular economy and the bioeconomy. While the circular economy focuses on sustainable and resource-efficient processes and business models, renewable and biodegradable materials can be used in the bioeconomy to substitute fossil-based non-renewable and non-biodegradable materials. A "**circular bioeconomy**" comprises all activities that transform biomass (primary, secondary or tertiary) for use in materials, chemicals, biofuels, food and other product streams. It is a central concept for the long-term sustainability of forest-based industries and includes sustainable forest management (SFM) in the forestry sector, optimised cascading use of wood at each

2 "Wood in its natural state as felled, with or without bark. It may be round, split, roughly squared or in other forms. Roundwood can be used for industrial purposes, either in its round form (e.g. as transmission poles or piling) or as raw material to be processed into industrial products such as sawn wood, panel products or pulp." – FAO, Forest harvesting glossary

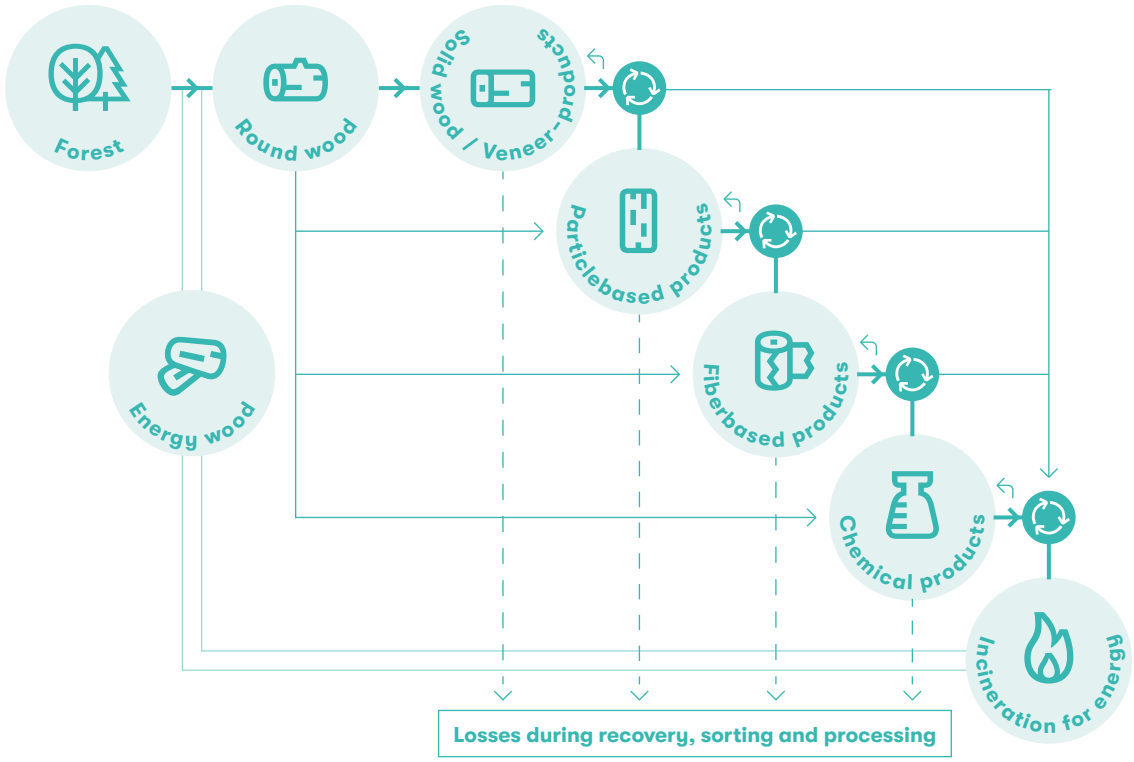
3 Verkerk, P.J., Hassegawa, M., Van Brusselen, J., Cramm, M., Chen, X., Maximo, Y. I., Koç, M., Lovrić, M. and Tegegne, Y. T. 2022. The role of forest products in the global bioeconomy – Enabling substitution by wood-based products and contributing to the Sustainable Development Goals. Rome, FAO.

production stage, and reuse, recycling or recovery of post-consumer (waste) wood at the end of product lifecycles.[4]

In contrast to technical materials (such as metals, glass or plastics), there are inherent limits to the recyclability of wood due to its natural tendency to degrade over time. Consequently, circularity for wood and wood-based products reflects the principle of **cascading use**, according to which products manufactured from wood are designed to maintain their functional performance for as long as possible while residues and by-products may undergo several additional cycles of reuse, recycling or recovery before being shredded or incinerated for bioenergy at the end of their lifecycle. High-quality material streams are used to produce high value-added products, with material use cascading down to lower-value products as the material degrades in successive processing cycles.

Cascading use has also been described as the "efficient utilisation of resources by using residues and recycled materials for material use to extend total biomass availability within a given system".[5] This underlines its value as a material efficiency strategy that can strengthen the sustainability and resilience of forest products value chains, particularly as competing demands increase for wood as a renewable material for construction, biomaterials, bioenergy and other uses over the coming decades.

The cascading use of wood



Source: UNECE/FAO, adapted from Höglmeier et al., 2015.

4 United Nations Publications, 2022. Circularity Concepts in Forest-Based Industries (UNECE and FAO).

5 CASCADES: Study on the optimised cascading use of wood: Vis, M., Mantau, U., Allen, B. (Eds.), 2016, N° 394/PP/ENT/RCH/14/7689 (European Commission).

Cascading of wood use has also been a significant focus of academic research by forestry and wood products faculties of Czech universities. As described by Hýsek Š. et al. (2021),[6] the basic processing sequence in an optimal cascading use scenario for wood is as follows:

01. Harvested round wood is used for production of timber structures and products (e.g. roof trusses, furniture, pallets).
02. End-of-life products from step 1 are shredded and used for production of particlebased products (pressed wood, OSB boards, fiberboards etc.)
03. Fibre waste or residues from particlebased products are used for production of fibrebased products (pulp and paper), chemicals or biorefinery products.
04. End-of-life products without further economically viable material use are incinerated for energy recovery. Ash from incinerated products may potentially be used as an additive for building materials.

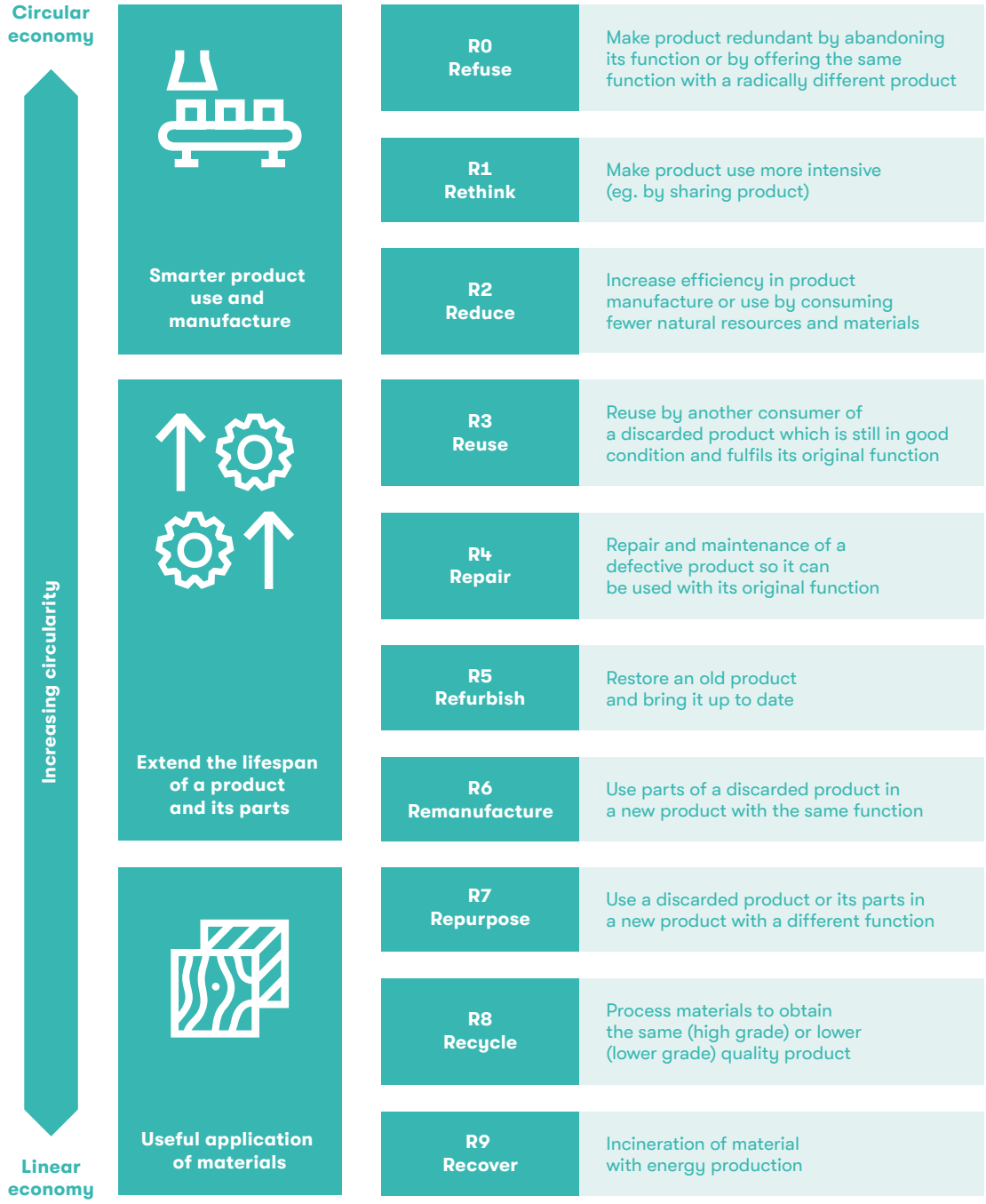
Several types of "bridges" also operate within the cascade:

- Harvested round wood flows directly to steps 2. and 3. of the cascade due to insufficient volume and/or quality of recycled wood.
- Byproducts from sawmills (e.g., wood chips and sawdust) are used in production of particlebased, fibrebased or chemical products.
- Material recovery loops enable recycling of materials at the same level of the cascade (e.g. "new paper from waste paper").

Although cascading use is a core "circularity" principle for wood processing industries, it focuses on the most efficient use of material flows at different stages of wood processing. To provide a comprehensive circularity framework for wood that also addresses product ecodesign, material efficiency and demand optimisation throughout the lifecycle of products, the UNECE/FAO framework uses the **9R model** to map opportunities across a range of forest product value chains.

6 Materiálové využití recyklovaného dřeva v České republice: Hýsek, Š., Hýsková, P., Fakulta lesnická a dřevařská, ČZU v Praze, Odpadové forum, Ročník 21, Číslo 1.

Circularity and the 9Rs



Source: UNECE/FAO, adapted from Ellen MacArthur Foundation (https://ellenmacarthurfoundation.org)

Prior to the efficient processing of materials and manufacture of products, there is a need to optimise material demand in the economy by adopting strategies to reduce the volume of primary wood biomass unnecessarily consumed, including through dematerialisation (**refuse**, e.g. digitisation to reduce paper use) or sharing of products (**rethink**, e.g. furniture rental) to increase their utilisation rate.

At the remaining levels, the UNECE/FAO 9R framework distinguishes between three types of interactions or "loops":

- User-to-user (**reduce** and **reuse** practices);
- User-to-business (**repair**, **refurbishing** and **remanufacturing** strategies); and
- Business-to-business (B2B) (**repurposing** and **recycling** of used materials).

Cascading wood use is focused on this latter "B2B" category but, for a fully circular system, it should take place within a wider environment of cascading demand in which final products are designed for maximum material efficiency and demand for those products per se is optimised to reduce production of new products in excess of economic needs.

The application of the 9R model to forest products should not be viewed as an argument for limiting the use of wood or prioritising forest conservation over their economic production function. Wood and wood-based products are a vital renewable resource that represents a strategic material base for the transition to a low-carbon and ultimately climate-neutral economy in multiple end-use markets.

Nevertheless, with strong expected growth in demand for harvested wood products in the coming years globally, in the EU and in Czechia, especially for timber construction and bioenergy, circularity and cascading wood use should be systematically explored and implemented in order to extend total wood biomass availability within the economy and thereby support the long-term economic function of forests within sustainable and ecological limits.

EU policy framework for forest products

This chapter provides an overview of current and forthcoming EU policies and legislative initiatives related directly and indirectly to forestry and forest products, with an emphasis on measures impacting the use of wood in major end-use markets. As this summary makes clear, cascading use of wood and circularity concepts are an integral part of the European Green Deal (EGD) policy framework, setting the direction for sectoral policies and legislative requirements in all EU Member States (including Czechia) in the coming years.

The flagship initiative of the EGD for the forestry and forest products sector is the **New EU Forest Strategy for 2030**[7]. A central element of the strategy on the demand side is the optimal use of forest biomass in line with the cascading principle and the circular economy approach.

The strategy summarises a range of proposed actions and related legislative initiatives under the Green Deal and highlights the following core principles:

- For production of short-lived products and bioenergy production, only wood unsuitable for long-lived materials and products, or secondary woody biomass such as sawmill by-products, residues and recycled materials, should be used.
- Use, reuse and recycling of all wood-based products should be prioritised, including from construction and demolition sites, to maintain wood-based products longer in the economy for the multiple uses.

7 New EU Forest Strategy for 2030 (COM/2021/572 final, European Commission, July 2021)

- Wood products have an important role in turning the construction sector from a major source of GHG emissions into a carbon sink and a 2050 roadmap for reducing whole life-cycle carbon emissions in buildings will be developed.
- Construction companies, following the principles of life cycle thinking and circularity, should reflect the full benefits of wooden construction in their risk premiums and business models.
- Member States should be encouraged to reflect best available scientific knowledge in designing regulations to promote use of long-lasting wood products, including the energy and environmental performance of building and construction products.

"Circularity as a prerequisite for climate neutrality" is an underlying principle of the **New Circular Economy Action Plan** (CEAP 2.0). One of the plan's three cross-cutting actions is the development of a regulatory framework for **certification of carbon removals** based on robust and transparent carbon accounting to monitor and verify the authenticity of carbon removals. In this respect "carbon removals can be nature based, including through restoration of ecosystems, forest protection, afforestation, sustainable forest management and carbon farming sequestration, or based on increased circularity, for instance through long-term storage in wood construction, re-use and storage of carbon in products such as mineralisation in building material."[8]

The European Commission's proposal, adopted in November 2022, sets out rules for independent verification of carbon removals and recognition of existing certification schemes that can be used to demonstrate compliance. It also establishes a set of four **"QU.A.L.ITY"** verification criteria: **Qu**antification (accurate and unambiguous removals); **A**dditionality (going beyond existing practices and legal requirements); **L**ong-term storage (duration of storage to ensure permanent solutions); and **S**ustainability (contributing to sustainability objectives, as defined in EU policy). One potential use of the certificates is income from the sale of carbon removal credits by construction companies or property owners investing into long-term use of sustainable (e.g., wood-based) building materials that remove and store carbon.[9]

At the time of writing, the EU's new **Regulation to curb EU-driven deforestation and forest degradation**, repealing the EU Timber Regulation (EUTR), had been adopted by the European Parliament and was pending formal endorsement by the European Council. It introduces requirements for operators to conduct and issue statements on due diligence for harvested timber, processed wood and major categories of wood-based products placed on the EU market, including traceability via the geographic coordinates of the land from which the wood was harvested and confirmation that, from 31.12.2020 onwards, the product was not sourced from deforested land or has not led to forest degradation. The Regulation does not apply to goods produced entirely from end-of-life (waste) material that would otherwise have been

8 A new Circular Economy Action Plan for a cleaner and more competitive Europe (COM/2020/98 final, European Commission, March 2020)

9 Commission proposes certification of carbon removals to help reach net zero emissions (European Commission, 30.11.2022)

discarded as waste, except for by-products of a manufacturing process involving material not classified as waste, as defined in the EU's Waste Framework Directive.[10]

The European Commission's proposal for a **Nature Restoration Law**, adopted in June 2022, includes measures for restoration of forest ecosystems through the development and implementation of National Restoration Plans to achieve an increasing trend, by 31.12.2030 and every three years thereafter, in the following indicators for forest ecosystems: (a) standing deadwood; (b) lying deadwood; (c) share of forests with uneven-aged structure; (d) forest connectivity; (e) common forest bird index; and (f) stock of organic carbon[11]. The law would also commit the EU and its member states to legally protect all remaining "primary" and "old-growth" forests on their territory. The proposal has proven particularly controversial for forest-based industries due to the uncertainty it has created around potential impacts on the sector and restrictions on future timber harvesting.[12]

Use of forest biomass for bioenergy

Part of the European Commission's "Fit for 55" package, the proposed revision of the **Renewable Energy Directive (RED III)** embeds in EU law the cascading principle of biomass use, to support development of innovative, high value-added bio-based products and a sustainable circular bioeconomy. According to the general approach adopted by the EU Council on the Commission's proposal, "Member States should not grant support to the production of energy from saw logs, veneer logs, stumps and roots and avoid promoting the use of quality roundwood for energy except in well-defined circumstances. In line with the cascading principle, woody biomass should be used according to its highest economic and environmental added value in the following order of priorities: 1) wood-based products, 2) extending their service life, 3) re-use, 4) recycling, 5) bio-energy and 6) disposal. [...] Waste prevention, reuse and recycling of waste should be the priority option. [...] Member States may derogate from the cascading principle when the local industry is quantitatively or technically unable to use forest biomass according to a higher economic and environmental added value than energy, for feedstocks coming from: (i) necessary forest management activities, aiming at ensuring pre-commercial thinning operations or in compliance with national legislation on wildfire prevention in high-risk areas; or (ii) salvage logging following documented natural disturbances; or (iii) harvest of certain woods whose characteristics are not suitable for local processing facilities."[13] A provisional political agreement between the Council and the European Parliament was reached on 30.3.2023.[14]

10 Parliament adopts new law to fight global deforestation (European Parliament, 19.4.2023)

11 Green Deal: pioneering proposals to restore Europe's nature by 2050 and halve pesticide use by 2030 (European Commission, 22.6.2022)

12 Lawmakers split over forestry in EU nature restoration law (Euractiv.com, 16.1.2023)

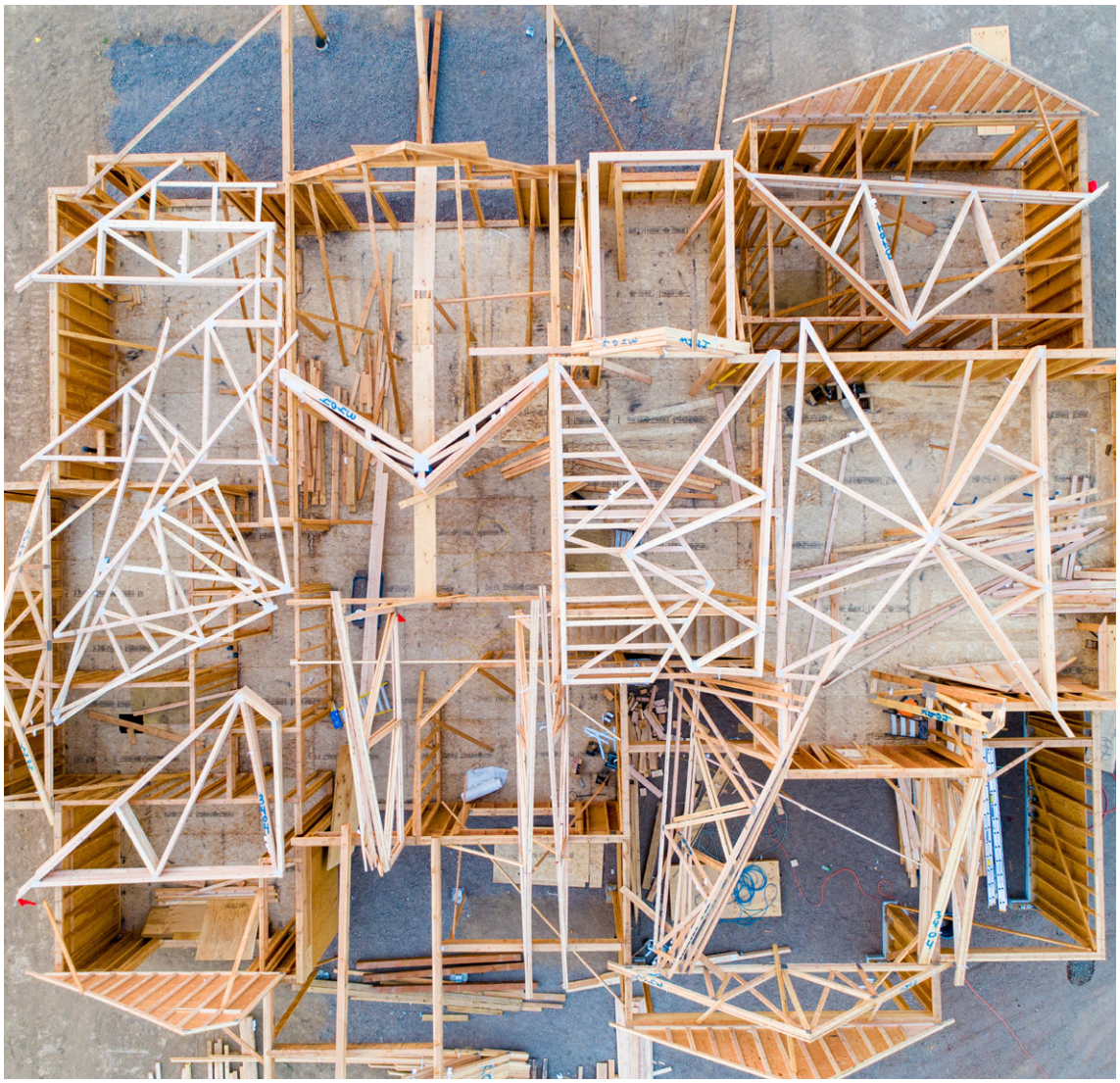
13 Interinstitutional File 2021/0218(COD), Council of the European Union, June 2022

14 Council and Parliament reach provisional deal on renewable energy directive (European Council, 30.3.2023)

Buildings construction

As highlighted by the Forestry Strategy, the buildings construction sector is a priority focus of initiatives related to the circular and cascading use of wood. Although focused on building renovations for energy efficiency, the EU's **Renovation Wave** strategy includes life-cycle thinking and circularity among its "key principles for building renovation towards 2030 and 2050". Minimising the footprint of buildings will require "resource efficiency and circularity combined with turning parts of the construction sector into a carbon sink, for example through the promotion of green infrastructure and the use of organic building materials that can store carbon, such as sustainably-sourced wood."[15]

Similarly, one of the thematic axes of the EU's **New European Bauhaus (NEB)** initiative is the "need for long-term, life-cycle thinking in the industrial ecosystem", including the prioritisation of "re-use, regeneration, life extension and transformation of existing buildings [...] over the construction of new buildings whenever feasible". In this context "recovered and renewable materials should be better



15 A Renovation Wave for Europe – greening our buildings, creating jobs, improving lives (COM/2020/662 final, European Commission, October 2020)

recognised by all relevant disciplines and become part of design paradigms. The use of sustainably produced and procured nature-based building materials, such as wood, bamboo, straw, cork or stone should be improved."[16] Notably, the NEB has given rise to the **Wood Sector Alliance for the New European Bauhaus** (Wood4Bauhaus), an open platform of European wood-based sector organisations and R&I programmes that aims to "raise awareness for the transformative power of the Circular Economy, put a spotlight on the versatility of innovative wood products and building systems, and facilitate dedicated co-creation partnerships with the wood sector for the New European Bauhaus."[17]

Specific legislative initiatives for the buildings and construction sector will have a positive indirect impact on demand for wood-based construction principally by introducing measurement requirements and subsequently maximum thresholds for **Whole Life Carbon (WLC)** of new buildings and renovations, including the embodied carbon in building materials.

