ESTABLISHING THE REAL VALUE CYCLES FOR TIMBER STRUCTURES – FINDINGS FROM CASE PROJECTS

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ABSTRACT

Background and aim. The four-year project SirkTRE aims to advance circularity in the timber industry, achieving key milestones in standardization, reuse, and market expansion through cooperation, innovation and targeted research. Historically, circular timber construction was common, and modern efforts, like Norway's SirkTRE, work towards reintroducing wood reuse and recycling. SirkTRE is targeting an 8% reduction in CO_2 emissions aligned with Norway's commitments under the Paris Climate Agreement by repurposing 50% of Norway's annual 800,000 tons of counted wood waste by 2030.

Methods and sata. Regulatory frameworks, including the Waste Framework Directive, Construction Products Regulation, and EU Taxonomy, drive towards circularity. Norwegian building regulations (TEK17) also promote climate accounting and reuse mapping. Overcoming market and logistical barriers is crucial. Coordinated efforts across regions, regulations, and industry standards will determine the success of circular timber construction. A new Norwegian standard (NS 3691) facilitates quality assurance for reclaimed wood. In contrast, practical projects—such as circular prefabricated housing, SirkBO, post-consumer wood from demolition and barns, and modular timber skeleton buildings—demonstrate scalable reuse models.

Findings. Studies confirm consumer readiness for recycled wood and highlight significant climate benefits from reuse over incineration. Research on digital product passports (DPPs) emphasizes their role in material tracking and lifecycle management.

Theoretical / Practical / Societal implications. SirkTRE has shown the viability of large-scale timber reuse, yet regulatory, logistical, and technological barriers remain. Future efforts must focus on policy adaptation, industry incentives, and scaling innovative reuse solutions.

KEYWORDS: circular economy, design for disassembly, innovation, post-consumer wood, regulations.

1 INTRODUCTION

1.1 BACKGROUND

Timber is an important contributor to the strategy of decarbonization in the EU. The building sector has major challenges, i.e. climate adaptation of buildings, vast maintenance needs, limited resources, and increasing costs. On the other hand, the building sector has major possibilities and potential in achieving climate, nature, and resource goals in our transition to a more circular economy.

Timber buildings, fit for reuse, were common a century ago in the Nordics; the components could most often be reused, i.e. log buildings. Thus, the non-circular, linear use of building materials has been in the period from industrialization up until our times. Our resources are limited, and our society of increased waste production must end.

In Norway, around 12 million m^3 of certified timber is harvested yearly (SSB 1, 2024). If our society is to succeed in reducing its greenhouse gas emissions, it is expected that the need for bioresources will be significantly greater. Recycled wood can be a crucial input factor through new reuse and material recycling solutions.

The Norwegian Green platform project SirkTRE aims to enhance longevity and reuse in timber construction.

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SirkTRE targeting an 8% reduction in Norwegian CO_2 emissions aligned with Norway's commitments under the Paris Climate Agreement (United Nations, 2015). Figure 1 shows Norway's annually collected wood waste, averaging 800.000 tons. Launched in 2021, SirkTRE seeks to repurpose half the wood waste into building products by 2030.

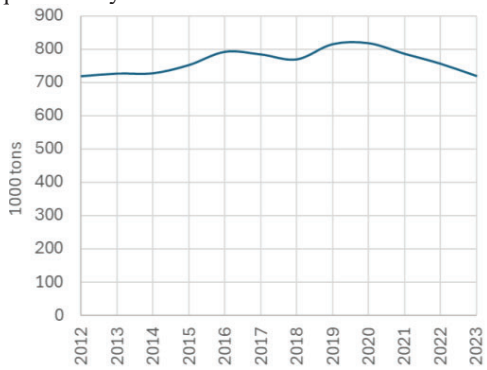

Figure 1 Collected wood waste in Norway from 2012 to 2023 (SSB B, 2024)

1.2 DESCRIPTION OF METHODS

The ambition is to prevent 1 million tons of CO_2 emissions by avoiding incineration of wood waste, while simultaneously sequestering nearly the same amount of in buildings through the reuse and recycling into wooden components.

SirkTRE includes a larger research project, CircWOOD, and five business-driven projects: INN – an innovation center, HELTRE – reuse of solid wood-based solutions, RESSURS – reduced resource use, REAL - realization of circular wood projects and TEK - new technology & new digital production.

SirkTRE ends in June 2025, and the research project CircWOOD ends in June 2026. The funding bodies are the Research Council of Norway, Innovation Norway, and the Industrial Development Corporation of Norway (SIVA), together with 23 business partners that contribute with in-kind hours or cash.

