Can the SIRKTRE Consortium Facilitate for 8% of the Norwegian Paris Climate Obligations With Their Circular Solutions

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This paper evaluates the importance, progress, and challenges of scaling circular wood solutions in the built environment, drawing on insights from the Norwegian SirkTRE project. It highlights that while circular timber solutions, such as reuse and reclaimed wood applications, are often technically feasible, their wider adoption is constrained by governance gaps, limited data availability, market barriers, and regulatory frameworks that continue to favour linear models.

This research is highly relevant to **Drastic**'s objectives and its **Nordic Demonstrator**, which focuses on the use of reclaimed timber for innovative structural and load-bearing applications in temporary commercial buildings. The paper's emphasis on robust assessment methods, transparent data flows, and viable circular business models closely aligns with Drastic's work to operationalise circularity through multi-cycle sustainability assessment, harmonised data collection, and cross-country piloting.

The connection to Drastic is strengthened by the involvement of project parnter **Omtre**, who contributed both to this research and who also co-lead Drastic's Nordic Demonstrator. Omtre's role helps align scientific advances in reclaimed timber assessment with the Demonstrator's practical objectives, furthering Drastic's broader efforts to advance circular, multi-cycle timber use.

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CAN THE SIRKTRE CONSORTIUM FACILITATE FOR 8% OF THE NORWEGIAN PARIS CLIMATE OBLIGATIONS WITH THEIR CIRCULAR SOLUTIONS?

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ABSTRACT: The Norwegian SirkTRE project (2021-2025) aims to enable a full value chain that adopts reuse and material recycling of post-consumer wood in Norway. The long-term ambition, proposed in 2021, was to facilitate for half of today's wood waste into building products by 2030, which would result in the reduction of the Norwegian climate obligations by 8% CO_2-e. This publication explains the calculation of the expected impact, estimated in 2021, and compares these with new insights about the project impact by reflecting on and collecting environmental impact data on experiences and achievements in SirkTRE early 2025. By applying a systems-oriented design approach to reach an increased uptake of post-consumer wood and increased positive environmental impact, we have been learning pain points in the past 4 years. There is not enough data about life cycle performances (LCA) of the solutions with high certainty, which is explained by a lack of budgeting in prospective LCA, lack of societal knowledge and data about availability and markets. This paper takes a humble and skeptical approach to the learning outcomes and the environmental impacts in SirkTRE and shares some insights that might inform next project designs at the same scale as SirkTRE. The answer to the title's question is negative, if not the transition to circularity, including common guidelines, industrial reproduction and culture, quickly gain speed.

KEYWORDS: circular economy, decarbonization potential, impact assessment challenges, timber construction

1 – INTRODUCTION

The climate crisis demands innovative strategies to mitigate carbon emissions, and timber construction emerges as a vital solution due to its carbon sequestration capabilities. However, the potential of timber construction extends beyond mere storage of carbon; by embracing circularity strategies, the industry could further enhance its environmental benefits. Valuable wood resources are often incinerated rather than utilized following wood cascading principles that could maximize their lifecycle and environmental benefits [1]. Amidst the multifaceted crises of climate change and waste management, Norway has initiated the SirkTRE project, successfully funded in 2021. One of the initial claims publicized was that SirkTRE's initiatives would contribute towards 8% of Norway's Paris climate agreement obligations in 2030, 5 years after project end. As the project progressed, initial plans were revised and new, pragmatic solutions were developed. Furthermore, SirkTRE encountered complexities in applying Life Cycle Assessment (LCA) for Circular Economy (CE) evaluations. The project's approach involved an intricate ecosystem, integrating various circularity strategies such as design for reuse across multiple levels, scales, and Brand shear layers, new products made of post-consumer wood, supplemented by digital and enabling solutions with potential multiplier effects at both Norwegian and European levels. Consequently, accurately assessing and validating the consortium's overall impact and the initial 8% claim, presents significant challenges. This paper serves three primary purposes: firstly, it aims to detail the decarbonization impacts from January 2022 to March 2025 of the products and implementation activities and estimate its potential up to 2030. Secondly, through a critical and reflective analysis, this paper will evaluate whether SirkTRE is on track to facilitate the 8% target. Thirdly, it will present pain points in the innovation and knowledge creation and management process in the past four years.

