CIRCULAR CONSTRUCTION:

FROM DREAM TO POLITICAL PRACTICE IN EU

Green Transition Denmark

ABOUT THE REPORT

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Green Transition Denmark

Green Transition Denmark is an independent non-profit enviromental organisation that has been advising on the green transition for over three decades. As a green solution think tank, we are committed to delivering concrete, achievable, and ambitious proposals designed to accelerate the shift toward an absolute sustainable society.

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CHAPTER 1

INTRODUCTION: A CIRCULAR BUILDING AND CONSTRUCTION SECTOR DEPENDS ON POLITICAL ACTION

Energy improvements and efficiency have long been considered key elements to making the European construction sector more climate-friendly. The focus has, however, largely remained on reducing CO_2 emissions from the operation of buildings, both politically and within the industry. Much less attention has been given to the significant resource and climate footprint of building materials – namely, the CO_2 emitted during material production, transportation, construction processes, renovation, and demolition.

However, the lack of circularity within the industry, the embedded carbon footprint, and the use of non-circular building materials put significant pressure on our resources and the environment. Currently, the construction and infrastructure sector accounts for between 36-40 per cent[1] of the EU's total climate footprint, with approximately one-third stemming from the construction process itself, particularly from the manufacturing of materials used in construction. Additionally, the construction industry is a significant consumer of natural resources such as sand, gravel, clay, metals, and wood, contributing to 50 per cent[2] of global material extraction. Moreover, construction and demolition waste (CDW) accounts for over a third of all waste generated in the EU, with only 11.7 per cent[3] of all materials used in the EU-27 coming from recycled waste in 2021.

This is unsustainable when looking into a future where resource scarcity is a reality and where reductions in resource consumption are crucial for addressing the climate crisis. The UN's annual status report on the construction sector[4] from 2022 also highlights the lack of measures and focus on material consumption and the climate footprint of materials as primary reasons why construction is currently not on the right track. As such, the sector is significantly off course from achieving decarbonisation by 2050, and the gap between its actual climate performance and the decarbonisation path is widening.

The circular transition of the building and construction sector is thus a prerequisite if the EU and its 27 member states are to deliver on their climate ambitions and achieve circularity in the construction sector by 2050.

There is a growing political focus on this issue. In recent years, we have seen some steps towards addressing reductions in the massive resource and carbon footprint that construction currently entails, both from the EU and member states. Countries such as Denmark, Finland, Sweden, the Netherlands, and France have introduced national legislation that addresses reductions in the climate footprint of building materials, requires whole life carbon analysis (WLC), promotes circular buildings and resource efficiency, encourages new production methods, and supports the development of more climate-friendly and circular construction products.

At the EU level, circular buildings and resource consumption in the construction industry are also gaining momentum. In 2024, the EU revised the Energy Performance of Buildings Directive (EPBD). Furthermore, the EU has presented and adopted a series of initiatives focusing on circularity and resources, such as the EU Taxonomy for Sustainable Activities, the Circular Action Plan, the Construction Products Regulation (CPR), the Ecodesign for Sustainable Products Regulation (ESPR), the Corporate Sustainability Reporting Directive (CSRD), and the European Sustainability Reporting Standards (ESRS).

Parts of the industry are also increasingly making efforts and initiatives to reduce the climate and resource impact of building materials. Many are looking into more environmentally friendly production methods, setting circular and resource reduction goals, and investing in the development of circular solutions that enable better utilisation and reuse of building materials.

Despite these efforts – both politically and from the industry – circular buildings and construction are still far from being the norm across all EU member states. There is still a long way to go in terms of effective regulation and ambitious requirements, development of concrete solutions, scaling, and ultimately realising a more circular building and construction sector. Circular construction remains underdeveloped, and the market for circular building materials is premature.

Therefore, there is a need to step up efforts and initiatives to help catalyse and accelerate the circular transition of the building and construction industry. One vital part of this is further regulation and political initiatives – both from the EU and from individual member states. There is a clear need for circular political ambitions, supported by requirements and frameworks, and efforts to remove barriers and create incentives for circular buildings and construction. What is currently in the pipeline will not get us there. Fortunately, politicians can change that both in the EU and member states.

WHAT IS A GREEN AND CIRCULAR BUILDING AND CONSTRUCTION SECTOR?

In this publication, a green and circular building and construction sector is defined as a sector that operates within the limits of the climate and the planet. This means a sector that:

- Minimises carbon footprint and resource consumption while eliminating waste and pollution
- Extends the lifespan of buildings and infrastructure
- Recirculate materials to their highest value
- Regenerates nature and contributes positively to biodiversity and ecosystems

CHAPTER 2

RECOMMENDATIONS FOR EFFECTIVE REGULATIONS – FOR EU AND MEMBER STATES

For years, energy improvements and energy efficiency have been seen as the primary answers when it comes to the decarbonisation of buildings. A series of policy initiatives and regulations have paved the way for substantial reductions in the energy consumption of the building stock, both at the EU level and in member states.

But now is the time for both the EU and member states to set a focus on raw materials and circularity. Therefore, politicians and authorities should, through regulation and initiatives, play a much more active role as a catalyst for a circular transition that has yet to be achieved.

Green Transition Denmark believes that the following **nine political measures** are crucial for the transition of the EU and member states' building and construction industry to a more circular and resource-friendly industry.

ON AN EU LEVEL

1 **Introduce an ambitious new Circular Economy Act** that places circularity and resource reduction at its core. This should include clear and measurable targets for circularity and resource reduction at the EU level, requiring each member state to adopt national targets in alignment with the EU's overarching targets. The targets should at least cover resource reduction, circular material use rate (CMUR), and waste reduction. The targets should be followed up with concrete initiatives aimed at improving circularity and reducing resource consumption, particularly in the most polluting and resource-intensive sectors, such as the building and construction sector.

2 **Introduce an EU-wide tax on virgin materials** to incentivise the use of circular building materials by making them price-competitive with new materials. This tax could help drive large-scale uptake of circular materials across the EU. The tax must be implemented at the EU level to ensure market harmonisation in the EU. For example, Denmark[5] and Sweden[6] currently have a tax on virgin materials such as sand, stone, and gravel, while several other member states do not. Revenue generated from this tax should be reinvested in fostering circular business models, innovation and R&D, empowering EU companies' position in the circular market and improving their supply security and competitiveness. To ensure a level playing field between producers in the EU and abroad, the tax should be supplemented by a virgin materials tax on goods imported into the EU, similar to the approach taken with the EU Emissions Trading System (ETS) and the Carbon Border Adjustment Mechanism (CBAM).

3 **Implement extended producer responsibility (EPR) for building materials** across the EU to drive the adoption of circular business models in the construction sector. This is important to enforce the 'polluter pays' principle and incentivise the development and production of more circular building materials. Countries like France[7] have already introduced this regulation, demonstrating its potential impact. The EPR scheme should include modulated fees to ensure that building materials are recovered as high up the waste hierarchy as possible, prioritising prevention and reuse. Revenues from EPR fees should be invested in the establishment and operation of organisations tasked with the reuse and recycling of materials from demolished buildings.

4 **Make green public procurement mandatory** across the EU to drive the uptake of more circular and climate-friendly building materials. With public procurement representing 14 per cent[8] of the EU's GDP, it has significant potential to promote circular business and development and thus act as a powerful driver for increased circularity in the construction sector. To unlock this potential, the EU Procurement Directives should be revised to make environmental criteria mandatory in public procurement. The revision must align with relevant sectoral regulations, such as the Ecodesign for Sustainable Products Regulation (ESPR) and the Construction Products Regulation (CPR), while ensuring that any potential loopholes are effectively addressed.

5 **Conduct an assessment of barriers within existing EU directives and regulations** that affect the implementation of circular policies in member states. The assessment should focus on determining the extent of these barriers and highlighting specific aspects of current EU policies that make it challenging for member states to adopt circular policies in the building and construction sector. For example, in Denmark, a proposal to remove the VAT on recycled building materials was rejected[9] due to restrictions under the EU's Directive on the common system of value added tax[10]. To truly accelerate circularity in the building and construction sector across the EU, it is essential to ensure that EU legislation does not obstruct member states from introducing ambitious and innovative circular initiatives and legislation.

ON A MEMBER STATE LEVEL

6 **Introduce circular building regulation** that foster the green and circular transition of the building and construction industry. The EU has recently adopted/ implemented several green and circular requirements that will soon impact the construction sector. This presents a significant opportunity for member states to proactively address these regulations and even go further by implementing green and circular policies. Doing so will be a vital step in ensuring the building and construction industry's security of supply and competitiveness. The policies should extend beyond new buildings to also promote renovation and transformation of the existing building stock. Several countries, including the Netherlands, France, Finland and Denmark are already leading the way with green and circular regulations in the building and construction sector. They demonstrate, that not only is this shift possible, but essential for member states to prepare their industries for the green and circular transition. There are several key steps that should be taken, including:

- Establishing mandatory green requirements in public tenders, e.g. by requiring that green considerations are given at least a 30 per cent weighting in all public tenders as implemented in Norway, or by aligning public tenders with the criteria and requirements outlined in the EU Taxonomy for sustainable activities.

- Introducing 'selective demolition' requirements, as in Denmark, where buildings are gently dismantled to ensure proper material sorting and the best possible condition for reuse and recycling. Moreover, resource mapping of the existing building stock should be required in connection with demolition and renovation.

- Implementing a tax on virgin materials such as sand, gravel, limestone, chalk, clay, stone etc. to ensure that the climate- and resource footprint of new building materials are reflected in the price.

- Introducing clear circular requirements in national building codes to reduce material consumption and waste, encourage the use of circular building materials and extend the lifespan of buildings through renovation or transformation rather than demolition and new construction. These requirements could include "preserve or explain" requirements for demolition permits, mandatory submission of a circular plan before granting building permits, and requirements for modularity, reused and recycled materials, design-for-assembly, and repairability and quality.

- Implementing a circular building and construction strategy with clear, binding initiatives and targets to drive the transformation of the sector in alignment with the Paris Agreement and planetary boundaries.

7 **Ensure ambitious national implementation of the whole life carbon (WLC)** measures to put the construction sector on the right path toward reducing its climate and resource footprint. As part of the recently adopted Energy Performance of Buildings Directive, coming into force in May 2024, a significant legislative framework has emerged to regulate the WLC of buildings, addressing both operational and embodied carbon. In broad terms, the WLC requirements encompass:

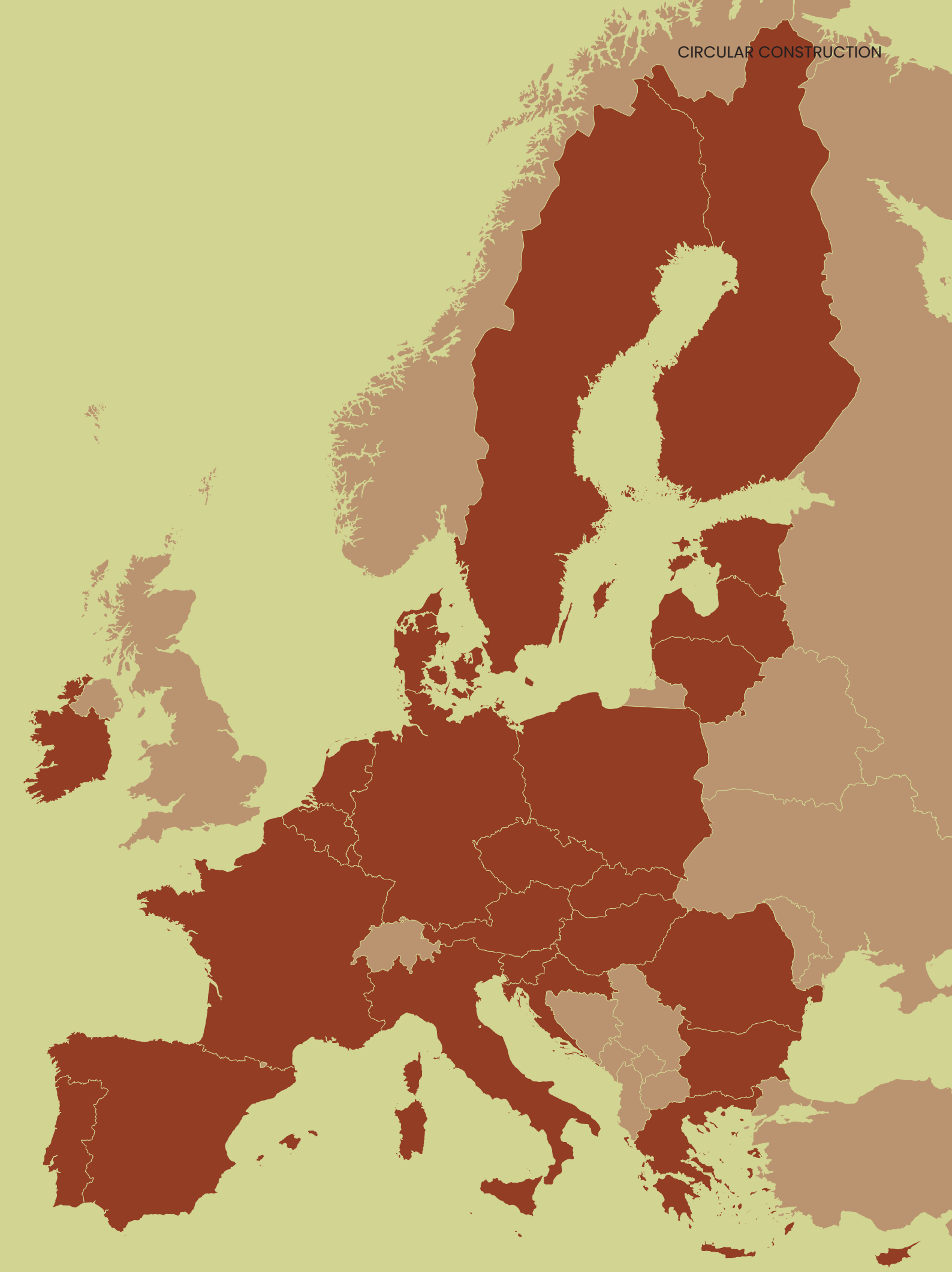
- Member states must calculate the life-cycle global warming potential (GWP) for all new buildings exceeding 1000 m2 from 1 January 2028 and for all new buildings from 1 January 2030.

