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CIRCULAR TIMBER: TIMBER ON THE WAY TO A SUSTAINABLE CIRCULAR ECONOMY

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ABSTRACT: The circular economy requires systemic changes within the economic system and is a key element for climate- friendly resource consumption in the construction sector. The future circular use of resources will consist of interconnected legal, ecological, financial and technical subsystems. Due to the currently unclear legal and technical framework conditions in the construction industry, despite existing solutions especially in timber construction, the transformation of the linear economic system into a circular economy has not yet been achieved. The European Union is currently in the process of revising old legislation and enacting new laws to help achieve the targeted emission reductions. The European Union Taxonomy defines which economic activities are to be classified as sustainable. In the first phase of the research project "Circular Timber", meta-studies and analyses of the taxonomy impact on timber construction are conducted. Circular economic strategies and recommendations for the further development of technical building regulations are planned, particularly take-back concepts, evaluation of used components and evaluation of buildings considering existing building certification systems. Based on this, the second phase of the research project will present successful examples to provide an overview of the technical solutions and concepts for reuse and recycling in timber construction.

KEYWORDS: European Union Taxonomy, timber, circular economy, reuse, recycling

1 – INTRODUCTION

The European Climate Law commits the European Union (EU) to becoming climate- neutral by 2050 and to achieving the ambitious pan-European greenhouse gas reduction targets set out in the Paris Agreement by 2050. In accordance with Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action [1] and with Decision 1/CP.21, § 35, in accordance with Article 4, § 19 of the Paris Agreement [2], EU Member States and Parties to the Paris Agreement are obligated to prepare and submit long-term strategies every ten years since 1 January 2020. These must be developed regularly and can be adjusted at five-year intervals, if necessary. The scope of these strategies has to be at least 30 years. By 2030, carbon dioxide (CO_2) emissions are to be reduced by 55% compared to 1990 levels. The Austrian government's 2020–2024 coalition agreement, formally known as the Climate Plan 2040, establishes the objective of attaining climate neutrality by the year 2040. This commitment positions Austria as one of the most ambitious nations within the European Union and globally.[3]

This national objective entails the balanced management of greenhouse gas emissions and their absorption by carbon sinks on a nationwide scale, as documented in the national greenhouse gas inventory, with the objective of achieving this balance by 2040 at the latest, thereby reducing emissions to net zero by that same year. The present strategy delineates the various sectors of activity that are to be pursued in order to attain climate neutrality by 2040. These strategies do not claim to define detailed measures; rather, they demonstrate how greenhouse gas emissions in specific areas can be reduced towards zero or how residual greenhouse gas emissions – particularly in the agricultural or industrial sectors – can be offset. The journey towards climate neutrality encompasses all three pillars of sustainability: economic, ecological, and social. This is because climate neutrality signifies a comprehensive transformation, a substantial change in the economy and society that will impact all facets of life.

The Vienna Climate Guide [4] provides a concise overview of the pivotal aspects of this imperative transformation. The Vienna Smart City Strategy establishes the following CO_2 headline goal for mobility:

Per-capita CO_2 emissions in the mobility sector are to be reduced by 50 percent by 2030 and by 100 percent by 2040 (compared to 2005). The strategy also delineates additional objectives to ensure the aforementioned CO_2 headline goal in 2030, while concurrently pursuing other objectives of a livable and innovative-friendly city. These objectives include the following:

- Commercial traffic within municipal boundaries is predominantly CO_2-free by 2030.
- The share of journeys made by eco-friendly modes of

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transport in Vienna, including shared mobility options, is expected to rise to 85 percent by 2030 and to exceed 85 percent by 2050, whereas the share of journeys made by private motor vehicles is projected to decrease to 15 percent.
To achieve Austria's climate targets by 2040 and those of the European Union by 2050, large sums will have to be invested. The EU Commission estimates that this will require around 350 billion euros in investment[5]. These investments must generate sustainable growth and thus create added value and jobs in sustainable sectors. Sustainable finance therefore plays a key role in achieving the political goals of the European Green Deal as well as the EU's international commitments regarding climate and sustainability goals. Therefore, in 2020, the European Union launched the EU Taxonomy – a classification system for sustainable investments – to accelerate the transformation to a climate-neutral continent. It is a European regulation that defines which economic activities are to be classified as sustainable and under what conditions.