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Following the example of [2], and the classifications on base of circularity strategies, Brand Layers and levels (product, element, building) [3], this conference paper will present an overview of the SirkTRE concepts, products and buildings. It will answer which applications of circular strategies have been used and what their individual carbon saving potentials were. Decarbonisation potentials are reported based on the functional unit and with reference to each case study's LCA. This study introduces novel elements compared to previous research on circular solutions in the built environment [3,4]. Specifically, it focuses solely on timber and conducts benchmarking within a Norwegian context.

2 – BACKGROUND

This paper explores the integration of sustainability and CE principles within timber structures.

2.1. Brand Layers and CE strategies

We employ Brand's (1995) framework of six shearing layers [3]—Site, Structure, Skin, Services, Space Plan, and Stuff—to categorize building components by longevity and impact. The classifications of circular economy principles and Brand's shearing layers are pivotal in enhancing the effectiveness of LCAs and sustainability practices within the construction industry. By categorizing strategies into closing, slowing, narrowing, and regenerating loops [5], stakeholders can identify and implement specific interventions tailored to optimize resource efficiency and minimize environmental impacts at different stages of a product's lifecycle.

In terms of Brand's shearing layers, the significance of categorizing building components by their durability is crucial. Each layer has a distinct average lifespan, which directly influences decisions in lifecycle assessments. For instance, components with shorter lifespans, such as "Services" or "Stuff," may require more frequent replacements or upgrades, which can significantly affect both the environmental impact and the maintenance costs over the building's life. Conversely, elements like "Structure" are designed to last for decades, hence decisions about these are often taken with long-term sustainability in mind. Understanding these differences helps stakeholders make more informed choices that align with both immediate needs and long-term environmental goals.

2.2. From products to circular solutions – for better comparison

Transitioning from a product-centric to a solution-oriented perspective is essential in the realm of sustainable development, particularly within the circular economy. This shift underscores the importance of aligning product development with user needs and environmental considerations. From a sufficiency perspective [5], CE-strategies, such as refusing and rethinking, challenge us to critically evaluate whether a product is truly necessary or if a more sustainable solution could be devised that minimizes waste and resource consumption.

Adopting a solutions-based approach also facilitates the identification of more accurate baselines for benchmarking and comparison from a life cycle perspective. Solutions are typically assessed based on their functional properties, utilizing the concept of a functional unit in LCA. For example, timber is often accounted in cubic meters [6], or the SirkTRE solution of Grape indoor wall is compared with a linear non-biobased solution with the same acoustic performance [7]. This approach allows for a more holistic evaluation of a solution's environmental impact relative to its intended function, providing a clearer picture of its true sustainability credentials.

2.3. From circular strategies to the Closed-loop, Cut-off and the multiple use cycle approach

All individuals engaged in the LCA of timber construction products, particularly those adopting a circular approach, recognize that existing LCA standards are predominantly designed for a linear economy [8]. A notable challenge arises during phase D, which involves accounting for recovery and reuse benefits. For instance, when a product (Product 1) is recycled into another (Product 2), determining the allocation of inputs between the two products becomes complex.

Various initiatives, such as the Drastic project, have highlighted the disconnect between LCA methodologies and the principles of circularity [8]. While this paper does not claim to offer a definitive solution—often referred to as the "perfect LCA method"—it aims to explore diverse approaches and caution that control over the methodologies employed by researchers in the secondary data compiled here is limited.

Among the approaches discussed are the closed loop, cutoff, and multiple use cycle approaches. In the closed-loop approach (also referred to as the *allocation at the point of substitution* or *system expansion*), a product that is recycled assumes the environmental burden of the dismantling and processing required for reuse but also receives credits for displacing virgin materials in its

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second life. The second life product, in turn, carries the burden of the recycled material's production, reflecting the avoided production of virgin materials.

In the cut-off approach, the first life cycle bears the full environmental burden up to the point of disposal, including any waste treatment or recycling processes. The second life product receives the recycled material burden-free, except for impacts related to collection and reprocessing (e.g., dismantling), effectively treating the recycled input as an input with no prior environmental history. However, uncertainties persist, such as how to account for biogenic carbon in reclaimed timber. One of the co-authors, involved in the LCA of the SirkTRE pilot project Re:Textile, has applied these considerations.