- Member states are required to publish a roadmap by 1 January 2027 detailing the introduction of limit values on the total cumulative life-cycle GWP for all new buildings and to set targets for new buildings starting from 2030.

The regulation has significant potential to mitigate the climate impacts of new buildings and accelerate the circular transition in the building and construction sector; however, this will depend on member states committing to ambitious implementation. To maximise the benefits of the WLC regulation in the EPBD, member states should prioritise a swift implementation of stringent limit values and targets. Here, inspiration can be taken from other member states, such as France and Denmark, which have successfully implemented WLC regulations for new buildings ahead of the EPBD's mandatory requirements. The sooner member states adopt these measures, the more rapidly the construction industry can adapt and initiate necessary changes to embrace a more climate- and resource-efficient future in new construction.

8 **Scale up research and development initiatives in the building and construction sector** to accelerate the green and circular transition. This means not only allocating funds for research into circular construction, focusing on the development, testing, and scaling of new circular materials and methods, but also investing directly in the circular transformation of the entire value chain. Key efforts should include boosting the market for circular materials, improving data creation, building a circular value chain (including test and upcycling facilities), creating innovative design processes, and enhancing circular skills throughout the industry.

9 **Advocate for ambitious implementation of circular policies at the EU level** to drive the green and circular transition of buildings while ensuring harmonisation of legislation across member states. This entails supporting the implementation of upcoming regulations and striving for greater ambitions through ambitious national positions. Such efforts are vital, as EU policies will significantly influence the future trajectory and pace of climate and circularity action in the construction sector for years to come. Additionally, establishing common requirements is essential to ensure that neither the construction industry nor individual member states alone bear the entire cost of the circular transition.



CHAPTER 3

BUSINESS AS USUAL IS NOT A POSSIBILITY

EU statistics paint a stark picture of the climate and environmental impact of the construction industry. At the EU level[11], the construction sector alone currently accounts for about 50 per cent of the EU's total resource and material consumption. Furthermore, it is responsible for 35 per cent of total waste generation, with about 11 per cent of the EU's total carbon footprint stemming from the extraction and manufacturing of building materials – the so-called embodied carbon.

These figures clearly indicate the need for action and initiatives to reduce the building and construction sector's footprint in the EU, as well as the need for immediate measures to set the sector on a reduction path to meet the Paris Agreement, the EU's climate ambitions, and to pave the way for resource consumption and a built environment within planetary boundaries.

Circular value chains, business models, new technologies, and solutions are an important and necessary part of this reduction path. Several analyses[12] and studies[13] in recent years have documented that a more circular building and construction sector is a crucial step in realising climate ambitions in the EU, its member states, and globally. The sector must transition towards thinking and acting circularly by reducing the number of new square meters being built, prioritising renovation and transformation instead of demolition and new construction, minimising the use of virgin materials, and increasing material reuse, upcycling, and high-quality recycling. This calls for the development and implementation of new circular value chains and practices that ensure fewer materials are disposed of through incineration, deposited in landfills, or crushed and reused in locations of considerably lower value, such as noise barriers or road substructures.

CLEAR REDUCTION POTENTIALS

Numerous analyses and studies in recent years have documented significant potential for climate reduction through the adoption of more circular practices within the building and construction industry. For instance, an analysis by the Ellen MacArthur Foundation highlights that transitioning to a more circular economy alone could reduce global CO_2 emissions from construction by as much as 38 per cent[14] by 2050, primarily through reducing demand for cement, steel, aluminium, and plastic in the construction sector.

Similarly, calculations[15] based on the Circularity Gap Report from 2021 estimate that a circular building and construction sector could pave the way for a reduction in material usage of 57 per cent and a reduction in CO_2 emissions of up to 50 per cent. Calculations from the UN International Resource Panel, focusing on the potential for reducing the construction sector's carbon footprint through material efficiency strategies in G7 countries, suggest that ambitious material efficiency policies, including the use of recycled materials, could decrease CO_2 emissions in residential building material cycles by over 80 per cent by 2050[16].

Looking at specific construction products and building materials, the reduction potentials are similarly substantial. An example is the report "Life Cycle Assessment for Circular Solutions with a Focus on Climate Impact – Preliminary study"[17], in which a range of newly produced and reused construction materials are compared. The analysis identifies significant CO_2 savings associated with material reuse, demonstrating substantial climate reduction potentials for the reuse of various materials, including roof tiles, bricks, and aluminium panels. See Box 1. Considering bricks alone, the total carbon impact for 1 square meter of reused brick masonry is 14.34 kg CO_2. In comparison, the total carbon impact for 1 square meter of conventionally constructed masonry is 64.11 kg CO_2 – more than four times higher than if built with reused bricks.

The research article "Reuse of Steel in the Construction Industry: Challenges and Opportunities"[18], published in the International Journal of Steel Structures in 2023, investigates the carbon reduction potentials of reused steel. The article concludes that "steel reuse can offer substantial environmental benefits, with potential reductions in GWPs of up to 95 per cent, 90 per cent, and 75 per cent, respectively, in comparison to primary steel production, recycled steel, and renewable energy-based recycled steel (...)."

Clear reduction potentials were similarly identified in the "Circular Builders"- project from 2022[19], where nine Danish and Swedish municipalities developed and tested solutions for circular construction to reduce energy consumption throughout the construction value chain. The results of the projects showed that elements such as reused windows, marble, natural stone, metal, and steel products could save up to 99 per cent CO_2 compared to the use of conventional materials.

BOX 1. SIGNIFICANT REDUCTION POTENTIALS THROUGH REUSE AND RECYCLING

"The Lifecycle Assessment for Circular Solutions with Focus on Climate Impact – Preliminary Study," conducted by the Danish Building Research Institute (SBi)[17] - demonstrates that there are climate benefits to be gained through increased circularity. In 15 out of 17 cases, climate-related savings are likely achievable by using a circular solution instead of a conventional one.

For a range of materials, there is a significant (>50 per cent) benefit to be gained from circularity. These include:

- Reused roof tiles (98,03 per cent)
- Reused concrete elements, columns and beams (95,6 per cent)
- Box windows made from reused double-glazed glass and virgin wood (95,5 per cent)
- Reused aluminium sheets as cladding for facades and roofs (81,2 per cent)
- Reused interior doors (80,15 per cent)
- Reused steel profiles (77,7 per cent)
- Reused load-bearing timber beams and posts (77,3 per cent)
- Louvered facades made of recycled window wood (77,3 per cent)
- Reused timber flooring (77,3 per cent)
- Masonry made from reused bricks and virgin lime mortar (76,9 per cent)
- Bitumen roofing with 10 % recycled bitumen roofing (69,4 per cent)
- Reused masonry elements supported by recycled concrete and reinforcing steel (60,7 per cent)
- Facade cladding made from reused ventilation pipes (56,3 per cent)

For other materials, there is a smaller (app. 10 per cent) benefit to be gained. These include:

- Chipboards with 70 per cent recycled wood (9,4 per cent)
- Plasterboards with 25 per cent recycled gypsum (9,6 per cent)

For certain material types, there is no climate benefit (<10 per cent) or even higher emissions associated with the recycled/reused scenario. These include:

- Concrete with 20 % recycled concrete (0,30 per cent)
- Facade cladding made from glass ceramics (sent for recycling after the end of its usage phase, is estimated to have a climate-related impacts 46 per cent higher than the conventional scenario)

CLEAR ECONOMIC POTENTIALS

The Chief Executive Officer of global cement manufacturer Holcim, Jan Jenisch, has referred to the circular economy as "the business opportunity of our time,"[20] highlighting that "some of the most exciting possibilities for a circular economy are in the construction sector." Holcim thus aims to double the ratio of recycled material in its product portfolio by 2030, from 54 million tonnes of material in 2021 to 100 tonnes in 2030.

Jenisch's perception is shared by many others, as various analyses similarly indicate that transitioning the construction industry to a circular model could lead to reduced expenses, help mitigate economic risks, and open new avenues for growth.

For instance, a 2023 study[21] on embodied carbon regulation in the European construction sector highlights the significant economic benefits associated with adopting circular solutions. By cross-examining 72 studies on embodied carbon reduction in the EU and UK, the research suggests that targeted design strategies can simultaneously reduce embodied carbon emissions and costs for buildings and infrastructure. The findings reveal that, on average, a 41 per cent reduction in embodied carbon could lead to a 9 per cent cost reduction compared to the business-as-usual scenario. Moreover, projections show that businesses embracing circular business models now will be in a better position, as, according to the World Economic Forum[22], "it is realistic to expect that during the 2030s the circular economy will not only be the mainstream economy, it will be the only economy."

A recent McKinsey article[23] focusing on the cement industry reaches a similar conclusion, suggesting that increased adoption of circular technologies could unlock new financial opportunities worth up to approximately €110 billion by 2050. This presents a promising growth avenue for cement companies, particularly as they face challenges with declining demand for their core products and significant external costs due to increased decarbonisation efforts and resource scarcity.

Important factors for these calculations include both an expected increased demand for circular alternatives driven by legislation and frontrunning companies, as well as growing uncertainty regarding supply. In recent years, actors in the construction industry[24] have experienced and anticipate further challenges in obtaining adequate supplies of certain materials and significant price fluctuations, for example, in steel.

CALLS FOR FUNDAMENTAL STRUCTURAL CHANGES

"Circular economy is not just an alternative business model, but instead a blueprint for any business building a sustainable future," writes Henrik Hvid Jensen, Chief Technology Strategist at the consultancy DXC Technology, in an article published by the World Economic Forum[25].

This statement underscores the fundamental need to reshape and realign the construction sector plans and actions across all parts of the value chain. See Figure 1 and Box 2. Mere adjustments are insufficient; what's necessary is a transformation that surpasses the mere tweaking of existing processes. As Henrik Hvid Jensen articulates, "It involves rethinking and redesigning the entire value chain." Only then can the construction sector capitalise on the possibilities and value inherent in circularity.

The Ellen MacArthur Foundation[26] further delineates that circularity demands a comprehensive revamping of the building and construction industry, encompassing product redesign, the establishment of new value chains, the cultivation of new partnerships, and the adoption of an entirely fresh perspective on construction projects.

Thus, a circular building and construction sector requires major efforts across the entire construction value chain to take circular action at several levels:

- **Reduce Resource Consumption:** Efforts should focus on minimising the construction of new buildings and infrastructure, decreasing per capita square footage, and optimising resource usage both in construction and in the production of building materials.
- **Increase the Lifespan of Buildings and Infrastructure:** This entails prioritising the maintenance and enhancement of current buildings, opting for renovation, transformation and adaptive reuse over demolition and new construction. It involves designing with circular principles in mind, emphasising longevity, quality, material availability, chemical composition, ease of disassembly, and functionality.
- **Develop New Material Flows:** We must improve resource management by considering our existing building stock as a valuable resource reservoir. Additionally, exploring alternative materials like bio-based resources in construction and leveraging waste streams from other sectors can foster synergies, that promote the reuse and recycling of residual materials.
- **Give Back to Nature and Ecosystems:** Prioritising the enhancement of biodiversity, bolstering natural ecosystems, and actively participating in their restoration is paramount within a circular construction sector. Simultaneously, we must strategically integrate buildings and infrastructure into climate adaptation and mitigation efforts.

BOX 2. CIRCULARITY ON DIFFERENT LEVELS

To achieve a truly circular building and construction sector, a more holistic approach to circularity needs to be taken. Considering the principles of circular economy, the narrowing, slowing, closing, and regenerating carbon, material, and energy flows should all be central to understanding, applying and working with circularity.

Besides the importance of considering circularity through the existence of different flows, it is also possible to consider circularity through the lens of different strategies for achieving circularity. These strategies can be divided into different levels of circularity - with recycling being considered as one of the lowest strategies. See figure 2.

An important part of achieving a circular construction sector is therefore to ensure that we are not limited to using strategies that can be considered low circularity, but that we strive to go as high up the scale as possible.