2 – MOTIVATION

A study by the Organization for Economic Cooperation and Development (OECD) looks into the future, specifically to the year 2060, and paints a bleak picture of raw material requirements and greenhouse gas emissions if there is no significant change of course. [6] A study by the German Sustainable Building Council (DGNB) shows that the real estate industry is not prepared for the transition to a circular economy prescribed by the European Union. [7] A total of thirty-eight projects involving a variety of building types in ten different countries participated in the study. The marketability of the circular economic criteria proposed in the EU taxonomy was examined based on real construction projects. However, none of the projects could be classified as taxonomy-aligned. [8] The conservation of resources through the reuse of components and the use of recycled materials, which took place today, proved to be particularly challenging. In addition, data and methods for circular construction were lacking. The study's findings indicate that the current resource-efficient use of building materials poses significant challenges. For instance, none of the projects achieved the stipulated material quota, which requires the utilization of at least 15% reused, 15% recycled, and 20% renewable, reused, or recycled building materials.[8]
In principle, two perspectives can be delineated when appraising the study's outcomes[8]:
The first perspective emphasizes immediate reduction of negative environmental impacts and resource consumption, e.g., through reuse or recycling [7].
Conversely, the second perspective emphasizes the preservation of resource value through future-proofing measures such as avoiding contaminated materials and ensuring the dismantling of structures.
The concept of "circular construction" is a focal point of numerous lectures, discussions, and media outlets. This suggests that the topic has gained traction within the industry. However, a significant proportion of new buildings, as evidenced by the DGNB study, fail to meet even half of the requisite criteria[7]. Moreover, the development of a circular built environment has been observed to be declining on a global scale, from 9.1% in 2018 to 8.6% in 2020 to just 7.2% in 2022 as well as 2023[9, 10].
There has been an increasing extraction and utilization of materials, leading to a growing reliance on new sources of materials for the global economy. It is evident that the circular economy is in a state of decline, concomitant with the general increase in global material extraction. Concurrently, an increasing volume of materials is being allocated to inventories such as roads, houses, and durable goods, resulting in a diminishing number of materials that can be reintroduced into the economic cycle. A circular economy that is exclusively focused on the recycle is unable to maintain pace with the unprecedented escalation in the consumption of new materials [9].

3 – SCIENTIFIC PROBLEM STATEMENT

In principle, the circular economy in the construction sector is a key element for climate-friendly resource consumption. As part of the Austrian Circular Economy Strategy[11] the Austrian Ministry for Climate Action proclaimed ten principles, shown in Figure 1, as guidance for the development of all further measures and instruments.

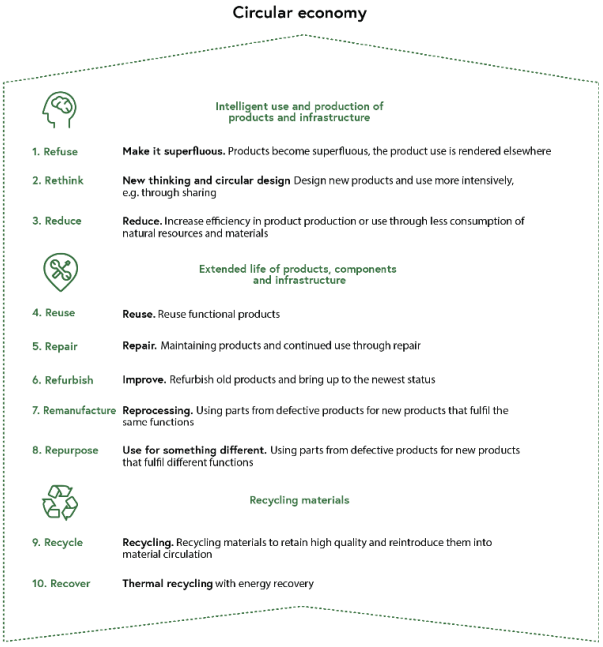

Figure 1: 10-R Steps of the Austrian Circular Economy Strategy (Source: BMK based on Potting et al. (2017)