Additionally, the Drastic project is developing a multiple use cycle approach [9], which contemplates an extended timeline—potentially up to 150 years, particularly for structural elements expected to last between 50 to 100 years. However, a shorter timeframe of 60 years may be relevant for elements like partition walls, which typically undergo changes every other decades or so.

3 – EXPERIMENTAL SET-UP

3.1. Prior to the project: SirkTRE's ambition and the calculation behind the 8% in 2021

We want to stress out that the 8% target lack standardized calculation methods. This paper takes a humble approach to the learning outcomes and the environmental impacts during and beyond the SirkTRE project. One of the most important learning outcomes is the identification of some pain points. There is not enough data about LCA of the solutions, which is explained by a lack of budgeting in prospective life cycle assessments, lack of societal knowledge and data about availability and markets, slow progress of harmonization of environmental impact assessment tools and the ongoing critique about the missing link between LCA and circularity [10]. The authors acknowledge the inherent complexities and assumptions involved in conducting LCA. The choice of analysis level—whether material, product, or sector—along with the selection of appropriate baselines, such as comparing impacts against steel versus prevailing virgin timber-based solutions, introduces significant variability in our findings [11, 12]. It is important to note that striving for perfect LCA guidelines could stall progress, given the ongoing debates and lack of standardization across the field. This is highlighted by the Omnibus Package in the EU, dated 26 February 2025, which emphasizes the need for 'simplification' in regulatory approaches [13]. The rigorous data collection required for accurate LCA is both labor-intensive and costly, and we learned in many discussions with researchers in CircWOOD, the fully financed research part of SirkTRE, and other cooperative projects, that the LCA standards do not support reclaimed timber products.

The ex-ante top-down *guestimation* method

In Norway, approximately 800.000 tons of wood waste are generated annually [14], corresponding to about 2 million cubic meters of wood, assuming a density of approximately 400 kg/m³. Noteworthy, the actual volume of wood waste is likely higher, as it is often more economical for individuals to use wood as firewood rather than disposing of it through waste treatment facilities. For environmental impact estimations, it is commonly approximated that one cubic meter of wood is equivalent to one ton of CO_2 equivalent (CO_2-e), despite the actual conversion factor being around 0.8 kg per liter for Norway spruce and pine. This rule of thumb facilitates straightforward calculations. Regarding the utilization of wood in construction, repurposing half of the collected wood volume, would sequester approximately 1 million tons of CO_2-e in buildings, preventing its immediate release into the atmosphere. By accounting that it is not sent to the atmosphere through incineration (saving 1 million tons CO_2-e), and that it is sequestered in buildings for at least 35 years [15] (another 1 million tonnes of CO_2-equivalent), SirkTRE aims to reduce CO_2-equivalent by 2 million tons. This would contribute approximately 8% towards Norway's updated obligations under the Paris Agreement to reduce greenhouse gases by 55% (2021: 50%) from the 1990 levels, where Norway emitted 52.8 million tons of CO_2.

Change in the Harvested Wood Products (HWP) was reported according to the EUs LULUCF. The SirkTRE scenarios was implemented in a study of the climate effects of increased use and efficiency of wood, that is HWP, in Norway [16]. Increased use of wood and return of waste wood will be a positive contribution to the Norwegian climate accountancy.

As aforementioned, in the past four years, we have been learning a lot, improved our knowledge graph on required knowledge, data availability, systemic barriers and pain points in the whole system, and we are aware that there is not enough data in Norway and beyond to validate this statement. In the next subsection, we explain how we still try to grasp SirkTRE's impact.

3.2. Post-project bottom-up approach in 2024-2025 with Life cycle Assessment (LCA)

A critical initial step in evaluating the decarbonization potential of circular solutions involves establishing a baseline for each strategy. As the environmental impact of construction materials gains attention, tools like (LCA) and Environmental Product Declarations (EPD) become essential. These tools help answer key questions such as "*Which material is better for the environment?*" For instance, Hill et al. [12] compared virgin wood with other materials, while Sæthre and O'Connor [17] performed a meta-analysis of 21 studies, concluding that substituting wood for non-wood materials results in an average displacement factor of 2.1. This indicates that using 1 tonn of wood can save 2.1 tonnes of CO_2 equivalent.