FIGURE 1. THE CIRCULAR VALUE CHAIN

A circular value chain[27] leads to substantial reductions in landfill and incineration. Similarly, there is a clear stagnation in the extraction of virgin materials and major changes in the production, to a much wider extent based on secondary materials. Circular construction also entails new methods in design processes and increased focus on renovation and transformation. In addition, there is progress in reuse and high-value recycling, while the proportion of materials used for other material recovery, such as downcycling or energy recovery, is decreasing.

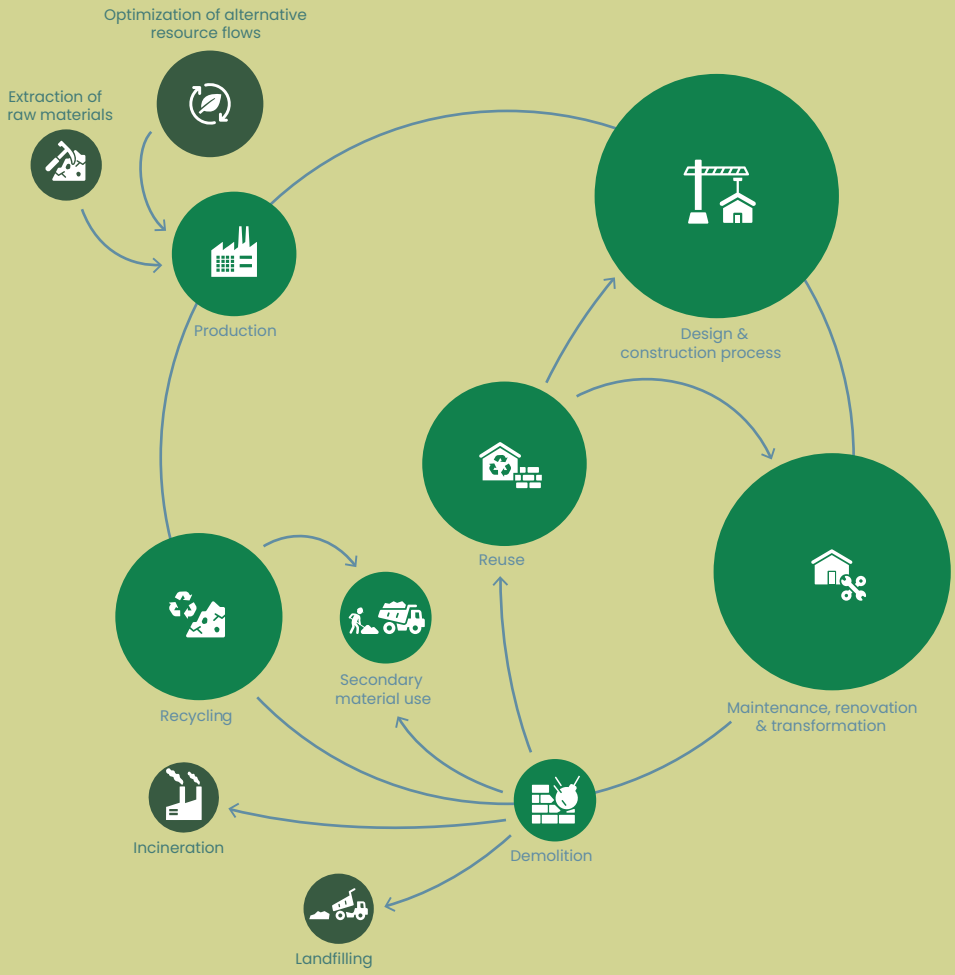
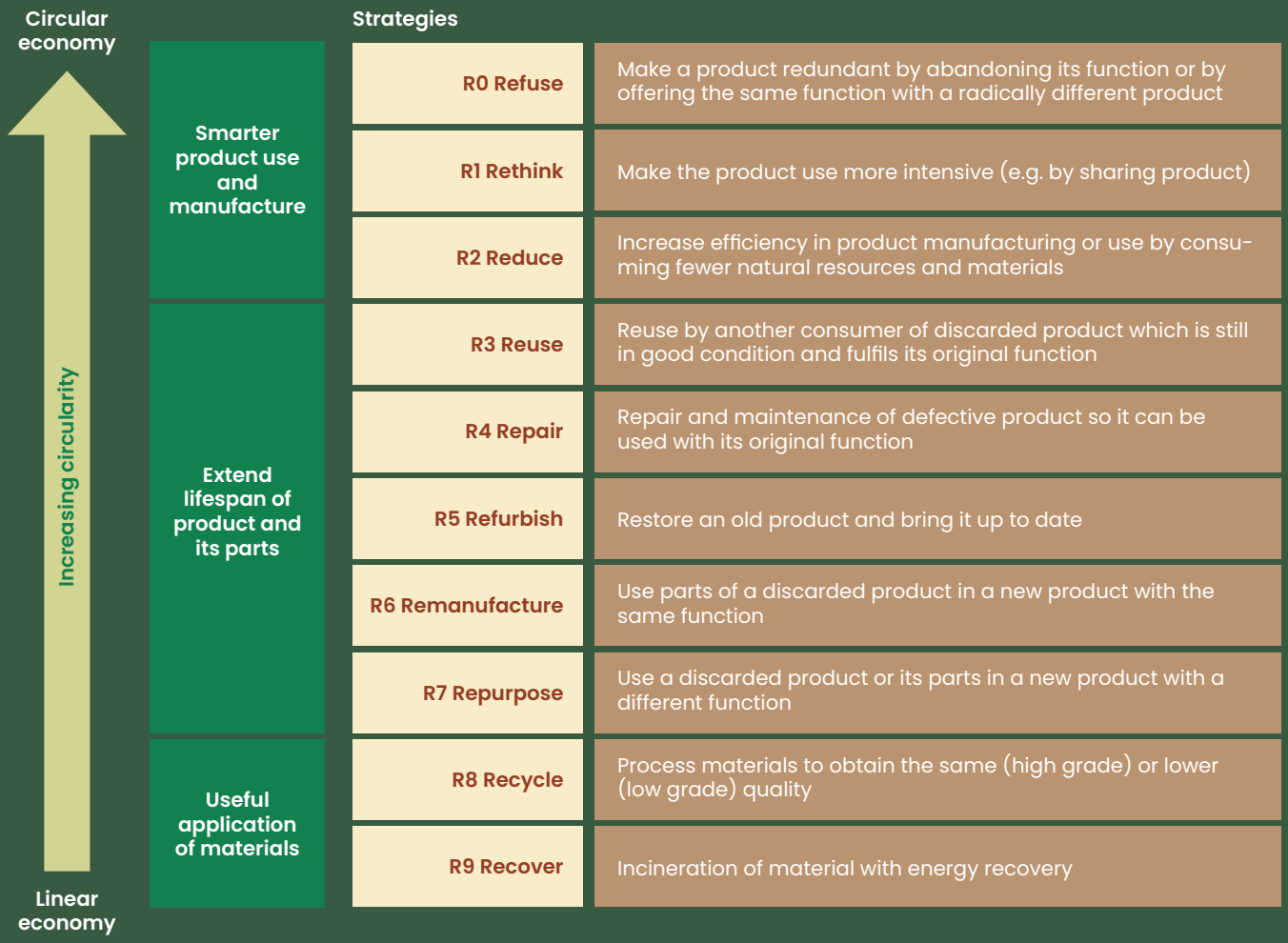


FIGURE 2. THE 9R FRAMEWORK

There are several strategies to achieve circularity, which can be categorised into different levels of circularity. The highest levels of circularity include refusing, rethinking and reducing, while recycling and recovering are at the lower level end of the circularity scale. Thus, the 9R framework prioritises actions that retain the most value from our resources[28].



CHAPTER 4

CIRCULARITY IS NOT THE NORM

In recent years, both politically and within the construction industry at large, there has been a notable surge in attention and rhetoric towards circularity, material consumption, and the imperative notion of recycling and reuse. The circular economy has recently surfaced as a central theme in conferences and political discourse alike. Terms like embodied carbon emissions, design for disassembly, cradle-to-cradle, and circular construction have similarly gained attraction across the EU's construction sector. Moreover, there has been an increase in industry stakeholders actively pursuing circularity, with a corresponding rise in circular projects ranging from specific products and technological advancements to large-scale building endeavours throughout the EU.

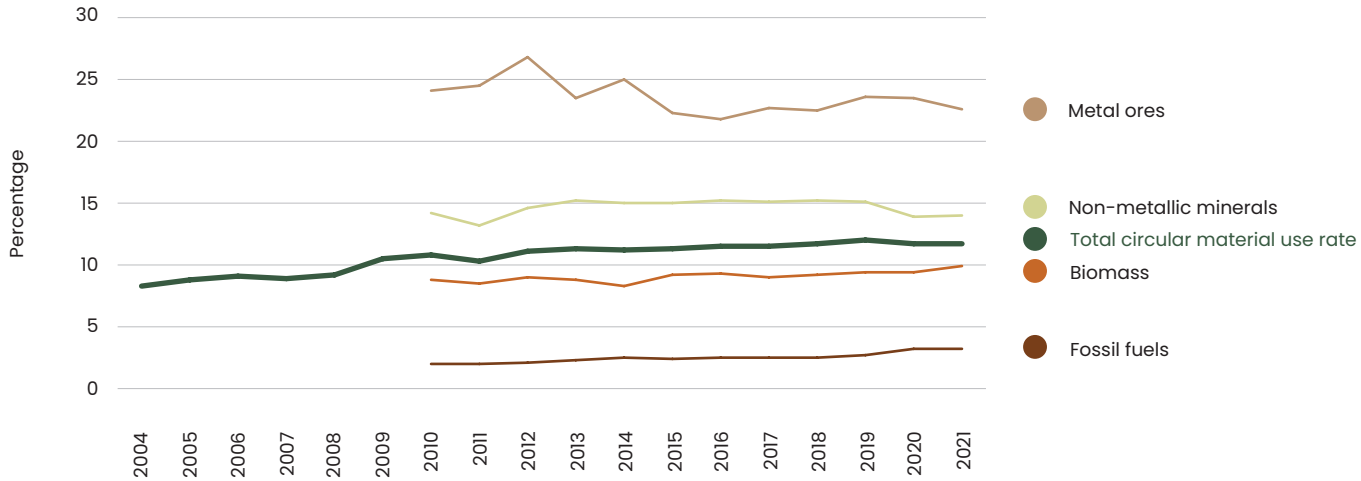
However, despite its increased focus, the integration of circularity into the construction industry remains far from mainstream. The industry continues to operate along linear principles, characterised by a consume-and-dispose mindset. Consequently, construction remains the foremost consumer of raw materials and the largest contributor to waste generation in the EU. Buildings alone account for a substantial portion of material consumption in the EU, including two-thirds of all cement, over a third of steel, a quarter of aluminium, and nearly 20 per cent of plastic usage, resulting in 250 million tonnes of carbon emissions annually[29].

While the EU's Circular Economy Action Plan[30] articulates ambitions of reducing consumption footprint and doubling the circular material use rate within the next decade, progress has so far been stagnant. According to a study[31] by the European Environmental Agency, there has only been a 3.4 per cent increase in the use of materials from recycled waste in the EU-27 over the past decade. More specifically, the use of materials from recycled waste has increased from 8.3 per cent in 2004 to 11.7 per cent in 2021. See Figure 3. As such, at the current rate of improvement, the EU is far from achieving its target of doubling the circular material use rate (CMUR) by 2030.

A recent study[32] conducted by the European Innovation Council, which assessed circular practices among 174 companies spanning the construction value chain, revealed a significant gap between rhetoric and action. While 86 per cent of these companies acknowledge circularity in construction as a high or very high priority, only a minority are actively measuring it. Moreover, the study highlighted a lack of quantification in these efforts. Despite 68 per cent of the companies mentioning circularity as part of their activities, only 38 per cent were actively measuring progress in this domain. See Figure 4.

FIGURE 3. CIRCULAR MATERIAL USE RATE IN TOTAL AND PER MATERIAL CATEGORY IN THE EU

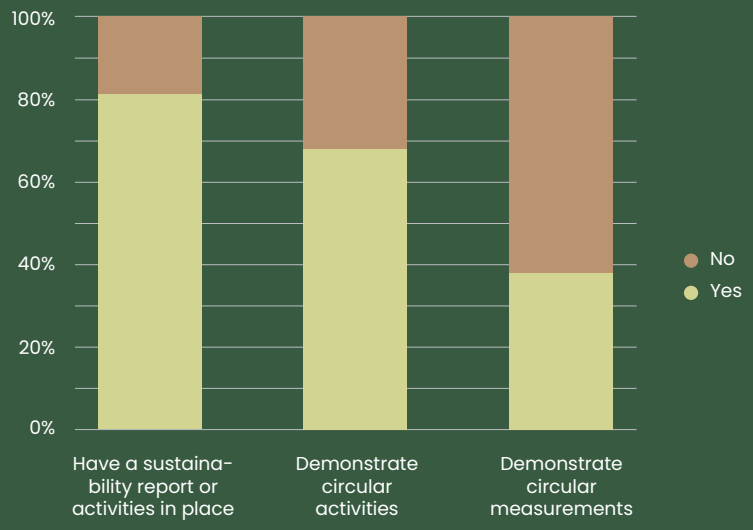
Total CMUR and by material category, EU-27, 2004-2021



At the individual material level, the share of recycled waste in the total input of biomass and fossil fuels has increased since 2010, while the share of recycled waste in the total input of metal ores and non-metallic minerals has declined. However, metal ores and non-metallic minerals are still having a much higher CMUR. Looking at the total circular material use rate, there has only been a slight increase from 2004 to 2021[33].