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Based on the EU taxonomy, the current main focus of project developers on real estate development is in the field of "smart building" and "green building", and consequently on the implementation of timber and timber hybrid buildings in large-volume construction projects. The aim of the research project “Circular Timber” is therefore to show how timber and/or timber hybrid construction – in new construction and renovation – can be planned and built in a reusable manner and with a recycling-oriented use of the raw material wood, following the hierarchy of the ten steps proclaimed in Figure 1.

Forward-looking approaches in timber and/or timber hybrid construction must be developed and actively co-designed. In this context, current developments – which are not currently coordinated – must be considered. The range of topics extends from the circular economy and new technological developments to focal points such as EU taxonomy in the building sector or digitalization. The instruments and methods used to assess the sustainability of buildings during planning and the effects of the EU Taxonomy Regulation are critically scrutinized.

The main advantage of timber construction is the significantly shorter construction period and consequently pre financing time. The high quality of living in timber buildings is also significant (social aspects of sustainability assessment). Consequently, in the inaugural phase of the research project Circular Timber, meta-studies and analytical investigations into the impact of taxonomy on timber construction will be conducted.

Furthermore, circular economy strategies and recommendations for the advancement of technical building regulations are planned, including concepts for take-back and the assessment of used components. Additionally, the evaluation of buildings considering existing building certification systems will be conducted.

Based on this, the second phase will show successful examples to provide an overview of the technical solutions and concepts for reuse and recycling in timber construction.

3.1 CO_2 PRICING

In late June of 2024, the Austrian federal government adopted the National Carbon Management Strategy (CMS) [12] as an important contribution to achieving climate neutrality in Austria by 2040. This strategy emphasizes technical and legal measures for creating CO_2 sinks, the development of an infrastructure network for technical sinks, and measures for implementing natural CO_2 sinks. Notably, this approach regards CO_2 as a substance that should be stored rather than avoided. The impact of the increased use of timber as a basic and building material to replace CO_2-intensive substances must be examined. To meaningfully curtail CO_2 emissions in the construction industry, the implementation of a CO_2 price that would exert a market-directing effect is a conceivable measure.

In Europe, a ton of CO_2 is not only priced within the framework of the EU Emissions Trading System. In this context, the effects of CO_2 pricing and the implementation of the EU taxonomy in valuation practices must be examined (comparison of implementation strategies), since CO_2 pricing is a central piece of the puzzle, but it requires an overall package consisting of many different instruments. This also includes a supportive legal framework and comprehensive support measures to achieve the reduction targets.

In Europe, CO_2 emissions are subject to pricing measures in multiple contexts. Within the EU Emissions Trading System, a regulatory framework established under the auspices of the EU, pricing is implemented on a ton basis. Additionally, numerous EU member states have instituted national CO_2 prices, albeit with notable variations in their signaling impact, as evidenced in Figure 2 on the following page.

The present CO_2 pricing structure in Austria has thus far not provided sufficient incentive for this to be the case, despite the calculated price of €880 per ton of CO_2 for 2024 [13] representing an equitable valuation of the future and current damages caused by the climate emergency. In Austria, the price per ton of CO_2 has been set at €45 since January 2024 [14]. However, an increase to a level similar to Sweden's could potentially lead to a rethink or the provision of real market guidance [15]. Guidance would also include a supportive legal framework and comprehensive funding measures to achieve the target reduction.

3.2 DEVELOPMENT OF TRADING WITH ETS-I AND ETS-II

At present, there are still different prices per metric ton of CO_2 in effect in the EU member states. These will be harmonized within the European Union over the next few years. [16] The ETS-I certificates related to the industrial and energy sectors. The ETS-II will include areas such as buildings, road transport and additional sectors such as commercial production. The EU ETS II will be fully implemented in 2027 and the regulated prices will be released for trading. Not only the EU member states, but also Norway, Iceland and Liechtenstein will adopt them.