Adoption of the revised **Energy Performance of Buildings Directive (EPBD)**, also part of the European Commission's "Fit for 55" package, is expected in Q3 2023. The Commission's proposal introduced first steps to addressing GHG emissions over the whole life cycle of buildings, covering both operational and embodied carbon. The life-cycle Global Warming Potential (GWP) of new buildings with a useful floor area larger than 2,000 square metres would have to be calculated as of 2027 in accordance with the EU's **Level(s)** framework, by measuring buildings' WLC. Where a national calculation tool or method exists, or is required for making disclosures or for obtaining building permits, that tool or method may be used to provide the required disclosure, provided that it is compliant with Level(s). The GWP calculation requirement would then apply to all new buildings from 2030.[18] The EU Council and Parliament have published positions on the proposal, while independent bodies such as ECOS and BPIE have called for more ambitious action and an expedited timetable for WLC.[19] Amendments adopted in March 2023 by the European Parliament proposed that GWP be calculated for all new buildings from 2027 and that Member States be required by 2027 to publish roadmaps introducing limit values on total cumulative GWP emissions of all new buildings and to set maximum GWP values for new buildings from 2030. Final agreement on the text of the recast between the EU institutions is expected by the end of 2023.

In parallel, several other EU initiatives related to embodied carbon and circularity of materials in the buildings sector are also in the legislative procedure or in preparation at the time of writing, including: the revised **Construction Products Regulation (CPR)**; updating of **Environmental Product Declarations (EPDs)** for construction products; updates

16 New European Bauhaus – Beautiful, Sustainable, Together (COM/2021/573 final, European Commission, September 2021)

17 New European Bauhaus, Wood4Bauhaus, (Accessed March 2023)

18 Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast) (COM/2021/802 final, European Commission, December 2021)

19 Seeing the forest through the trees: How sustainable timber buildings can help fight the climate crisis (ECOS, March 2023); Reducing carbon emissions over the life of a building: opportunities in the 2022 EPBD recast (BPIE, September 2022)

to public procurement rules and **Green Public Procurement (GPP)** criteria for buildings; adoption of Level(s) as a framework for assessing buildings sustainability and circularity; and a planned 2023 revision of the **Waste Framework Directive (WFD)** to update rules on construction and demolition waste (CDW).

Ecodesign criteria for sustainable products

European ecodesign rules have until now focused on energy efficiency performance and labelling of energy-related products. In March 2022, the European Commission published its proposal for a new **Ecodesign for Sustainable Products Regulation (ESPR)** under the CEAP 2.0. This shall embed comprehensive circularity and material efficiency requirements in the ecodesign framework for a much wider range of products, including both new categories and those regulated under existing rules.

The overall objective of the ESPR is to "make sustainable products the norm" in the EU, by introducing a horizontal framework to cover almost all physical products placed on the EU single market, updating existing product and sectoral legislation and adopting over thirty new delegated acts to define specific ecodesign criteria and rules for individual categories of products. On January 30, 2023, the Commission launched a public consultation regarding the new product categories and measures to be addressed first in the new ecodesign rules. Among the potential priorities identified in a preliminary assessment by the Commission's Joint Research Centre (JRC) are **furniture** as an end-use product category and **paper, pulp paper and boards** as an intermediary category.[20]

The ESPR framework regulation is scheduled for adoption during 2024. Its key measures include minimum product design criteria for sustainability, circularity and environmental impact reduction, information requirements on the environmental sustainability of products, labelling (including reparability aspects), mandatory minimum GPP criteria, digital product passports for regulated products and the restriction or prohibition of destruction of unsold consumer goods. Specific ecodesign parameters will be defined for each product category but include: durability, reusability, upgradability, repairability, recycled content, reprocessing and recycling options, carbon and environmental footprint and waste minimisation.

Product-specific ecodesign requirements under the ESPR are yet to be adopted, but potential parameters can be gleaned from existing voluntary criteria related to use of wood in buildings, furniture, wood flooring and paper products in EU GPP guidelines, the EU Ecolabel scheme and/or the EU's Taxonomy for sustainable investments. A summary of these criteria, with links to the source documents, is provided in Annex 1.

The EU Taxonomy and Corporate Sustainability Reporting Directive (CSRD)

Aside from minimum mandatory ecodesign criteria under the ESPR, the EU's policy framework for sustainable finance and corporate sustainability reporting is intended to motivate companies with mandatory reporting requirements under the

20 Ecodesign for Sustainable Products Regulation (ESPR) – preliminary study on new product priorities (JRC, January 2023)

Taxonomy and the CSRD to adopt sustainable solutions, practices and business models as applicable to their respective sectors of activity. Only large public-interest companies with more than 500 employees are currently required to report non-financial information under the EU's **Non-Financial Reporting Directive (NFRD)** as well as the % of their turnover, opex and capex that is compliant with the EU Taxonomy.

Under the CSRD, the number of EU companies with mandatory reporting will increase almost fivefold from the 2025 financial year onwards, with significantly expanded reporting requirements on sustainability topics according to new **European Sustainability Reporting Standards (ESRS)**. These requirements will also have a cascading impact on data flows and reporting from companies directly in the CSRD scope to their broader value chain, including suppliers and customers.

The main impact of the **Taxonomy** on forest products will come from the pending Environmental Delegated Act implementing its four "non-climate" objectives.[21] This is expected to come into force in late 2023 or the beginning of 2024. On the demand side (the focus of this study), detailed circular economy criteria[22] are being developed for a wide range of product sectors, including:

- **Buildings construction** (new build and renovation): consumption of primary raw materials in the construction of buildings is minimised by the use of secondary raw materials. If bio-based materials (including wood) comprise one of the three heaviest categories of materials (in kilograms) used for construction, the maximum share of primary raw materials in this category is 80%.
- **Furniture**, including manufacturing, repairing, refurbishing, remanufacturing, sale of spare parts, sale of second-hand furniture, product-as-a-service and other circular use – and result-oriented service models.
- **Packaging** (including paper-based materials) for the sale of spare parts, second-hand goods and product-as-a-service models: at least 65% is made of recycled material. In the case of paper and board, the remainder of the material shall be certified according to FSC, PEFC or similar certification systems.

Under the **CSRD**, companies are required to report their GHG emissions not only from direct and indirect (purchased) energy use but also "Scope 3" value chain emissions from both products or services purchased from suppliers or lifecycle impacts from use of the company's products or services by its customers and end-users.[23] Where material to the company's activities, reporting will also address impacts on **biodiversity and ecosystems** (ESRS E4), as well as policies, targets, actions and key performance indicators related to **resource use and circular economy** (ESRS E5).[24]

In addition to circular economy strategies and initiatives (soft data), "in scope" wood processing enterprises and manufacturers and suppliers of wood-based products will

21 These are: sustainable use and protection of water and marine resources; the transition to a circular economy; pollution prevention and control; and the protection and restoration of biodiversity and ecosystems (European Commission, Directorate-General for Financial Stability, Financial Services and Capital Markets Union).

22 These are currently in draft form based on the European Commission's June 2023 proposal and are subject to change in the final adopted Delegated Act.

23 As defined by the Greenhouse Gas Protocol (WRI, WBCSD).

report quantitative indicators (hard data) on key material inputs (split between renewable and non-renewable) as well material outputs (both products and waste flows). This will include the ratio of products that follow circular design principles.

Summary

The material use of harvested wood products as a renewable low-carbon resource is supported across multiple policy areas under the EGD. In particular, EU buildings sector strategies and policies are starting to address WLC in buildings, favouring the adoption of timber construction as an alternative to cement and steel that can store carbon in long-lasting structures.

In the coming years, EU ecodesign rules will also establish mandatory material efficiency and circularity criteria for wood-based products including wooden furniture and paper and paperboard products. High circularity performance in all of these product areas is already supported through voluntary instruments including GPP and the EU Ecolabel, and will be reflected in sustainability reporting requirements under the EU Taxonomy and the CSRD.

Increasing demand for wood from multiple sectors calls for an integrated approach and an optimal balance between economic, climate mitigation and adaptation and biodiversity objectives. As such, the EU Forestry Strategy and the RED III proposal formalise the biomass cascading principle, prioritising long-lasting wood products, reuse and recycling over bioenergy or disposal except in specific cases.

Note: This chapter has focused mainly on policy and legislation related to circularity and the demand side of the forest products and wood value chain. The Wood for Life Foundation has launched a project "EU Forestry Legislation" with the aim of informing and educating the professional community in particular about the importance of being active in the development of forestry legislation. The project offers advice to the forestry sector, forest owners and other stakeholders on development of sustainable forest management practices in the context of proposed EU legislation.[25]

24 First Set of draft European Sustainability Reporting Standards (ESRS) (EFRAG, November 2022)

25 Wood for Life Foundation, Lesnická legislativa EU

Wood circularity – innovations from Norway

Although not an EU Member State, Norway is an important player in the European forest products economy, as highlighted by pioneering research currently being undertaken on digital and circular wood value chains by NIBIO, the country's leading bioeconomy research institute. This bilateral cooperation project provides an opportunity to draw upon the latest research directions and innovations from Norway to identify best practices in high-value cascading of wood and greater circularity through the forest products sector.

Norway has a long tradition of sustainable management of forest resources and was the first country in the world, in 1919, to map the relationship between forest density and regrowth. On average, Norwegian forests increase by about 25 million m^3 of timber per year, while around 12 million m^3 are logged. Norway is also a leader in innovation and new applications for forest-based raw materials, from building materials to bioenergy and processed raw materials (e.g., lignin and cellulose). The domestic forest products industry adds more than tenfold to the value of the log as it is processed.[26]

As detailed in this chapter, three current projects in which NIBIO is engaged are of particular interest for the topic of this study. In October 2020, NIBIO launched the 8-year SFI Smart Forest project to improve the efficiency of the Norwegian forest sector by harnessing digital technologies to transform forest information, silviculture, forest operations, wood supply and the overall digital information flow in the sector.[27]

26 Ministry of Agriculture and Food, Government of Norway, Forestry, Use of Wood.

27 NIBIO, Division of Forest and Forest Resources, SFI SmartForest: Bringing Industry 4.0 to the Norwegian forest sector.

In January 2022, NIBIO initiated the four-year circWOOD research project as part of the broader SirkTRE programme for a sustainable and circular wood and construction industry. The project aims to address knowledge gaps on availability and quality of recycled wood and investigate aspects of wood use in the Norwegian economy, focusing on reuse of wood in construction, and recycled wood as a raw material in the wood processing industry. It will also analyse the sustainability and environmental footprint of the wood value chain and identify ways to simplify processes, including through use of digital tools and platforms.[28]

SMARTForest / Industry 4.0 for the Norwegian forest sector

SMARTForest is a project financed by the Centre for Research-based Innovation (SFI) led by NIBIO, with funding of NOK 234 million (over EUR 20 million) from the Research Council of Norway. The project consortium consists of research institutes and universities, international partners, forest management and owners' associations, sawmilling industry, machine manufacturers and contractors, technology providers, data and service providers, and the public sector.

Its overall vision is to "contribute to a Norwegian forest sector with higher production and environmental efficiency through smart implementation of enabling technologies in the value chain", from individual trees to sawmills. Its main goal is to create "a long-term, world-leading, industry-focused research and development environment" by harnessing enabling technologies for digital transformation of the forest sector.

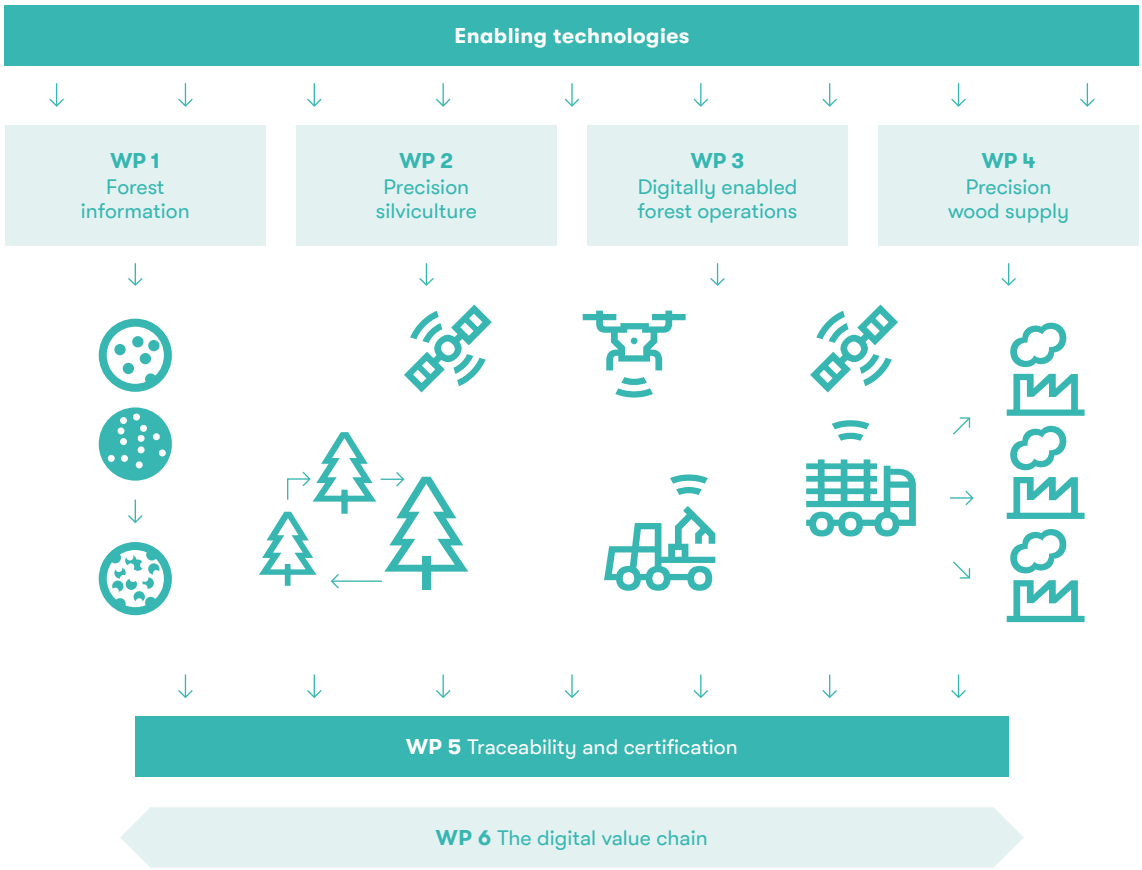
Key intended outcomes of the project are:

- Adoption of leading digital technologies in the Norwegian forest sector.
- Leveraging new technologies to create innovations for operationalisation and commercialisation by project partners.
- Enhanced information flows, production and environmental efficiency and the overall value of production from the forest-based value chain.
- Improved recruitment of professionals and researchers in the forest sector.
- Stimulation of the green transition in Norwegian industry (through increased value creation and international competitiveness in the forest sector, support development of a forest technology sector in Norway).

As show in the figure below, the project comprises six work packages (WP):

- WP1 – Improved cost-efficient operational systems for continuously updated forest information
- WP2 – Cost-efficient precision silvicultural practices that can increase the growth rates of Norway's forest
- WP3 – Digital approaches that reduce the cost of forest harvesting and reduce the environmental impacts
- WP4 – Reduce costs of logistics, reduce seasonal fluctuations in wood supply, and increase the value creation of the harvested wood.
- WP5 – Enable full traceability of wood from the stump to the end product and enable digitally supported certification procedures.
- WP6 – Enable a fully digital information flow along the value chain for private and public actors in the Norwegian forest sector

28 Circular use of wood for increased sustainability and innovation (circWOOD) (NIBIO, Division of Forest and Forest Resources)

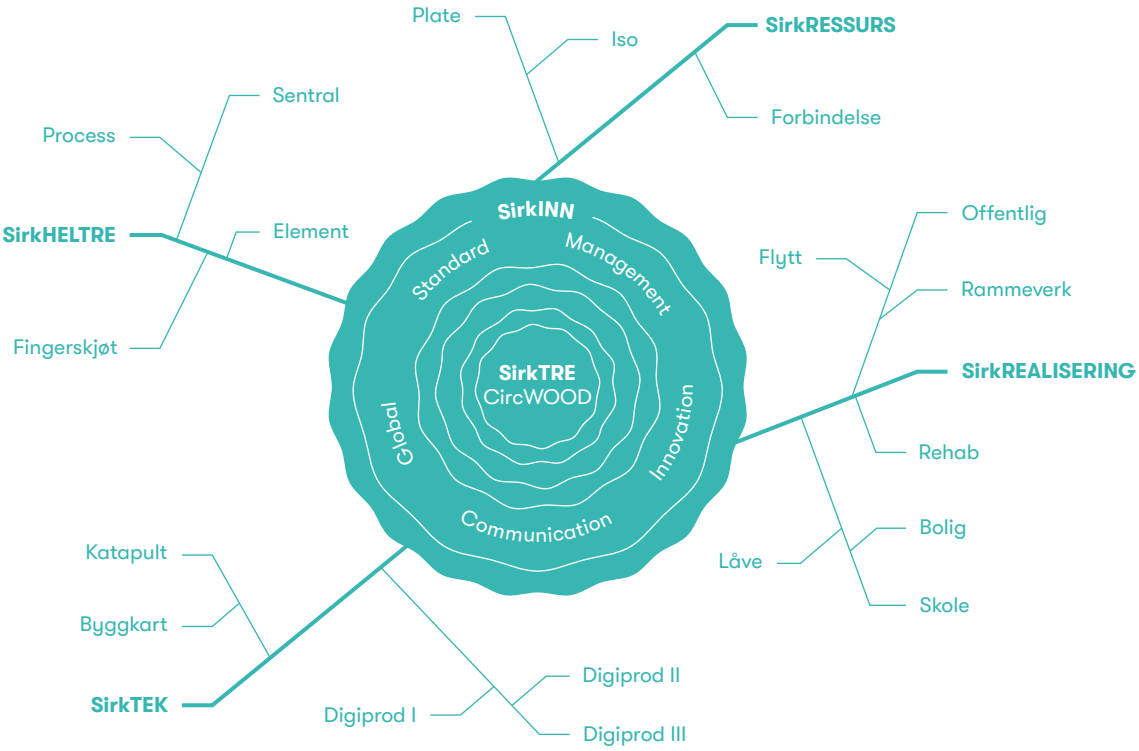


Source: SMARTForest project presentation

SirkTRE / Establishing a holistic circular value chain for wood

Initiated by the Norwegian Wood Cluster, **SirkTRE** is a 42-month (2022–2025) research project with a total budget of EUR 19 million, including support from Innovation Norway, the Norwegian Research Council and SIVA through the Green Platform Initiative. The project brings together forest owners, the timber processing industry, architects, consultants, contractors, waste and recycling operators, property owners and developers, research institutions and standardisation bodies to boost the reuse of recycled wood. It comprises the innovation centre **sirkINN** (including the research and competence project circWOOD) and four other sub-projects:

- **SirkHELTRE** (reuse of solid wood-based solutions)
- **SirkRESSURS** (reduced resource use)
- **SirkREALISERING** (implementation of projects with circular wood products, solutions and designs for reuse)
- **SirkTEK** (new technology and new digital production).



Source: SirkTRE project presentation

The overall programme objective is to establish a holistic circular wood value chain by reducing waste and increasing reuse and material recycling. A strategic goal is to achieve material use of 250,000 m^3 (100,000 tonnes) of wood waste in Norway by 2024 and 1 million m^3 (400,000 tonnes) by 2030, contributing to carbon removals of 0.5 million tonnes of CO_2 by 2024 and 2 million tonnes of CO_2 by 2030.

CircWOOD / Circular wood use for sustainability and innovation

CircWOOD is a 5.5-year EUR 3.8 million research and competence project within the wider SirkTRE project. Its research partners are NIBIO, the Norwegian University of Life Sciences, Norwegian Institute of Wood Technology, Norwegian University of Science and Technology, and Inland Norway University of Applied Sciences Search.

According to 2020 statistical data, the production of wood waste in Norway was 818,00 tonnes (39% household, 35% construction, 9% industry and 15% service sectors) and paper and cardboard waste a further 730,000 tonnes. Wood is chewed up in demolition and contaminated wood is then chipped and burned. This is the equivalent, in waste wood volume terms, of burning 250,000 single-family houses in Norway every year. An additional 600,000 tonnes of wood chips, shaving and bark are generated as by-product streams in the wood processing industry.