FIGURE 4. FAR FROM ALL CONSTRUCTION COMPANIES MEASURE PROGRESS IN THEIR CIRCULARITY PERFORMANCE

European Innovation Council's desk research of 174 construction companies' work on sustainability and circularity shows that many construction companies are engaged and interested in sustainability and circularity – but it is far from all that are taking direct action[34].



SEVERAL BARRIERS STAND IN THE WAY

Achieving a genuine circular transition in the EU's building and construction sector necessitates more than a singular solution; rather, it requires several fundamental structural changes.

Looking at both the industry and the policy framework for buildings and construction, the focus on circularity and resource consumption has been largely absent, and we are still a long way from seeing the necessary structural changes materialise.

This is largely due to several key barriers that currently hinder the circular transition in the building and construction industry – barriers that must be effectively tackled if the structural changes needed to achieve circularity are to truly gain momentum in the construction sector. These barriers are:

1. Lack of legislation
2. Lack of other strategies than recycling
3. Immature circular market
4. Lack of circular value chains
5. Lack of data
6. Higher costs

1. LACK OF LEGISLATION

The primary obstacle impeding the circular transition of the construction sector lies within the legislation. Numerous studies[35] have emphasised the pressing need for a stronger and more effective regulatory framework that can support the development of a circular building and construction sector.

Historically, political ambitions and initiatives around decarbonisation and the climate agenda have largely overlooked circularity. Legislation targeting buildings and the construction sector, both at the EU and member state levels, has predominantly focused on promoting energy efficiency enhancements. In recent years, circularity has ascended in the EU agenda, evidenced by action plans, strategies, and revisions of key regulations and directives such as the Construction Products Regulation (CPR) and the Energy Performance of Buildings Directive (EPBD). Additionally, some member states, like Portugal, have also adopted National Circular Economy Action Plans.

Despite these political initiatives, a regulatory framework designed to accelerate the circular transition of the building and construction sector has yet to be adopted and implemented – both at the EU level and across individual member states. Essential elements such as political ambition, frameworks, requirements, and incentives necessary to support the development of a circular market and business models within the construction sector are still lacking. For instance, there's a notable absence of resource reduction and circularity targets for construction towards 2030 and 2040, both at the EU and individual member state levels.

While the EPBD includes whole life carbon (WLC) measures in its new revision, the timeline for implementing roadmaps detailing the introduction of limit values is set to 2027, and the reduction

targets to 2030, with no clear minimum reduction requirement, leaving uncertainties regarding its efficacy in driving circularity, GWP and resource reductions in the coming years.

Many existing building regulations in the EU also pose challenges to the commercialisation of reused products and materials due to safety and standard requirements, with some regulatory barriers directly hindering the promotion of circularity in construction. An example of this is the Netherlands, which, despite being a global frontrunner in the circular domain, often lacks specific provisions for resource efficiency and sustainable materials in its construction legislation.

Construction sectors are often heavily regulated, and for good reasons, but circular initiatives' implementations are thus often hampered, with several examples of existing laws hindering recycling, use of biomaterials, and reuse efforts. One example: The Danish fire regulation is hindering the use of multi-storey wooden construction[36], even though this is fully practised in Sweden, and besides the fact that the nation has a long history working with these materials. In addition, EU and national public procurement rules often do not prioritise circularity and carbon footprint as standard requirements in public tenders, hampering the market development of a circular economy. Moreover, incentives and requirements that support the renovation and transformation of existing buildings rather than demolition and building new ones are far from being the norm.

Additionally, extended producer responsibility (EPR) schemes for construction products and requirements for the careful dismantling of buildings to ensure intact sorting of high-quality components have mostly yet to materialise. A few notable exceptions do exist, with France introducing EPR requirements for the construction sector, including the imposition of eco-taxes to encourage waste reprocessing and recycling with the adoption of The Anti-Waste and Circular Economy Act (AGEC) in 2022[37]. As well as Denmark, where from July 2025, ensuring careful dismantling and mandating recycling plans for buildings above 250 m2 will be mandatory[38].

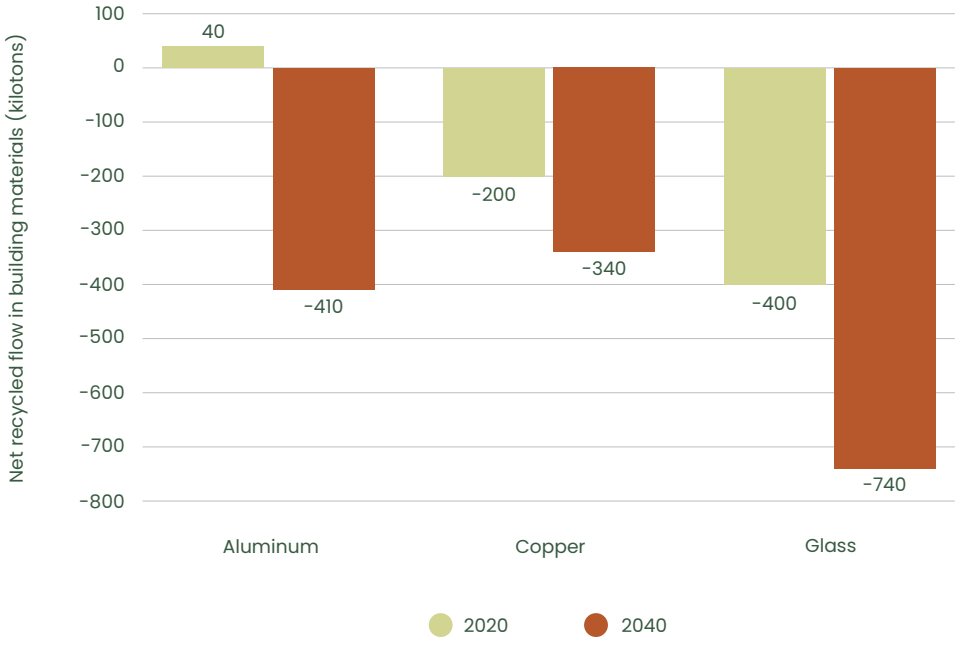
2. LACK OF OTHER STRATEGIES THAN RECYCLING

Another obstacle lies in the prevailing approach and mindset towards circularity within the building and construction sector. There is a pronounced emphasis on recycling as the primary circular solution, dominating production, construction, and design endeavours. However, there is a pressing need to broaden the focus on circularity and prioritise strategies that go beyond recycling.

Currently, there is a lack of construction actors developing models for reuse, contemplating strategies for reduced consumption, applying circular design principles, minimising demolition, and reducing new construction. Moreover, opportunities for synergies and partnerships with other sectors, particularly regarding residual products and alternative resource streams, remain largely untapped.

Expanding the circular mindset is a prerequisite for achieving a circular construction sector, as the volume of materials salvageable from buildings at the end of their lifespan falls short of meeting the material inputs necessary for new construction projects. Thus, it is by no means enough to just focus on recycled materials. See Figure 5.

FIGURE 5. THE RISE IN DEMAND FOR RECYCLED MATERIALS WILL RESULT IN SHORTAGES OF RECYCLED BUILDING MATERIALS



Bain & Company estimates that by 2040, there will be a significant shortage of recycled building materials for new construction, largely due to the long lifespan of buildings and the volumes of materials salvageable at buildings' end of life[39].

3. IMMATURE MARKET

When assessing the commercialisation and economic feasibility of circular construction practices in the EU, notable challenges also emerge. At present, the market for circular construction products remains limited, primarily consisting of smaller entities reliant on irregular material supplies. The majority of circular construction products emerging today are thus still in a testing phase, with a long way to go to reach scale and commercialisation. Consequently, circular products are not readily available on the European market in standardised quantities, complicating the decision-making process for industry professionals seeking sustainable alternatives. The current market landscape lacks widespread accessibility to circular products, impeding their integration into the industry.

In recent years, we have slowly begun to see contractors, architects and entrepreneurs demanding more circular alternatives and incorporating climate and circularity into specific building projects and material choices. However, this is far from being widespread throughout the construction sector, and circular buildings and materials are still the exception, with major players continuing to prioritise conventional construction materials.

Moreover, with the expected increase in the construction volume in the future, there will be insufficient availability of used building materials unless significant constraints are imposed on construction activities, both domestically, within the EU, and globally. Hence, there is a necessity to explore the development of circular material streams from other sectors, such as agricultural residues and biogenic building materials, to prevent a substantial increase in the construction industry's resource footprint and embedded CO_2 emissions in the coming years. However, active cultivation of value chains and the establishment of commercially viable material flows on a sufficient scale have not yet been realised.

4. LACK OF CIRCULAR VALUE CHAINS

There are notable barriers to overcome in forging partnerships and developing new value chains that extend beyond the construction industry. For example, collaborations with agriculture hold promise for creating products derived from residual materials from other industries.

Today, circular value chains and production flows remain largely underdeveloped in the construction sector, failing to ensure that used building materials are given a new life rather than simply being incinerated. This deficiency underscores the importance of establishing processing facilities, upcycling centres, and testing facilities, which play pivotal roles in preparing and verifying the quality of reused and recycled building materials. In France, the implementation of the legislation AGEC of 2022 has introduced a polluter-pays system, encouraging the establishment of reprocessing centres and mandating that they accept building waste free of charge. These measures have effectively curbed illegal dumping in the country while simultaneously bolstering recycling initiatives.

5. LACK OF DATA

Insufficient transparency and lack of data are other barriers impeding the advancement of more circular business models within the construction sector. An analysis[40] carried out by the German Sustainable Building Council (DGNB) underscores the lack of comprehensive information and data as one of the primary barriers hindering EU countries' ability to meet circular requirements.

Presently, there is a notable absence of concrete and standardised data regarding the material content, traceability, and standardisation of reused materials. While some EU countries are progressing in the development of material passports, including those for secondary materials, the absence of harmonised requirements and limited data accessibility persist even at the national level.

Moreover, there is a significant gap in data about the potential resource and climate impacts of circular building materials. Industry stakeholders currently face challenges in accessing readily available and credible data concerning individual building materials, building profiles, and material flow forecasts for upcoming construction projects where materials are in transit.

6. HIGHER COSTS

Building in a circular manner often leads to higher costs, primarily due to the immature market for circular building materials, resulting in limited availability of reused and recycled construction materials. Furthermore, the process of dismantling, quality assurance, processing, and reusing specific building materials is typically more expensive than purchasing newly produced alternatives or resorting to downcycled materials. Additionally, the environmental benefits of reuse and recycling, such as reduced carbon emissions and resource conservation, are not adequately factored into the pricing of circular building materials.

Moreover, the pricing of virgin materials and production of construction materials fails to accurately reflect their true climate and resource impact. Non-harmonised tax structures vary among nations. While the recent changes in the EU quota system and the Carbon Border Adjustment Mechanism (CBAM) will raise prices on some of the biggest construction products, they remain insufficient in delivering the necessary reductions required for achieving the EU's goals. The full implementation of these measures is still a decade away, and the tax rates are not sufficiently high to effectively promote circularity or transition.

LEGISLATION AS THE MOST IMPORTANT DRIVER OF CHANGE

Addressing these multifaceted barriers to achieve a genuine circular transition in the EU's construction sector thus requires both independent political action and industry-driven changes. While strides have been made in recognising the importance of circularity, substantial gaps persist, particularly in legislative frameworks, market maturity, data transparency, and financial incentives. Parameters which the Ellen MacArthur Foundation and consulting firm Arup have similarly identified in their report "First steps towards a circular built environment"[41] from 2022. See Box 3.

Overall, there exists a critical political need for stronger and more effective regulations that support circular construction practices, including extended producer responsibility and incentives for renovation over new construction. Moreover, policies must broaden their focus beyond energy efficiency to encompass circularity goals, such as resource reduction targets and requirements for careful dismantling of buildings.

On the industry front, change is also needed. The construction sector needs to support political initiatives, e.g. embrace producer responsibility, integrate circularity into business practices, and foster collaboration to develop circular value chains. This includes prioritising reuse, applying circular design principles, and investing in the development of processing facilities for recycled building materials.

In essence, achieving a circular construction sector necessitates a collaborative effort between policymakers and industry stakeholders, with a shared commitment to overcoming barriers and driving meaningful change towards a sustainable future.