The research project CircWOOD is investigating aspects of wood use in the Norwegian economy, with particular emphasis on the reuse of wood in construction projects, and recycled wood as raw material in today's wood industry. Research results, especially related to resource access and material flows, are linked to the facilitation of the circular flow of goods, handling, environmental impact, design, and production of wood in, and towards, relevant markets in Norway and abroad. The project analyses the sustainability and environmental footprint of the wood-value chain based on strategies and new technologies that contribute to circularity. Furthermore, CircWOOD identifies and investigates ways in which processes can be simplified by using methods for digital collection, analysis, and sharing of data and at the same time addresses the underlying political frameworks and the economic impact cascading of wood. Scientific competence building is one of the main outcomes of the completion of 4 PhD candidates covering material flow and quality of wood resources, policy and governance, socio-economic impacts, and digital tracking and tracing of wood.

1.3 WHY IS THE USE OF WOOD NOT CIRCULAR?

Despite wood's potential as a renewable and sustainable material, its value chains remain among the largest sources of bioenergy incineration (Ellen MacArthur Foundation, 2021). The principles of circularity—extending lifespan, enabling cascade use, and facilitating reuse—have not yet been fully integrated into the wood sector. Several barriers that hinder the transition to circular wood use are collected in SirkTRE:

- Logistical challenges: The distribution and storage of reclaimed building materials pose significant logistical difficulties, require efficient collection systems and storage solutions to prevent material degradation (European Commission, 2020).
- Underdeveloped market: The market for reused building materials remains immature, with limited demand, supply-chain inefficiencies, and a lack of established business models (Gorgolewski, 2017).
- Technological and processing limitations: Current technology and handling systems for returning, sorting, and reprocessing used materials into high-quality, reusable building components are insufficient or underdeveloped (Ellen MacArthur Foundation, 2021).
- Quality assurance and regulatory concerns: There is uncertainty regarding the quality and structural integrity of reused materials, requiring extensive documentation and testing to meet building regulations and standards (Anastasiades, 2021).
- Design-phase constraints: The potential for reuse is often determined early in a product's life cycle, particularly through material selection and construction techniques that may hinder disassembly and repurposing (European Commission, 2020). Delayed time of involvement and thus, not time to influence and plan circular built, neither design, nor use of reclaimed materials (Deloitte, 2022).
- Economic barriers: Virgin raw materials are often more cost-competitive than secondary materials, reducing financial incentives for reuse and making circular alternatives less attractive in the market (OECD, 2024).
- Traditional LCA does not always fully account for circular construction, multiple use, or increased robustness for prolonged lifetime, but extended LCA methodologies and circular

economy-integrated LCA approaches can include these aspects (van Stijn, 2021).

These barriers underscore the need for systemic changes in policy, technology, and market structures – challenges that SirkTRE addresses.

1.4 AIM

As SirkTRE wraps up, the transition to a circular use of wood is complex, however, the relatively low-hanging fruit of the reuse of waste wood is analyzed and more clearly defined.

This paper sums up the upcoming legislation, technology, and needs to ensure that waste wood becomes a valuable source for the timber industry in the future. Furthermore, it also gives insight into innovations and new solutions that have been produced within SirkTRE together with some of the scientific findings that can have a direct impact on the transition to a more circular use of wood.

2 EMERGING FRAMEWORK

Adapting to a more circular approach requires targeted developments and concerted efforts to overcome the barriers outlined in Chapter 1.3. Regulatory frameworks play a crucial role in facilitating this transition.

First, the Paris Agreement (United Nations, 2015) establishes the overarching global ambitions for sustainable development, aiming to ensure that human activities remain within planetary boundaries.

Second, the European building sector is subject to evolving EU regulations designed to promote circularity. Through the European Economic Area (EEA) Agreement, these regulations also apply to Norway, requiring national adaptation to align with European sustainability goals.

Third, each EEA member state integrates EU regulations into its national legal and policy frameworks. In Norway, regulatory developments increasingly reflect principles of the circular economy, including within the building sector.

Beyond regulatory adaptation, the establishment and implementation of standardized guidelines are essential. Industry standards must be developed to provide clear directives, ensuring that the construction sector effectively interprets and complies with new regulatory frameworks, thereby achieving the intended sustainability objectives.

2.1 EU REGULATIONS

Since the EU's launch of the Green Deal in 2019, massive developments in EU regulations have been notified and implemented. The reasoning behind the Green Deal is growth and competition, self-sufficiency, and climate and environment (European Green Deal, 2020).