However, our reliance on secondary data meant we were dependent on the baseline choices made by other researchers, which varied significantly—from virgin timber to materials reused before incineration. The definitions of circular solutions also varied, ranging from multiple-use virgin timber to reclaimed timber designs, which might still end up incinerated if they score low on Design for Disassembly (DFD), now a requirement in the Norwegian building codes, TEK17 [18]. Control over the selection of EPDs, such as those from EPD Norge, was not always possible within the SirkTRE project. However, we will also speculate that if the others used virgin wood as a baseline, to use the average displacement factor of 2.1, to understand even the bigger decarbonisation potential when non-wood materials are substituted by reclaimed timber, and to validate some numbers that we got from SirkTRE partners. Noteworthy, this study is not itself an environmental impact assessment, but rather a display of some impact numbers and, more importantly, discussion regarding scalability and wider impact beyond the SirkTRE project. Sensitivity analysis, as observed in many prospective life cycle assessments, is outside the scope of this conference paper.

3.3. Real case studies at product and building level in the SirkTRE project's timeframe

Unfortunately, we are aware that only five of ten circular solutions at the product level have undergone an LCA, and none have been validated or published in an EPD yet. An EPD is not required at the stage when the products are not market ready. The LCA's done include Omtre's REjoin, which is finger jointed reclaimed timber compared to virgin timber boards but is still at a low TRL; Omtre's REblåkk walls compared to traditional stud walls; Omtre's facilitation of reuse of reclaimed timber from deconstruction, and Grape's indoor wall, which is compared to a gypsum-steel wall with similar acoustic performance. Additionally, Norsk Massivtre has initiated a life cycle inventory for a circular element, comparing it with their virgin timber-based wall, roof, and balcony elements. Rang-Sells have initiated a "white chips" project, intended to serve another SirkTRE partners wood chip sourcing. These tests have not yet reached the development of an LCA.

At building level, we only have LCA results for one pilot project (Re:Textile) and LCA results from a feasibility study for an unrealized project (Svalbard's Elvegranda). As of March 31, 2025, there were five construction projects utilizing Norsk Massivtre's Sirkulær element, one with Grape's wall element, and three with Omtre's REblåkk. There were no construction projects using Omtre's REjoin, but Omtre and other reuse centrals turn long length timber, for direct reuse. Table 1 displays a list of all the SirkTRE solutions and SirkTRE pilots, and the availability of LCA data on the product or building level. Significantly, within SirkTRE, there were key insights gained regarding the business model and product identification. In certain instances, the solutions were predominantly service-oriented, such as those provided by architects. These professionals offer services including project design, management, and, importantly, the facilitation of material (and often data) relocation (Product 3). Table 1 indicates that three SirkTRE partners are providing this type of service. Extensive discussions ensued concerning the allocation of environmental impacts to such facilitators, not only encompassing architects but also including entities like intermediate storage centers, exemplified by the facility managed by the SirkTRE partner Sirkulær Ressurssentral. This dialogue raised more questions than answers, highlighting the limitations within the SirkTRE project's scope and underscoring the need to extend these inquiries to new publicly funded projects.

TABLE 1: OVERVIEW OF SIRKTRE SOLUTIONS AND PILOTS

SirkTRE solution	LCA?	SirkTRE pilot	LCA?
Omtre's REjoin, 100% reclaimed timber – (***P1***)	Yes	None	N.A.
Omtre's REblåkk partition wall ***(P2a)***	Yes	Renovation projects	No
Omtre's REblåkk one-story house (anneks) ***(P2b)***	No	Cabin; food shop; sauna	No.
Omtre facilitating reuse of reclaimed boards and barn timber ***(P3a)***	No	Re:Textile (***D1***)	**Yes**
Holar's facilitating reuse of reclaimed timber ***(P3b)***	N.A.	School turning into kindergarten	No
LPO facilitating reuse or reclaimed timber ***(P3c)***	No	Cancelled – Elvegranda ***(D2)***	**Yes.**

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Grape's indoor wall – SirkREHAB (***P4***)	Yes	Nydalen Factory (retrofit)	Coming soon.
Norsk Massivtre's Circular Element, solid wood with reclaimed timber – wall ***(P5a)***	Coming soon	Noresund barn (new construction); Nydalen Factory (retrofit); Norsk Massivtre factory; different cabins, sauna	No.
Circular element – slab ***(P5b)***			
Circular element – partition wall ***(P5c)***			
Circular element – roof ***(P5d)***			
Circular element – balcony ***(P5e)***			
Haugen-Zohar circular house – SirkBo (***P6***)	No.	Coming soon	No.
Fragment's Rammeverk – adaptive housing system ***(P7)***	No.	No.	No
Hunton (***P8***) – reuse of residuals in new isofiber production	N.A.		
Ragn-Sells white woodchips solution ***(P9)***	N.A.		