BOX 3. CIRCULAR CONSTRUCTION: THE MAJOR DRIVERS OF CHANGE

In the report "First steps towards a circular built environment,"[41] the Ellen MacArthur Foundation and the consulting firm Arup identify the three major drivers of change – politicians, investors, and developers – with the greatest potential to promote circularity in construction. The report highlights the key actions that each of these agents of change can initiate to promote the transition to a much more circular construction industry:

Politicians should:

- Collaborate with the industry to develop a supportive policy framework at multiple levels
- Utilise policy levers such as public procurement to stimulate demand for circular solutions
- Initiate and facilitate public-private partnerships to develop scalable projects

Investors should:

- Engage in public-private partnerships to develop scalable projects
- Support research into new valuation techniques that eliminate structural waste and maintain or increase the value of materials

Developers should:

- Lead public-private partnerships to develop scalable projects
- Develop evidence-based data that demonstrates the value of a circular built environment

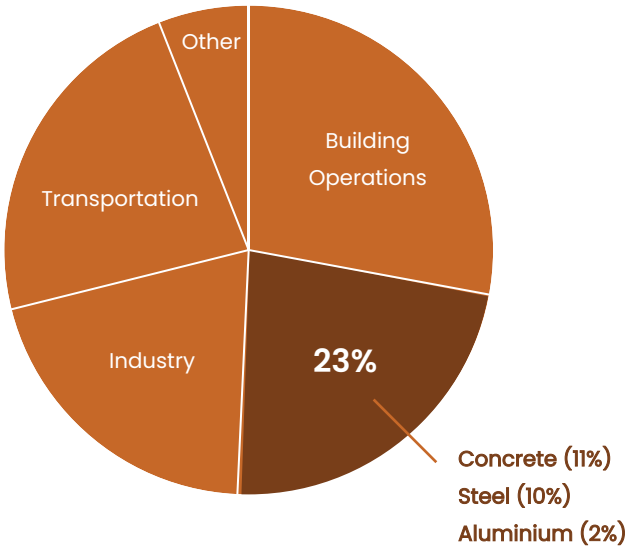
CHAPTER 5

DEEP DIVE INTO THE THREE MOST RESOURCE-HEAVY BUILDING BLOCKS: STEEL, CEMENT AND ALUMINIUM

Steel, aluminium, cement and concrete present three massive challenges in the construction sector when it comes to reducing resource consumption and CO_2 emissions – in member states in the EU and globally. Concrete alone is the most widely used building material in the world, and cement, which is a key component in concrete, accounts for 8 per cent of the global CO_2 emissions. Overall, these three materials globally contribute to 23 per cent of the total CO_2 emissions[42] – with the majority of steel, concrete, and aluminium consumption being utilised in construction. See Figure 6.

FIGURE 6: HUGE CLIMATE FOOTPRINT FROM THE THREE POPULAR CONSTRUCTION MATERIALS[43]

Transport, others, operation of buildings, industry, and cement, concrete, steel, aluminium, per cent



So far, efforts in improving energy intensity and energy conversion have not been sufficient in curbing carbon emissions from the manufacturing of either steel, aluminium, cement or concrete. Consequently, all four materials are still considered hard to abate. According to the IEA, CO_2 emissions from the steel industry have increased over the past decade – primarily due to an increase in demand. Looking at forecasts for urban development and expected construction activity in the coming years, demand for all three materials is expected to rise continually. This will inevitably lead to an increase in CO_2 emissions and resource consumption unless a series of measures to tackle the climate and resource footprint are implemented. Looking solely at concrete, global cement production is expected to increase from the current level of 4.4 to 7.0 billion tons per year by 2050[44].

The World Green Building Council thus also asserts that finding more sustainable building materials will be one of the most effective means of achieving our global climate goals[45]. Therefore, there is a clear and growing pressure on these specific industries and the construction industry in general to develop and scale new practices, technologies, and business models that can contribute to pushing climate-heavy building materials toward a more resource and climate-friendly direction.

This action has become even more relevant and urgent in light of the recent EU taxonomy requirements, the revised EPBD and the inclusion of WLC measures in the directive – adding further pressure on the industry to pursue more circular business models.

GAINING ATTENTION

This realisation has luckily struck several actors within all three sectors. In recent years, a great increase in steel, aluminium, cement and concrete manufacturers have been setting ambitious climate goals, formulating sustainability strategies, forming alliances and partnerships, and increasing investments in the development and implementation of new and more climate-friendly solutions. One example: The European Cement Association – Cembureau - states that the cement sector "will need substantial investments between now and 2050 to carry out research into the new technologies identified, to conduct demonstration scale projects and then to roll out these technologies across Europe."[46]

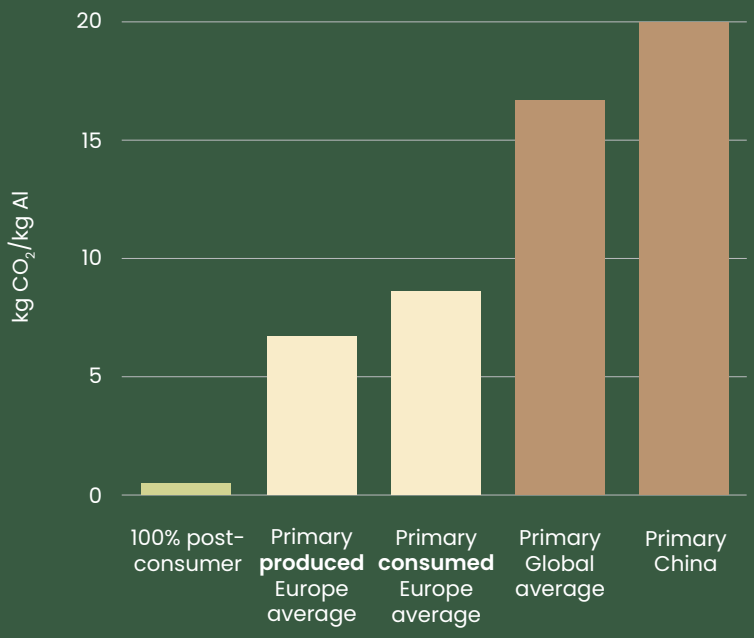
So far, the focus across all three sectors has primarily been on the energy transition, with investments from several manufacturers in energy efficiency and the development of new production methods based on electrification or less climate-damaging energy sources. One area that is getting much attention right now is Power-to-X (PtX)– which is a conversion to production based on renewable energy sources through electrolysis.

Similarly, there has been an emerging focus on resources and optimising material consumption. The development and scaling of more circular business models and increasing the reuse and recycling of material streams are also beginning to gain traction – with a growing recognition that this can lead to significant climate benefits if scaled.

A wide range of analyses and assessments also show that there are significant climate benefits to be gained from a circular transition of steel, aluminium, cement and concrete. For example, according to European Aluminium's memo "Recycling Aluminium: A Pathway to Sustainable Economy," the recycling process requires only 5 per cent of the energy consumption compared to the production of primary metals[47]. When considering the production of aluminium based on scrap (recycled), only 0.5 kg of CO_2 is emitted per kg of aluminium produced. In comparison, 16,7 kg of CO_2 is emitted per kg of virgin aluminium produced (global average) – depending on whether the energy source is coal-based or based on hydropower or nuclear power, which are the most common energy forms used in aluminium production today. See Figure 7.

FIGURE 7. THE RECYCLING OF ALUMINIUM HAS SIGNIFICANT CLIMATE POTENTIAL

Recycling aluminium offers substantial potential for reducing emissions. In the EU, the average primary production emits 6.7 kg of CO_2 per kg of aluminium, whereas recycled aluminium from 100 per cent post-consumer material emits only 0.5 kg of CO_2 per kg. Looking beyond the EU to the global and Chinese averages, the potential for reduction is even greater[48].



DIRECT REUSE IS STILL AN EXCEPTION

In both the steel and aluminium industries, recycling is already an attractive business model. Both materials can be remelted and recycled without deteriorating in property or quality, collecting and recycling both steel and aluminium is profitable. There are, consequently, already several processes and systems in place today that ensure that both steel and aluminium can be repurposed multiple times. The recycling rate is high on a global scale – also within the construction sector. Notably, regarding aluminium today, it is estimated that on a European level, around 75 per cent of aluminium exists in some form of circular loop, with 90 per cent of building aluminium being collected and recycled[49].

When it comes to concrete, however, the material value of concrete is currently much lower, and the recycling business is therefore challenged. As a result, a large portion of the existing concrete used in buildings ends up being demolished and incinerated. According to the European Commission, annual waste from construction and demolition sums up to about 450-500 million tonnes[50], with at least one-third being concrete waste. Whilst concrete contains almost fully recyclable capabilities, only around 30 per cent is recycled in the EU. However, the percentage of use of recycled concrete varies drastically from member state to member state, with multiple examples of aggregate demolition concrete being recycled into new concrete, such as in the Netherlands.

However, the greatest resource and climate savings in relation to all three building materials are not achieved through recycling but through actual reuse of the materials. A significant reason hereof is that the entire energy consumption from the processing of the materials and the following production of new building material is avoided – which constitutes a large portion of the materials' CO_2 footprint, even when some or all of the production is based on non-virgin materials. A preliminary study[51] by the Danish Building Research Institute (SBi) from 2019 that examines the climate impact of 11 building materials showed that directly reused concrete elements and concrete columns/beams emit 13.4 kg of CO_2 per m3, which is equivalent to 95.6 per cent less than its conventional concrete counterpart. In comparison, concrete with 20 per cent recycled aggregates has a potential CO_2 savings of only 0.3 per cent. Similarly, the study showed the potential for over 70 per cent CO_2 savings from the reuse of steel profiles and aluminium plates.

NOT DESIGNED FOR REUSE

Nevertheless, when it comes to creating high-value circular material flows within all three material industries, much development still remains to be initiated. As is the case for most materials in the construction sector, there is currently very little direct reuse of aluminium, steel, and concrete[52]. When concrete, steel, and aluminium elements are directly reused today, it is primarily on an experimental basis or in isolated construction projects where an architect or builder conceives the idea of basing something on reused materials. In other words, it is not something widely practised in the industry and has not yet reached industrial scale or commercialisation[53].

One of the primary barriers to a more direct reuse of steel, aluminium, and concrete in construction, as well as for many other building materials, is that the business case is not yet attractive. The costs of reused construction materials, such as concrete walls or windows with aluminium, are much higher than choosing new materials.

This is partly because many of the materials that entered the construction sector over a decade ago were not designed with reuse and dismantling in mind. Consequently, the materials were often manufactured in a way that makes them difficult to disassemble – for example, precast concrete elements that are typically cast together with steel and iron, making it difficult to separate them without damaging the individual parts. Additionally, years of extensive use of chemicals in building materials are one of the major obstacles to direct reuse, as there may be uncertainty about chemical content and safety requirements regarding whether the building materials meet current standards in the field.

REDUCTION STRATEGIES ARE LIMITED

However, reuse and recycling are one thing – reducing material consumption is another, which remains a very limited area of focus across all three sectors and the building and construction sector in general. A focus on less and reduced consumption has gradually gained traction as part of the future profitability model - it will become an inevitable task they must deal with.

We will not have enough used construction materials, scrap aluminium, steel, and demolished cement and concrete to meet the current and growing demand. The research article "Reuse of Steel in the Construction Industry: Challenges and Opportunities,"[53] published in the International Journal of Steel Structures in 2023, states that "the global steel demand exceeds the availability of scrap by a factor of 3" and concludes that "without a dramatic decrease in material usage, the need for primary steelmaking to meet tomorrow's demands will only increase."

NEW DESIGN APPROACHES AND REDUCTION INITIATIVES ARE NEEDED

From a resource and climate perspective, it is pivotal to ensure that buildings and infrastructure projects using steel, aluminium cement and concrete products are designed for circularity. This calls for new design methods that focus on simpler product compositions and disassembly, reduced use of chemicals, modular design, functionality, etc. This has been attempted in projects such as the Danish project Circle House, where the building's concrete elements are bolted together instead of being cast together so that they can be disassembled later and reused elsewhere. See Box 4 and case page 44 (Building for reuse - Circle house in Denmark). Manufacturers and actors across the construction value chain are slowly beginning to develop circular design approaches. However, there is still a long way to go before this can be considered a standard design approach.

Besides designing for circularity, another important step is to develop and scale solutions that enable the reuse of all the steel, aluminium, and concrete materials that are already part of our existing building stock. That is also an area that needs significant improvement, as there is currently a lack of common practice and commercially viable solutions – across the entire EU. Many countries have yet to establish the necessary incentives, technical solutions, systems, partnerships and value chains needed to ensure that the materials can and will be reused after dismantling.

Finally, there is a great barrier regarding reducing the massive material usage when it comes to steel, cement and aluminium. Across EU member states, we have yet to see the political initiatives, incentives, and regulation and the circular commitment from businesses necessary to halt the growing demand – and ensure that resource consumption is, in fact, reduced.