Below is an excerpt of already ratified regulations relevant to improving the circular activities concerning the transformation of waste wood into a source for the timber industry.

New regulations on the circular economy are notified. An Action Plan for Circular Construction and a Circular Economy Act are upcoming (CEAP, 2020).

2.1.1 Waste Framework Directive

This Waste Framework Directive (WFD, 2019) establishes a waste hierarchy where reuse and recycling are given priority over recovery and disposal. EU countries are obliged to facilitate the separate collection, sorting, and material recovery of waste, including wood.

The EU Waste Framework Directive set a 70% material recovery target for construction and demolition waste by 2020. As of 2023, Norway had achieved 46% material recovery, falling short of this goal (SSB B, 2024).

2.1.2 Construction Products Regulation

The Construction Products Regulations (CPR) set requirements for construction materials, including reused and recycled wood materials (CPR, 2024). This revised version of the CPR strengthens the requirements for circular economy, digital tracking, and market watch and includes more products and a wider scope compared to the former CPR (CPR, 2011).

2.1.3 EU Taxonomy and Sustainable Finance

EU Taxonomy and Sustainable Finance supports the transition to a circular economy, including design for disassembly and reuse of wood materials (EU Taxonomy, 2020). The reuse of wood in construction qualifies as a sustainable investment.

2.1.4 Energy Performance of Buildings Directive and the revised Energy Efficiency Directive

The EU aims for all new buildings to be zero-emission by 2030 and for all existing homes to achieve zero-emission status by 2050 (EPBD, 2024). These energy directives mandate the calculation of life cycle carbon emissions for buildings. Incorporating reused and recycled wood materials can significantly reduce a building's carbon footprint, offering a competitive advantage to developers.

2.1.5 Deforestation-free products regulation

The EU Timber Regulation (EUDR, 2023) applies to imports of wood and wood products, requiring proof that they have not contributed to deforestation. This regulation may incentivize the increased use of recycled and reused wood as an alternative to virgin timber, thereby reducing compliance challenges.

2.1.6 The Ecodesign for Sustainable Products Regulation

The EU has established a framework to enhance the sustainability of products on the European market (ESPR, 2024). The ESPR outlines requirements for the durability, reparability, and reuse of wood materials in sectors such as furniture, construction, and others.

2.1.7 Carbon Capture and Storage

The Carbon Removal Certification Framework (CRCF, 2024) sets rules for carbon sequestration in buildings and the reuse of wood. It has been established to certify carbon sequestration, including bio-based carbon sequestration in

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construction. Reusing wood in buildings can contribute to long-term carbon sequestration, qualifying for carbon credits. As such, the CRCF aims to create incentives for the conservation and reuse of wood, encouraging alternatives to incineration or landfilling.

2.2 NORWEGIAN REGULATIONS VALID AND EMERGING

Norwegian building regulations (TEK17, 2023), latest adaptations, valid from July 1st, 2023, are towards improving the built environment's climate footprint, and circular construction. These changes include:

1. Climate accounts for materials in building projects
2. Reuse mapping of buildings prior to demounting
3. Construction work shall be designed and prepared for later dismantling when this can be carried out within a practical and economically justifiable framework.

For these regulations to have an impact, all these changes need supplementary legal requirements and standards:

1. Boundary lines are allowed for climate gas emissions.
2. Mapped used materials, fit for reuse, should be made available in an open information flow. The digital passport development of CPR provides the basis for this development.
3. Design for disassembly must become regulatory. Thus, further standardization in this field is required to define the future design of the different materials and building categories.

2.3 CIRCULAR CONSTRUCTION CEN/TC 350/SC 1

The CEN/TC 350/SC 1 refers to the standardization committee under the European Committee for Standardization (CEN), specifically focused on sustainability in construction, with a subcommittee dedicated to circular construction practices.

The standardization committee will specify circular principles, guidelines, and requirements to support more sustainable practices. The entire life cycle of construction works is covered, from design and construction to dismantling and end-of-life, including both new and existing buildings and structures.

2.4 IMPACT ON THE CIRCULAR BUILDING SECTOR

The construction sector is increasingly incentivized to incorporate reused wood, driven by evolving regulations and market dynamics. The European Union (EU) has implemented several measures to promote the use of recycled and reused materials, including wood, in construction projects.