As a result, the price of CO_2 will be more in line with where it is produced and will ultimately lead to a reduction in emissions. In addition, Austria, the Netherlands, and Sweden have expanded the areas not covered by the ETS-II. Until 2027, a minimum amount will be applied as a cap for all countries, currently €57,03, as shown in Figure 2. However, it is important to note that the regulated ETS-II prices depicted in the diagram are only applicable until January 1, 2027. Subsequent to that date, all companies within the European Union will be obligated to trade CO_2 certificates.

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3.3 LAWS AND REGULATIONS

The Nordic countries of Europe, namely Sweden, Denmark and Finland, plan to harmonize Carbon Limit Values for Buildings and implement mandatory life cycle GHG disclosures for existing buildings [17]. The Danish Ministry of Interior and Housing introduced 2023 embodied carbon limits into building regulations for new constructions above and below 1000m^2. Lowering those limits biannually to 7,5kg CO_2 eq/m^2/y by 2029. By making these adjustments to the legal framework, Denmark is promoting a reduction in CO_2 emissions independently of the development of the ETS II prices.

In addition to the possibility of using new, primary materials with low CO_2 emissions when constructing a new building, there is the necessity of including a source that has not yet been developed. Achieving climate targets will require the use of components in designs that facilitate reuse, obviating the need for complete reconstruction. Timber construction, with its prefabricated components and elements, serves as a positive example of a leading indicator of the imminent change in thinking.

Subsequent to the technical evaluation, there are already legal possibilities for the reuse and recycling of load-bearing components. However, these possibilities are currently difficult to locate in various directives and laws at the national and EU levels. Since refurbishment is not equivalent to new construction with primary building materials, important legal bases can be found not only in the texts for building products or in national building codes, but also in the regulations of waste management and finance. According to prevailing legislation, the area between waste and building products harbors significant potential for preserving components facing demolition in the final phase of a building's life. This area corresponds to the "life cycle" phase D of a building (see Figure 3). This phase represents the culmination of the loop of a circular economy, spanning phases A and C.

This transformation entails a change in thinking from a linear construction industry, characterized by a single-use orientation towards waste, towards a paradigm of reuse and further utilization of components from existing buildings. However, this transition is encumbered by numerous legal uncertainties.

As can be seen in Figure 4, the boundaries between demolition and construction activities are in flux in the segments "preparation for reuse" and "recycling". There is potential for transformation of the existing building stock here because the boundaries and transitions are debatable. In principle, the legal framework is the EU-wide regulations and directives, such as the harmonized rules for the marketing of construction products and repealing Regulation [18] , the EU Directive on waste [19], and its 2018 amendment [19].

However, this indeterminate transition zone, as explained above, is insufficiently addressed here. Therefore, a construction product that is still functional is often downgraded in the "waste hierarchy" from renovate, to the selective deconstruction to selective stripping and decontamination (see Figure 4). This downgrading currently tends to lead to the declaration of status waste. This area is currently regulated and interpreted differently at a national level. At the same time, there is a lack of guidelines and easy-to-understand explanations for maintaining the component status in this case. At the European level, efforts are currently being made to correct this situation by harmonizing regulations.[20]