BOX 4. Design for disassembly

The ISO standard, DS/ISO 20887, provides a new framework for " Design for Disassembly and Adaptability" in construction[54]. The standard guides stakeholders in the construction industry on how to design a building or construction project so that the various building components can be disassembled later – as part of ensuring the transition to a more circular construction industry. The new standard is also mentioned in the EU taxonomy as a recommended method for improving the building's circularity. The standard presents 10 design principles for constructing buildings, as follows:

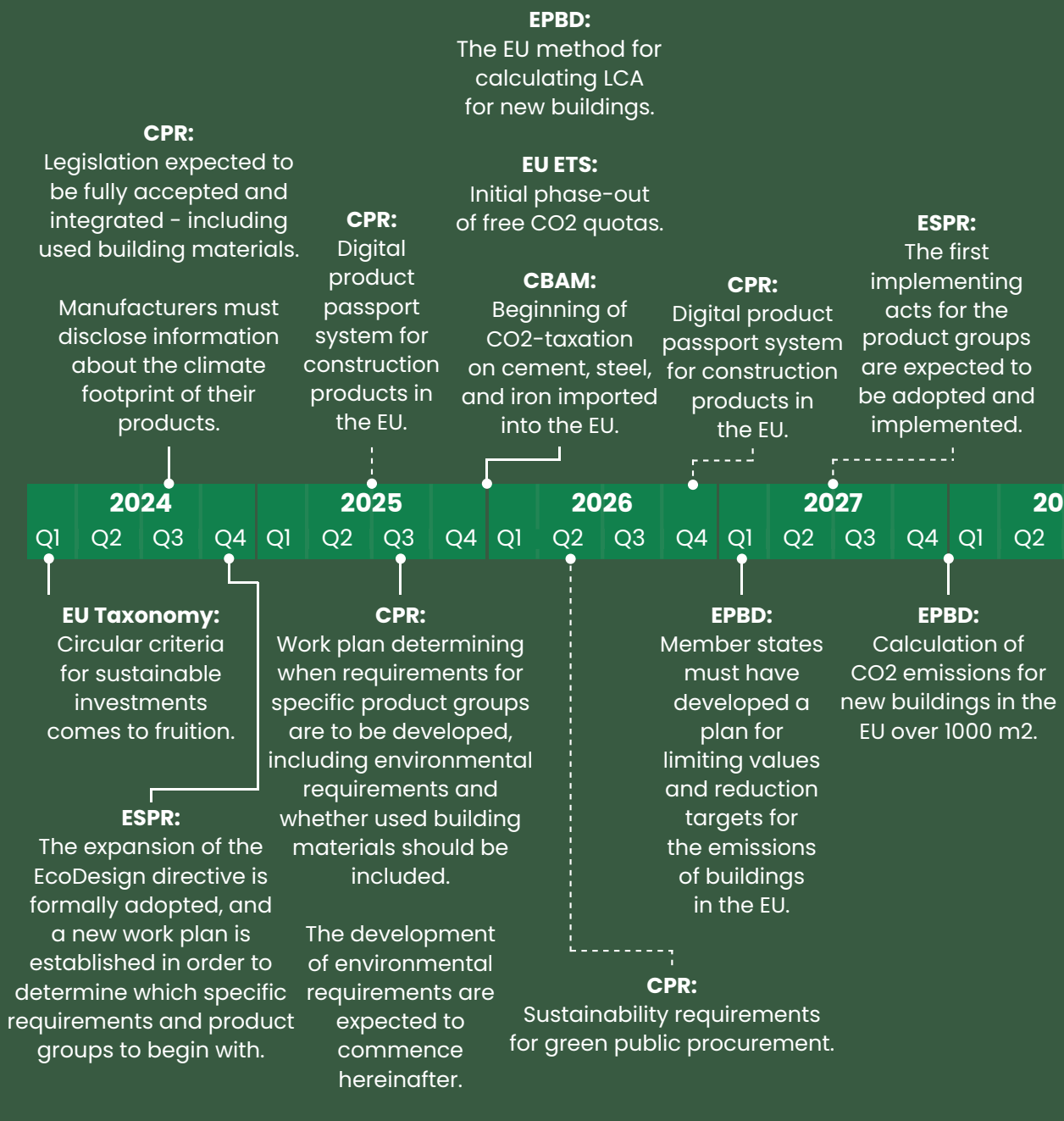
- Versatility
- Convertibility
- Expansion possibilities
- Easy access
- Independence and reversible assemblies
- Avoidance of unnecessary treatments and finishes
- Support for the circular economy
- Simplicity
- Standardisation
- Safety in disassembly

CHAPTER 6

EU LEGISLATION WILL DEMAND INCREASED CIRCULAR ACTION

The EU has, through a series of initiatives, objectives, and policy measures in recent years, placed circular transition and reduction of resource consumption high on the agenda, with a significant focus on circular construction as well. With initiatives such as the EU's Circular Economy Action Plan, the revision of the Construction Products Regulation (CPR), the Ecodesign for Sustainable Products Regulation (ESPR), the EU Taxonomy for sustainable activities, the Energy Performance of Buildings Directive (EPBD), and EU's Emissions Trading System & Carbon Border Adjustment Mechanism (ETS & CBAM), the construction industry across member states will be required to meet a range of new environmental, climate, and resource stipulations by 2030, with even more to come. See Figure 8.

This will require action across the construction sector's value chain in all member states and requires the development of more circular business models and materials for the value chains to accelerate. For member states, this will similarly require increased political action if they are to succeed in implementing and aligning with the coming EU legislation.


EPBD:
The EU method for calculating LCA for new buildings.
CPR:
Legislation expected to be fully accepted and integrated - including used building materials.
Manufacturers must disclose information about the climate footprint of their products.
CPR:
Digital product passport system for construction products in the EU.
EU ETS:
Initial phase-out of free CO2 quotas.
CBAM:
Beginning of CO2-taxation on cement, steel, and iron imported into the EU.
CPR:
Digital product passport system for construction products in the EU.
ESPR:
The first implementing acts for the product groups are expected to be adopted and implemented.
2024
2025
2026
2027
20
Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2
EU Taxonomy:
Circular criteria for sustainable investments comes to fruition.
ESPR:
The expansion of the EcoDesign directive is formally adopted, and a new work plan is established in order to determine which specific requirements and product groups to begin with.
CPR:
Work plan determining when requirements for specific product groups are to be developed, including environmental requirements and whether used building materials should be included.
The development of environmental requirements are expected to commence hereinafter.
CPR:
Sustainability requirements for green public procurement.
EPBD:
Member states must have developed a plan for limiting values and reduction targets for the emissions of buildings in the EU.
EPBD:
Calculation of CO2 emissions for new buildings in the EU over 1000 m2.

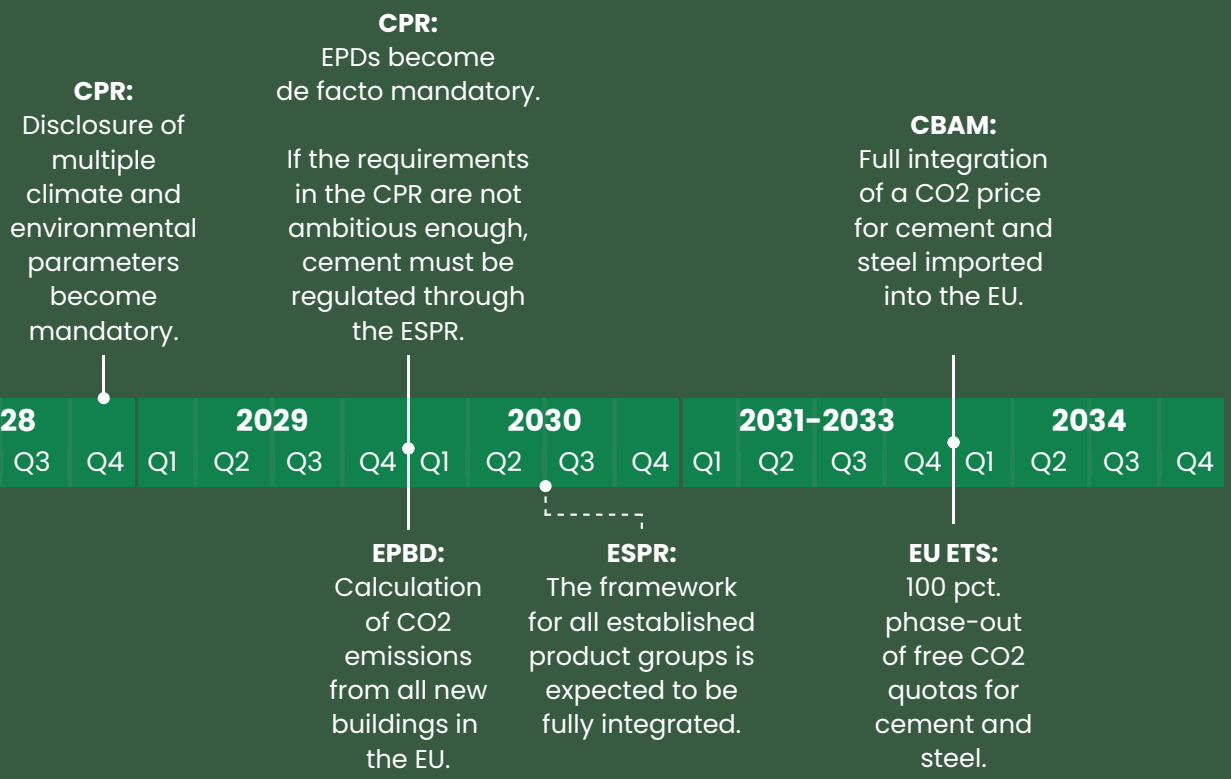


FIGURE 8. Upcoming EU legislation aimed at circularity and resource consumption

Over the coming years, the EU will introduce a wide range of legislative packages aimed at promoting more circularity and less resource consumption in construction.

EU'S KEY CIRCULAR INITIATIVES

It is not merely one, but several legislations being adopted in the EU in recent years that focus on circular construction and buildings. Therefore, to understand how the European building and construction industry will be impacted on the circular front in the coming years, it is necessary to delve deeper into these various legislative packages.

The new circular requirements from the EU that will impact the construction industry are comprised of the following legislative packages:

1. ECODESIGN FOR SUSTAINABLE PRODUCTS REGULATION (ESPR)

ESPR is a legislative framework aimed at paving the way for more environmentally friendly and circular products within the EU – including critical and commonly used building materials such as aluminium, iron, and steel.

It includes the following four primary focus areas:

1. New sustainability requirements for products including aspects such as product durability, repairability, recyclability, expected waste generation, and a requirement of a reduced environmental footprint. All products will not be regulated simultaneously but rather continuously. Priority will be given to product categories with the greatest environmental impact first, with specific green requirements established for each product group.

2. A digital product passport will be mandatory for products marketed within the EU. The intention is to assist consumers in their choices and ensure greater transparency regarding product data and better information flows across the entire value chain.

3. Focus on green public procurement setting mandatory criteria for green public procurement to ensure sufficient demand for more environmentally sustainable products. The requirements will mean that the public sector, in specific product purchases, must increasingly include parameters related to aspects such as durability, repairability, reuse, recycling, energy consumption, and the environmental footprint of the product measured over its lifecycle.

4. Companies must disclose products delivered for reuse, remanufacturing, recycling, energy recovery, and disposal. This information must be made available to consumers and other companies alike to prevent the destruction of unsold products. Additionally, the European Commission will have the option to introduce prohibitions on the destruction of unsold goods if it is assessed that it has a significant environmental impact.

2. CONSTRUCTION PRODUCTS REGULATION (CPR)

With the new revision of the CPR, the focus is on promoting more climate-friendly and circular construction products in the EU. Specifically, it contains three primary elements:

1. Requirements for building materials environmental and climate impact. This entails that in the future, a vast range of building materials under the new CPR must meet a series of individual and shared environmental requirements in terms of how they are designed, produced, and used. The final environmental requirements are determined per product group and may relate to:

- Prioritising durability, minimising emissions, and using safe, sustainable, and recyclable materials.
- Repair and recycling efforts, providing spare parts for at least a decade, and accepting returns of unused materials.
- Resource efficiency, energy standards, modularity, sustainable sourcing, minimal packaging, and minimising waste generation, especially hazardous waste.

2. A digital product passport. As part of the CPR, a digital product passport system for building materials will be established, closely aligned with the digital product passport defined in the ESPR. The purpose is to ensure easily accessible information about building materials in the EU for all actors in the value chain. Additionally, it will contribute to easing the control of CPR requirements for authorities and, notably, ensure better traceability of building materials throughout the value chain.

3. Requirements for public procurement. In the CPR revision, the EU also focuses on how to strengthen green public procurement of building materials. Specifically, the CPR stipulates that minimum requirements for the environmental sustainability of building materials should be developed in connection with green public procurement.

3. ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE (EPBD)

With the revision of the EPBD, we now have legislation in place in the EU that focuses on the embodied carbon of building materials. Specifically, the EPBD states that member states must, by 2027 at the latest, develop a roadmap for the implementation of limit values and set reduction targets for new buildings from 2030. Furthermore, it is stated that by 2030 at the latest, greenhouse gas emissions from all new buildings in the EU must be calculated and disclosed.

Looking at the immediate impact of the EPBD, many member states will need to tighten and reduce emissions from both the operation and construction of future buildings. With the revision of the EPBD, concrete requirements, such as reductions in buildings energy consumption and the installation of solar panels, will be required. For reductions in energy consumption, a target has been set for residential buildings to reduce the average energy consumption for heating per square meter in existing buildings by 20-22 per cent by 2035. The requirement to install solar panels, however, initially applies only to larger public and other non-residential buildings. In 2028, the requirement will also apply to larger renovations of non-residential buildings, and from 2030, the requirement will apply to all new residential buildings.