EU Regulations and Incentives:

- **Cascading Use of Biomass:** The revised Renewable Energy Directive (RED III), effective from November 2023, introduces principles and rules for Member States to prioritize the use of woody biomass in material applications before burning wood for energy. This approach encourages the use of wood in construction and other material applications, potentially reducing the availability of wood for energy purposes and thereby increasing its value in the construction sector (ECOS, 2024).

National Initiatives:

- **Germany:** The Investment and Support Bank of Hamburg (IFBHH) offers financial support for the use of wood in construction. For residential buildings, the bank provides 30 cents EUR per kg of wood, amounting to approximately 5,000-6,000 EUR for a 140m² apartment. This initiative serves as a strong incentive for builders to incorporate wood into their projects. (Interregeurope, 2021).

Implications for Norway:

While specific national incentives in Norway are not detailed in the provided sources, the EU's overarching policies and frameworks are likely to influence Norwegian construction practices. The emphasis on carbon storage in buildings and the promotion of reused materials, including wood, aligns with Norway's sustainability goals. As EU regulations often set precedents, similar incentives and requirements may be adopted or adapted within Norway's regulatory framework, encouraging the use of reused wood in construction projects.

In summary, both EU-level regulations and national initiatives are creating a conducive environment for the increased use of reused wood in the construction sector. These developments are expected to play a significant role in promoting sustainable building practices in Norway and across the EU.

3 RESULTS FROM SIRKTRE

The SirkTRE project aimed to make the timber industry more circular over four years. Though its scope was broad and several key actions have advanced the circular timber sector, including: the development of standards for evaluating reclaimed wood, reducing the carbon footprint of reuse, and potentially expanding the timber industry's market share through larger sourcing volumes. The different initiatives test the way of the transition to a fully circular, green shift in the timber and construction industries. Some examples from the SirkTRE are highlighted.

3.1 STANDARDIZATION – REUSE OF WOOD

As part of SirkTRE, the new Norwegian Standard series for recycled wood aims to simplify the evaluation and quality assurance of used wood and wood-based materials for reuse in new construction products. NS 3691, 'Evaluation of Reclaimed Wood,' (NS 3691, 2025) defines reclaimed wood as material sourced from dismantled

structures, packaging, or offcuts, including surplus materials from construction activities. It does not include surplus materials or by-products from sawmills or forestry operations. A standard method for evaluating reclaimed wood can streamline quality assurance and potentially reduce the costs of reused wood.
The standard series consists of three parts:

- NS 3691-1 Evaluation of reclaimed wood – Part 1: Terminology and general rules
- NS 3691-2 Evaluation of reclaimed wood – Part 2: Impurity
- NS 3691-3 Evaluation of reclaimed wood – Part 3: Visual strength sorting

The goal is to support the transition to a more circular wood products industry and reduce valuable waste. In addition to the three existing standards, two more are being developed: one for composite timber components, such as nail-plate frames or glulam, and another for the competencies required to evaluate reclaimed wood.
The Norwegian mirror committee is active in the CEN and ISO development of circular standards.

3.2 NEW SOLUTIONS

The SirkTRE project is driving innovation to make the timber industry more circular, focusing on sustainability and waste reduction. Through various initiatives and activities, SirkTRE is developing new technologies, products and practices, as well as building necessary scientific knowledge, to support the reuse and recycling of wood materials. Each project and activity within SirkTRE has its unique focus and ambition, and short films highlighting their work are available to explore. For more details, visit www.sirktre.no. Below are some selected outcomes presented.

3.2.1 Circular prefabricated house

SirkTRE partner Haugen/Zohar Architects has developed a circular housing series, offering innovative solutions for sustainable housing. The SirkBO concept, see Figure 2, focuses on designing recyclable and reusable components to enter new cycles, reducing environmental impacts. The use of modular and standardized elements simplifies construction and shortens assembly time significantly. (*retracted for peer-review*).

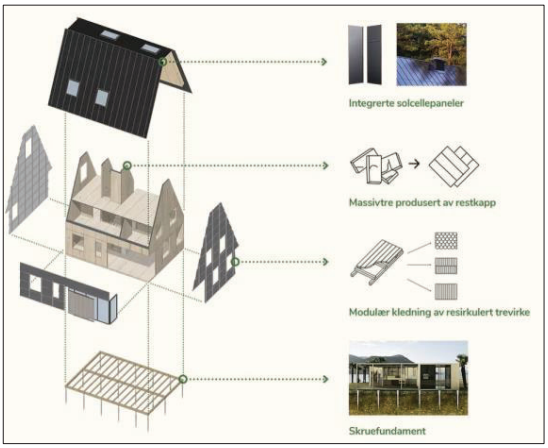

Figure 2. Circular building components of the prefabricated house. Credits: Haugen/Zohar Arkitekter.