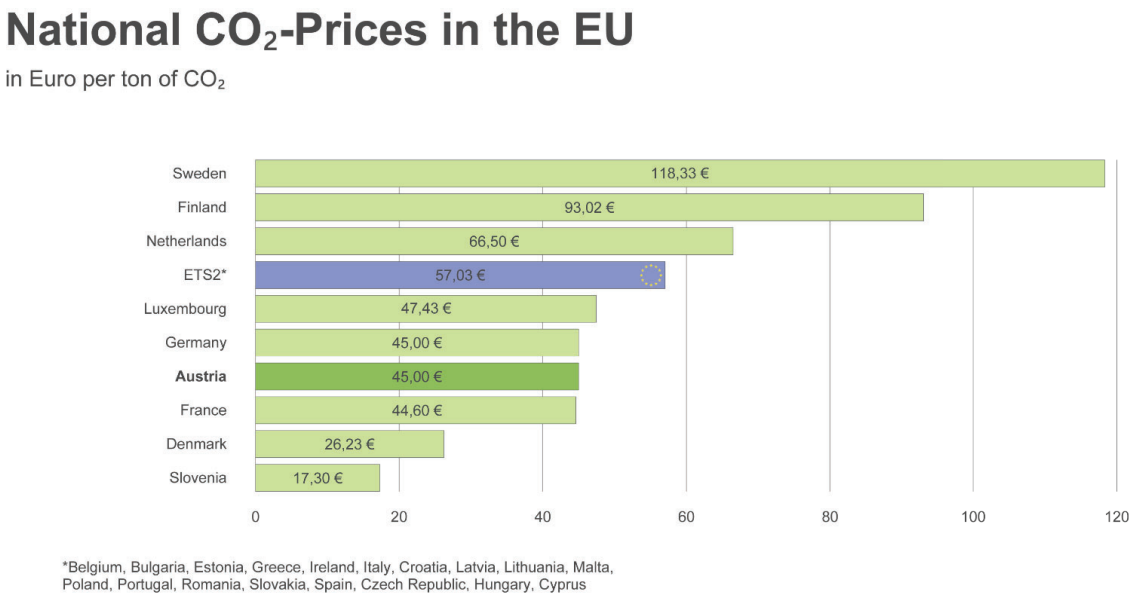

Figure 2:In this comparison of CO_2 prices within the EU per ton of CO_2 emitted Denmark's CO_2 pricing is only half of the ETS-II, as of 2024 (Own visualization based on data sources: wienenergie.at, Tax foundation, Carbon Pricing Dashboard, World bank, 2024)

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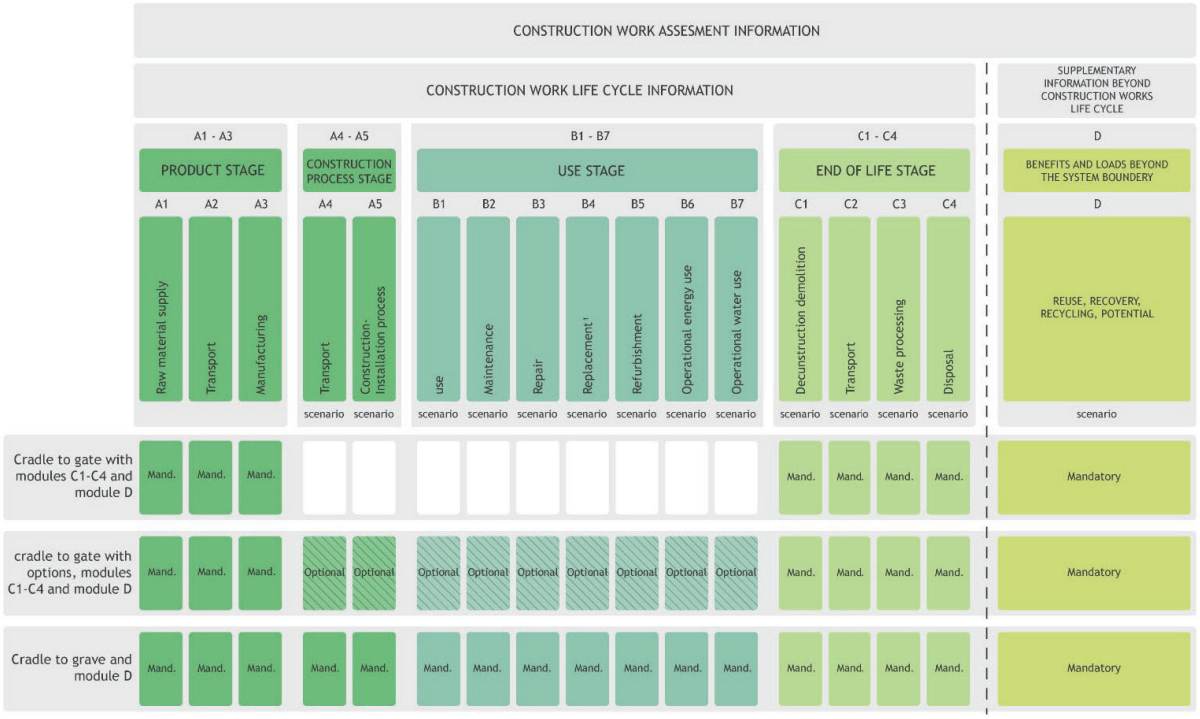