4. CARBON BORDER ADJUSTMENT MECHANISM AND EU EMISSION TRADING SYSTEM (CBAM & ETS)

The EU aims to push heavy industries into climate action, and producers of energy-intensive building materials such as cement, iron, steel, and aluminium are high on the list. Therefore, the Union is reforming the EU ETS - the EU's quota system – to make CO_2 emissions more expensive for companies in the EU. Specifically, for energy-intensive products, the EU plans to eliminate the allocation of free CO_2 allowances, which weakens the pricing point and incentivises reductions of CO_2 emissions. However, the EU wants to ensure fair conditions, whether energy-intensive products are produced inside or outside the EU. Therefore, the EU is also introducing CBAM, which imposes a climate tariff on energy-intensive goods produced outside the EU. From 2026 and onwards, the allocation of free CO_2 allowances for products such as cement, iron, steel, and aluminium produced within the EU will gradually be phased out, while a CO_2 tax will be imposed if they are produced outside the EU's borders and imported into the EU.

The reform of the EU ETS and CBAM will thus have a significant impact on the production of some of the most commonly used and carbon-intensive building materials in the EU, which are expected to become much more expensive. This will both push for the development of more climate-friendly alternatives and for a higher proportion of construction waste being reused and recycled.

5. EU FINANCIAL REGULATION

The EU has adopted a wide range of measures aimed at increasing the share of sustainable investments and strengthening sustainability reporting.

An important part of this is the EU taxonomy for sustainable activities, which requires further documentation of climate and environmentally sustainable economic activities, which also has and will have a significant impact on the construction industry. The taxonomy sets six specific climate and environmental objectives that companies can use to document their sustainability:

1. Climate change mitigation
2. Climate change adaptation
3. Sustainable use and protection of water and marine resources
4. Transition to a circular economy
5. Pollution prevention and control
6. Protection and restoration of biodiversity and ecosystems

Furthermore, the EU has adopted the so-called Corporate Sustainability Reporting Directive (CSRD), which requires companies to report on their sustainability, including their environmental, social, and governance impact. The reporting requirement will be phased in gradually, applying to listed companies with over 500 employees from this year. In 2025, companies falling into the C-large accounting class, employing more than 250 employees, will be subject to these requirements, and from the reporting year 2026, small and medium-sized listed companies with fewer than 250 employees will be covered - however, micro-enterprises will be exempted.

The reporting requirements are determined through European Sustainability Reporting Standards (ESRS), but it is up to each

company to assess which information they report based on the so-called double materiality perspective. Looking at environmental sustainability, ESRS has been developed in five categories, with the fifth category primarily focusing on resource consumption and the circular economy. Within that category, companies must report, among other things, on their resource consumption, waste generation and management, and the circularity of products and value chains.

Finally, the EU has also introduced the Sustainable Finance Disclosure Regulation (SFDR), which sets requirements for financial advisers and market participants to disclose how they incorporate environmental, social, and governance risks and impacts. Specifically, the aforementioned actors must disclose how they address sustainability risks, as well as consider adverse impacts on specific sustainability factors and information about a product's sustainable investment objective or promotion of environmental characteristics (if claimed). Overall, SFDR will contribute to increasing sustainable financing in the EU and protecting investors from greenwashing by ensuring harmonised information about sustainable investments.

WHAT DOES THE EU LEGISLATION MEAN FOR THE CONSTRUCTION SECTOR?

The comprehensive package of climate, environmental, and circular requirements coming from the EU will impact and require action across a wide range of areas throughout the construction sector value chain and across all member states. The requirements largely stem from the measures for construction and infrastructure initiated with the adoption of the EU's Circular Economy Action Plan in 2020, which prioritises material efficiency improvements and reduction of construction and infrastructure's climate impact.

With new circular product requirements, both manufacturers and construction actors will need to place much greater focus on the climate, environmental, and resource footprint of the materials and products used in construction. This include data and knowledge about material composition and attributes, design, use, separation and recyclability methods, as well as the development of new and more circular products and business models, to meet new thresholds and requirements for recycled content and the reuse of building materials.

This will be supported by the new financial measures from the EU, which will increasingly create clear economic incentives over the coming years to transition member states to move in a more circular direction. While much of the legislation targets the financial sector and large companies in the construction sector, it will have implications for all actors in the construction value chain. For example, with the EU's new reporting requirements for documentation of climate and environmental

sustainability, larger actors will be compelled to set requirements further down the value chain. Therefore, EU initiatives and measures in the circular field must naturally be on the radar of actors across the construction industry throughout Europe and acted upon in the coming years. As such, there is a significant risk for companies that fail to adapt and act proactively to the new circular requirements, but conversely, there is also an opportunity for companies that manage to be proactive and stay ahead of the new requirements.

WHAT DOES THIS MEAN FOR THE EUROPEAN POLITICAL LANDSCAPE?

Politically, throughout Europe, the amount of national green initiatives set in motion regarding construction differs vastly. Some countries have chosen a path in recent years where they aim to be among the leading countries when it comes to the climate regulation of construction, while others are falling behind. Even so, in the wake of the new climate, environmental, and circular requirements coming from the EU, there will be a need for all member countries to go much further and significantly raise their ambition levels in order to efficiently combat climate change. The EU's current goals are a solid foundation upon which more must be built. An example hereof is the EPBD and the new requirements for member states to calculate and reduce the embedded CO_2, which may potentially push some countries to regulate and tighten limit values faster than what has been planned so far in accordance with the Paris Agreement – at least it will be necessary if nations aim to be among the ambitious end of the climate spectrum, that can effect real change.

EU's forthcoming requirements for construction and infrastructure should, therefore, be firmly on the political radar of any nation. Firstly, it should be ensured that relevant authorities are geared to comply with and enforce the new requirements and, in that process, support companies in the construction industry so they are equipped to meet these requirements. Secondly, nations should be aware that the EU's new circular requirements are a unanimous minimum starting point, meaning many countries today either are or should be moving significantly faster on their own.

However, at the same time, the EU's circular efforts are far from being concluded. If nations aim to obtain a green and circular lead, they must expect, adapt to and address the fact that the EU will tighten the circular screw even further in the future.

CHAPTER 7

FRONTRUNNERS: SEVERAL COUNTRIES ARE SCALING UP THEIR CIRCULAR EFFORTS

Several European countries are leading the pursuit of circularity and have scaled up their efforts through various initiatives. While still far from any finish line when it comes to promoting the circular transition of buildings and construction across the EU, there are examples of frontrunner countries that, through a political increase in both ambitions and efforts, have achieved various circular successes in recent years.

These examples of various best practices from other countries, such as France, Norway, Finland, The Netherlands, England, Germany, Sweden, and Denmark, include circular political strategies, concrete changes in regulations and legislation, public development funds, new circular products, and partnerships that can inspire other nations, in how to tackle the task of promoting the circular transition of construction.

These nations' circular transformations are far from complete – however, they are good examples of effective legislation, which also show that many efforts and political initiatives are needed if the transformation is to be successfully realised.

As such, these best practices are examples that show that there is significant political potential to push for the development of a more circular building and construction sector and that political initiatives can have a great impact across the construction value chain in terms of developing and strengthening circularity.

THE NETHERLANDS: A POLITICALLY ADOPTED STRATEGY FOR CIRCULAR TRANSITION AND AN IMPLEMENTATION PROGRAM FOR CIRCULAR CONSTRUCTION

The Netherlands has made significant strides in fostering a circular construction sector through various political initiatives and strategic collaborations with private actors. Since 2015, partnerships like the Biobased Building Green Deal have propelled the Dutch construction industry's expertise in biobased materials, particularly in hemp concrete. This effort, initiated over a decade ago, aimed to boost circularity and sustainability by leveraging biogenic construction materials.

In 2016, the Netherlands established a national objective to achieve full circularity by 2050, with an interim goal of reducing mineral, metal, and fossil consumption by 50 per cent by 2030.

To drive this transition, the Netherlands has implemented various measures within the fields of:

- Data Strategy Development: Emphasizing data exchange in the construction chain, such as building passports, to enhance transparency and accountability.
- Circular Procurement Support: Facilitating circular procurement through buyer groups to incentivise product reuse and recycled content, with a particular emphasis on promoting biobased materials.
- Circular Design Promotion: Encouraging circular design practices and implementing measures to mitigate the environmental impact of transportation and infrastructure, aligning with area-based approaches.
- Plastics Optimization: Pursuing lifecycle optimisation for plastics in construction and exploring extended producer responsibility feasibility studies to address plastic waste challenges.

These efforts have yielded tangible results. The Netherlands recently boasts an overall circularity rate of 24.5 per cent, positioning the country as a European leader in the circular economy, way ahead of any other nation in the region. Notably, the construction sector has made significant reductions in resource consumption and increased material reuse.

The impetus for these achievements can be traced back to comprehensive political initiatives dating back to 2012. The introduction of the Building Decree (Bouwbesluit) marked a pivotal moment, making the Netherlands the first nation to mandate reporting on buildings' embedded CO_2 footprints.

Subsequent regulations, such as the adoption of the MPG tool in 2018, a measurement unit reflecting the building's sustainability in terms of material usage, lifespan, and renovation needs, have furthered sustainability efforts by requiring climate impact assessments for new buildings.

Building on these foundations, the Dutch government has set ambitious targets for the construction sector, outlined in the "Biobased Economy Vision", specifically in looking to:

- Optimising material use throughout the lifecycle of the buildings – in terms of value preservation, cost savings, increased reuse, and reduced environmental impact.
- Aiming to limit new raw materials in construction in general, and thus widely available sustainable manufactured materials should be used more frequently to reduce environmental costs and promote reuse, further minimising CO_2 emissions from the construction sector – both in the construction and operational phases.
- Making sure the construction sector proactively responds to changes in society's demands from consumers and private companies and having them focus on developing new production methods and designing new circular innovative products that can reduce emissions and waste.

Collaboration between the public and private sectors has similarly been instrumental in driving these initiatives forward. Various green deals, including the Circular City, Circular Buildings, and Biobased Building agreements, have facilitated cooperation and knowledge exchange, leading to concrete actions to reduce environmental impact and promote circularity.

Despite these achievements, The Netherlands' circular transformation of the construction industry is far from the finish line. Regardless, the Dutch government's proactive stance and collaborative approach have laid a solid foundation for the construction industry's circular transition. By fostering innovation, incentivising sustainable practices, and addressing regulatory gaps, the Netherlands is paving the way as a European frontrunner toward a more circular future in construction.

FRANCE: EXTENDED PRODUCER RESPONSIBILITY FOR BUILDING MATERIALS AND FOCUS ON BIOECONOMICS

France has made significant strides in advancing its bioeconomy, investing 420 million euros in 2018 to promote biomass and biobased materials across key sectors like construction, agriculture, energy, and industry. This initiative aims to lessen reliance on fossil fuels while fostering a circular economy. Notably, hereof, France mandated that the 2024 Olympic Village would be constructed entirely with biobased materials, signalling a strong commitment to sustainability. France has also partnered with England, through the Sustainable Bio & Waste Resources Project for Construction, to develop biogenic construction materials based on waste and by-products from their respective agricultural sectors.

The Anti-Waste and Circular Economy law (AGEC) enacted in 2022 further demonstrates France's proactive approach to sustainability. With 98 specific legal obligations, including Extended Producer Responsibility (EPR) for the construction industry, this law imposes eco-taxes to incentivise waste reprocessing and recycling. It establishes a polluter-pays system, encourages the establishment of reprocessing centres, and mandates these centres to accept building waste for free, combating illegal dumping and enhancing recycling efforts.

NORWAY: ENVIRONMENTAL CONSIDERATIONS MUST ACCOUNT FOR 30 PER CENT IN PUBLIC PROCUREMENT

Norway's commitment to climate action has reached a significant milestone with the enactment of new procurement legislation effective in 2024. Public tenders in Norway must now integrate climate and environmental requirements, weighted at a minimum of 30 per cent, into their evaluations. This shift underscores the nation's determination to utilise public procurement as a vital tool in achieving its ambitious climate goals, including halving CO_2 emissions by 2030.

The decision to prioritise climate and environmental considerations in public tenders stems from the recognition that public procurement exerts substantial influence, constituting 16 per cent of Norway's total climate footprint and 17 per cent of its GDP in 2017. The revised legislation reflects a strategic effort to harness this influence for climate-friendly and circular practices, with a focus on enhancing sustainability across sectors like construction.

This legislative change has received widespread acclaim, particularly from business communities, including the construction industry, which views it as pivotal for driving the green transition. Organisations such as the Confederation of Norwegian Enterprise and Construction have voiced support, emphasising the potential for strengthening markets for environmentally friendly solutions.

The new regulations mandate a minimum 30 per cent weight for climate and environmental considerations in procurement evaluations, ensuring a significant emphasis on sustainability. However, flexibility exists for alternative weighting or specification requirements if superior climate and environmental benefits can be demonstrated. This shift is expected to yield further environmental gains compared to previous practices, which often allocated only 15 per cent weight to environmental factors.

Implementation of the new law necessitates comprehensive changes throughout the procurement process, prompting initiatives like the Action Plan for increased climate-friendly procurement and green innovation. This plan aims to equip public procurers with the necessary competencies and practical guidance to align procurement practices with environmental obligations. The Norwegian Agency for Public Management and eGovernment also offers specific guidelines and webinars to support procurers and stakeholders in adapting to the legislative changes, underscoring Norway's commitment to fostering a greener future through strategic public procurement.