Several barriers and challenges for more circular use of wood have been identified:

- Disruption of the traditional material flows within the forest, construction, and bioeconomy sectors, affecting the market.
- Unknown impact on the climate and the environment.
- Current statutory framework which may not facilitate a circular economy.

- Insufficient understanding of material flows beyond saw mills.
- Technology gaps that prevent full implementation of new technologies.

CircWOOD's overall research objective is to "explore potentials and benefits of improved circular use of wood in Norway" through the following research questions:

- What are the potential future secondary wood resources (quantities and qualities) that will enter the circular wood value chain?
- How will higher utilisation of reclaimed wood influence the demand for future solid wood products, impact wood availability, economic, environmental and societal factors?
- How can we securely use, share and exchange the information from different resources within the wood value chain including reuse and recycling?
- How does the current policy framework shape the current opportunity space of use of reclaimed wood and what changes need to be made to encourage beneficial behaviour?
- What technologies need to be developed to improve secondary material quality and enhance value added?

The project comprises the following five work packages:

- WP 1 (NIBIO) – Availability and quality: Mapping, modelling, and simulating the quantities and qualities of reclaimed wood for reuse and recycling.
- WP 2 (NTNU) – Digital tracking of circular wood value chain: Develop technology for tracking the circular wood value chain securely on a shared platform.
- WP 3 (NMBU) – Wood sector modelling: Assess and quantify how different wood cascading alternatives influence harvested wood products demand and performance.
- WP 4 (NWT) – Environmental impact of cascading: Visualise and frame the environmental analysis in the context of optimal cascaded wood use to find the most environmental beneficial strategies.
- WP 5 (HINN) – Framework, scenarios, and roadmaps for the future: Map current potentials and barriers for cascading of wood in national and EU regulations, examine acceptance of reclaimed wood along the value chain and provide a roadmap for circular use of wood targeted to the Norwegian policymaker.

Sources: SirkTRE project presentation (shared by NIBIO), circWOOD project Website.

Opportunities for circularity and cascading use of wood in Czechia

Policy context

At a national level, the following strategic documents address directly or indirectly different elements of sectoral policy affecting forestry and wood-based industries:

- Strategic objectives for forestry by 2030 (MoA, 2016);
- Bioeconomy concept in the Czech Republic from the perspective of the Ministry of Agriculture (2019–2024) (MoA, 2019);
- National Energy and Climate Plan (MIT, 2019);
- Update of the Secondary Raw Materials Policy 2019–2022 (MIT, 2019);
- Concept of the State Forestry Policy until 2035 (MoA, 2020) – Long-term objective C: Ensure the competitiveness of forestry and related industries and their importance for regional development;
- Public Procurement Law: Obligation to take into account environmental impact and sustainability life cycle costs and impacts procured products and services (MRD, since 1.1.2021);
- State Environmental Policy of the Czech Republic (MoE, 2021);
- Guide to using wood in public procurement (MoA, 2021) – recommendations for use of wood in public procurement in cases where it can replace other materials, including examples of good practice.
- National RIS3 Strategy of the Czech Republic 2021–2027 (MIT, 2021);
- Strategic Framework Circular Czechia 2040 (MoE, 2021);
- Update of the Waste Management Plan of the Czech Republic 2015–2025, with a view to 2035 (MoE, 2022);

- Programme Statement of the Government – Forestry: increase the competitiveness of small and medium-sized timber and forestry companies in obtaining state contracts, support wood as a renewable material in construction, develop Raw Material Policy for Wood, etc. (updated, March 2023).

However, most of these policy documents are either not up-to-date or focus on specific policy areas in isolation. An integrated raw material strategy for sustainable and economic use of wood biomass resources in Czechia has until now been lacking. To this end, the Ministry of Industry and Trade (MIT) and the Ministry of Agriculture (MoA) in cooperation with the Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences Prague (ČZU FLD) initiated in mid-2022 the development of a new national **Raw Material Policy for Wood**. The policy is intended to address the complex long-term challenges of the forest products value chain in Czechia and respond to EU policies and legislative changes arising from the EGD, and is expected to be finalised and adopted by the end of 2023.

The forestry sector (domestic wood supply)

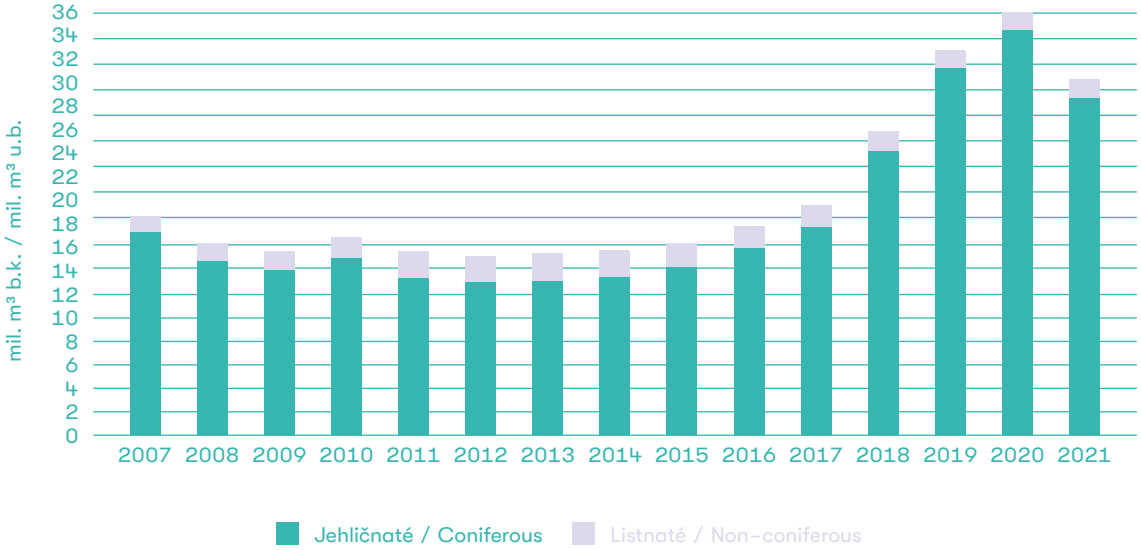
Czechia has a forest area of around 2.7 million ha, with a forest cover ratio of 34% (2020), somewhat below the EU average of 39%.[29] There has been a long-term increase in the officially reported **growing stock** of forests, from 564 million m^3 in 1990 and 630 million m^3 in 2000 to around 700 million m^3 in 2020/2021. The sharp increase in roundwood removals in 2017–2021 (principally spruce) due to the **bark-beetle calamity**, reaching a peak of almost 36 million m^3 in 2020, has temporarily reversed this trend. According to Hruška et al. (2022),[30] in the years up to 2015 Czech forests sequestrated an average of 6 Mt of CO_2eq annually. As a result of recent forestry challenges, including climate change, high salvage felling and soil degradation, forests moved from being carbon sinks to becoming a significant **source of CO_2 emissions** to the extent of 10 to 15 million tons of CO_2 per annum.[31] The calamity has led to opening of forest stands and the creation of large clearings that will need to be regenerated over many years, although a positive trend was already evident in 2021, with a strong rate of reafforestation.

29 39% of the EU is covered with forests (Eurostat, March 2021)

30 Hruška et al., Odhad potencialni sekvestrace uhliku v ceskych lesich aneb od pasek k prirode blizkym lesum, magazine Lesnická práce, May 2022

31 České lesy emitují víc CO_2, než zadrží. Na vině je hospodaření, degradace půdy a změna klimatu, říká expert Lněnička (Fakta o Klimatu, 2022)

Roundwood removals in Czechia, 2007–2021



Source: Czech Statistical Office

Of the raw timber harvest over the period 2019–2021, around 60% was roundwood, over 20% pulpwood and other industrial timber and just under 20% fuel wood, with coniferous dominating all categories (95% of the total). Despite increased domestic demand, the **high export ratio** of recent years continued in 2021, at 54% for domestic coniferous roundwood. 93% of exported raw timber was destined for other EU member states, primarily cross-border trade to processing facilities in neighbouring countries (Austria, Germany, Poland and Slovakia) offering favourable pricing or based on multi-year supply contracts. Conversely, 2 million m^3 of raw timber was imported, particularly for use by domestic processing facilities in regions bordering on Slovakia, Poland and Germany, typically due to favourable prices.[32] Although data for 2022 had not been released at the time of this report, preliminary estimates indicated a further decline in the raw timber harvest to approximately 21 million m^3, with the larger share of timber deliveries now going to domestic processors.[33]

Based on data from the Forest Management Institute (FMI), the share of coniferous stands in total forest area has been on a declining trend and fell to just under 70% in 2021 (48% spruce, 16% pine and 5% others), with close to 30% for broadleaves (the balance being clearings). A key future impact of the **declining share of spruce** on wood processing industries will be the need to adjust processing technologies and equipment to other types of wood, such as pine, oak, beech, birch and Douglas tree.[34]

According to sector experts, due to limited resources for preparation of Forest Management Plans (FMPs), growing timber

32 Zpráva o stavu lesa a lesního hospodářství České republiky v roce 2021 (MoA, November 2022)

33 Ceny dřeva byly vloni na rekordu, letos se čeká pokles; Česko vloni vyvezlo nejméně dřeva od roku 2018. Snížila se těžba, pomalu roste i využití dřeva doma (Hospodářské noviny, 27.3.2023)

34 Vývozy smrkové kulatiny bychom měli zastavit. Ne politicky, ale ekonomicky (Interview with Stanislav Polák, Konstrukce, 2023); Consultation with Forestry and Game Management Research Institute, Forestry Management Institute, Association of Suppliers of Prefabricated Buildings (ADMD)

stock figures (in m^3/ha) in these plans are generally underestimated. However, these stock figures cannot be exceeded when reporting the volume of harvested timber when the trees are felled. As a result, the actual raw timber harvest volume may be significantly higher than that reported in official statistics. Requirements to report actual harvest volumes, based on the EU Timber Regulation, have not so far been introduced. Whatever the true numbers, the chief constraint in recent years has not been domestic timber supply (even excluding the impact of high salvage cutting from the bark-beetle calamity) **but domestic processing capacities**, especially for higher value-added operations that can afford prices for domestic timber competitive with those offered by export customers. A fundamental challenge is also the **lack of integration** between the domestic forestry sector and downstream wood processing industries. Forestry operators are primarily concerned with finding buyers for raw timber, whether domestically or in neighbouring countries, with little motivation to maximise supply to domestic processors. Due to cross-border export flows, domestic sawmills can struggle to secure raw timber, despite a large timber harvest surplus. Consequently, investments in sawmill capacity expansion can seem risky, compounded by fears that wood availability will be further constrained in the coming years if the bark-beetle calamity (and associated salvage cutting) continues to abate and depending on the implementation of EU forestry policies.[35] A **stable supply outlook** for wood is a key indirect factor for stimulating long-term investments in new and state-of-the-art processing technologies and higher value-added products.[36]

In an analysis of the development of **future timber stocks and harvests** in Czechia to 2053, Synek et al.[37] (FMI, Brandýs nad Labem) have used both FMI models and the European Forestry Dynamics Model (EFDM) to develop two possible scenarios for the next thirty years. Both scenarios aim to take into account the bark-beetle calamity, but result in widely different outcomes. While the FMI scenario, based on FMPs, indicates average annual harvest potential over the whole period at around 15 mil. m^3, corresponding to pre-calamity levels, the EFDM scenario, based on the national forest inventory (NFI) data, predicts an average of 23 mil. m^3 for the period 2020–2025, decreasing over time to 21 mil. m^3 for 2045–2050. This gap may be explained by the aforementioned inaccuracies in the growing stock volumes stated in FMPs. The EFDM scenarios reflect higher growing stock estimates based on the more accurate NFI surveys but are at the same time influenced by the exceptional surge in incidental cutting in the 2016–2020 period. FMI's modelling indicates that the EFDM scenario would result in growing stocks declining from over 840 million m^3 in 2020 (based on NIL data) to around 785 million m^3 by 2055 and, as such, is not sustainable over the long term. As the differences in the two scenarios illustrate, the impacts and possible future development of climate change make predictions on future raw timber supply highly variable over a 30-year period, creating significant uncertainty in terms of future wood availability.

35 Consultation with Moravian Forestry Institute, Wood for Life Foundation and others

36 Consultation with Forestry and Game Management Research Institute and others

37 Synek et al., FMI Brandýs nad Labem, Analýza vývoje zásob a těžebních možností do roku 2053, magazine Lesnická práce, February 2023

Project snapshot

Norway policy framework

As part of the MultiForest Horizon 2020 project, NIBIO recently led a long-term (70 year) policy analysis on the Norwegian forestry and forest products sectors regarding future wood demands and ecosystem trade-offs. It concludes that under current national policy scenarios, Norway will be able to satisfy wood demands of up to 17 million m^3 in 2093. Development of Norwegian forests was simulated under different management regimes and national policy scenarios, including the national forest policy, biodiversity policy, and bioeconomy policy. The research team carried out 100-year simulations into the future to forecast wood availability, including variables such as temperature and moisture, approaching the topic in a holistic and systemic way.[38] Such long-term scenario modelling provides an example of integrated policy analysis that can bring together stakeholders from forestry, wood processing, environmental protection and other sectors, and allow development of meaningful predictions and science-based policy options.

Approximately two thirds of Czech forests (by area) are certified for **sustainable forestry practices** under PEFC (Programme for the Endorsement of Forest Certification schemes) but only 5% according to FSC (Forest Stewardship Council). FSC requirements are set at a national level, with those in Czechia being relatively strict compared to some other countries. As a result, Czech suppliers may sometimes seek FSC certification through other national certification schemes. According to studies comparing PEFC and FSC, **FSC certification** can significantly contribute to promotion of all forest functions and to implementation of the principles of sustainable forest management. It strictly defines permitted and prohibited forestry management methods and can contribute to higher biodiversity and healthier forest conditions. This may result in a better ability to adapt to rapidly changing climatic conditions.[39] However, a key disadvantage of FSC certification is perceived by several stakeholders interviewed to be its high administrative requirements and costs, as well as differing requirements in individual countries.[40]

38 Vergarechea et al., Future wood demands and ecosystem services trade-offs: A policy analysis in Norway, February 2023. Conducted

39 Lněnička J., Přibyla O., Jaký přínos pro les v časech klimatické změny může mít lesní certifikace? (Fakta o klimatu, April 2023); Porovnání vybraných environmentálních aspektů certifikačních systémů FSC a PEFC v ČR s důrazem na půdu, vodní zdroje a biotu lesních ekosystémů (Hošek, 2018)

40 INCIEN consultation with stakeholders

According to an earlier analysis, **PEFC certification** can lead to improvements, but does not guarantee sustainable forestry practices to the same level as FSC as it allows, for example, large clearings even on steep slopes, does not require correction of species composition and does not ensure biodiversity conservation.[41] Criteria are mostly formulated in general terms and often only as recommendations. Usually, PEFC does not require more than is mandated by current national legislation.[42] Despite the reservations of many in the wood processing industry on the need for certification schemes, FSC is often required by international buyers in downstream sectors including furniture manufacturing. The low level of FSC certification of Czech forests remains a factor preventing Czech forestry and wood processing sectors from participating more fully in some downstream value chains internationally and shifting to more valued added production.[43]

An important aspect of sustainable forestry practices is the management of **logging residues** (bark, branches, foliage and treetops with stems under 7 cm diameter, representing 10–15% of trees' aboveground biomass volume), i.e. whether to process and work them back into forest soils for improved soil nutrient balance or remove them for use in bioenergy production. The latter remains a common practice in Czechia and there are no national regulations currently in force to limit their removal. New guidelines proposed in 2021 by the Forestry and Game Management Research Institute highlight that these residues contain a disproportionately **high share of critical nutrients** in the felled biomass, including on average roughly 50% of magnesium, 55% of calcium and 75% of phosphorus, the nutrients most lacking in forest soils in Czechia. For different risk zones of forest area with respect to soil health, it recommends either non-removal or limits on removal of logging residues up to a maximum of two thirds of volume in low-risk areas. The possibility to recover ash from biomass combustion and return it to forest soils should also be considered.[44] The MoA issues recommendations on the retention of logging residues in forests and has provided subsidy programmes for forest operators to incentivise this practice. However, the volume of logging residues is not systematically recorded other than by larger forest operators for their own management purposes.[45]

41 Srovnání standardů FSC a PEFC v České republice z hlediska záruk trvale udržitelného lesního hospodaření (Hnutí DUHA, 2017)

42 Lněnička J., Přibyla O., Jaký přínos pro les v časech klimatické změny může mít lesní certifikace? (Fakta o klimatu, April 2023)

43 Identifikace potenciálních příležitostí v cirkulární ekonomice v lesnictví (BIC/INCIEN, 2020)

44 Doporučené metody nakládání s těžebními zbytky v lesních porostech s významnou produkční funkcí z hlediska udržitelnosti bilance hlavních živin (doc. Ing. VÍT ŠRÁMEK, Ph.D. at al., Lesnický průvodce, 3/2021)

45 Consultation with MoA

As summarised in Annex 3, several current Horizon Europe projects related to forestry focus on the creation of **circular bioeconomy strategies** to develop the forest products value chain, improve resilience of European forests to climate change and other disturbances, develop adaptation measures and support future restoration.

The wood processing sector

Harvested timber is the input material for production of a large number of products used in various end-use markets, including construction and interior design, furniture, transport packaging, paper and paper products, textiles, and various consumer goods. Lower quality biomass is used for energy production. Nevertheless, there remains a large potential for improved competitiveness of the Czech wood processing sector, especially by shifting to products with higher added value, adopting state-of-the-art technologies and strengthening cooperation with international actors.[46]

Several analyses of cascading use of wood in Czechia have been undertaken in recent years by the Department of Forest and Wood Products Economics and Policy at Mendel University in Brno. This included the development of a **national timber flow model** (illustrated on the next page) using official statistics for roundwood inputs and a reverse input method derived from revenues of wood processing companies to estimate primary processing volumes, due to gaps and inaccuracies in official statistics.[47]

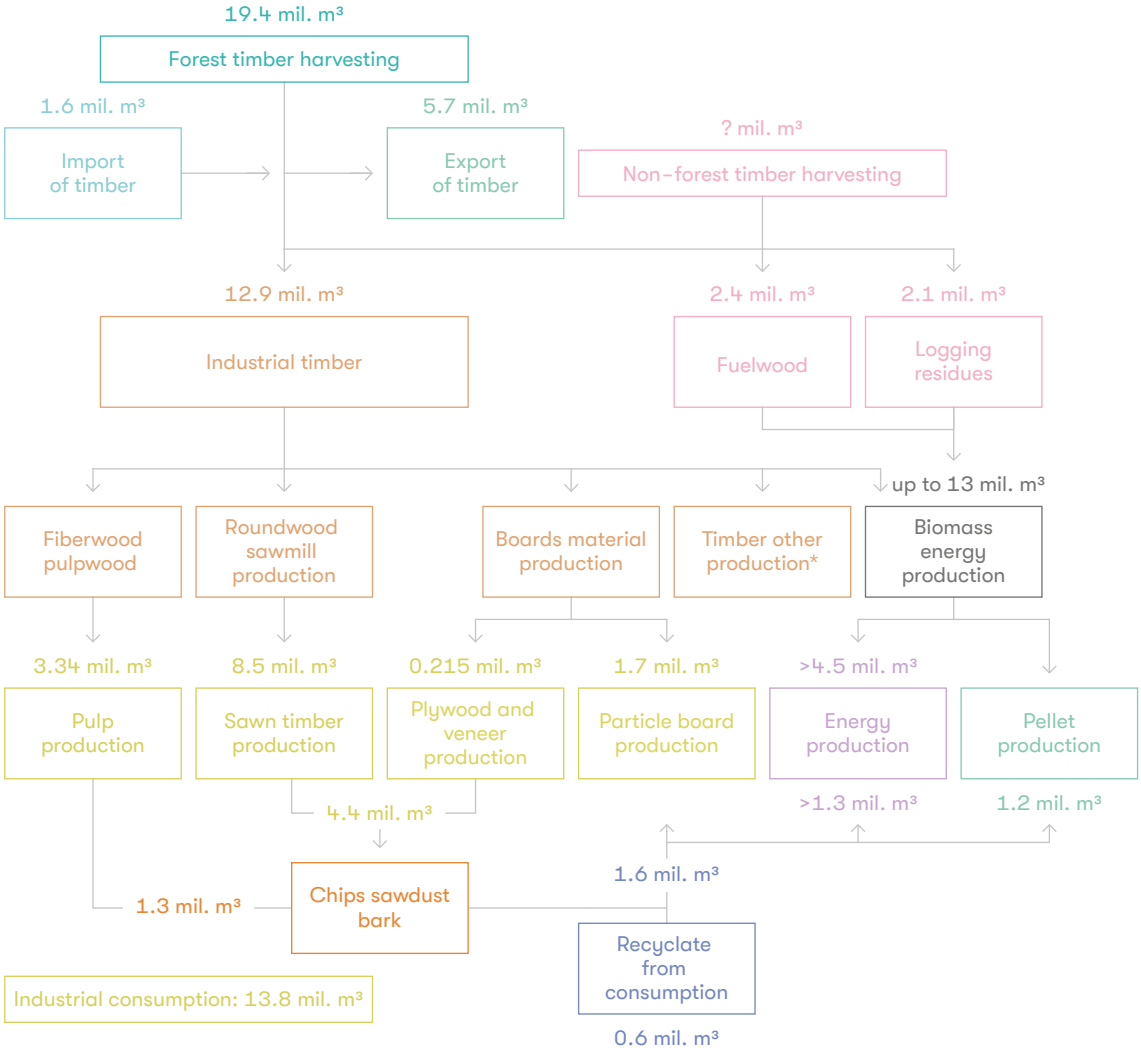
Using this model (2017 data), harvested timber in the wood processing sector flows into two main segments, **industrial timber** for pulp, sawn timber, boards material and other timber production, and **biomass energy production**. The volumes indicated in the flow diagram below reflect the industry situation prior to the peak of incidental cutting volumes in 2018–2020. One of the research articles drawing on this model highlights that cascade use of wood in Czechia shows a high rate of low-added-value primary processing and energy production.[48]

46 Panorama zpracovatelského průmyslu (MIT)

47 Šafařík, D.; Březina, D.; Michal, J.; Babuka, R. Analysis and prediction of the development of the raw material base of forest dendromas for energy purposes with regard to the current development of incidental felling in the Czech Republic. Brno University of Technology: Brno, Czech Republic, 2019.