3.2.2 Cattle barn built in post-consumer wood

The first SirkTRE case project, a barn in Noresund, Norway, was the first and largest modern agricultural building built in solid wood with a large proportion of recycled wood, see Figure 3. The recycled wood is exposed in the walls on the inside of the barn. The screwed solid timber wall elements consist of 75% recycled wood of 48x98 mm, edge-set, and screwed together in vertical lengths. The initial desire was 100% recycled wood, but to ensure structural safety, every fourth lamella is continuous and made of virgin wood.

Figure 3. Barn raised with 75% reused lamellas in screwed solid timber wall elements. Photo: Authors

3.2.3 Sirkulær Ressurssentral – Circular Resource Hub

Located in a 4,500 m² tent at Økern, Oslo, Sirkulær Ressurssentral has created one of Europe's largest recycling hubs. As part of SirkTRE, Sirkulær Ressurssentral processes reclaimed wood from building projects, reintegrating it as a raw material in the wood industry or into new building projects. Reuse requires value creation in an upcoming market. Regions like Oslo show prosperous solutions for such initiatives.

3.2.4 Flexible building in timber

Rammeverk is a new, modular building model, shown in Figure 4, of an apartment building, a so-called "open building", which allows for resident participation in the planning and gives both the developer and residents great

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flexibility throughout the life of the building. This timber frame house is an apartment building that can be ordered flat-packed from a glulam factory.

Figure 4. Frame house for flexible housing. Photo rendering: Fragment

3.2.5 Aanesland Treindustri – production facility in timber

Aanesland Treindustri's new steel-free production building in Lillesand is 1,900 m² and was completed in 2022 (Figure 5). The facility was designed by the timber architects at Helen and Hard, Stavanger, Norway. The load-bearing systems for the building were supplied by Aaneslands glulam-production, Sørlaminering, and self-produced oak dowels. Thus, the use of steel was reduced to a minimum. In the SirkTRE -project of Aanesland has been to further develop moment-stiff timber frame connections with oak or beech dowel connections. The use of this technology is available for design in the software for timber engineering TimberTech (2024). https://en.timbertech.eu/.

Figure 5. Timber frame from Aanesland Treindustri production facility during assembly, before installing oak dowels, built in 2022. Photo: Aanesland Treindustri.

3.2.6 Circular interior wall system

Today, interior office sectioning walls are often changed every seventh year in Oslo, Norway. Thus, a reusable interior wall system using timber, suitable for use in both rehabilitation and new building projects, is developed by the architect's office Grape. This wall system offers the flexibility to be disassembled, moved within the same building, or reused in other contexts. The design aims to achieve strict sound insulation, targeting a reduction of approximately 48-49 dB. A wall with an open lock system is shown in Figure 6.

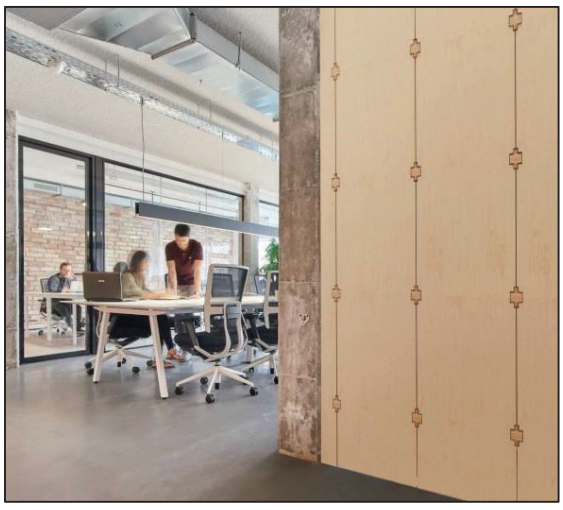

Figure 6. Circular wall system with reused wood. Photo rendering: Grape Architects

3.2.7 Reblåkk

Reblåkk is a patented building block system based on CLT off-cuts (Figure 7). With the increasing CLT

production capacity, the cut-off lacks refined use. Reblåkk is optimized for mass production, where a compact production can be attached to an existing CLT production. The development of Reblåkk is currently a scale-up, defining its potential for re-use and in a circular business strategy. Reblåkk fulfils the Safe and Sustainable by Design framework (SSbD) (European Commission, 2022)

Figure 7. Mounting Reblåkk. Photo: Authors

3.3 CONSUMER ATTITUDE

The construction sector has a significant environmental impact, which can be reduced by increasing the use of recycled materials. This has been the backdrop for a study that explored Norwegian consumers' willingness to use recycled wood in houses and cabins, applying the Diffusion of Innovations theory (Khatri et al, 2025). Surveys of 913 homeowners revealed strong consumer readiness, with Relative Advantage and Compatibility as key adoption drivers. Perceived Risk had minimal impact, while Green Values influenced adoption indirectly. These insights can help businesses design appealing recycled products and inform policies that promote circular practices in construction.