Figure 3: Representation of different Phases of a Life Cycle Assessment including calculation scenarios of cradle to gate and cradle to grave (own visualisation based on DIN EN 15804:2022-03)

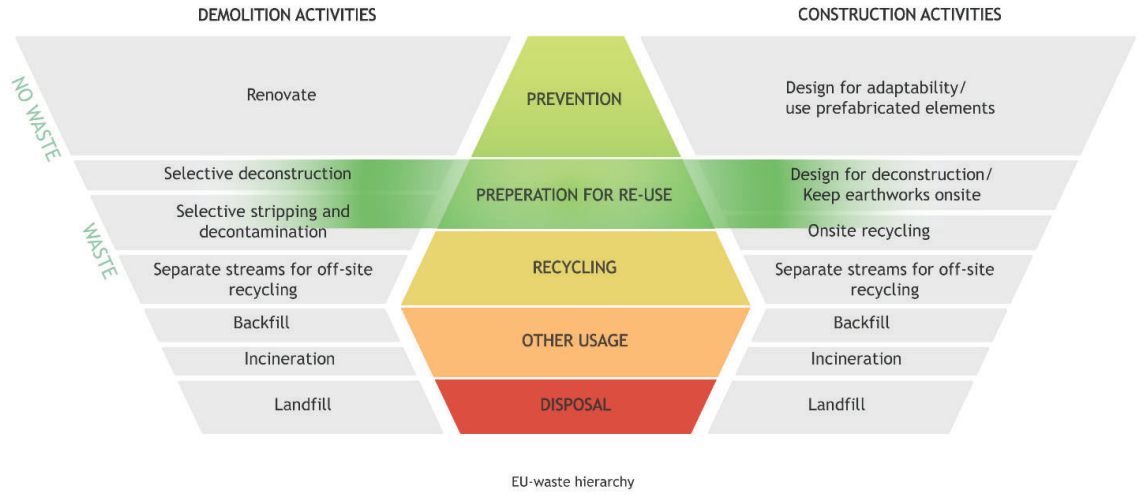

Figure 4:Relating the EU waste hierarchy to construction and demolition activities with a focus on maintaining the status as building product (own visualization based on Donatello S., Dodd N. & Cordella M., 2021. Level(s) indicator 2.2)

4 – CONCLUSIONS

Achieving the climate targets set by Austria and the European Union by 2040 and 2050, respectively, requires substantial investment. Sustainable finance is vital to achieving the political objectives of the European Green Deal and the EU's international commitments concerning climate and sustainability goals. The EU Taxonomy shall accelerate the transition to a climate-neutral continent. Timber and timber hybrid construction must develop and co-design forward-looking approaches; current developments are not coordinated. Topics include the circular economy, technology, the EU's taxonomy regulation for the construction industry, and digitalization. The currently ongoing research project “Circular Timber” aims to identify and evaluate new ways in which timber and hybrid elements can be reused as loadbearing elements and wood as a raw material can be used more efficiently

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in a circular manner.
The research project starts with metal studies and analysis of the impact of taxonomy on timber construction.
The current pricing structure for CO_2 per ton within the European Union is not representative of the valuation of the future and current damage from climate change, but by 2027 all companies within the European Union will be required to trade CO_2 certificates. Countries like Denmark already implemented embodied carbon limits into their national building regulations for new constructions above and below 1000m^2.