48 Babuka, R.; Sujová, A.; Kupčák, V. Cascade Use of Wood in the Czech Republic. Forests 2020, 11, 681.

Timber flow model for Czechia (2017)[49]



* Production of matches , special pencil cutters, production of peeled and turned columns, poles, palisades and rounded products.

According to a database of wood processing capacities in Czechia compiled by Lesy ČR, raw timber processing capacities for industrial timber production increased during the calamity period from 12.8 million m³ in 2019 to almost 15 million m³ in 2021/2022, based on company data collected to date. On average in the 2019–2021 period, approximately 67% was roundwood for sawn timber production (54% roundwood, 7% 45+ logs and 6% pallets) and 33% was pulpwood for pulp (22%) and board material (11%) production. Spruce accounted for almost 85% of total harvested timber processed.[50]

49 Šafařík, D.; Hlaváčková, P.; Michal, J. Potential of Forest Biomass Resources for Renewable Energy Production in Czechia. Energies 2022, 15, 47.

50 Dřevozpracující kapacity v ČR (Lesy ČR, 2023), data processed by INCIEN

Sawmill production

Approximately 9 million m^3 of harvested timber was processed in Czechia sawmill production in 2022 (including pallets). Large and mid-sized timber processing plants (notably Labe Wood in Štětí and Stora Enso in Ždírec nad Doubravou) have taken advantage of the surplus of spruce wood on the market during the calamity period by increasing processing capacities in recent years. However, the sector is still characterised by a large number of micro and small enterprises. The 12 largest sawmills in the Lesy ČR database (with annual log cut of 100,000 m^3 or higher) accounted for 57% of sawn timber production in 2019–2021, with around 600 entities making up the balance.[51]

A shortage of workers remains a key constraint in wood processing facilities. In the context of Industry 4.0, an increasing number of companies have also been investing into production automation to reduce manpower requirements, although for smaller sawmills, automation is often not a viable option, especially for those also involved in forestry activities related to growing forests and harvesting timber.[52]

Under the OP PIK programme (2014–2020), the MIT supported a total of 462 projects in the wood processing and wood products manufacturing sector (excluding furniture) with total subsidies valued at approximately CZK 2.7 billion, as well 10 investment incentives of CZK 9.5 billion (of which CZK 2 billion in state support), mainly during 2017–2020.[53]

Despite this, a high volume of roundwood is still exported without added value, mainly due to higher selling prices in export markets, as well as continuing gaps in capacity or capabilities of domestic processing facilities. In addition, forestry operators that have favourable long-term cross-border contracts with foreign buyers, especially from Germany and Austria, have no reason to discontinue these supply relationships.[54] The same is true for domestic production of sawn timber products, with over 45% exported in 2021, while over 15% of domestic demand for sawmill products was met by imports. Due to higher prices, even large domestic sawmills continue to be dependent on exports to processors in Germany (sawn timber, construction joinery and pallets) and Austria (roundwood, sawn timber, veneers and agglomerated products and plywood).[55]

Roundwood at sawmills is processed into beams for trusses, planks or lateral sawn timber. Beams for trusses are prism-shaped, come from the centre of the tree and are the highest value sawmill product. Planks can be used in the production of CLT panels, while lateral sawn timber, the least expensive part of roundwood logs, is also used in construction. As a general rule, approximately 60% of roundwood volume in sawmill operations is used for products and 40% is wood-based waste.[56]

51 Dřevozpracující kapacity v ČR (Lesy ČR, 2023), data processed by INCIEN

52 Panorama zpracovatelského průmyslu (MIT)

53 Consultation with MIT, Department of Sectoral Expertise

54 Consultation with MoA, Department of Forestry Management Policy

55 Market Statement of the Czech Republic, UNECE, Committee on Forest and the Forest Industry, 80th session, Geneva, November 2022.

56 Consultation with Czech University of Life Science Prague

There are ongoing efforts, using new technologies, to maximise yields in order to reduce the amount of waste wood during logging and sawmill production.[57] Large sawmills and woodworking plants aim to have a zero-waste operation by utilising or selling all offcuts and residues. These can be used in production of building materials, plywood, veneer, packaging and furniture. Finally, this closed cycle model includes recovery of bioenergy, i.e. processing of any residual waste streams in combustion and heating of kilns and buildings at the sawmill.[58] Other by-products of sawmill operations are leftover bark, which can be composted or made into mulch, sawdust and shavings, which can be utilised in chips or small pellets. Process waste can also be used to produce biodegradable materials from fungal mycelium, such as packaging and design products (Myco, Mykilio – a member of the Progresus group).[59]

Boards material production

Solid wood board products with original structures comprise single-layer and multi-layer boards (from 3 to 7 layers). Single-layer boards are used for production of furniture, building panels, door construction, boxes and packaging. Three-layer solid wood panels (SWP) are used mainly for furniture production and also in construction. Among crosswise multi-layer panels used in construction the most well known is **cross laminated timber (CLT)** with its benefits of high structural strength, high sound and thermal insulation and natural regulation of air humidity in building interiors. Another product made from layered veneers is **laminated veneer lumber (LVL)**, which is used as a construction material andin a wide range of structural and interior elements.

A variety of **wood-based board** materials have been developed to enable the production of large-scale boards. Specific design solutions, such as cross-bonding or production by joining disintegrated small pieces of wood into one, allow for more efficient use in new areas of the construction industry. Input materials for the production of these types of boards include harvested wood, used wood and waste wood. These materials are produced in different ways from various wooden elements of different sizes and density (veneer, wood chips, particles, fibres etc.), sometimes bonded together with glue and often impregnated with chemicals, e.g. biocides or flame retardants, for specific functional properties.[60]

Various types of **composite** products are used based on different properties (mechanical, aesthetic etc.):

- Composites made from wood chips (for example OSB – oriented standard board and MFP – multifunctional panels)
- Particleboards with mineral binders (composite materials based on wood, e.g. SVD gypsum fibreboards, CTD – cementitious particle board, CVD – cement fibre board, CBPB – cement-bonded particleboard).
- Wood-based fibreboards (MDF – medium density fibreboard, with a fine and homogeneous structure, HDF – high density

57 Gaff Milan, Produkty z recyklovaného dřeva (Současnost a budoucnost recyklovaného dřeva 23.9.2019). Consultation with NIBIO.

58 Consultation with Nadace Dřevo pro život

59 https://www.myco.cz/en/; https://www.mykilio.cz/

60 Široká, Helena. Stavebnictví3000.cz: Přehled moderních materiálů na bázi dřeva (2020)

fibreboard, and other hard fibre boards with various hardness)
- Wood-plastic composites (WPC – composites of wood fibres/flour and thermoplastics).[61]

Wood-based boards (x-layer boards and composites) offer the key advantages of solid wood, such as insulation, high strength, aesthetics and easy processing while avoiding some of its negative properties (anisotropy, inhomogeneity and hygroscopicity). Other advantages include customisation to required dimensions (technical limitations are mainly the maximum size of boards produced by machines), more efficient use of wood and easier adaptation to market requirements.[62]

In terms of its share of total production (2021) in European countries included in UNECE/FAO statistics, Czechia has significant production of particleboard (excluding OSB – 965,000 m^3, 3%), OSB (924,000 m^3, 11%) and plywood (260,000 m^3, 5%). Notably, Czechia is the 4th largest producer of OSB in Europe, after Romania, Germany and Poland. However, it is only a minor producer of fibreboard (45,000 m^3, <0.5% of production, versus 3.3% of consumption).[63]

Wood recyclate as a replacement for harvested wood fibres in particleboard and OSB allows for processing into various forms and shapes, in addition to offering multiple lifecycle environmental benefits. Manufacturers of these products are looking at ways to progressively increase the rate of waste wood use. According to a case study from ČZU[64], benefits of using waste wood for board production include:

- energy savings resulting from lower moisture content of recycled wood (reduction of drying time compared to logged wood);
- faster production process;
- lower production costs;
- lower CO_2 emissions due to less burning of waste wood;
- reduction of emissions of other pollutants, for example formaldehyde from recycled wood is bound into new products and is not emitted into the atmosphere by waste wood burning;
- risk mitigation of future spruce wood shortages following bark-beetle calamity;
- lower transport CO_2 footprint if using recycled wood from local sources rather than importing recycled wood.

61 Široká, Helena. Stavebnictví3000.cz: Přehled moderních materiálů na bázi dřeva (2020)

62 Gaff Milan, Produkty z recyklovaného dřeva (Současnost a budoucnost recyklovaného dřeva 23. 9. 2019)

63 UNECE/FAO Forest Products Annual Market Review, 2021–2022 (November 2022)

64 Přemysl Šedivka, ČZU FLD, Katedra zpracování dřeva a biomateriálů, Využití recyklovaného dřeva v konkrétním provozu – případová studie (workshop 23.9.2019)

Company spotlight

Kronospan CR

Kronospan CR in Jihlava is the leading processor in Czechia of waste wood, which it has been using since 2006. Its production of particleboard (capacity of ~820,000 tonnes/year) has approximately 50% recycled wood content, but with an ultimate target of increasing this to 90%. A patented technology for OSB production (capacity of ~420,000 tonnes/year) was also launched in 2022 with 50% recycled wood content.[65] Jihlava and one other Kronospan location are the only two OSB production facilities to date with this capability. Following this innovation, the Jihlava facility's annual consumption of wood recyclate is approximately 600,000 tonnes, replacing the equivalent of around 900,000 harvested trees and contributing to carbon removals of up to 3 million tonnes of CO_2. However, due to lack of consistent waste wood collection in Czechia or specific targets or policy support for recovery of this waste stream, up to 50% of waste wood for domestic board production is still imported.[66] [67]

A research project by ČZU FLD under the TAČR GAMA 2 programme ("Green Industry for sustainable wood raw material management in Czechia: composite materials from recycled wood", 2020–2022) has even developed particleboard and OSB made of 100% recycled wood and bonded with powder lignin-based adhesive.[68] Other research projects on wood-based boards at Mendel University in Brno have evaluated an OSB production process using chips produced from recycling of old wooden beams recovered from a demolished building[69] and developed a process for moulding of wood-plastic composites from waste materials processed with the use of high-speed milling technology in cooperation with a private company.[70]

With continuing growth in wood-based construction materials, improvement and expansion in the rate of collection of recycled wood is critical to scale up

65 Examples of the circular economy in the Czech Republic (Synek Martin (FMI), 43rd session of the Joint Working Party on Forest Statistics, Economics and Management, Geneva 1.-3.6.2022)

66 GAFF, Milan, Kamil TRGALA a Tereza ADAMOVÁ. Environmentální přínos využívání recyklovaného dřeva při výrobě aglomerovaných materiálů: Odborná studie. Mojekrono.cz [online]. Praha: Kronospan, 2017

67 Rostislav Habán, Kronospan, Současnost a budoucnost recyklovaného dřeva (workshop 23.9.2019) Consultation with Kronospan (May 2023).

68 Consultation with ČZU LDF

69 MENDELU, Vědci chtějí vdechnout starým trámům nový život, June 2022

70 MENDELU, Projekty

use of processes based on recycled wood with a high share of locally recovered waste. Improved collection of wood packaging materials and wooden furniture offers the potential for a relatively achievable increase in wood recyclate volumes. Residual material from production of CLT panels, which is today mostly burned for energy, also has potential for higher added value. Contamination of some wood wastes places a limit on which waste materials can be recycled. In this respect, there is a lack of official standards for quality assessment of products made from recycled wood, i.e. secondary wood products. As a result, quality control has to be undertaken internally by each manufacturer. Kronospan CR has a detailed set of criteria for collected wood waste and a three-level quality control process to ensure that only clean material flows enter the production process.[71]

Project snapshot

EcoReFibre Project

NIBIO is a research partner of the Horizon Europe project EcoReFibre, which aims to develop and prove commercially viable methods for recycling fibreboards, currently a major contributor to incineration or landfilling of waste wood, into new fibreboards. The project brings together key actors from across the European fibreboard value chain in five industrial pilot projects, with the ambition to substitute 25% of virgin fibres with recycled fibres in European fibreboard production, through the utilisation of a circular economy approach.

Pulp production and biorefinery products

There are three pulp producers in Czechia:

Mill	Production 2021, thousand tonnes	Description[72]
Mondi Štětí	611	Kraft pulping process for packaging paper production from both harvested pulpwood and recovered paper. Consumes ~2 million m^3 of coniferous pulpwood per annum (80% or more from Czechia) and ~1 million m^3 of chips and other residues from wood processing industries.
Lenzing Biocel Paskov	285	Dissolving pulp process based on magnesium bisulfite for processing into man-made cellulosic fibres (lyocell, viscose, viscose modal etc.) at Lenzing group facilities in Austria, Indonesia and China. Consumes ~1.1 million m^3 of spruce pulpwood per annum (90% sourced from Czechia and the balance from neighbouring countries).
OP papírna (Delfort)	3	Pulp from annual plants for production of cigarette and narrow papers.

71 Consultation with Czech University of Life Sciences in Prague and Kronospan

72 Sources: Market Statement of the Czech Republic, UNECE, Committee on Forest and the Forest Industry, 80th session, Geneva, November 2022; Lesy ČR – Databáze zpracovatelů dřeva v ČR (as of 12.4.2023); Sustainability Report 2022 Lenzing Group.

In the kraft process, wood chips are boiled in a mixture of water, sodium hydroxide (NaOH), and sodium sulphide (Na2S) (white liquor) to break the bonds between lignin, hemicellulose, and cellulose. After boiling, the lignin and a small part of the cellulose from the wood is dissolved in the liquor to produce "black liquor", which is thickened and burned in a regeneration boiler. After burning, inorganic residues are dissolved in a "green liquor" and regenerated with the use of lime back into white liquor, forming a chemical recycling loop. Of the wood material inputs, approximately 50% is retained in the pulp and the balance comprises processing residues. These residues are typically used for on-site bioenergy production.[73]

In the case of the Paskov dissolving pulp mill:

- 41.5% of the wood raw material is converted into pulp;
- 51.0% is converted into bioenergy for on-site use (with a surplus fed into the local grid);
- 7.5% is utilised in production of biorefinery products, including:
  - LENZING™ Soda Ash (for use in glass manufacturing, paper production and as a cleaning product);
  - LENZING™ Magnesium-Lignosulphonate Biobased (for use in animal feed, fireproof bricks and tanning agents, auxiliary material for construction, fertilisers, ceramics or chipboard and fireboard).[74]

Important by-products of kraft pulping of coniferous softwood globally are **crude sulphate turpentine** (used in fragrances, cleaning products and solvents for dyes and varnishes) as well as products from black liquor: crude tall oil (40–45%), lignin (35–45%) and other organic compounds (10–15%). **Crude tall oil,** which is extracted from tall oil soap, can be further distilled to produce tall oil fatty acids (35%), tall oil rosin (30%), tall oil pitch (20%), tall oil heads (10%) and distilled tail oil (5%). While **lignin** is mostly used in pulp mills as a low-value material for heat recovery and regeneration of pulping chemicals, various high value-added material uses exist in the production of advanced biofuels, adhesives, impregnation materials, coatings and many other products. These material uses currently account for less than 2% of its total global use, indicating a vast untapped potential in high-value biomaterial applications.[75]

Other recent research by ČZU FLD has developed a pelletisation method for powdered lignin, not for combustion purposes but for easier handling and transport to enable its further processing, for example in production of lignin-based resins for manufacturing of high-pressure laminates, plywood, fibreboard or other wood-based composite materials.[76] Related to this is ČZU FLD's aforementioned project on the development of particleboard and OSB made from 100% recycled wood that is bonded with powder lignin-based adhesive.

73 Interview with Mondi Štětí

74 Lenzing Biocel Paskov – Products

75 Hassegawa, M.; Van Brusselen, J.; Cramm, M.; Verkerk, P.J.: Wood-Based Products in the Circular Bioeconomy: Status and Opportunities towards Environmental Sustainability. Land 2022, 11, 2131.

76 HÝSEK, Štěpán. Inovované možnosti využití dřeva. Lesnická práce. 2021, 100(8), pp. 30–32. ISSN 0322-9254.

An earlier Czech-Norway research collaboration (CYTOWALL – CEITEC Brno and Norwegian University of Science and Technology, 2016) patented a method to increase lignin production in trees through genetically engineered seeds (e.g. for populus trees) to enable its expanded use as a biofuel with high thermal value or for production of specialty biochemicals such as vanillin.[77] In addition to these, Borregaard in Norway already produces various lignin-based biorefinery products as additives for kaolin (used in ceramics production), concrete admixtures, substitute polymers to polyurethane foams used in the automotive industry and other applications.[78]

Biomass energy production

As discussed in Chapter 2 on the EU policy framework, in accordance with the biomass cascading principle in the EU Forestry Strategy and proposed RED III directive, wood biomass should be used for other purposes than for incineration, except in specific cases (necessary forest management activities, salvage logging, wood types unsuitable for local processing facilities). Where biomass combustion occurs, the resulting ash can still be used as an ingredient in building materials or is compostable.[79]

Bioenergy is the currently main source of renewable energy in the EU, accounting for 60% of the total.[80] The EU's 2030 target for the share of renewable energy in total energy consumption under current legislation is 32%, but is to be increased under the EU's REPowerEU plan and RED III directive to 42.5%, with an "additional 2.5% indicative top up" to 45%. [81] In Czechia, bioenergy's current share in renewables is well above the EU average (80–85%), while renewables satisfy approximately 18% of total energy consumption.[82] The 2030 renewables share target (22%) in Czechia's current National Energy and Climate Plan (NECP) is to be significantly increased in its 2023/2024 revision, in line with the EU's increased ambition.

Forms of forest-based biomass energy include traditional firewood (used by ~2 million buildings in Czechia), wood briquettes or wood pellets (used by ~45,000 households and companies in 2022). Although pellet prices spiked during the 2022 energy crisis, the increase was around half that for electricity or district heating. Total production of **wood pellets** was 538,000 tonnes in 2022, of which 94% was ENplus-certified A1 grade pellets, similar to volumes for 2021. Most mills produce less than 15,000 tonnes of pellets per year. The top three producers account for over 60% of production.[83]

77 Vědci z CEITEC MU patentovali metodu zvyšující využitelnost dřeva (CEITEC, October 2016)

78 https://www.borregaard.com/product-areas/

79 Materiálové využití recyklovaného dřeva v České republice: Hýsek, Š., Hýsková, P., Fakulta lesnická a dřevařská, ČZU v Praze, Odpadové forum, Ročník 21, Číslo 1.

80 Biomass (European Commission, Directorate-General for Energy)

81 Council and Parliament reach provisional deal on renewable energy directive (European Council, 30.3.2023)

82 Market Statement of the Czech Republic, UNECE, Committee on Forest and the Forest Industry, 80th session, Geneva, November 2022.

83 Produkce dřevních pelet si v Česku drží dynamickou úroveň (Klastr Česká peleta, 4.4.2023)

Company	Location	Production 2022, thousand tonnes
Pfeifer Holz s.r.o.	Chanovice, Trhanov	157
Mayr-Melnhof Holz Paskov s.r.o.	Stařič	102
Stora Enso Wood Products s.r.o.	Štírec nad Doubravou	67

A 2021 research article by the Department of Forest and Wood Products Economics and Policy at Mendel University in Brno concluded that available wood biomass volume for bioenergy in Czechia, at 13.5 million tonnes per year up to 2036 (of which around 7.6 million tonnes from primary wood production) is already at its maximum available limit according to sustainable forestry principles. It will therefore be insufficient to meet the growth required to meet even current national targets for renewable energy production by 2030 without negatively impacting material use of wood in sawmill, pulp and paper and board production sectors. An increase in the share of forest biomass in the national energy mix in the last several years is another result of salvage cutting due to the bark-beetle calamity. This is assumed to be a temporary phenomenon and its impact beyond the short term will be a reduction in wood biomass availability for bioenergy due to the need for reafforestation of affected areas.

Estimated total annual available volume of dendromass for energy production in Czechia for the period to 2036[84]	
Type of Forest Biomass	**Annual volume, million m³**
Fuelwood (up to 7 cm without bark)	8.165
Forest residues	4.185
Pre-production	5.169
Non-industrial wood production	1.488
Non-industrial wood recyclate	0.558
Secondary production (by-products of industrial, construction, demolition, and packaging processes)	2.200
Total (13.5 million tonnes)	**21.765**

84 Šafařík, D.; Hlaváčková, P.; Michal, J. Potential of Forest Biomass Resources for Renewable Energy Production in Czechia. Energies 2022, 15, 47.