In pilots which Norsk Massivtre and Omtre were involved in, we have an overview of how many cubic meters of reclaimed timber are used in the pilots. This data informs us in the scenario building.

Finally, none of the SirkTRE solutions at the product and building levels have incorporated radical business models, such as product leasing. The implications of circular business models fall outside the purview of this evaluation paper. However, the concept of Brand layers, coupled with varying average lifespans, suggests the potential for multiple use cycles. For instance, Grape considered this aspect in their calculations (see section 4.1.), which could lay the groundwork for understanding and developing a circular business model.

3.4. Design of scenarios

Using market-informed scenarios including new and renovation projects for 2025-2030, the decarbonisation potential will be calculated for Norway. The scenarios are designed by the last author, who held various science fiction prototyping workshops, joined other future method workshops, industrial and trade conferences with market watch insights, and did interviews in the past 4 years around wood circularity, some of which are already processed in other articles [19, 20, 21, 22]. In February and March 2025, we had interviews with the developers of Norsk Massivtre and Grape to understand the market potential and the ways forward for the solution. In addition, the last author used Gigamapping, a method from system-oriented design to dive into the complexity and to visualise learning outcomes about pain points, barriers and possible gain points and mitigation measures.

4 – RESULTS

4.1. Environmental impacts of SirkTRE products and pilot buildings

The results section will commence with a bottom-up analysis of secondary data, which will be categorized at both the product and building levels. Subsequently, we will transition to discussions of scalability, progressing from detailed assessments of pilot projects and demonstrations of circular solutions to broader considerations of scalability. This approach ensures comprehensive exploration from localized instances to broader applicability.

Product or solution level

At the product (or solution) level, we examined LCA studies and began to explore scalability from a theoretical perspective, considering hypothetical production lines in Norway and incorporating industry data from across Europe. Table 2 enumerates the 3 cases for which an LCA has been conducted. The second column describes the linear solution or baseline used for benchmarking purposes. Additionally, the table outlines the Brand layer application. The decarbonization potential, along with its source provided in parentheses, and the reduction potential are also detailed.

For example, Grape architects conducted a comparative LCA for the wooden inner wall solution during an NMBU course in 2024. The study compared a linear solution, consisting of a wall made with gypsum and a steel frame achieving the same acoustic performance, to the Grape-wall, which is assumed to be reusable six times over 60 years with a 10% material loss each cycle, whereas the linear solution is utilized only once before demolition. Both assessments were based on the functional unit of 1 m^2 of wall with identical acoustic performance at the element level, specifically a partition wall. The Global Warming Potential (GWP) measured for the linear solution was 720 kg CO_2-e/m^2, whereas the SirkREHAB solution registered a GWP of -686 kg plus 34 kg CO_2-e/m^2 [18], demonstrating a decarbonization potential of approximately 1370 kg CO_2-e/m^2. This represents nearly a 200% improvement in decarbonization potential compared to the linear solution. Interestingly, this is close to the 2.1 average factor of 2.1 in the study of replacement of wood [17].

TABLE 2: DECARBONISATION AT THE PRODUCT LEVEL

Case	Linear solution	Brand Layer	Decarbonisation potential	Reduction potential
P1	Rejoin 80% reused vs. 100% virgin timber	Structure	23 kg CO_2-e/m^3 (A1-13) [6]	~51%
P2a	REblåkk vs.Stud wall – timber, mineral wool, OSB, gypsum	Structure and skin	14 kg CO_2-e/m^3 [21]	871%
P4	Indoor wall gypsum-steel	Space	1370 kg CO_2-e/m^2 [7]	~200%

Another analysis assessed the use of REblåkk, an innovative circular timber construction product made from upcycled CLT cut-offs. By repurposing waste from CLT manufacturing into modular blocks for walls, REblåkk contributes to carbon emission reduction and extends material life. A comparative LCA of a 150 m^2 wooden house evaluated its impact against traditional stud walls, focusing on external and internal walls over two 50-year life cycles. The results show an 87% reduction in climate change impact with REblåkk, with 65% of the blocks successfully reused in the second life cycle. Additionally, the system demonstrated a decarbonization potential of 47 kg CO_2-e/ m^2[23].