5 – OUTLOOK

The next phase involves formulating circular economy strategies and recommendations for technical building regulations. These strategies include developing take-back concepts and evaluating used components, as well as assessing buildings within existing certification systems. Successful case studies, providing a comprehensive overview of technical solutions and concepts for reuse and recycling in timber construction will be presented.
At the same time, the aim is to raise public awareness of the forward-looking issues being addressed. The basic idea behind the investigated materialization is the enormous development in the field of manufacturing and processing, which has led to the fact that industrially manufactured, versatile wood products already exist on the market, especially in Austria. These can be manufactured in cascade processes by reusing used products. In addition to the consideration of modern production and application possibilities, composite technologies and mixed construction solutions are to be investigated. In other words, the use of renewable resources that can continue to be used to a high standard beyond the life cycle of a building, provided that the construction is recyclable.
To this end, a corresponding methodology is developed which is dedicated to the challenges of the changed planning task in timber construction. The integration of new production approaches, digital design methods and the development of new side streams for zero-waste management in cascading timber construction play a significant role here. With critical consideration of the areas of re-usability and re-utilization and the direct applicability to residential and functional buildings, cascading thinking in timber construction is to be expanded to include cyclical thinking. Circular application proposals for different typologies are presented. Primary (first used) and secondary (reused) timber components and building materials are used together, thus promoting work with timber as a material. The applicability of the versatile reuse and continued use options, with adaptation of the legal framework, is thus established and the use of wood as a durable and future-oriented material is generally strengthened.
There is an urgent need to expand climate adaptation and mitigation innovations. These should promote carbon-neutral economies while generating decent employment and supporting millions of people. The sustainable bioeconomy integrates biological resources to replace fossil fuels, driving progress across economic sectors. Successful bioeconomy approaches must prioritize sustainability and circularity. Forest products from sustainable and responsibly managed forests are critical to bioeconomy, replacing non-renewable resources in sectors like construction, pharmaceuticals, and agriculture. Sustainable forest management for the bioeconomy requires balancing social well-being, economic development, and environmental values. In this context, the Country and Organization-Led Initiative (COLI) on Sustainable Forest-based Bioeconomy approaches, initiated by Austria's Federal Ministry of Agriculture, aims to advance global development of the forest-based bioeconomy.
The initiative is founded on scientific evidence and the most recent advancements in the sector, with the objective of promoting the sustainable utilization of forestry products and encouraging sustainable production and consumption practices. It facilitates the continuation of the global discourse on wood solutions and other forest-based bioeconomy approaches in a changing climate, while also inviting country representatives and other relevant stakeholders to collaborate. The initiative is structured to facilitate the exchange of ideas and foster a sense of collaboration within the global community dedicated to the advancement of the forest-based bioeconomy. The COLI initiative is aligned with the actions outlined by the United Nations Forum on Forests and the FAO's Committee on Forestry, as shown in Figure 5.

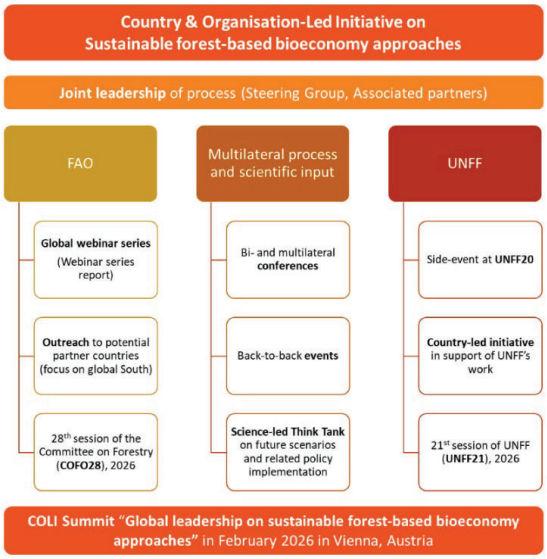

Figure 5: Overview of the COLI structure (Source: BML)

The primary objective of the COLI is to establish a constructive multilateral dialogue that facilitates the exchange of ideas on sustainable forest-based bioeconomy approaches. This is achieved by connecting a diverse range of stakeholders and leveraging synergies to optimize the collaborative efforts in this domain.

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The research project “Circular Timber” is part of the “multilateral process and scientific input” segment within the COLI initiative and will contribute the findings to facilitate the achievement of the set Climate Action Strategy goals of Austria, the EU Member States and Parties to the Paris Agreement.

6 – ACKNOWLEDGMENTS

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