To meet EU and national targets for renewable energy including from wood biomass, the article argues that focus should be on any additional waste recovery from paper mills, sawmills or the construction industry. However, the additional potential is likely to be small and will compete with other material uses of these streams based on the biomass cascading principle. At the time of writing, the MoE was in the process of finalising a long-awaited "Decree laying down the conditions under which solid fuel from waste ceases to be waste" (and thereby falls outside the waste management regime). The decree was due to come into effect in June 2023, following a second round of inter-ministerial consultation in March 2023. Article 3 of the draft states that "fuel from waste biomass ceases to be waste if it is produced only from other [specified] wastes that cannot be managed in a more appropriate way in accordance with the waste hierarchy".[85] These "other wastes" include:

Catalogue n°. (N=hazardous)	Waste type
03 01 05	Waste from wood processing and production of boards and furniture — sawdust, shavings, off-cuts, wood, particle board and veneers (non-hazardous)
15 01 03	Wooden packaging
17 02 01	Construction and demolition waste — Wood
19 12 01	Paper and cardboard
19 12 07	Wood waste from waste treatment not otherwise specified (e.g. sorting, shredding, baling, pelletizing) (non-hazardous)
20 01 38	Municipal waste — components from separate collection other than packaging (non-hazardous) — Wood

As noted by Kronospan CR, limiting the exemption from waste management rules to wastes that "cannot be managed in a more appropriate way in accordance with the waste hierarchy" is becoming difficult to implement in practice in an environment of growing demand (as well as rising prices and subsidies) for waste biomass for energy recovery; as a result, even wastes that are in principle suitable for recycling in board production are increasingly diverted into the energy sector.[86]

85 Návrh vyhlášky o stanovení podmínek, při jejichž splnění přestává být tuhé palivo z odpadu odpadem (Úřad vlády České republiky, ODok portál, accessed 14.5.2023)

86 Consultation with Kronospan CR

Wood-based product value chains

Wood construction

The use of wood in buildings has a history going back millenia, but has in recent decades played a relatively small role in the European construction industry outside of Scandinavia. In the context of the European Green Deal and the EU's commitment to achieving climate neutrality by mid-century, wood construction has reemerged in the last several years as a major topic in the context of pathways to reduce extraction of finite mineral and metal resources and mitigate CO_2 emissions embodied in energy-intensive production and transportation of building materials (especially steel and cement). Wood is a renewable material that can store carbon in long-lasting products and structures. As such, construction represents by far the leading opportunity and source of demand growth for wood products in the coming years. Aside from its function as a carbon sink, wood has many other benefits in construction in terms of its technical properties, flexibility and recyclability, speed, precision and efficiency in manufacturing and assembly as well as positive impacts on buildings' interior environment quality and energy efficiency. The increased use of wood in construction is currently supported through multiple EU policy and legislative initiatives, as outlined in Chapter 2 of the study.

There is a large and expanding literature on wood construction covering technical aspects and its mitigation potential as a substitute material as well as innovative methods of mass timber construction to expand its use to larger and taller buildings in residential, commercial and mixed-use developments, industrial facilities and the public sector. A growing number of international timber skyscraper projects have attracted attention as showcases in recent years with up to 25 storeys. One planned project in Switzerland will have as many as 32.[87] As these topics have been extensively covered in international studies, industry periodicals and even the mainstream media, the wider discussion around wood construction will not be repeated here. A major recent contribution to the educational literature in Czech is the 2022 publication **"Dřevo!"** (Wood!) by architect Matyáš Cigler, which provides an encyclopaedic treatment of wood and its use in multifarious aspects of buildings in the past, present and future in both an international and local context.[88] A comprehensive list of other relevant sources on this topic is provided in Annex 4.

The focus of the following section is on the role that circularity concepts should play in supporting the long-term sustainability of wood construction, as well as recent trends in wood construction in Czechia.

Circularity in the context of wood construction

The application of circular concepts to the construction sector as a whole has also been the subject of numerous studies over the past three years. The use of mass timber products to replace emission-intensive materials in buildings is often discussed as an important "circular" strategy in its own right, but the application of circularity principles to how wood is itself used in buildings has only recently begun to

87 Rocket&Tigerli, Winterthur, Switzerland (SHL Architects)

88 Dřevo! (Matyáš Cigler, Premium Media Products, s.r.o., 2022)

receive more systematic attention. In particular, following a broader assessment of circularity in forest-based industries, the Joint UNECE/FAO Forestry and Timber Section published a draft study on its application to wood construction in October 2022.[89] The following text summarises the main themes of the study related to circularity.

For the production/construction phase of wood buildings, three modern construction techniques are highlighted – mass timber, panelised and modular construction. These techniques embody the circularity principle of **material efficiency**, as they are characterised by a high level of off-site prefabrication, enabling faster and more resource-efficient in-plant assembly, reduction in process waste (up to 80% or more in the case of modular systems)[90] and more effective reuse or recycling of recovered waste compared to on-site methods.

Project snapshot
SirkRESSURS

SirkRESSURS is a sub-project within the wider SirkTRE project focusing on reduced resource use. Its three work packages aim to develop wooden connectors to use in wooden structures for industrial use, in order to minimise use of steel for such applications and increase recyclability. Furthermore, it focuses on creating a common guide for the planning and laying of water heaters in wood-based panels, and lastly reducing waste from construction sites and creating value through its utilisation for new products, on the basis of circularity principles.

With the scale-up of commercial production of cross-laminated timber (CLT) over the last 20 years, in combination with other engineered wood products, **mass timber construction** (MTC) has become a headline construction industry trend, especially for tall buildings. CLT panels can be used for floors, ceilings and roofs as well as exterior and interior walls, staircases and other parts of buildings, in combination with concrete and/or steel structures. In addition to the climate benefits of wood, other advantages of MTC (compared to traditional reinforced concrete structures), including shorter construction time, fewer construction trades and on-site workers, and reduction in transport and on-site facilities, have been documented in various studies.

Timber-based **panelised** construction comprises off-site prefabrication of wall and roof sections at various levels of completion, but may also include engineered floor systems installed on a pre-laid foundation. Offsite prefabrication of buildings is most advanced in Sweden, with

89 Circularity concepts in wood construction (draft) (United Nations (UNECE) and FAO, ECE/TIM/2022/INF3, October 2022)

90 Loizou, L., Barati, K., Shen, X. and Li, B. Quantifying Advantages of Modular Construction: Waste Generation. Buildings 2021, 11(12), 622 (December 2021)

panelised single-dwelling homes making up 80% of the housing market.[91] In **modular** systems, almost all components are factory-assembled based on precision design tools (such as CAD and BIM) and completed modules are delivered to site with finished exteriors and interiors. Both techniques enable major reductions in on-site construction times compared with traditional on-site construction.

From a circularity perspective, both are also well suited to subsequent **disassembly** and **refurbishment/reassembly** for use in other buildings or for different purposes, creating opportunities to extend the service life of wooden structures and retain their embodied carbon while potentially displacing new construction that might arise in a less adaptable system.

Project snapshot

SirkREALISERING

SirkREALISERING is a sub-project within the wider SirkTRE project focusing on≈the implementation of projects with circular wood products, solutions and designs for reuse. One of its aims is to motivate the prefabricated houses industry to produce circular homes with minimum climate footprint, with focus on demountability. A further goal is upgrading buildings to current regulations with the use of recycled materials, as well as developing methods and collaborative processes for the implementation of buildings through reuse solutions, as well as facilitating reuse of building materials. Another initiative is the creation of a prototype fully circular wall that can be dismantled and moved or reused.

During and at the end of a building's service life, the principle of **cascading use** that applies to the wood processing industry as a whole can and should be applied to wood structures and components in the building, i.e. first their retention or **reuse** through **repair, refurbishment or rehoming**, failing that their **recycling** into other wood-based products, or, where even that is not feasible, the **recovery of the embodied energy** in bioenergy production. Notably, if carbon contained in wood structures is not retained at the end of building life, the relative lifecycle carbon advantage of wood over alternative materials can fall by up to 50%, according to two 2013 studies on end-of-life CLT buildings.[92] This underlines the importance of the end-of-life phase of wood buildings in fulfilling long-term decarbonisation and circularity goals.

91 How Sweden became the home of the prefab (Built Offsite magazine, Issue 05)

92 Darby, H., Elmualim, A. and Kelly, F. 2013. A Case Study to Investigate the Life Cycle Carbon Emissions and Carbon Storage of a Cross-Laminated Timber, Multi-Storey Residential Building; Durlinger, B., Crossin, E. and Wong, J. 2013. Life-Cycle Assessment of a Cross Laminated Timber Building.

Project snapshot
REWINNUSE

NIBIO and Slovenian partners cooperate within the Norway Grants project REWINNUSE, focusing on implementing circularity principles in the design of window frames. The project focus is twofold; firstly, developing a new model of wooden windows with glass, designed for disassembly, reuse and recycling and eliminating use of adhesives and silicones. Secondly, replacing spruce as an input material by an alternative wood source, as well as reusing waste wood to make window frames. These strategies will lead to increased reuse and recyclability, as well as reduction in material consumption, which is especially important in the context of declining availability of spruce wood due to changing forest structures.

Similarly to other building materials, end-of-life management practices for wood in buildings currently fall far short of the cascading principle and represent the largest improvement opportunity for wood circularity, i.e., greater recovery of wood for reuse or recycling. According to an analysis by the BioREG Horizon 2020 project (2018), the potential annual volume of **construction and demolition waste (CDW) wood** in the EU is over 50 million tonnes. The largest producers of CDW wood in Europe are Germany, France, Italy, UK and the Netherlands. The potential assessed volume for Czechia was around 300,000 tonnes (six times higher than in official statistics and around 70% of all reported sources of wood waste).[93]

Only a tiny fraction of end-of-life wood in buildings today is reused for construction or renovation of other buildings and the major share is incinerated or landfilled, with a smaller portion chipped for recycling in production of particleboard products. Procedures for conducting **pre-demolition audits** of buildings followed by **selective demolition** and **disassembly** of materials and components to separate CDW in its constituent waste streams are set out in the EU's Demolition and Construction Waste Management Protocol and Guidelines.[94] The Czech Ministry of Environment (MoE) has also published a set of national guidelines as a supplement to the national Waste Management Plan.[95] However, these are non-binding guidelines, and such practices remain an exception due to the additional time and cost involved.

In 2022, the Platform for Sustainable Finance (PSF) proposed technical screening criteria for sustainable activities related to "Construction of New Buildings", "Renovation of Existing Buildings" and "Demolition of Buildings and Other Structures'', to be included in the Environmental Delegated Act of the **EU Taxonomy**, with effect from 2024. The

93 European wood waste statistics report for recipient and model regions (BioReg, D1.1, November 2018)

94 EU Construction and Demolition Waste Management Protocol (European Commission, September 2016); Guidelines for the waste audits before demolition and renovation works of buildings (May 2018)

95 Metodický návod pro řízení vzniku stavebních a demoličních odpadů a pro nakládání s nimi (MoE, August 2018)

proposal would require Taxonomy-compliant demolition activities to include a pre-demolition audit, all CDW to be treated in accordance with the EU Protocol and at least 90% (by weight) of total non-hazardous CDW – and at least 70% of the non-mineral / non-stony fraction of this waste, including wood – to be prepared for reuse, for recycling or for closed-loop recycling. The EU **Level(s)** indicator 2.2 (construction and demolition waste and materials) is the proposed reference framework, using its Level 3 reporting format for different waste streams.

The most effective strategy for increasing reuse and recycling rates of end-of-life building materials over the long term, including wood, is through the adoption of **design practices for adaptability, renovation, deconstruction, reuse and recycling**. Although this has been an active topic of research for decades, only a negligible part of today's existing building stock is designed according to these principles. To stimulate adoption of these principles in practice, another criterion proposed by the European Commission for the Taxonomy Environmental Delegated Act is that "construction designs and techniques support circularity via the incorporation of concepts for deisgn for adaptability and deconstruction [...] Compliance with this requirement is demonstrated by reporting on the Level(s) indicators 2.3 (design for adaptability and renovation) and 2.4 (design for deconstruction) at Level 2."[96]

Project snapshot
SirkTEK

SirkTEK is a sub-project within the ongoing SirkTRE project focusing on new technologies and digitalisation. It aims to develop an overview of existing buildings that are planned to be dismantled, in order to better understand the properties of wood used in those buildings and its potential for reuse. Furthermore, it aims to develop solutions for material, process and information flow (ICT) for more circular and efficient production.

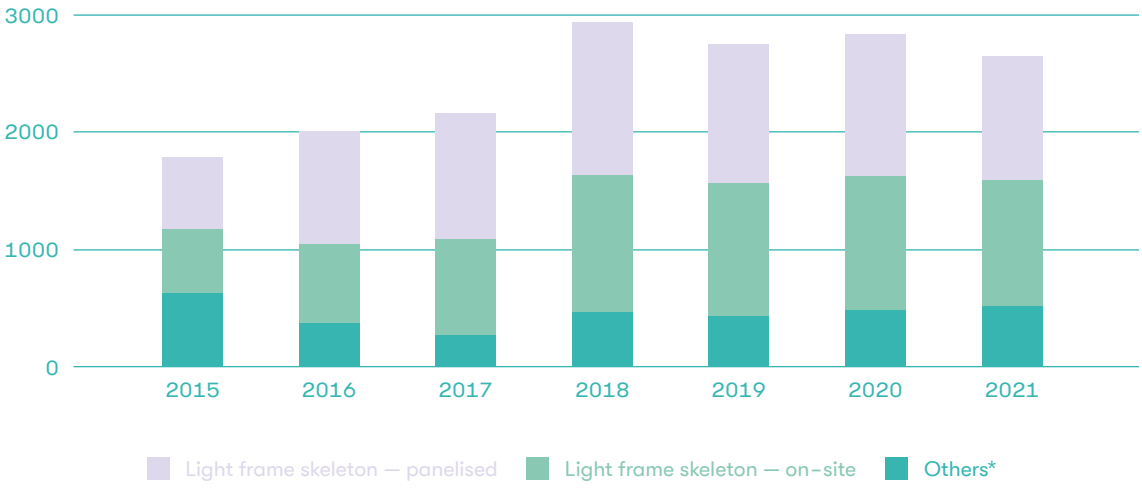
96 European Commission (June 2023): Taxonomy Environmental Delegated Act – Annex II: Transition to a circular economy (draft).

Wood construction in Czechia

Reflecting international trends, wood construction has become an increasingly hot topic in **Czechia** in the last several years. This is in part a reaction to the large increase in salvage timber felling during the bark-beetle calamity, which the domestic wood processing industry lacked adequate capacities to exploit, leading to high volumes of exported roundwood with no added value. It is also gaining more attention from local real estate developers, architects, construction firms and policy makers due to a growing awareness of the need to address not only operational CO_2 emissions from buildings (energy efficiency) but also the embodied carbon in building materials as well as to mitigate the risk of declining local availability of sand and aggregates.

According to national building fire safety standards, the height of wood structure buildings that fall within standard permitting procedures is currently capped at 12 metres above ground, imposing an effective limit of four to five storeys. As a result, wood construction in Czechia is found primarily in **family houses**. Its share in this segment has grown significantly since 2015, averaging around 15% of total completed family houses over the period 2015–2021.[97] Growth in absolute units levelled off during the COVID-19 pandemic, due to delays in building permits, the increased price of timber and prolonged delivery times. In line with international practice, there is also a trend towards more panelised and modular construction using off-site prefabrication techniques, which are faster than traditional timber construction, while reducing waste on construction sites.

Construction of wooden family houses in Czechia (units)



* Others include log cabins and log houses, solid wood panel construction and heavy skeleton wood buildings (post and beam structures). Source: CZSO

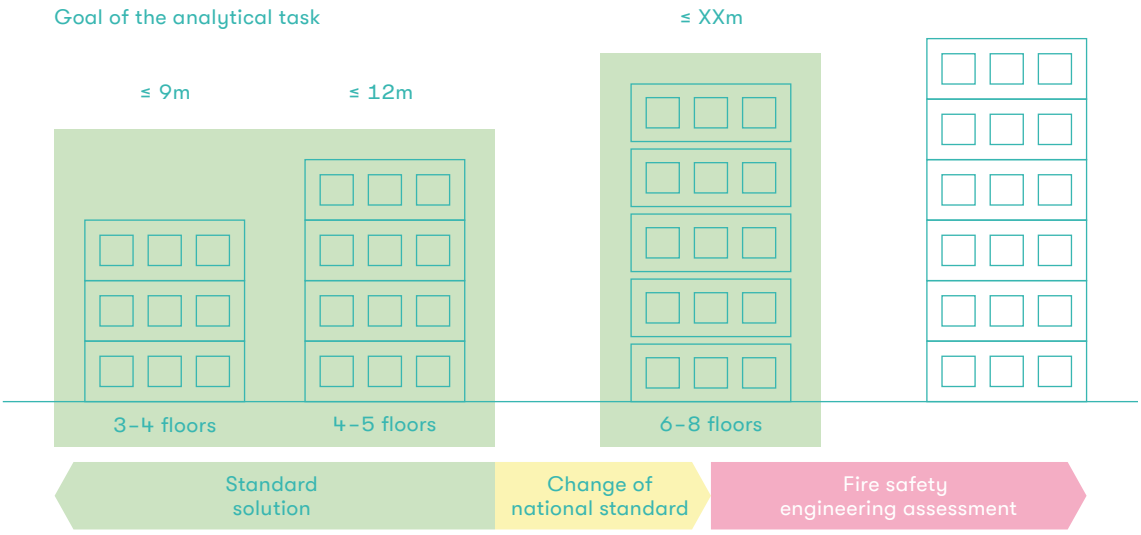
97 Completed buildings by Construction Materials 2000–2021 (CZSO, 6.9.2022)

By contrast, wood (including MTC) has less than 1% share in residential construction of multi-dwelling buildings (apartments) in Czechia, compared with 7% in Germany, 10% in Austria and Switzerland and over 60% in Scandinavia.[98] Although wood construction in buildings over 12 metres in height is theoretically possible in Czechia, it requires a performance-based fire safety design, which is a complex and lengthy process without guarantee of success. From a practical standpoint, this makes such projects generally unviable for investors.[99]

Key actors in the Czech wood processing and construction sectors have been advocating for less restrictive national fire safety standards for wood construction for many years without significant progress.

Nevertheless, a potential breakthrough is in prospect in the coming years. The University Centre for Energy Efficient Buildings (UCEEB) under the Czech Technical University in Prague (ČVUT) is undertaking a set of 12 analytical tasks for the Czech Standardisation Agency to address current problem areas in national technical building standards. One of these is to update current standards to allow greater use of wood in construction. The goal by 2025 is to propose a revision of national standard ČSN 73 0810 (Fire protection of buildings) and related standards that would extend the scope of standard permitting procedures to wood structures of 6–8 storeys and streamline performance-based fire safety design requirements for even taller structures.[100]

Multi-storey wood structure buildings in Czechia



Source: UCEEB

98 Data cited by Lesy ČR

99 Interview with Progresus; Seminar in Czech Chamber of Deputies, January 2023

100 Aktivity a plány na změnu českých požárních norem a předpisů pro umožnění širšího využití dřeva ve stavebnictví (ČVUT UCEEB, Seminar in Czech Chamber of Deputies, 10.1.2023)

Pending the outcome of this review, projects are under way to introduce MTC in multi-dwelling residential buildings. The largest of these at the time of writing was Skanska's "Radlický dřevák" project in Prague's Radlice district. With a design by Jakub Cigler Architects, the project will include one four-storey MTC apartment building of approximately 80 units as a pilot for benchmarking the climate, energy and other benefits of MTC using CLT panels for lead bearing structures against two adjacent buildings with a conventional reinforced concrete structure. Timber used in the construction (1,600 m^3) will replace almost half of the concrete required in conventional construction, reducing the building's embodied carbon by almost 30%, as well as storing approximately 1,400 tonnes of CO_2 during its lifetime. Construction may begin as early as 2024, with a plan to expand MTC to a commercial building at a later stage.[101] Meanwhile, UBM Development launched in April 2023 construction and sale of its "Timber Praha" project in Prague's Řeporyje district, part of the Arcus City development, with completion planned by Q4 2024. Based on an in-house adaptation of a traditional concrete structure, it will comprise 62 apartments, using spruce CLT panels for internal load-bearing walls and ceilings of above-ground floors and the Two-By-Four (TBF) system (post-and-beam larch timber frame construction) for external facades. UBM anticipates embodied carbon savings of up to 60% relative to a conventional concrete structure.[102]

On the supply side, central Europe (principally Germany, Austria and Switzerland, but also Italy and Czechia) remains the leading production region for CLT panels, accounting for over half of global output. Production in these countries has grown from 1 million m^3 in 2020 to close to 1.3 million m^3 in 2022.[103] Czech CLT lines have been relatively small in scale to date (Agrop Nova, FHS Holzbau, Nema), but the country's first large-scale CLT line, at Stora Enso's Ždírec nad Doubravou facility, was launched in Q3 2022, with full operation from Q1 2023 and a second shift planned by Q2 2023. Stora Enso indicated plans to produce 28,000 m^3 in 2023 and scale up to its target full capacity of 120,000 m^3 by 2026. The new line will bring its group capacity, including two CLT facilities in Austria and one in Sweden, to almost 0.5 million m^3.[104]

Aside from MTC, specific timber technologies have also been developed by UCEEB for energy-efficiency applications in multi-storey buildings, including ENVILOP (lightweight timber-based building envelope insulation system), MORE-CONNECT (prefabricated modular timber-based facade components for fast deep energy retrofits) and TICO (energy-efficient prefabricated system combining lightweight non-load-bearing timber-based structures with high-value concrete load-bearing structures), in cooperation with RD Rýmařov, ŽPSV and other partners. Other timber-related UCEEB projects include Automation4Timber (digitalisation of the design and construction of prefabricated

101 Skanska plánuje v České republice postavit první bytový dům ze dřeva s téměř 80 byty (Skanska press release, 20.10.2022)

102 UBM zahajuje výstavbu a prodej projektu Timber Praha (UBM press release, 18.4.2023)

103 DACH/Italy/Czech Republic: Production of cross-laminated timber to set a new record: +17% to 1.3 million m^3 (TIMBER-ONLINE.net, 7.11.2022)

104 Budoucnost dřeva jako stavebního materiálu – Otevření linky Stora Enso na CLT panely ve Ždírci nad Doubravou (Lesnická práce magazine, 11/2022)

timber houses to optimise order to delivery times), a Czech pilot project for the Ecokit 4.0 modular timber house system and, for the end-of-life phase, the Web portal "Let's recycle buildings!", commissioned by the Czech Standardisation Agency, to support selective demolition and CDW recycling.[105]

Sustainable finance can help stimulate demand for timber construction in private sector real estate development through provision of favourable loans for sustainable and energy efficient building projects or more generally by allocating capital towards such projects in line with banks' ESG strategies. However, the EU Taxonomy climate delegated act that is currently in effect focuses on the energy efficiency of buildings rather than the materials used, so does not provide incentives for the use of wood over other building materials.[106]
The **Environmental Delegated Act** of the Taxonomy, from 2024, will assess construction activities primarily in terms of circularity. The proposal adopted by the European Commission in June 2023 includes a criterion that consumption of primary raw materials in buildings construction should be minimised by use of secondary raw materials. If bio-based materials (including wood) comprise one of the three heaviest categories of materials (in kilograms) used, the maximum share of primary raw materials in this category is 80%.