Building level

As of March 31, 2025, data on the building level remains scarce. There were several SirkTRE pilots, but only one LCA was conducted for a new construction project. No LCAs were completed for renovation or maintenance, and there was just a feasibility study for deconstruction and reuse in new construction or even relocating entire houses over ice.

Case Study D1- Re:Textile Factory, demonstrating the reuse of glulam and reclaimed barn timber

The Re:Textile project demonstrates the potential of circular economy principles in construction by utilizing reclaimed materials such as timber, glulam beams, steel roof plates, and insulation panels from a decommissioned crypto mining warehouse, see Fig. 1. LCA results show a 38% to 95% reduction in key environmental impact categories, including climate change, acidification, human toxicity and resource use, with a total reduction of 8.6 tons of CO_2-e emissions. Despite challenges in end-of-life waste management, the project highlights how reusing materials can significantly lower the environmental footprint of buildings.

Figure 1: Pilot building for textile sorting. Reuse of glulam, nailplate-frames, barnwood and planks.

TABLE 3: DECARBONISATION AT THE BUILDING LEVEL

Case	Linear solution	Brand Layer	Decarbonisation potential	Reduction potential
D1	GLT, timber, insulation, cladding, steel plates,	Structure and skin	72 kg CO_2-e/m^2	38%

Reusing recovered materials, as in the Re:Textile project, can reduce emissions by 72 kg CO_2-e/m^2, highlighting the potential of circular construction to lower environmental impacts.

4.2. Unfulfilled Pilots

In the SirkTRE project, various architects and developers explored potential pilots to demonstrate solutions, employing products and strategies aimed at sustainability. Notable among these was the feasibility study conducted by LPO for the Elvegranda project in Longyearbyen, Svalbard. The context of Svalbard is different than the context of mainland Norway, especially regarding regulations.

Case Study D2- Statsbygg's Buildings in Longyearbyen, Svalbard: For Statsbygg, a notable effort was made to perform LCA calculations on their buildings in Longyearbyen, Svalbard. These efforts were part of a feasibility study aimed at understanding the specific environmental impacts in a unique and sensitive geographical context. Vill Energi and LPO architects collaborated to estimate the impacts of the baseline of new buildings, with imported materials from mainland Norway, and the two circular strategies of deconstruction and reuse of elements or moving the whole building. This last circular strategy was a traditional way of moving houses, from example one extraction area (e.g. mining) to the next one. However, the building owner went for business as usual. The energy system in Longyearbyen was until November 2023 based on coal incineration. From November 2023, diesel CHP is an intermediate

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solution. To reach political target of 80% reduction of carbon emissions in 2030, renewable energy production and energy efficiency actions are needed. LCA calculations performed by Vill Energi, shows that one year after the climate target is reached, energy upgraded reused houses have lower climate emissions than passive houses with new materials [24].

4.4. From "Small" pilots to "Scale": Discussion about post-SirkTRE

Within the SirkTRE project, significant learning effects were observed, such as through a failed project (not listed in table 1) which led to faster and more streamlined processes. Learning effects themselves can have CO_2 equivalent impacts, which need consideration in understanding impacts on a wider scale. However, a key issue with pilot projects is their limited representativeness for a future where such sustainable building practices become mainstream and the learning effects (e.g. wasted materials and energy in prototyping) are less and we would use more standard products and buildings. Generally, one recurring challenge within SirkTRE, particularly evident during phases of prototyping, construction project development, and execution, was that some SirkTRE solutions exhibited a Technology Readiness Level (TRL) that was insufficiently developed. It has been observed that LCA typically occurs at a higher TRL. However, there is some advocacy, as noted in previous work, e.g. [9], for implementing prospective LCA at earlier stages of emerging solutions. Within SirkTRE, such proactive assessment across all solutions was not initially planned, suggesting that considerations like LCA, Life Cycle Costing (LCC), and business modeling were somewhat secondary. This approach drew criticism for SirkTRE's excessive focus on technology, prompting questions about whether the project sought appropriate funding, which required in-kind contributions from partners. It is often recommended to seek full funding when technology's maturity is low.