3.4 CLIMATIC IMPACT

Reusing waste wood can be a better climate solution than incinerating it for energy recovery, and Hansen et al. (2023) showed that a scenario involving reusing waste wood without processing and distributing it through a reuse center near new construction activities had the highest avoided greenhouse gas emissions. Another reuse scenario, where waste wood is sorted at waste facilities and requires cutting and additional machinery, also results in significantly greater avoided emissions than the reference scenario. A sensitivity analysis, based on reuse through a dedicated station, indicated that increasing the reuse rate from 20% to 80% could lead to approximately 50% higher avoided emissions.

3.5 DIGITAL PRODUCT PASSPORTS

Lyse (2024) explored the role of digital product passports (DPPs) in promoting the reuse, recycling, and recovery of building materials, thereby reducing the need for new raw material extraction. DPPs can help consumers and manufacturers make sustainable choices by providing essential product information and minimizing waste. The study focuses on how DPPs can effectively track and manage building materials at the end of their life cycle to support a circular economy in the construction industry. The research identified a lack of existing studies on how DPPs should be structured, what information they should contain, and how they should be validated. A literature review and a survey of 51 respondents from different sectors (reuse, recycling, repurposing, research, and education) were conducted to fill this gap. Findings highlight five key information categories for DPPs: 1) Product information, 2) Manufacturer details, 3) Installation and assembly data, 4) Maintenance guidelines, and 5) End-of-life information. Additionally, Lyse (2024) proposed a framework for DPPs, outlining necessary validation procedures. Several information models were developed to support the implementation of DPPs in the construction sector. This research provides insights into how digital tracking systems can improve resource efficiency and circularity in the industry. XX had from the start ambitions to show the practical effect of the reuse of large volumes of timber. Lack of investment due to weak construction activity has, however, led to low demand.

4 CONCLUDING REMARKS

The circular timber building sector is within reach. The results show a multitude of examples of how circularity can develop. SirkTRE recommends further development of standardization on all levels, from products and materials to material sourcing and building operations. The analysis indicates substantial potential for carbon savings through SirkTRE initiatives. Initial calculations supporting the 8% reduction target are currently critically reviewed and compared with updated data from ongoing activities, suggesting a promising trajectory toward achieving these climate goals and emphasizing the effectiveness of circular strategies in timber construction. The results enhance theoretical frameworks on circular economies while providing practical insights for policymakers and industry stakeholders. It underscores the importance of innovative resource management in mitigating climate change, fostering sustainable practices in the construction sector, and promoting a circular economy in Norway and beyond.

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4.1 INCREASING INTEREST

SirkTRE has drawn inspiration from previous projects and has also served as a catalyst and initiator for numerous consortiums, leading to funded projects. A selection is listed below.

4.1.1 Basajaun, Horizon 2020, 2020-24

Basajaun focused on demonstrating how sustainable wood construction can contribute to a circular bioeconomy. It developed innovative wooden building systems using locally sourced materials, optimizing the entire value chain from forest management to construction. The project showcased two full-scale demonstrators in France and Spain, proving the feasibility of high-performance, low-carbon timber buildings. By integrating digital tools and sustainable practices, Basajaun aimed to enhance resource efficiency and promote the use of wood in European construction.

4.1.2 InnoTLT, Bioeconomy in the North, 2023-2026

InnoTLT aims to advance cross-laminated timber (CLT) into Tailored Laminated Timber (TLT). The project focuses on developing innovative TLT panels for walls and floors, enhancing structural performance, stiffness, and load-bearing capacity. InnoTLT seeks to revolutionize the timber industry by promoting a circular economy and sustainable construction practices.