To support demand for wood in public sector construction projects, the MoA, in cooperation with the Wood for Life Foundation, has published guidelines on use of wood in **public procurement**, including benefits and limitations of wood construction, potential criteria to include in tender documentation, use of preliminary market consultations and examples of good practice.[107]

Longer-term, a key demand driver for wood construction will be introduction of requirements related to **Global Warming Potential (GWP)** of buildings, also known as **Whole Life Carbon (WLC)**. This includes the total lifecycle GHG emissions of buildings, including embodied carbon in building materials. Currently, calculation of GWP is only a technical screening criterion in the EU Taxonomy for new buildings with a useful floor area of 5,000 m^2 (hence a voluntary parameter in order for a building to be "Taxonomy aligned"), but introduction of mandatory requirements for measurement of GWP for new buildings is planned from 2027 onwards under the proposed recast of the EPBD, as outlined in Chapter 2.

Several EU countries, notably France, Sweden, the Netherlands and Denmark, have already introduced mandatory national reporting requirements for WLC of buildings, but no such plan or nationally adopted method for calculating WLC currently exists in Czechia. Since mid-2022, UCEEB has been developing proposals for such a method, including the preparation of case studies and benchmarks. In March 2023, together with the Czech Green Building Council and Chance for Buildings, it also launched a national building LCA data accelerator as part of the international INDICATE project. In addition to analysing existing LCA case studies, 50 additional LCA case studies will be

105 Further details at: ENVILOP; MORE-CONNECT; TICO; Automation4Timber; Ecokit; http://www.recyklujmestavby.cz/

106 Projekty ze dřeva z pohledu Komerční banky a zeleného financování (Komerční banka, Seminar in Czech Chamber of Deputies, 10.1.2023)

107 Průvodce využitím dřeva ve veřejných zakázkách (MoA, undated)

108 INDICATE Website (Smith Innovation)

created to help define robust WLC benchmarks for Czechia's building stock.[108]

In another initiative related to LCA of buildings, the Timber Institute has recently undertaken a study on behalf of the MIT to demonstrate potential energy savings from the use of wood and other wood-based materials with natural insulants throughout the life cycle of a building. A potential result of this assessment is a coefficient factor that could be applied to calculation of a building's Energy Performance Certificate (EPC) when using renewable raw materials such as wood. The final deliverables of the project are catalogue tables for selected construction systems using renewable materials.[109]

Lack of awareness and technical knowledge of wooden construction among builders, construction companies, architects and other associated professionals is another barrier to greater demand for wood construction. For example, architecture students are rarely taught how to design timber buildings so are less likely to consider timber solutions when designing buildings in professional practice. Similarly, there remains relatively low, albeit growing, public and investor awareness of the possibilities and benefits of timber construction. For the past 13 years, the Wood for Life Foundation has organised the **Wooden Building of the Year** competition, under the auspices of the MIT, to raise awareness and recognise outstanding wooden structures, buildings and interiors, both small and large.[110] Through its **Wood Camp** project, the Association of Suppliers of Prefabricated Buildings (ADMD) also aims to raise awareness and develop skills through regular seminars for designers, architects and construction supervisors on how to design and construct wood buildings.[111]

Given the low penetration rate of wood construction in Czechia, wood circularity in buildings has received limited attention to date. Nevertheless, there is increasing interest in the topic with the prospect of further growth in the prefabricated housing market and wider development of multi-storey timber buildings, including the need for demountable and modular buildings in which individual parts can be easily replaced as needed, and used wooden components reused, recycled or upcycled.

Wooden furniture

Circular strategies to prolong the use and maintain the value of wood used in wooden furniture can be applied in the following main areas:

- Circular design of furniture, whether destined for the domestic market or export;
- Rental or furniture-as-a-service models, to increase utilisation of furniture and keep products in active circulation;
- Second-hand furniture markets, to prevent premature end of product life;
- Effective collection of end-of-life wooden furniture in local markets (whether imported or locally manufactured) for recycling;
- Use of recycled wood in furniture manufacturing.

109 Výzkumný a vývojový ústav dřevařský, Praha, s. p. se zabývá energetickou účinností dřevostaveb (MIT, October 2021); consultation with Timber Institute

110 Dřevěná stavba roku (Website of Wood for Life Foundation)

111 Wood Camp (Website of Association of Suppliers of Prefabricated Buildings)

In the coming years, building on existing GPP and EU ecolabel criteria, furniture is a likely priority product category for sectoral rules under the proposed **Ecodesign for Sustainable Products Regulation (ESPR)**, setting minimum ecodesign parameters for all products placed on the EU market as well as introducing minimum mandatory GPP criteria. For companies reporting their alignment with the EU Taxonomy, transition to a circular economy is also the primary objective for technical screening criteria under Phase II of the Taxonomy from 2024, covering repairing / refurbishing / remanufacturing and sale of spare parts, sale of second-hand, product-as-a-service and other circular use – and result-oriented service models.

Various types of **rental/service models** can be operated for wooden furniture at the retail and use stage to support higher use of furniture and provide flexibility to users with temporary or changing needs, as described in the table below. Types of services through these models include subscription-based with return; subscription-based with option to purchase; rental packages (for whole rooms or apartments); and short-term rental (e.g. for event organisers and home stagers).[112]

[1]

112 Twin Transition in the Wood-Furniture Value Chain – State-of-the-art on Environmental Certification Practices and Industry 4.0 in the Wood and Furniture Sector (INTRUST, 2022)

[2]

[1] [2] New office building of Kloubocká lesní, Brumov-Bylnice, completed in December 2022. 2023 Wooden Building of the Year winner in the categories "Constructed wooden buildings – expert jury selection" and "Constructed wooden interiors – expert jury selection". Source: Kloubocká lesní, Nadace Dřevo pro život

Model	Description
External furniture providers	Commercial (digital) marketplaces that rent furniture to customers while working in partnership with furniture manufacturers for warehousing and logistics.
Peer-to-peer platforms	Connecting owners of furniture (and other household products) with other users for rental, usually based on a commission, without providing delivery services.
Full stack models	Rental platform services provided directly by furniture companies that design and manufacture the furniture.

Most furniture currently sold in the EU is not currently designed for dismantling or recycling. Of approximately 10–11 million tonnes of furniture waste generated annually in the EU, at least 80–90% of discarded furniture is estimated to be landfilled or incinerated.[113] Specific figures for furniture waste are not reported in waste statistics, and these flows are typically captured in the category of "bulky waste". The share of furniture in bulky waste composition analyses conducted in various European countries has ranged from 20% (Vienna, for upholstered furniture only, 2021) to over 40% (UK, for furniture overall, 2012).[114]

An example of good practice in waste management policy for furniture is France, where an **Extended Producer Responsibility (EPR)** scheme for collection, recovery and recycling of waste furniture has been in place since 2013. It is operated through two Producer Responsibility Organisations (PRO) and funded from eco-fees (based on product weight) included in the price of new furniture sales. The country's 2020 circular

113 Estimate by European Federation of Furniture Manufacturers (UEA), as cited in Circular Economy Opportunities in the Furniture Sector (EEB and Eunomia, September 2017)

114 As cited by Municipal Waste Europe (22.2.2022) and Waste and Resources Action Programme (WRAP) (7.12.2012)

economy law additionally stipulates for product categories including furniture that PROs will have to finance a repair fund and retailers will be required to take back used furniture at no cost.[115]

A leading example of adoption of circular business models in the furniture industry is the multinational **IKEA**. In its supply chain, all wood used in furniture manufacturing is to be sourced either from FSC-certified wood suppliers or made using recycled wood. In the 2021 fiscal year, over 98% of wood sourced by IKEA globally already met these requirements. In the 2022 fiscal year, about 15% of total wood use was recycled wood.[116] As part of its commitment to becoming a circular and climate positive business by 2030, the company has updated its **Circular Product Design Guide** and provides an open access online assessment tool that define four circularity loops (reuse, refurbishment, remanufacturing, recycling) and eight associated circular design principles (designing for: renewable or recycled materials; standardisation; care; repair; adaptability; disassembly and reassembly; remanufacturing; and recyclability).[117]

Wooden furniture in Czechia

The value of **Czech furniture production** has shown a compound annual growth of approximately 3.5% over the past five years, reaching CZK 53 billion in 2022, mainly due to rising prices. Czech furniture production is export-oriented, with a focus on higher quality and higher value furniture. The ratio of exports to production value has risen from 61% in 2017 to 75% in 2022. These figures include all types of furniture, including materials other than wood. Leading export markets for Czech-made furniture are Germany, France, Slovakia and the Netherlands. Although domestic furniture demand (in value) has grown at the same rate as production since 2017, the share of **imported furniture** has increased from 52% to over 70% in 2021 and 2022. Poland, Germany and China are the leading sources of imported furniture.[118]

Leading furniture retailers in Czechia include IKEA, JYSK, KIKA, XXX Lutz, Sconto, Asko-Nábytek, and Möbelix CZ. The furniture market has long been highly competitive, and the growth of online retailers has further intensified price competition. There is strong domestic demand for adaptable and easy-to-handle furniture suitable for smaller living spaces (apartments, small rooms), as many new apartments sold in Czechia are studios and one-bedroom apartments. A further constraint on domestic sales of Czech furniture producers in recent years has been the low share (5%) of Czech forests with **FSC certification**, which has been a requirement of major retail chains such as IKEA and XXX Lutz for procurement of wooden furniture. Examples of major wooden furniture producers in Czechia are BJS Czech, which supplies particleboard products mainly to IKEA,[119] and TON, a traditional and well known manufacturer of wooden bentwood furniture.[120]

115 Jacques Vernier, Extended producer responsibility (EPR) in France, Field Actions Science Reports [Online], Special Issue 23 | 2021, online since 23.11.2021

116 The IKEA Forest Positive Agenda, Wood and forestry (IKEA Website, accessed 23.4.2023)

117 Designing for circularity and our future (IKEA Website, accessed 23.4.2023)

118 Association of Czech furniture producers, Press release 30.3.2023 – Statistical annex

119 Panorama zpracovatelského průmyslu (MIT)

120 TON, Wooden bentwood furniture

Post-consumer **wooden furniture waste** in Czechia may be recorded in municipal waste statistics under either waste code 20 01 38 (non-hazardous wood waste, ~75,000 tonnes) or 20 03 07 (bulky waste, ~687,000 tonnes), based on CZSO data for 2021. Within this total of ~762,000 tonnes, over 40% may comprise wooden furniture based on the aforementioned international analyses of bulky waste. A key barrier to greater reuse and recycling of wooden furniture is currently the absence not only of an EPR system for furniture but also of separate tracking, reporting, collection and sorting infrastructure for this specific sub-category of waste in the municipal waste management system.

Company spotlight

IKEA in Czechia

Czechia is one of the first countries in which IKEA has introduced a used furniture buy-back service ("Giving furniture a second life"), whereby consumers can return used IKEA furniture to IKEA stores for a pre-agreed price, and the item is then put up for sale at the same price in a discounted items section with a one-year warranty. Since June 2022, available items from these used furniture sections in IKEA stores in Czechia have been accessible online for viewing and reservation for collection within a 48-hour period. Customers are now also able to drop off used furniture and purchase commonly used furniture spare parts at IKEA stock points in eight regional Czech cities, without needing to visit an IKEA store.[121] These services are still in the introductory stage in Czechia. In 2022, approximately 6,000 items of used furniture were bought back from customers and subsequently resold, and close to 9,000 customers ordered furniture spare parts online.[122] Internationally, to support repair and prolong lifespan of products, IKEA sold close to 22 million assembly parts in 2022, including through online tools.[123] In 2020, IKEA also initiated a pilot for furniture rental services for the B2B sector in Czechia. Through this model, IKEA retains ownership of the furniture, can repair and refurbish it to extend service life and is able to recover materials and components for recycling at the end-of-life stage. Startups are a priority customer segment.[124] This service is still under evaluation, as credit risks for the service provider need to be carefully managed.

121 IKEA spouští cirkulární hub online, použitý nábytek vykoupí i v regionech, kde nabídne také náhradní díly (Press release, 7.6.2022)

122 Data provided by IKEA Czech Republic

123 Transforming into a circular business (IKEA Website, accessed 23.4.2023)

124 Firmy zkoumají cesty k udržitelnosti: Ikea zkouší pronájmy nábytku (Ekonews, 13.9.2020)

There are various other projects and companies related to collection and renovation of used furniture in Czechia, including **Z pokoje do pokoje** (From Room to Room), **Nanovo** (Back to New), **Sedíme stylově** (Sitting with Style) and the pilot project **Re-use** of the HYB4 Circular workshop in Kampus Hybernská in central Prague, in cooperation with Prazské služby, INCIEN and the Waste department of the City of Prague. In the Re-use project, used furniture is sorted in three public collection yards in Prague and the circular workshop offers this furniture free to the public with the possibility of repair. Testing of the operation of this re-use centre also provides practical experience for potential setup of similar centres in individual Prague city districts, as the city of Prague is considering. The aim is to create re-use centres that will help reduce the amount of waste, create new jobs and be economically sustainable at the same time.[125] There are also a number of Czech companies offering **furniture rental** both for office furniture and for decorative furniture for special events.

Green public procurement is a critical tool for stimulating demand for wooden furniture designed and supplied using circular and sustainable principles. In addition to voluntary EU GPP criteria,[126] the Czech Ministry of Labour and Social Affairs (MoLSA), in cooperation with INCIEN, published detailed guidelines in 2021 on responsible public procurement and the circular economy specifically for furniture.[127] As shown in the figure below it outlines a decision tree for circular furniture procurement that prioritises reuse, repair, refurbishment, service-based models or second-hand options, where available and appropriate, over purchase of new

125 Cirkulární dílna v Kampusu Hybernská zachraňuje nechtěný nábytek (Zajimej.se, 28.3.2023)

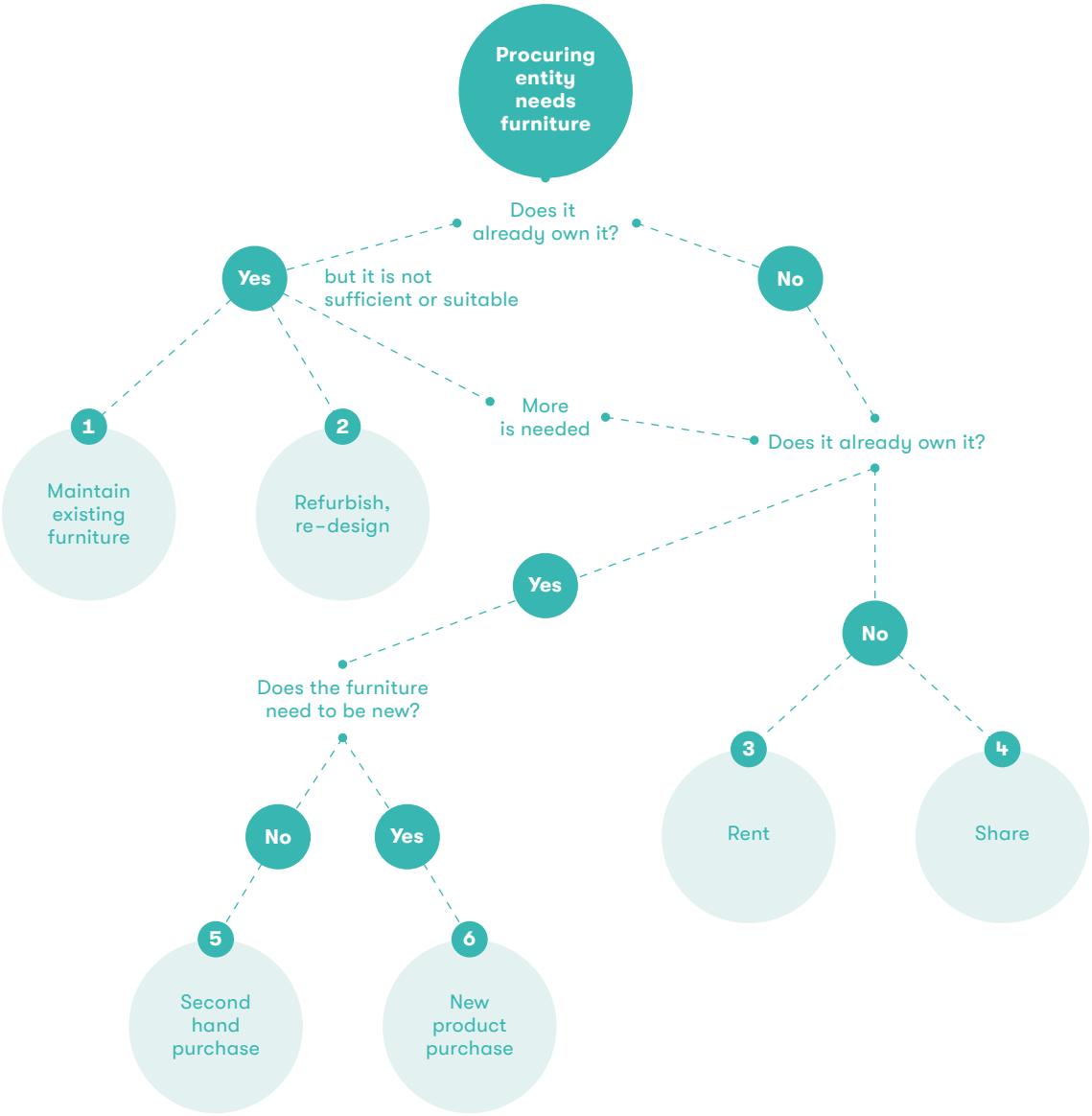
126 EU Green Public Procurement criteria for Furniture (SWD(2017) 283 final/2, Brussels, 27.7.2018)

127 Odpovědné veřejné zadávání a Cirkulární ekonomika – Nábytek (MoLSA, INCIEN, 2021)

products, which should meet ecodesign criteria based on the **EU Ecolabel** or national "**Ekologicky šetrný výrobek**" label as well as sustainable forestry criteria based on FSC or PEFC certification. Specific guidance and examples of good practice are provided for each scenario.

A broader methodology for circular public and private procurement, covering wood, furniture and several other product categories, was also published in 2022 by INCIEN, BIC Brno, INCIEN Slovakia and BIOAZUL (Spain).[128]

How to procure furniture – Step by step



Source: Odpovědné veřejné zadávání a Cirkulární ekonomika – Nábytek (MoLSA, INCIEN, 2021)

128 INCEPPP: Innovative method of circular economy in public and private procurement (Erasmus+ programme, Project number: 2020-1-CZ01-KA202-078442, May 2022)

Wooden pallets

Internationally, one of the longest-running examples of a circular business model is the **Euro pallet** system managed by the European Pallet Association e.V. (EPAL), the standardisation body responsible for monitoring the safety and quality of Euro pallets and organising the **European Pallet Pool (EPP)** since 2016. There are currently over 500 EPAL licensees producing new Euro pallets and 1,100 repair operations servicing and supplying used Euro pallets internationally. Thanks to access to the reusable EPP and repair network, the service life of wooden Euro pallets is usually between six and ten years. Based on this service life and historical production levels, the current size of the EPP is estimated at 650 million units, along with 20 million EPAL Box pallets. With strong global logistics demand in the last several years, production of new Euro pallets has continued to grow, exceeding 100 million in 2021 and reaching 109 million in 2022.[129] Despite the existence of the EPP, there remains a large market for non-standard one-way pallet production for supply chains such as automotive components; the largest Czech wooden pallet manufacturer, **Klaus Timber**, specialises in such products.[130]

The regional wooden pallet market has experienced volatile conditions over the last three years. Exacerbated by high exports of wood, pallet producers experienced a severe shortage of sawn timber for pallet production by mid-2021. One consequence of this was an increased supply of various imitation Euro pallets to make up the shortfall, especially from Ukraine and Belarus, although these products do not comply with EPAL standards. With the start of the Ukraine war, the supply of these products dried up, although pallets that had been imported before the war have continued to circulate. In addition, supply chain disruptions caused by the war resulted in a shortage of pallet nails and a sharp fall in supply of sawn timber for pallets – a major share of both of these raw materials have historically been imported from Ukraine, Belarus and Russia. In 2022 this led to a situation where the normally cheaper used Euro pallets were in high demand and available at a similar or even higher price level than new pallets.[131] By early 2023, Klaus Timber indicated signs of a saturated market and anticipated a 20% drop in pallet demand for the year as a whole. Despite this, short supply of timber for pallet production and very high prices continued to impact the market.[132] Due to high energy prices, there has also been a growing practice of

Ateliér Paletky: Atrium for office of PR Agency Ogilvy & Mather
https://www.paletky.cz/project/atrium-ogilvy-mather

129 Record EPAL Euro pallet production achieved again in 2022 (EPAL, 27.3.2023)

130 https://www.klaustimber.cz/

131 AČPP, papír a celulósa 77 (6) 2022

companies selling off used pallets to their employees, who subsequently burn the pallets for energy, in contravention of the country's Waste Act and the waste hierarchy.[133]

Pallets that cannot be economically repaired and returned to service can be collected for recycling into particleboard products or even **upcycled** to retain the embodied CO_2 in the wood and replace demand for virgin wood supply. For example, Atelier Paletky, a member of the Czech Circular Hotspot, designs ecological interiors and upcycles one-way pallets from non-traditional woods that would otherwise be incinerated or landfilled. These pallets are dismantled and remanufactured into various types of furniture and other home accessories. For the PR agency Ogilvy & Mather, for instance, the atelier provided interior design services and supplied upcycled and other used furniture for the atrium of the agency's offices to create an informal and relaxing space for employees and clients.[134]

In view of material shortages and volatile prices for wooden pallets, an example of **cascading use** of wood in this sector through processing of sawmill by-products is a joint project between the Timber Institute and a Czech private sector company. The research team of the institute proposed a certified production method for wooden pallets, covering the design of the production process, technical composition and certified testing, based on sorting, pre-treatment and processing of sawdust, shavings, off-cuts, wood chips and other waste wood streams.[135]

Paper and board products

European paper and board consumption reached a peak before the 2008 global financial crisis and has been more or less stable since 2010, with a gradual decline in consumption of **graphic papers** (digitalisation trend) offset by strong growth in **packaging paper and board** demand (reflecting growth in ecommerce). The latter now accounts for 60% of total European paper and board consumption. The European paper industry has been working continuously to increase utilisation of (waste) **paper for recycling** in paper production. From 2000 to 2021, the overall recycling rate for recovered paper in European countries covered by Confederation of European Paper

132 Enormní poptávka je pryč, ekonomika ochlazuje, říká král českých palet Marcel Klaus (E15.cz, 27.3.2023)

133 Palety – odpad nebo materiál? (Průmyslová ekologie, 7.10.2022)

134 Most z kůrovcového dřeva, zelená energie, upcyklované paletky: takto vypadá praxe cirkulárního zadávání v Čechách (Zajimej.se, 29.12.2022)

135 Případová studie Dřevařského ústavu pro upcyklaci: Převedení odpadu na vstupní výrobní materiál (Timber Institute, 2023)

Industries (CEPI) statistics rose from 52% to 71%. Over the same period, the share of recovered paper for recycling in total paper and board production rose from 45% to 56%. Germany accounted for 36% of European (CEPI) recovered paper use in 2021, followed by Italy (12%), Spain (11%) and France (10%), with other countries making up the balance (31%). By product category, recycled paper content is highest in case materials (93%) and newsprint (92%), followed by wrapping and other packaging papers (51%). By production volume, 79% of total paper for recycling in 2021 was consumed in packaging paper and board, 13% in graphic paper, 5% in sanitary and household and 3% in others.[136]

The European Commission's proposal for a **Packaging and Packaging Waste Regulation (PPWR)** proposes an 85% recycling rate target for paper-based packaging by 2030. In 2020, the European fibre-based packaging industry had already achieved an 82% recycling rate (based on Eurostat data) and, through the **4evergreen** alliance, has made a sectoral commitment to reach a 90% recycling rate by 2030. Established in 2019, 4evergreen now comprises over 100 manufacturers, designers, brand owners, researchers and recyclers of fibre-based packaging.[137] To this end, its has set the following targets by 2025 (with four associated work streams):

- The fibre-based industry recognises and uses 4evergreen's **recyclability evaluation protocol** and its **circularity by design guidelines**;
- **Separate collection streams** are available for all fibre-based packaging types, including those used in household, out-of-home and on-the-go consumption;
- All paper for recycling is **sorted** according to the paper and board categories specified in the **EN643 standard**;
- 100% of collected fibre-based packaging is recycled.