There is still a lot of speculation, because most products do not have a production line yet. This explains the low volumes in the SirkTRE project. In the case of Norsk Massivtre, there is a production facility already. For Norsk Massivtre's product (P5), which participated in the most SirkTRE pilots, we collaborated with their manager and engineers to estimate the market potential based on observations and lessons learned during the SirkTRE project from 2022 to February 2025. Under a business-as-usual scenario from 2025 to 2030, we project sales of approximately 265 cubic meters. In a more optimistic scenario, sales could reach around 2350 cubic meters. However, these volumes are modest compared to the targets set in SirkTRE's goal of contributing 8%.

This calls for new production facilities entirely dedicated to SirkTRE/circular solution production. When we calculated the annual CO_2 savings for the speculative REblåkk facility's production of -for example 2300 m^3-, finding an approximate reduction of 16 tons of CO_2 annually by implementing circular solutions. Additionally, applying similar practices across European CLT production with an average cutoff rate of 7.5% results in potential savings of approximately 700 tons of CO_2 annually. These savings stem from a potential cutoff volume of about 100.000 m^3 from the total European CLT production [23]. However, the investment costs for such a production facility are yet to be designed. High investment costs are often seen as a barrier in circular manufacturing [2]. The main share of the expected reuse of waste wood is by wood chip production for material recycling in wood-based boards. SirkTRE has estimated 75-80% being returned as wood chips.

4.5. Prospects for 3 Scenarios

Numerous scenarios are conceivable, influenced by social, legal, and economic factors, as well as trends. These are further shaped by insights gained from the challenges and opportunities (gain and pain points) identified over the past three years within Norwegian and European markets and their respective infrastructures. While data on trends such as housing needs in Norway and Europe over the next five years are available, we have chosen to maintain a speculative stance in this subsection. We have pinpointed both challenges and opportunities, which have informed the development of several potential scenarios. These pain points have also been observed in other markets, such as the United Kingdom [25].

We have already discerned which scenarios need to be realized and are now exploring whether achieving the 8% target is feasible. However, at this juncture, we are unable to provide quantitative data, as we await findings from the researchers engaged in more scientifically rigorous projects such as CircWOOD, DRASTIC, CIRCULess and RAW.

Scenario 1: Regulations and market are business as usual

In this scenario, pilot projects will continue sporadically. Concurrently, an increasing number of actors and projects focusing on circular wood are emerging across Norway and Europe, accompanied by a growing number of construction and renovation projects that incorporate

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circularity strategies. More buildings will probably adhere to designs for disassembly in response to regulatory requirements; however, these are future investments that are unlikely to impact the decarbonization potential of solutions involving reclaimed timber immediately. Additionally, Ragn-Sells has tested several models for preserving the quality of collected structural timber, to supply SirkTRE partners with reclaimed wood for reprocessing and further use. However, due to the large volumes they handle, they have shifted towards increased sorting and the production of clean wood chips, referred to as 'white woodchips'. While the volumes are high, the extent of their decarbonization potential remains uncertain. Further research is required to ascertain these impacts.

Scenario 2: Compulsory CO_2 budgets in Norway for all construction project from 2027 onwards

The second scenario draws inspiration from recent developments in Denmark, such as the mandatory CO_2 budgets set for all construction projects in Norway starting in 2027. This will necessitate an increase in LCA data availability, particularly EPDs at both the product and solution levels. Additionally, there will be a need to refine LCA methodologies at the building level that incorporate multiple use cycles and address varying lifespans as outlined in the Brand layers. Given that the displacement factor between wood and non-wood materials averages 2.1 [17], and data from SirkTRE suggest an even greater benefit from substituting non-wood materials with reclaimed wood, this could be a significant game-changer.

However, challenges remain, notably in the infrastructure and capacity required to supply large volumes of reclaimed timber. In the many dissemination activities, we observed that many builders in Norway and the Nordic countries are keen on using reclaimed timber, but the current lack of infrastructure and the capacity to manage, diagnose, sort, treat, and prepare reclaimed timber for production pose significant obstacles. Addressing these pain points, such as enhancing infrastructures for knowledge management and material processing, is critical to achieving the targeted 8% decarbonization potential. This leads us into the third scenario, where the central question and theme of this conference paper—whether significant decarbonization targets can be met—may indeed receive an affirmative response.