4.1.3 DRASTIC, Horizon Europe, 2023-2027

DRASTIC aims to reduce whole life cycle GHG emissions in new construction and deep-energy retrofits by demonstrating affordable, innovative circular solutions across five geographical zones and multiple building layers. The project will develop and apply a multi-cyclic performance assessment framework, integrating multi-cycle LCA, multi-cycle LCC, circularity, and sufficiency for construction and building-related products. It will also demonstrate the feasibility of promising, cost-effective technologies, processes, and business models to accelerate market adoption. This will contribute to more sustainable buildings with lower life-cycle carbon emissions, enhanced performance, and reduced costs.

4.1.4 Woodcircles, Horizon Europe, 2023-2027

Transforming sustainability in the construction industry, Woodcircles pioneers' circular solutions for sustainable wood construction. By reducing Europe's reliance on non-renewable resources, the initiative lowers greenhouse gas emissions and minimizes waste. Key innovations include the eco-friendly and efficient construction of an 'urban sawmill' and the use of digital twins. Through integrated, circular, and digitally supported solutions, Woodcircles advances waste reduction and carbon capture in buildings, ushering in a new era of eco-conscious construction that benefits both the environment and the economy.

4.1.5 CIRCULess, Horizon Europe, 2024-2027

CIRCULess aims for a circular solution for construction and manufacturing waste. The process industry needs to embrace a circular economy and restorative feedback loops to optimize resource use and reduce supply costs. The construction sector is expected to benefit significantly from these models. However, reclaimed materials must meet the same standards as new materials. The goal is to promote circularity in the construction and manufacturing industries by reducing construction, demolition, and manufacturing waste, focusing on mineral and timber-based material streams. The project will develop new circular products and processing techniques to improve the quality and performance of secondary materials.

4.1.6 RAW project, EIC Pathfinder, 2024-2027

The full name of the project is 'Computation For A New Age Of Resource Aware Architecture: Waste-Sourced And Fast-Growing Bio-Based Materials'. The project aims for a paradigm-shifting new digital infrastructure that combines non-destructive material sensing technologies with adaptive design and fabrication. This will allow the building industry for the first time to assess and use natural materials in the variability with which they are grown or have been reclaimed, minimizing the current energy consumption and wasteful practices of material homogenization. With a focus on reclaimed timber, biopolymers from agricultural waste, and composites from fast-growing hemp fibers the project will help to reduce CO_2 emissions, support the circular economy, and create new aesthetic possibilities for architecture.

4.1.7 WoodStock, Horizon Europe, 2024-2028

The WoodStock project aims to promote climate-smart, circular, and zero-waste utilization of underutilized wood from forests and existing buildings in the construction sector, supporting the New European Bauhaus initiative. The project focuses on quantifying and mapping wood resources, including underutilized streams, using Harvested Wood Products accounting, dynamic Material Flow Analysis and LCA to assess wood utilization potential, climate mitigation impacts, and resource availability. Through six Living Labs across different European regions, WoodStock develops zero-waste and circular building designs, leveraging digital twins and co-creation activities to enhance human health and well-being. The project also establishes the European Wood Construction Observatory, an AI-powered hub for best practices and innovative solutions, ensuring long-term impact beyond its duration. Empowering climate-smart, circular, and zero-waste use of underutilized wood from the forest and building stock in the construction sector.

4.2 TRANSITION TO A CIRCULAR ECONOMY IN THE EU AND THE NORDIC COUNTRIES

EU's Circular Economy Action Plan (CEAP) (European Commission, 2020) challenges the member states to test out incentives to promote a circular economy.

In the Nordics, Sweden responded to this challenge in 2024, with two incentives for the built environment (Söderholm et al., 2024).

1) Incentives for reuse, collection, and material recycling. Thus, increasing the producer's

responsibility for building products. Proposals that lead to increased collection and recycling should be analyzed further.

2) Incentives for economically motivated renovations and efficient use of outer building elements. Several regulations and regulations should be reviewed based on how they provide incentives for socially and economically motivated renovations and efficient use of space.

Norway has a panel of government-appointed experts who are writing a report planned for May 2025 that will cover incentives to increase circularity, proposed new and simplified regulations, tax and different support schemes. This will be the start of a follow-up mission of holistic implementation of the circular economy in Norway. SirkTRE and CircWOOD are represented in both the expert group and the reference group.

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REFERENCES

Anastasiades, K. et al. (2021) Standardisation: An essential enabler for the circular reuse of construction components? A trajectory for a cleaner European construction industry, Journal of Cleaner Production, (298) https://doi.org/10.1016/j.jclepro.2021.126864.