Paper and board industry in Czechia

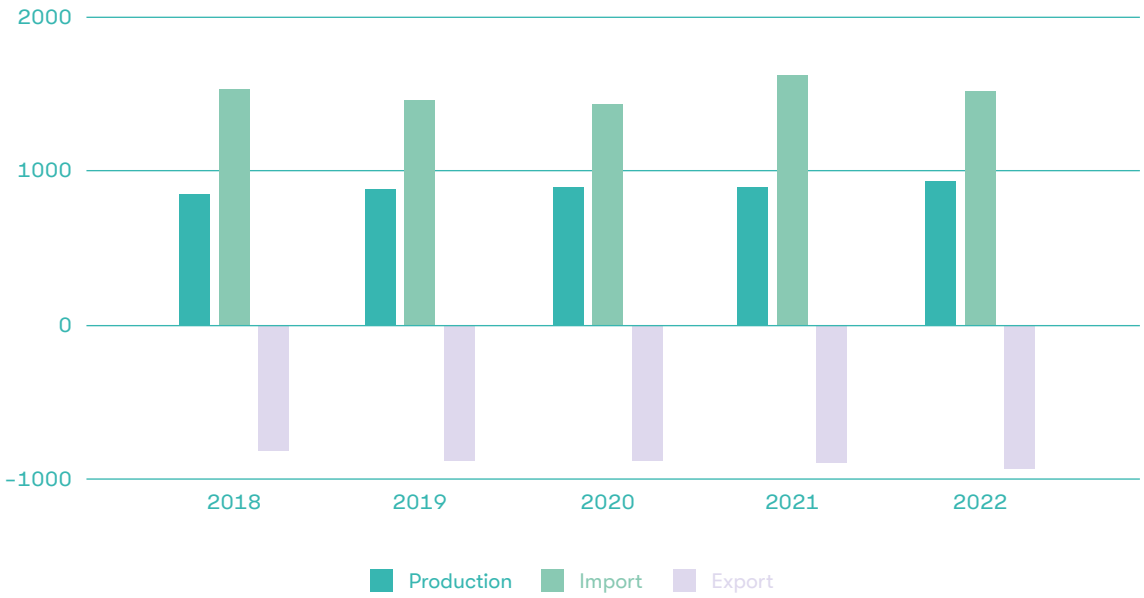
Czechia has a relatively small paper and board industry in the European context, accounting for 1% of total production and 2% of consumption in CEPI countries. Total domestic paper and board production was 0.93 million tonnes in 2022 (growing at around 3% CAGR over the last five years), while consumption was 1.53 million tonnes. Per capita consumption is close to the EU average at around 150 kg. Production volumes over the last five years are very close to export volumes, as domestic production is predominantly for export. As a result, domestic demand (with the exception of hygiene products) is predominantly satisfied by imports. In some years and product categories, exports have exceeded production due to overstock of imported paper and board products and their subsequent re-export.[138] Main producers in the country include Mondi Štětí, Huhtamaki Česká republika, Balsac papermill, JIP – Papírny Větřní, KRPA PAPER, Smurfit Kappa Czech, OP papírna, EMBA, Cardboard and PAPOS Trade.

136 CEPI Key Statistics 2021 (July 2022). Note: CEPI statistics cover 91% of European pulp and paper production, excluding the Russian Federation.

137 https://4evergreenforum.eu/

138 Annual statistical data from Papír a celulóza (periodical of the Czech paper industry association), processing by INCIEN.

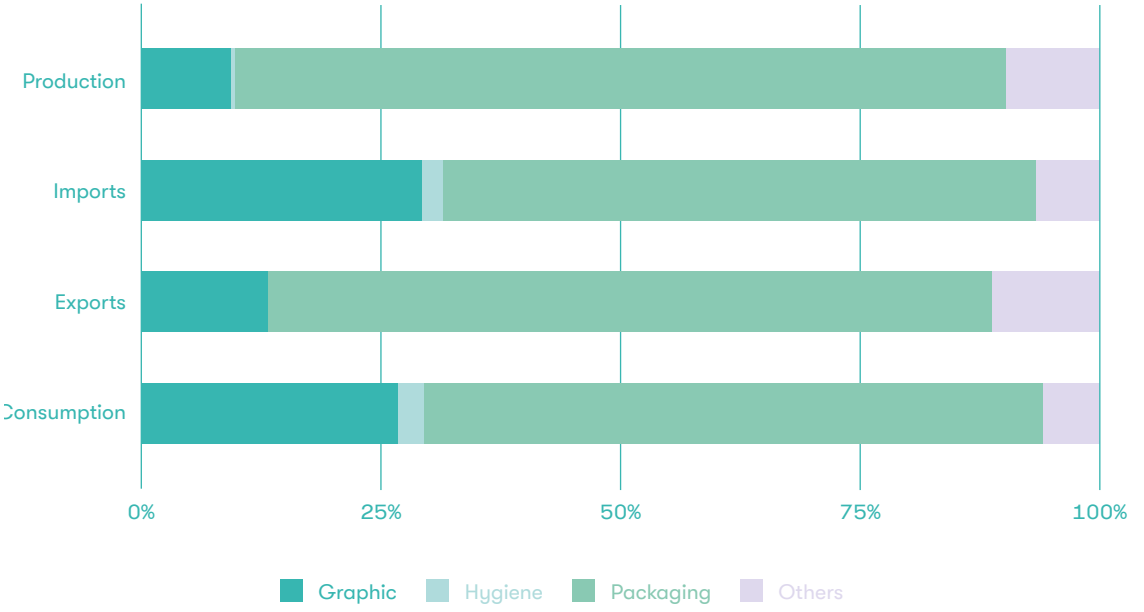
Czechia paper and board supply/demand (thousand tonnes)



Source: Asociace českého papírenského průmyslu (ACCP) – Papír a celulóza (periodical)

In terms of product category mix, both production and consumption in Czechia have followed the European trend. Packaging papers and boards have accounted for 80% or more of domestic production over the last four years. The share of graphic papers in domestic consumption has declined from 35% to 27% in 2018–2022 while that of packaging papers and boards has increased from 56% to 65% over the same period.

Czechia paper and board split by category, 2022, % of total



Source: Asociace českého papírenského průmyslu (ACCP) – Papír a celulóza (periodical)

The collection rate for used paper and board in Czechia is already high and the EU 2030 target for paper packaging recycling (85%) has in theory already been met, with a 91% recovery rate in 2021, including 88% as paper for recycling.[139] However, these percentages refer to collection, not actual recycling by domestic mills. Total collection of used paper in Czechia, including from paper products and paper-based packaging of domestically produced and imported goods, is around 1 million tonnes per annum, higher than the total volume of domestic paper and board production. Only 0.21 million tons of this recovered paper (including imports) was consumed domestically in 2022 and over 80% was exported. As such, the rate of paper for recycling actually consumed in domestic paper and board production was only 23%, half of the average for European paper and board production overall.[140] Aside from recycling in paper and board production, around 30,000 tonnes of recovered paper is processed annually by CIUR (Brandýs nad Labem) for production of cellulose-based insulation materials and a range of other industrial products.[141]

In principle, close to 80% of paper and board products produced are currently recyclable, with 5–7 potential processing cycles. The balance comprises 5% for hygienic and toilet papers that are unrecoverable and around 15% of other products that are unrecyclable based on their end-use application, including medical disposables or chemically processed papers. However, paper for recycling can only be processed by mills with machines designed for this raw material and product lines that are suitable for recycled paper. Over the past decade, several machines for recycled paper in domestic paper mills became outdated and were taken out of service, while new investments have focused on quality improvements and capacities based on primary softwood pulp, with total domestic paper recycling capacity falling below 300,000 tonnes. Over the same period, there have been a series of investments in new paper recycling capacity in neighbouring countries, further increasing the country's dependence on external trade for this commodity.[142] More recently, unstable pricing of paper for recycling over the last three years due to supply/demand fluctuations (resulting from lower collection volumes and sustained packaging demand during the COVID-19 pandemic) has been a further barrier to investment in additional capacity.[143] Nevertheless, given the high share of packaging paper and board in the national production mix and low current utilisation of domestic collected paper for recycling, significant investment in new capacities will be necessary in the coming five years to meet the industry's European recycling targets.

139 EKO-KOM Annual Summary 2021 (May 2022)

140 Annual statistical data from Papír a celulóza (periodical of the Czech paper industry association), processing by INCIEN.

141 https://www.ciur.cz/en/

142 Aktualizace Politiky druhotných surovin – Papír (MIT and AČPP, December 2018)

143 Starý papír je opět v kurzu. Sběrny za kilo dávají i pět korun (Denik.cz, 17.5.2022)

Company spotlight

Mondi Group

In October 2022, Mondi Group announced a major new €400 million investment in a sixth paper machine at Štětí, the largest pulp and paper mill in Czechia, with a planned annual capacity of 210,000 tonnes of kraft paper for packaging applications and estimated start-up in 2025. This will expand mill capacity by around 30% to a total of approximately 900,000 tonnes. The investment is intended to meet rising demand for sustainable and recyclable paper-based flexible packaging. Continuing recent investment trends in Czech paper production, the machine will process primary softwood fibres from certified sources. The mill currently consumes about 60,000 tonnes of paper for recycling on one machine (close to 30% of domestic consumption), to produce paper shopping bags. However, in view of the industry's 2030 commitments to achieve 90% recycling rates for fibre-based packaging, Mondi is also evaluating reinvestment in upgrading its current recycled paper machine as well as investment in additional paper-for-recycling capacities to process volumes currently outsourced to other European countries.[144]

144 Mondi Group Integrated report and financial statements 2022; Seznam zprávy (Papírny větší než město. Díky odporu k plastům je čeká boom za 9 miliard, 25.9.2022); Interview with Mondi Štětí (Sustainability department)

Waste wood and end-of-life products

The table below shows Czechia's 2021 waste volumes for separately reported categories related to wood waste, drawn from data in the MoE's national Waste Management Information System (ISOH) and CZSO statistics.

Recorded wood waste production in 2021		
Catalogue no. (N=hazardous)	**Waste name/type**	**Amount (tonnes)**
0301**	**Waste from wood processing and production of boards and furniture:**	**48,553**
030101	Waste bark and cork	5,705
030104 N	Sawdust, shavings, off-cuts, wood, particle board and veneers (hazardous)	140
030105	Sawdust, shavings, off-cuts, wood, particle board and veneers (non-hazardous)	42,611
030199	Waste not otherwise specified	97
030301	**Waste bark and wood from pulp, paper and paperboard production and processing**	**2,971**
150103	**Packaging (including separately collected municipal packaging waste) – Wood**	**222,853**
170201	**Construction and demolition waste – Wood**	**46,685**
1912**	**Waste from waste treatment facilities not otherwise specified (e.g. sorting, shredding, baling, pelletizing)**	**41,623**
191206 N	Wood wastes from waste treatment (hazardous)	3,916
191207	Wood wastes from waste treatment (non-hazardous)	37,707
2001**	**Municipal waste – separate collection (excluding 150103 packaging waste)**	**74,807**
200137 N	Municipal wood waste from separate collection (hazardous)	176
200138	Municipal wood waste from separate collection (non-hazardous)	74,631
	TOTAL (Hazardous)	**4,232**
	TOTAL (Non-hazardous)	**433,260**
	TOTAL	**437,492**

Source: MoE – ISOH – https://isoh.mzp.cz/visoh, CZSO
** Total for category is only the sum of selected sub-categories shown in the table

According to MoE statistics for **wood packaging waste**, 39% was recycled and 4% used for energy in 2021. This already exceeds 2030 EU and national targets for wood packaging recycling (30%), which is the lowest target among all packaging materials. The majority of wooden packaging waste that is not recovered is either burned, reused or repurposed by households and businesses (including reusable pallets) or disposed of in mixed municipal waste and landfilled.

Wood packaging waste production and treatment 2017–2021					
Wood packaging (tonnes)	2017	2018	2019	2020	2021
Waste production	148,657	169,982	183,847	177,040	222,853
Material recycling	73,306	76,426	77,792	61,588	87,247
Energy use	4,694	2,344	2,364	5,656	9,157
Other use	–	–	–	–	490
Incineration	151	690	343	1,469	–
Total recovery (including incineration)	78,151	79,461	80,498	68,712	97,461
Recycling rate, %	49.3%	45.0%	42.3%	34,8%	39.4%
Total recovery rate (including incineration), %	52.6%	46.7%	43.8%	38.8%	43.5%

Source: Packaging waste and waste treatment statistics (MoE)

There are significant gaps in wood waste statistics that prevent a complete picture of waste flows. For example, as detailed in the earlier section on wooden furniture, the majority of waste in this category is hidden in the larger category of "bulky waste" and could comprise as much as 300,000 tonnes of additional wood waste that is not separately reported. Additional waste furniture may be disposed of in illegal or unmanaged landfills or burnt by households for heating. Other blind spots in waste statistics include sell-off of unused wooden pallets and crates by companies to employees (as mentioned above), lack of selective demolition practices in construction to properly separate waste streams on site and limit contamination, and informal flows of recovered waste construction timber that are not reported in the system.[145]

In summary, data on wood waste flows is incomplete and only a minority share of the total wood waste produced is currently recovered for material use. Due to current data limitations, the total potential volume of waste wood for material recovery is not known, nor how much is too contaminated to be suitable for recycling. However, based on the above considerations it could be in the order of 1 million tonnes. This would be in line with the potential volume of wood waste required for domestic

145 Consultations with CYRKL and Kronospan

particleboard and OSB production within the next several years based on current production trends and technologies to increase the rate of recyclate use in these products.

According to Kronospan CR,[146] products suitable for production of wood recyclate at the end of their useful life include untreated wood, clean pallets, crate boards, particleboard, wooden furniture, OSB, glulam, three-layer wood flooring and fruit crates. The following types of end-of-life wood-based products are currently unsuitable for recycling and are typically landfilled or incinerated:

- Windows and window frames;
- Doors and wooden door frames;
- MDF boards;
- Impregnated and coated (painted) wood waste from exteriors (e.g. fences, garden houses and furniture);
- Wood-fibre insulation boards and wood wool boards with cement binder;
- Laminate flooring (mainly made up of fibreboard);
- Polluted pallets;
- Multiplex boards and slip-resistant boards;
- Materials containing hazardous substances: wood contaminated with asphalt and roofing felt, glued parquet flooring.

Under Czechia's new Waste Act (from January 2021), implementing the requirements of the EU 2018 first circular economy package, fees for landfilling of recoverable waste are gradually increasing (from CZK 800 per tonne in 2021 to CZK 1,850 per tonne by 2029), which should increase motivation to sort waste. However, the effective date of the ban on landfilling of recoverable waste,

146 Kronospan. Recyklované dřevo, třídění povoleného a nepovoleného recyklátu, 2022

including wood, which was originally 2024 in Czechia, was postponed in the EU framework directive until 2030.

The potential for higher waste wood recovery in Czechia is large; it is a question of establishing a proactive and effective policy environment and the appropriate infrastructure to support more robust collection, separation and monitoring of waste flows for wood. As noted by Hýsek et al.,[147] Belgium and Germany offer examples of best practice in this area. For a number of years already in Belgium, volumes of recycled wood in the domestic wood processing industry have been multiple times greater than the volume of processed harvested wood products. In Germany, recycling of wood is governed by a special regulation and there has been a ban in place on the landfilling of wood waste for twenty years (2003).

The civic initiative "Kam s ním?" (Where to put it?) set up by the non-profit organisation "Uklid'me Česko" (Let's Clean Up Czechia) offers a relatively recent Czech example of good practice. Launched in 2020, it provides via a web and mobile app a searchable directory and map for over 50,000 collection points nationwide where citizens can legally and appropriately dispose of a wide range of waste and end-of-life products or pass on products for reuse or repair, to avoid them falling outside the official EPR systems or collection infrastructure for bulky or hazardous waste, including furniture and wood waste.[148]

Norway insights

SirkHELTRE

SirkHELTRE is a sub-project of the Norway Wood Cluster's SirkTRE project. Its focus is on the reuse of solid wood. A first aim is to analyse the product flows of reclaimed wood. Secondly, there is focus on the Fingerskjøt plant and its associated sorting plant to ensure efficient sorting and utilisation of reclaimed wood. Another aim is to further develop the building design and production line of Norsk Massivtre, in order to facilitate use of recycled wood and increase its efficiency. Lastly, a hub named SirkSENTRAL has been set up to receive and store reclaimed wood that cannot be sent directly to the customer. These activities aim to overall reduce the climate footprint through their activities by approx. 100,000 tonnes of CO_2 equivalent.

147 Materiálové využití recyklovaného dřeva v České republice: Hýsek, Š., Hýsková, P., Fakulta lesnická a dřevařská, ČZU v Praze, Odpadové forum, Ročník 21, Číslo 1.

148 Examples of the circular economy in the Czech Republic (Synek Martin (FMI), 43rd session of the Joint Working Party on Forest Statistics, Economics and Management, Geneva, 1.-3.6.2022)

Annexes

Annex 1.
EU sustainability and circularity criteria related to use of wood

Category	GPP criteria	EU Ecolabel	EU Taxonomy: Technical screening criteria for Climate Delegated Act[149]	EU Taxonomy: Draft criteria for Environmental Delegated Act[150]
Buildings	Office Building Design, Construction and Management (2016, to be revised by end of 2023)	Currently on hold, pending new GPP criteria.	Circular economy – "**Do no significant harm**" criteria: 7.1 Construction of new buildings 7.2 Renovation of existing buildings	Criteria for "**substantial contribution**" to transition to a circular economy 3.1 Construction of new buildings 3.2 Renovation of existing buildings 3.3 Demolition and wrecking of buildings and other structures
Floor coverings	–	Wood-, cork – and bamboo-based floor coverings (2017)	–	–
Furniture	Furniture (2018)	Furniture (2016)	–	5. Services: repairing / refurbishing / remanufacturing and sale of spare parts, sale of second-hand, product-as-a-service and other circular use – and result-oriented service models
Paper products	Copying and graphic paper (2008, to be updated)	Paper, including: Printed paper, stationery paper, and paper carrier bag products (2020); Graphic paper (2019); Tissue paper and tissue products (2019).	–	5. Services (as above) – requirements for packaging

149 Commission Delegated Regulation (EU) 2021/2139 of 4 June 2021 supplementing Regulation (EU) 2020/852 of the European Parliament and of the Council by establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or climate change adaptation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives.

150 European Commission (June 2023): Taxonomy Environmental Delegated Act – Annex II: Transition to a circular economy (draft).

Annex 2.
Key stakeholder organisations in Czechia

Note: Focus is on sectoral organisations and initiatives (not private enterprises) with activities related to cascading use of wood and the circular economy.