Scenario 3: Policy high tax on virgin materials, and subsidize high-risk high impact investments like a Resawmill

Sustainability transitions broadly refer to how we can achieve large-scale, long-term societal changes to enable more sustainable patterns of production and consumption [26]. Thus, providing technology for REjoin-facilities at regional level, in areas with wood waste handling, seems logical.

An important point is that these changes have been driven by public intervention to influence demand through various policy tools. This supports the idea that governments should actively intervene in markets. National support schemes also have symbolic value, giving actors confidence that they are following the "right" path.

In addition to stabilizing new practices, it's equally important to phase out old ones—sometimes through bans or stricter regulations. History shows that government intervention is often necessary to drive change, as seen with the phase-out of CFC gases, the smoking ban, or the ban on new petrol and diesel cars from 2035 in the EU and 2025 in Norway.

Scenario 3 can jumpstart the circular timber industry. Other means may be regulating an open digital flow of information of secondary materials, public procurement, regulating a minimum fraction of reused and recycled materials in building projects.

7 CONCLUSIONS

Can SirkTRE's outcomes and exploitable results contribute to 8% of the Paris Agreement's obligations? The response is negative for five interrelated reasons associated with the identified challenges. Firstly, the time to scale is longer than expected. Secondly, LCA methodology is not sufficiently developed. Thirdly, the financing of pilots are challenging. Fourth, a scientifically informed affirmation is precluded due to the insufficient data and the utilization of methods not yet validated for circularity, coupled with the absence of harmonized assessments at both the product and building levels. Fifth, the rationale is grounded more profoundly in our comprehensive understanding of the wood circularity system within Norway and beyond. The impact hinges on multiple factors including social acceptance by various ecosystem stakeholders. For significant impact, radical transitions are required in changes of regulations and from SirkTRE partners and all related industry actors, encompassing both demand and supply sides, as well as intermediary entities such as universities, insurance companies, and governments.

The potential impacts of the SirkTRE project are intricately linked to social acceptance and ecosystem development. Initial studies offer crucial recommendations for extensive transitional efforts

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needed to achieve desired outcomes [10]. However, a critical limitation of SirkTRE was the lack of financing to scale industrial pilots, like REjoin. Instead, an easier narrow focus was on small-scale products and pilots, with limited scalability. This lesson has informed subsequent projects like Drastic and CIRCULess [26], involving entities such as Omtre and NTNU. Moving forward, projects funded by the EU, such as Drastic will continue to focus on ecosystem formation. The CIRCULess project, for instance, aims to scale up the processing of reclaimed timber into construction products. While SirkTRE and associated projects have laid a foundational framework and initiated numerous potential pathways, it is still too early to fully comprehend the environmental impacts of these initiatives. The success of ventures such as Omtre's proposed resawmill, capable of handling 10.000 cubic meters annually in Norway, will be a significant test of market acceptance and practical impact.

In March 2025, the most promising SirkTRE pilot got concluded: the Nydalen Factory; it demonstrates various SirkTRE solutions. Additionally, the building's ownership by the well-known developer, Avantor, enhances its visibility and potential impact. Pilot projects are typically small-scale initiatives that provide valuable insights and exposure to new products. This strategic selection could serve as a springboard, significantly boosting the exposure and adoption of SirkTRE's solutions. This further substantiates the fact that SirkTRE, despite nearing the conclusion of its funding and official closure, have impacts that are yet to be fully realized. In subsequent projects such as Drastic [9] and RAW [27], there is an opportunity to continue monitoring these initiatives, gather additional data, and collaborate with European partners who are refining the methodology and engaging with European standardization bodies. In the RAW project, for instance, researchers aim to enhance and integrate a prospective LCA with a dynamic material flow analysis. Undertaking such a comprehensive analysis for multiple SirkTRE solutions is ambitious, given the complexities involved with even one product. This challenge is compounded by limitations in manpower and computational resources, necessitating substantial data acquisition.

Challenges remain in the form of entrenched path dependencies and lock-ins, which necessitate dismantling for progress. Future efforts must not only focus on continuous research but also on fostering negotiations among ecosystem players to overcome these barriers effectively. The journey towards substantial decarbonization in construction requires a concerted effort from the entire ecosystem, highlighting the need for increased funding and strategic collaboration to address these complex challenges.

Although, without these findings, turning wood waste to new use would have been even further behind. SirkTRE may have been the project that got the snowball running.

8 – ACKNOWLEDGEMENTS

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