CEAP, 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN

CRCF (2024) Carbon Removal Certification Framework (EU/2024/3012 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202403012

CPR (2024) EU 2024/3110. https://eur-lex.europa.eu/eli/reg/2024/3110/oj/eng

Deloitte (2020) Circular economy in the construction, civil engineering and real estate industries. Sirkulær økonomi i bygg-, anlegg- og eiendomsnæringen Directorate for Public Administration and Financial Management (DFØ) In Norwegian. www.anskaffelser.no/sites/default/files/2023-01/Sirkular-okonomi-i-BAE-naringen.pdf

ECOS 2024. An emerging framework for timber buildings policy and standards briefing, www.ecostandard.org/wp-content/uploads/2024/09/2024-09-09_ECOS_Framework-timber-buildings.pdf

Ellen MacArthur Foundation (2021). Circular Economy in Construction: Rethinking Materials and Waste.

EPBD (2024) energy performance of buildings EU/2024/1275; EU/2023/1791 https://eur-lex.europa.eu/legal content/EN/TXT/?uri=OJ:L_202401275&pk_keyword=Energy&pk_content=Directive

ESPR (2024) EU 2024/1781 Ecodesign requirements for sustainable products. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1781&qid=1719580391746

EUDR (2023) Deforestation and forest degradation and repealing https://eur-lex.europa.eu/eli/reg/2023/1115/oj/eng

European Commission (2020). Circular Economy Action Plan: For a Cleaner and More Competitive Europe.

European Commission (2022). Directorate-General for Research and Innovation, *Safe and sustainable by design chemicals and materials – A European assessment framework*, Publications Office of the European Union, https://data.europa.eu/doi/10.2777/86120

European Green Deal (2020) Communication from the commission to the European parliament, the european council, the council, the European economic and social committee and the committee of the regions the European green deal https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

EU Taxonomy (2020) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32020R0852

Gorgolewski, M. (2017). Resource Salvation: The Architecture of Reuse. Wiley.

Hanssen, M. R, Thorkildsen, T. E, Nyrud, A. Q. (2023). Life Cycle Analysis of Reuse of Waste Wood. In Norwegian: Livsløpsanalyse av ombruk av returtre. *MINA fagrapport 91*. Ås: Norges miljø- og biovitenskapelige universitet, Fakultet for miljøvitenskap og naturforvaltning, 35 s. https://static02.nmbu.no/mina/publikasjoner/mina_fagrapport/pdf/mif91.pdf

Interregeurope.eu (2021) Wood as a sustainable construction material. https://www.interregeurope.eu/find-policy-solutions/stories/wood-as-a-sustainable-construction-material?

Khatri, S., Sjølie, H. K., & Nyrud, A. Q. (2025). Consumer drivers for intended adoption of recycled wood as construction material. *Cleaner and Circular Bioeconomy*, 10. https://doi.org/10.1016/j.clcb.2024.100129.

Lyse, S. M. (2024). Digital Product Passports for Efficient Tracking and Monitoring of Building Materials. In Norwegian: Digitale produktpass for effektiv sporing og følging av byggematerialer. Master's thesis. Norwegian University of Science and Technology (NTNU).

NS 3691 (2025). Evaluation of return wood. Evaluering av retur tre. In Norwegian. Norsk Standard

SSB A, (2024). Avfallsregnskapet. https://www.ssb.no/natur-og-miljo/avfall/statistikk/avfallsregnskapet

SSB B (2024). Skogavvirkning-for-salg https://www.ssb.no/jord-skog-jakt-og-fiskeri/skogbruk/statistikk/skogavvirkning-for-salg

https://doi.org/10.52202/080684-0005

Söderholm P. et al. (2025). Om ekonomiska styrmedel för en mer cirkulär ekonomi Betänkande av Kommittén om ekonomiska styrmedel för att främja omställningen till en cirkulär ekonomi. In Swedish. SOU 2024:67, Stockholm, Sweden.
TEK 17 (2023). Regulations on technical requirements for construction works. In Norwgian. Norwegian building authority. ttps://www.dibk.no/regelverk/byggteknisk-forskrift-tek17
TimberTech (2024) Software for timber structure design. https://en.timbertech.eu/.
United Nations. (2015). Paris Agreement. United Nations.
van Stijn, A., et al. (2021) A Circular Economy Life Cycle Assessment (CE-LCA) model for building components, Resources, Conservation and Recycling, 174, https://doi.org/10.1016/j.resconrec.2021.105683.
WFD (2019). Waste Framework Directive https://eur-lex.europa.eu/eli/dec_impl/2019/1004/oj#:~:text=Commission%20Implementing%20Decision%20(EU)%202019,2384%20(notified%20under%20document%20C(