Organisation	Category	Key activities related to cascading use and circularity of wood and forest products
Czech University of Life Sciences Prague, Faculty of Forestry and Wood Sciences (ČZU FLD)	University	Research and development on new wood-based products, for example composite wood-based boards from waste wood and lignin-based adhesives, and development of processes and technologies to support cascading use of wood.
Mendel University in Brno, Faculty of Forestry and Wood Technology (MU LDF)	University	Research and analysis on cascading use of wood and potential of forest biomass for renewable energy production in Czechia. Other projects have investigated wood recycling in terms of parameters of recycled wood and its potential economic benefits and production of composite wood and plastic based boards from waste material.
University Centre for Energy Efficient Buildings (UCEEB), Czech Technical University in Prague (ČVUT)	University Research Institute	Research and development on innovative timber-based construction, technical solutions and processes in building systems. Also responsible for the review and proposed update of national fire safety standards for buildings, to simplify planning rules for multi-storey mass hybrid timber construction. Other current projects focus on development of life cycle analysis methodologies for measuring the Whole Life Carbon of buildings.
Timber Institute (Timber Research and Development Institute, Prague, s.e.)	Research Institute	Certification of wood-based products and processes, research and innovation in the wood processing industry. Current projects focus on green (wood-based) versus conventional insulants in buildings, promotion of timber construction in buildings and development of processes for recovery of wood waste and by-products.
Ministry of Agriculture (MoA)	Central state administration	Management of state forests, primarily through Lesy ČR, which has developed a database of wood processing capacities. Preparation and administration of legislation, concepts, strategic planning documents and statistics related to sustainable forest management. Co-development of new national Raw Material Policy for wood.
Forest Management Institute (FMI) (Ústav pro hospodářskou úpravu lesů Brandýs nad Labem – ÚHÚL)	Government organisation under the MoA	Maintenance of the National Forest Inventory (NFI) and monitoring of the status and development of forest ecosystems. Preparation of regional forest development plans. Support for the state administration of forests and awareness-raising activities for the general public.
Forestry and Game Management Research Institute (FGMRI) (Výzkumný ústav lesního hospodářství a myslivosti, v. v. i.)	Public research institute under the MoA	Departmental forestry research institute focusing on forest management, forest protection services and expert, advisory and other service activities for the state administration of the forestry sector and for owners or managers of forests of all categories.
Ministry of the Environment (MoE)	Central state administration	Preparation and administration of legislation, concepts, strategic planning documents and statistics related to climate change, biodiversity, environment and sustainable development and waste management, including waste wood.
Ministry of Industry and Trade (MIT)	Central state administration	Preparation and administration of legislation, concepts, strategic planning documents and statistics related to the energy sector, construction, heavy industry, manufacturing and policies related to the use of primary and secondary raw materials. Co-development of new national Raw Material Policy for wood.

Organisation	Category	Key activities related to cascading use and circularity of wood and forest products
Association of Forestry and Wood Processing Enterprises (Asociace lesnických a dřevozpracujících podniků)	Association	Cooperation and advocacy for creating and maintaining a competitive economic and legislative environment for the forestry and wood processing industries, efficient, long-term sustainable forest management and use of timber resources in the Czech Republic and promotion of wood as a renewable material.
Association of Suppliers of Prefabricated Buildings (Asociace dodavatelů montovaných dřevostaveb – ADMD)	Association	Marketing and education in the field of mass timber buildings and prefabricated timber housing construction, providing a list of verified construction companies, support services for the construction process and Wood Camp educational project for civil engineers and architects.
Wood for Life Foundation (Nadace dřevo pro život)	Private foundation	Community activities to connect experts and the public through projects promoting the sustainable use of wood, including educational activities for schools and the public, annual competitions for timber structures and wood buildings, exhibitions, fundraising for forest restoration and advisory services on legislation related to forestry and wood processing industries.
Agency for Forestry Initiatives 2035 (Agentura lesnických iniciativ 2035 – ALI 2035)	Private sector initiative	Development of projects and initiatives to support transformational change and modernisation of the forestry and wood processing industries in Czechia, including smart forestry and digitalisation, integrated and value added production, sustainable business models, cascading use of wood and the circular economy.

Annex 3.
Key research initiatives in Czechia

Note: This annex lists selected recent and current research projects and initiatives related to the study topic involving Czechia research institutions and other sectoral organisations.

Project	Organisation	Time frame	Summary
Horizon Europe CEE2ACT	ČZU FLD	2022–2025	Supports states in Central Eastern Europe including Bulgaria, Croatia, Czech Republic, Greece, Hungary, Poland, Romania, Serbia, Slovakia and Slovenia with the development of circular bioeconomy strategies and action plans via innovative governance models. The objective is to enable better informed decision-making processes, societal engagement and innovations. Main countries providing examples of best practice and knowledge transfer are Austria, Germany, the Netherlands, Belgium, Spain, Finland, and Sweden.
Horizon Europe CLIMB-FOREST	ČZU FLD	2022–2027	Project title: CLImate Mitigation and Bioeconomy pathways for sustainable FORESTry (CLIMB-FOREST). Connects 18 European organisations using up-to-date research and forestry data to create new tools, interactive maps and best practice guidance. The project aims to ensure Europe's forests are resilient to climate change and support people and nature, via collaboration with the forestry sector and policy makers.
Horizon 2020 RESONATE Resilient Forest for Society	ČZU FLD	2021–2025	Aims to improve direct decision-making towards enhancing the resilience of forests and forest value chains in response to four resilience challenges: changing suitability of tree species due to climate change, increased risks of forest disturbances, changing societal demand on forest products and ecosystem services, and a decline in biodiversity. Includes an integrated resilience and vulnerability assessment to determine how past and current site factors and management influence forest system resilience in different forest types and management systems across Europe.
Horizon 2020 SUPERB: Upscaling Forest Restoration	ČZU FLD	2021–2025	Aims to create lasting transformative change towards large-scale forest and forest landscape restoration, supporting decisions for the restoration of biodiversity, ecosystem services and carbon sequestration to maximise synergies. The project includes 12 large-scale demonstrations on best practices in forest restoration and will develop a multi-language, online Forest Ecosystem Restoration Gateway to provide practical, economic and governance supporting materials and best practice examples.
TAČR GAMA 2 PP1 Green industry for sustainable wood raw material management in Czechia: Composite materials from recycled wood[151]	ČZU FLD	2020–2022	Part of the Technology Agency of the Czech Republic project TP01010050. The project developed OSB (oriented standard board) and particleboard made of 100% recycled wood and bonded with powder adhesive made from lignin (a by-product of pulp production). Part of the project was to acquire a patent dealing with the treatment of recycled wood leading to the reduction of contaminants contained in the recycled wood.

151 Consultation with ČZU FLD

Project	Organisation	Time frame	Summary
TAČR Prostředí pro život, project SS06020121 Development of a system of efficient use of wood from low and medium forest into final products with high added value	ČZU FLD, Pila Benda	2023–2025	Development of products of structural and non-structural glued laminated timber from selected broad-leaved tree species with the possibility of using an assortment from low and medium forests. Products will be fully recyclable at the end of their life cycle. Adaptation of the system for growing saplings of low and medium forests to achieve the necessary assortments for the production of laminated wood. Low and medium forests can contribute to increasing the species, structural and habitat biodiversity of forest complexes. However, their disadvantage is the low value production of wood. The project aims to find a system which, as a whole, could significantly increase the potential of these biologically and ecologically interesting forest forms.
Gregor Johann Mendel grants Use of recycled wood for OSB production[152]	MU LDF, Faculty of Business and Economics	2022–2024	Aims to extend the life cycle of wood as much as possible by multiple recovery of the material in new products, delaying the energy processing of wood. Objectives are to create an ideal OSB production process using recycled wood, including analysis of the properties and production of OSB prototypes with superior characteristics to those produced by the conventional process.
Development of compression of wood-plastic plates from waste materials[153]	MU LDF, FF servis company	—	Development of compression of wood-plastic boards from waste materials processed using high-speed milling technology.
Ministry of Agriculture, project OK1820358 Potential of Forest Biomass Resources for Renewable Energy Production in the Czech Republic[154]	MU LDF	Published in December 2021	Based on official statistics and energy policies, the project calculated the potential of forest biomass resources for production of electrical and thermal energy over a 15-year period to 2036 in the context of the bark beetle calamity. It concluded that domestic resources are insufficient to meet targets for renewable energy even under existing EU and national targets.
National Agency for Agricultural Research of the Czech Republic, project QK1820358 Cascade Use of Wood in the Czech Republic[155]	MU LDF	Published in June 2020	The study analysed wood flows in the Czech Republic using the cascading principle of biomass use and applied a reverse input method due to lack of valid and reliable input data from official statistics. Calculation of raw wood volume consumption in primary processing was recalculated in order to build up a basic model of multi-stage cascade wood use. The analysis indicated a high rate of wood use in primary processing with low added value and in energy generation.

152 MENDELU, Vědci chtějí vdechnout starým trámům nový život, June 2022

153 MENDELU, Projekty

154 Šafařík, D.; Hlaváčková, P.; Michal, J. Potential of Forest Biomass Resources for Renewable Energy Production in Czechia. Energies 2022, 15, 47. https://doi.org/10.3390/en15010047

155 Babuka, R.; Sujová, A.; Kupčák, V. Cascade Use of Wood in the Czech Republic. Forests 2020, 11, 681

156 Výzkumný a vývojový ústav dřevařský, Praha, s. p. se zabývá energetickou účinností dřevostaveb (MIT, October 2021); consultation with Timber Institute

Project	Organisation	Time frame	Summary
EFEKT II (MIT) Evaluation/potential for energy savings in the construction industry when using domestic renewable and secondary raw materials and the environmental impacts of their use throughout the building life cycle[156]	Timber Institute (Dřevařský ústav)	2021–2022	This study aimed to demonstrate potential energy savings from the use of wood and other wood-based materials with natural insulants throughout the life cycle of a building. A potential result is a coefficient factor that could be applied to calculation of a building's Energy Performance Certificate (EPC) when using renewable raw materials such as wood. The final deliverables of the project are catalogue tables for selected construction systems using renewable materials.
Lesnická legislativa EU[157]	Wood for Life Foundation	Starting in 2023	This initiative aims to inform and educate the professional public in particular about the importance of being active in the development of forestry legislation, by offering strategic advice to the forestry sector, forest owners and other stakeholders to develop sustainable forest management in the context of new EU regulations.
Wood Camp[158]	Association of Suppliers of Prefabricated Buildings	Starting in Q2 2023	The project includes regular seminars for civil engineers, architects and construction supervisors and aims to build competence in how to design and implement mass (hybrid) and timber construction projects.

157 Nadace dřevo pro život, Lesnická legislativa EU

158 Association of Suppliers of prefabricated buildings, Wood Camp

Annex 4. Additional sources of information

The following list provides links to selected studies, analyses and resources for further information from organisations active in the topics of cascading use of wood, the circular bioeconomy, timber construction and other fields of direct relevance to this study. The list includes items published up to the end of April 2023. Publications are listed in reverse chronological order of publication date.

Forestry sector

- Jaký přínos pro les v časech klimatické změny může mít lesní certifikace? (Fakta o klimatu, April 2023)
- Future wood demands and ecosystem services trade-offs: A policy analysis in Norway (Forest Policy and Economics, February 2023)
- Information on Forests and Forestry in the Czech Republic by 2021 (MoA, 2022)
- Porovnání vybraných environmentálních aspektů certifikačních systémů FSC a PEFC v ČR s důrazem na půdu, vodní zdroje a biotu lesních ekosystémů (Platforma pro krajinu and Ekologické služby, 2018)

Circular bioeconomy and cascading use of wood

- Wood-Based Products in the Circular Bioeconomy: Status and Opportunities towards Environmental Sustainability (European Forest Institute, Land, November 2022)
- Everything from Wood – The Resource of the Future or the Next Crisis? (WWF Germany, July 2022)
- Circularity concepts in forest-based industries (FAO/UNECE, May 2022)
- Forest products in the global bioeconomy, Enabling substitution by wood-based products and contributing to the Sustainable Development Goals (FAO, 2022)
- Guidance on cascading use of biomass with selected good practice examples on woody biomass (European Commission, 2018)
- CASCADES: Study on the optimised cascading use of wood (European Commission, 2016)

Timber construction

- Seeing the forest through the trees: How sustainable timber buildings can help fight the climate crisis (ECOS, March 2023)
- Circularity concepts in wood construction (draft) (FAO/UNECE, October 2022)
- Handbook: Bio-Based and Circular Buildings for Healthy, Clean Cities (EIT Climate-KIC, July 2022)
- Carbon Accounting for Building Materials – An Assessment of Global Warming Potential of bio-based construction products (LBP Sight, June 2022)
- Circular Tool Box – Using Timber in Construction (Metabolic, 2022)
- Evaluation of the climate benefits of the use of Harvested Wood Products in the construction sector and assessment of remuneration schemes (European Commission, December 2021)
- Quantifying Advantages of Modular Construction: Waste Generation (Buildings, December 2021)

- Building a Future in Timber, Scenarios for Buildings with Bio-based Materials (Circle Economy, December 2020)
- Impact of wooden buildings on climate, embodied energy and GHG-emissions (Guidehouse for the European Commission, December 2020)

Wooden furniture

- Twin Transition in the Wood-Furniture Value Chain – State-of-the-art on Environmental Certification Practices and Industry 4.0 in the Wood and Furniture Sector (INTRUST, 2022)
- Circular Economy & the Furniture industry: The state-of-the-art in the EU & Sweden (Research Institutes of Sweden, 2021)
- Circular Economy Opportunities in the Furniture Sector (EEB and Eunomia, September 2017)

Particleboard/OSB production and recycling of waste wood

- Recyklované dřevo, třídění povoleného a nepovoleného recyklátu (Kronospan CR, 2022)
- Environmentální přínos využívání recyklovaného dřeva při výrobě aglomerovaných materiálů (ČZU FLD and Kronospan CR, 2017)
- European wood waste statistics report for recipient and model regions (BioReg, November 2018)

Paper and paperboard products

- Papír a celulóza – Odborné periodikum českého papírenského průmyslu (AČPP)
- European Declaration on Paper Recycling 2021–2030 – Monitoring Report 2021 (European Paper Recycling Council, 2022)
- KEY STATISTICS 2021, European pulp & paper industry (CEPI, July 2022)
- Analýza současného stavu vybraných komodit druhotných surovin a jejich zdrojů včetně vize rozvoje daného odvětví – Podklad pro aktualizaci politiky druhotných surovin České republiky (MIT, December 2018)

Wood-based products in public and private procurement

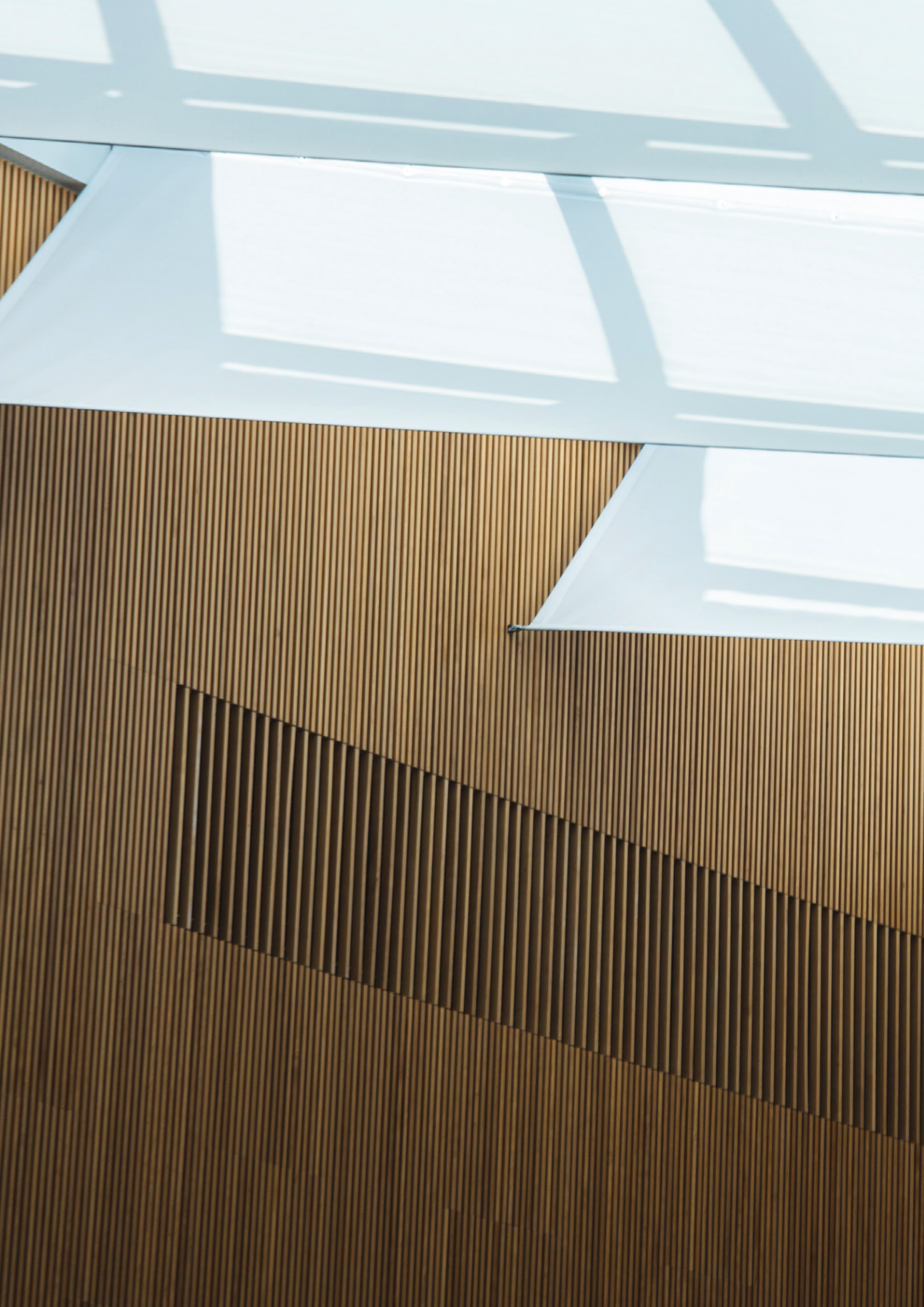
- Innovative method of circular economy in public and private procurement (ERASMUS+ InCEPP, May 2022)
- Odpovědné veřejné zadávání a Cirkulární ekonomika – Nábytek (MoLSA, INCIEN, 2021)
- Průvodce využitím dřeva ve veřejných zakázkách (MoA, undated)

Other Horizon 2020 and Horizon Europe research projects

- BASAJAUN – Sustainable wood construction for rural development and urban transformation
- Build-in-Wood – Drastically increasing the proportion of timber construction in Europe
- EcoReFibre – Upscaling end-of-life recycling and circular use of recovered wood in the European wood panel industry
- WoodCircus – Promoting wood-based value chains as a key part of a circular bioeconomy in Europe

Annex 5. / Acronyms and abbreviations

Acronym	Designation
ADMD	Association of Suppliers of Prefabricated Buildings
B2B	Business to Business
BIM	Building Information Modelling
CEAP 2.0	New Circular Economy Action Plan
CLT	Cross-laminated timber
CSRD	Corporate Sustainability Reporting Directive
CZSO	Czech Statistical Office
ČVUT UCEEB	University Center for Energy Efficient Buildings of the Czech Technical University in Prague
ČZU FLD	Czech University of Life Sciences Prague, Faculty of Forestry and Wood Sciences
EPBD	Energy Performance of Buildings Directive
ESPR	Ecodesign for Sustainable Products Regulation
ESRS	European Sustainability Reporting Standards
EU	European Union
FAO	United Nations Food and Agriculture Organisation
FMI	Forest Management Institute (Ústav pro hospodářskou úpravu lesů – ÚHÚL)
FMP	Forest Management Plan
FSC	Forest Stewardship Council
GHG	Greenhouse gases
GWP	Global Warming Potential
INCIEN	Institut cirkulární ekonomiky (Institute of Circular Economy)
JRC	Joint Research Centre (European Commission)
MDF	Medium density fibreboard
MIT	Ministry of Industry and Trade
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoLSA	Ministry of Labour and Social Affairs
MRD	Ministry of Regional Development
NEB	New European Bauhaus
NIBIO	Norwegian Institute of Bioeconomy Research
OSB	Oriented strand board
PEFC	Programme for the Endorsement of Forest Certification schemes
RED III	Proposed revision of the Renewable Energy Directive
UNECE	United Nations Economic Commission for Europe
WLC	Whole Life Carbon



INCIEN would like to thank the following organisations for their input and feedback during the preparation of this study, whether through online questionnaires, individual consultations or comments on the draft report. INCIEN is solely responsible for the study and the conclusions and recommendations it contains. It contains assumptions and points of interpretation that are subject to uncertainty. As such, the study is provided without guarantees regarding its accuracy or completeness.

Research organisations

- Norwegian Institute of Bioeconomy Research (NIBIO)
  - Division of Forest and Forest Resources
    - Wood Technology
    - Forest Operations and Digitalization
- Czech University of Life Sciences Prague – Faculty of Forestry & Wood Sciences (ČZU FLD)
- Czech Technical University in Prague (ČVUT) — University Centre for Energy Efficient Buildings (UCEEB)

Government

- Ministry of Agriculture of the Czech Republic
- Ministry of Industry and Trade of the Czech Republic

Members of the Czech Circular Hotspot

- Atelier Paletky – Tailor-made furniture production using one-way pallets
- Balance is Motion – Ecodesign studio
- Nema – Producer of mass timber family houses and CLT
- Progresus – Investment group and producer of mass timber family houses, cooperation with universities
- Škoda Auto – Auto production, waste and material management of wood packaging
- Dřevařský institut (Timber Institute) – Certification and technical research institute
- ZERO Architecture – Sustainable architecture and consulting

Other companies

- APICON Consulting – Business and management consulting for forestry, woodworking and furniture sectors
- Kloboucká lesní – Forest cultivation, logging, sawn timber products
- Kronospan – Production of wood-based board products, cooperation with universities
- Mondi – Pulp, paper and board production
- IKEA – Furniture production and sale, circular business models for wooden furniture
- CYRKL – Waste management digital marketplace and services

Sectoral organisations

- Asociace dodavatelů montovaných dřevostaveb (Association of Suppliers of Prefabricated Buildings)
- Moravský Lesnický Institut (Moravian Forestry Institute)
- Nadace Dřevo pro život (Wood for Life Foundation)
- Pro Silva Bohemica
- Sdružení vlastníků obecních, soukromých a církevních lesů v ČR (Association of Municipal, Private and Church Forest Owners in the Czech Republic)
- Ústav pro hospodářskou úpravu lesů (Forest Management Institute)
- Výzkumný ústav lesního hospodářství a myslivosti (Forestry and Game Management Research Institute)
- World Wildlife Fund Central and Eastern Europe (WWF CEE)

Study
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Circular Bioeconomy Opportunities
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Products and Wood in Czechia

Produced by
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Financially supported by
Fund for Bilateral Relations,
EEA and Norway Grants 2014–2021
Initiative number: EHP-BFNU-OVNKM-4-094-2022

Please cite as
INCIEN (May 2023): Closing the
Loop on Wood. Circular Bioeconomy
Opportunities in the Value Chain for
Forest Products and Wood in Czechia.

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