FINLAND: AMBITIOUS LEGISLATIVE REFORMS AND STRATEGIC INITIATIVES

In 2016, Finland adopted the so-called Timber Material Program, a government-driven strategy for timber construction, with the aim of increasing the use of timber in urban development and public buildings. The program introduced a requirement that 45 per cent of all public construction in Finland should be based on timber constructions by 2025, of which the Ministry of Agriculture estimated in 2022 to have reached 31 per cent.

Moreover, the comprehensive reform of the Land Use and Building Act, effective from January 2025, marks a significant milestone in Finland's circular transition. This reform introduces stringent CO_2 requirements, mandates for building quality and lifespan, and digitalisation efforts to streamline building permits and land use plans nationwide. Notably, it emphasises material selection, necessitating life cycle assessments and carbon declarations for buildings.

The reform also prioritises technical requirements for enhanced durability, repairability, and future dismantling to facilitate material reuse. Applicants for permits must collect data on all materials, promoting transparency and accountability in resource management. Digitalisation plays a pivotal role, with a common information system slated for implementation by 2024 to bolster data accuracy and inform smarter, climate-friendly decisions.

This legislative overhaul aligns with Finland's broader circular strategy, aiming for carbon-neutral and circular status by 2035. It sets ambitious targets for reducing resource consumption and increasing resource productivity. Despite challenges posed by Finland's high material footprint, particularly in construction, initiatives like the Green Deals program and sustainable architecture policy signal proactive steps towards sustainable, circular practices.

Economic incentives also feature prominently, with reduced electricity taxes for industrial recycling and increased waste taxes to incentivise circularity. Discussions in the nation are ongoing, attempting to strike the right balance between voluntary measures and economic incentives to promote the use of recycled building materials, reflecting Finland's commitment to fostering a thriving circular economy.

DENMARK: NEW REQUIREMENTS FOR EMBEDDED CO_2 IN NEW CONSTRUCTION

Due to outspoken demands from the construction sector itself to reduce the CO_2 emissions from construction, the Danish government has, through the so-called Building Regulation, set several requirements for energy consumption and efficiency in construction to be further tightened over the coming years. In 2021, in cooperation with the industry, a broad political agreement was reached on the National Strategy for Sustainable Construction, which, with 21 concrete initiatives, set a strategic framework for the Danish construction sector up to 2030, herein including requirements for embedded CO_2 in new construction.

As part of the implementation of the strategy, specific climate requirements for the construction sector have been officially introduced since January 2023. Specifically, this entails that it is now a legal requirement to conduct a life cycle analysis (LCA) for all new construction and, further, introduce a limit on CO_2 emissions for all new construction over a thousand square meters. For large new constructions, this rule stipulates that there should be no more than 12 kg of CO_2 per m2 per year. A limit that will be reduced further over the coming years.

In May 2024, Danish politicians decided to further reduce the limit values and differentiate them based on various building typologies. As a result, starting in July 2025, the limit values will be lowered to an average of 7.1 kg CO_2 per m2 per year. Additionally, it has been indicated that this limit value will be further reduced to an average of 6.4 kg CO_2 per m2 per year in 2027 and 5,8 kg CO_2 per m2 per year in 2029. However, this should be considered preliminary estimates for the limit values in 2027 and 2029 as negotiations in 2026 and 2028 will show whether these will be reduced even further.

Additionally, it has been decided that requirements for embedded CO_2 in building regulations from 2025 will apply to all new construction. Furthermore, it has been politically determined this year that from January 2024, construction projects can now account for recycled products with a fixed percentage of CO_2 emissions (until now, recycled materials have, in LCA calculations, had the same impact as new building materials, which undermines its use) - as such, incentives to use recycled building materials in new construction have vastly increased. An initiative that has only been partly implemented in a few other countries, such as Holland, Sweden and Norway.

GERMANY: PUBLIC INVESTMENTS IN TIMBER CONSTRUCTION

The BMEL (the German Ministry of Food and Agriculture) have invested heavily in promoting timber constructions throughout Germany in recent years. As a result, the investment has led to the nation's timber construction percentage exceeding 20 per cent of the material used in their total constructions in 2020.

In addition, through DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen), a reward system has been developed, creating monetary incentives for builders to choose sustainable materials, including biogenic materials, in construction.

SWEDEN: BIOECONOMY HAS BECOME PROFITABLE THROUGH A SIMILAR UTILISATION OF THEIR RESOURCE STREAMS

Because forests today cover about 60 per cent of Sweden's area, the timber sector has experienced significant economic and circular importance, with an estimated annual value of 258 billion Swedish kronor, equivalent to about six per cent of the country's GDP. Therefore, Sweden has invested heavily in timber construction in order to meet climate adaptation needs.

As part of this, they have developed significantly more flexible fire regulations (something that remains a widespread barrier to timber constructions in many other nations), resulting in every fifth multi-story building now being constructed in timber.

In addition, through their simpler and more cost-effective certification system, the so-called Miljöbyggnad (which also involves LCA), they have significantly increased the use of both timber and other biogenic and circular materials in construction by rewarding their use through the system's final assessment.

UK: LONDON HAS MADE CIRCULAR ECONOMY STATEMENTS A PREREQUISITE FOR BUILDING PERMITS

As of 2022, all major construction projects in the greater London area are required to submit a so-called Circular Economy Statement (CE-Statement). This statement includes a LCA analysis and addresses various aspects of circular construction, including modularity, design for disassembly, alternative use, and maintenance. The statement has been developed in collaboration with the Greater London Authority and engineering firms like Cundall and Targeting Zero, as well as other industry stakeholders.

The CE-statements are a strategic move to embed circular economy principles into building design, construction, and lifespan. The aim is to curb resource consumption and waste, which currently amounts to 400 million tons of materials annually and 54 per cent of London's total waste.

The process hereof unfolds in three stages:

1. Pre-application: Developers submit a draft outlining the strategic approach to circularity, including material intensity calculations and estimates of reuse quotient and breakdown percentages for each material.

2. Full application: A detailed CE-Statement focuses on how circularity will be realised in the building's design, providing actual material intensity calculations, circular reuse content, and breakdown estimates.

3. Updates after planning and completion: Ongoing updates track progress against previous goals and commitments established in stages 1 and 2, as stipulated by public authorities.

To secure building permits, CE-Statements must include recycling and waste reporting forms aligned with London's policy goals, such as achieving 95 per cent reuse and recycling of construction and demolition waste by 2030. Furthermore, developers must detail waste generation estimates, landfill diversion strategies, and plans for reducing material requirements, promoting reuse, and enabling end-of-life dismantling and recycling.

London's proactive stance thus underscores its commitment to fostering sustainable construction practices and minimising environmental impact. This initiative is currently applicable citywide and is extending to neighbouring areas, with further aims to inspire similar measures nationally as well as worldwide.

CHAPTER 8

CIRCULAR CONSTRUCTION: BEST PRACTICE EXAMPLES

A social housing project in Denmark constructed according to circular principles. A Cradle to Cradle certified company building in Austria. A Dutch company, SmartCrusher, that has developed a technique for recovering sand, gravel and cement from concrete.

These are just some of the innovative and inspiring examples of how circular buildings and products are developed and tested across the EU in recent years. Examples that show great potential in the implementation of circularity in construction and buildings and document significant reductions in CO_2 emissions and resource consumption. Examples that also prove the economic potential and business case of circular construction and show how circularity can be implemented and used as a defining strategy – both for manufacturing construction products and in the construction phase.

However, these examples also underline the fact that circularity in the construction industry and building projects is still an exception and currently far from being a standard practice, that circularity is not a well-developed and scaled business model but is currently implemented in many ways, with different strategies, different ambitions and different results.

CIRCULAR BUILDINGS

Across the EU, there are best practice examples of building projects – both new building projects and renovation projects - where circularity has been a clear and defining part of the process – and where there are clearly documented benefits in regard to carbon and resource reductions.

BUILDING FOR NO WASTE – CIRCL COMPLEX IN AMSTERDAM

Circl Complex[55] in Amsterdam is a building created to serve as a social meeting place that was constructed in 2017. The building was created from almost all reused materials, which can be demounted and reused again. It has over 500 solar panels generating energy, meeting the building's needs and minimising energy loss. The isolation of the building is made of old clothing and window frames from old offices. The building was designed to be circular, both in the construction and in the use of the building, with a focus on purchasing second-hand furniture, and the activities in the building should focus on promoting circularity and knowledge sharing on circularity.

According to a KPMG study, the Circl building has a 40 per cent smaller CO_2 footprint compared to the reference "linear" building build. The building is set to have a bigger contribution by material design and energy neutrality over 30 years. The main goal of Circl Complex was to create a building without waste.

BUILDING FOR REUSE – CIRCLE HOUSE IN DENMARK

Circle house[56] is the first social housing in Denmark constructed according to circular principles. The building was constructed in 2023. The design and construction of the building are created in a way that 90 per cent of the building materials can dismantled, reused or sold without the loss in value of the materials. Besides concrete and cement as the main building materials, Circle house is constructed of alternative reused materials such as cork and old newspapers for the facade of the building, eelgrass and granules for insulation and used car tyres for the flooring underlay.

This building is built as an example of the application of circularity from the start of the design process all the way to the realisation of the project. This kind of circular approach to construction can result in CO_2 reduction emissions of construction by 38 per cent by 2050.

BUILDING IN HARMONY WITH NATURE – TRIODOS BANK IN THE NETHERLANDS

The Triodos Bank[57] in the Netherlands was designed to create a balance between nature, culture and economy. Finished in 2019, the building is the world's first fully circular, demountable office building with a design focus on future reuse and value preservation. The building is constructed entirely from wood, and the building and the landscape are created to enhance the biodiversity of the area. A green rooftop was created to support biodiversity and capture the rainwaters, cool the building in summer, and provide space for insects and birds.

The building was designed to be energy-positive. Due to the choice of material, the building captured more CO_2 than it had emitted during its fabrication and construction, making it one of the first carbon-negative office buildings in the world of this size. Triodos Bank Nederland has also achieved the BREAAM "Outstanding certificate".

In addition, the Triodes Bank building was designed to be fully demountable. The building is screwed together with 165,312 screws. This means that by ever taking the building apart again, the circular potential can be 100 per cent activated without loss of value of materials, components and products.

BUILDING FROM WASTE – THE AUSTRIAN PRINT HOUSE

The Cradle to Cradle certified Austrian print house, Gugler[58], is a company building that opened in 2017 and was designed and constructed based on circular design principles with a focus on reusability. 95 per cent of the materials used to construct the building can be reused when the building is demolished.

Furthermore, 43 per cent of the materials used are recycled sourced from companies' products or other sources of materials. The building is constructed, among other things, by using printing plates from the company production for facades, the insulation is created from companies' wastepaper, and the floor is made from recycled concrete. The building is TQB certified (Österreichische Gesellschaft für Nachhaltiges Bauen).

BUILDING FOR CIRCULARITY – UPCYCLING CENTRE IN ALMERE

The Upcycle Centre in Almere[59], the Netherlands is a place that was created to serve as a civic amenity site. As the building itself serves as an incitement to be circular with resources, it was also developed and designed circularly. The idea was to build as circularly as possible. The foundation of the building is made of construction rubble, old bannisters and benches from a demolished swimming pool and a sports hall have been incorporated into the front of the recycling centre. The beams and steel roof construction come from a demolished printing firm. The building is 100 per cent energy neutral, and rainwater is used for toilets and cleansing. This building is also designed for dismantlement as all parts were screw mounted.

BUILDING FOR PRESERVATION IN DUIVEN

In 2015, a big circular renovation project[60] was conducted in Duiven, the Netherlands. The results of the building renovation are reflected in the building energy use as it supplies more energy than it consumes, and more than 80 per cent of the materials have been recycled. Furthermore, the renovation also achieved a doubling of the office space available. The wood used for the inner wall is integral waste wood. They guarantee the building will deliver the promised energy performance.

CIRCULAR PRODUCTS

Across the EU, there are best practice examples of new products, technologies and companies based on circular principles and practices - and where there are clear documented benefits in regards to carbon and resource reductions.

CHAPLIN – THE NETHERLANDS

CHAPLIN[61] is a program created as a collaboration of partners along the entire construction value chain. It is a systemic approach to creating sustainable road construction. It functions by supporting companies like road builders, asphalt producers and lignin suppliers with research and technology development. Rijkswaterstaat, provinces, and municipalities are heavily involved as road authorities, and they are committed to the development of biobased asphalt into a fully commercially available and specified product.

Lignin plays an important role and is a substance that is a natural binder and gives strength, as it does in plants and trees. When plants and trees are growing, carbon dioxide is absorbed from the atmosphere, and once processed into asphalt, it is fixed in the road for a long period of time. The development is at TRL 6, with 20 test strips on public roads. With 50 per cent replacement, 75 per cent CO_2 reduction can be achieved.

ZIRKULIT – CZECH REPUBLIC

Zirkulit® concrete[62], created in the Czech Republic, is a concrete made from secondary raw materials which was used in buildings made from recycled concrete. It is concrete produced in accordance with SN EN 206 and SIA data sheet 2030 and is characterised by equivalent static properties in all respects compared to primary concrete. Zirkulit® concrete is used in the usual compressive strength classes up to and including C30/37 for all components.

The material is made from secondary raw materials, and buildings made from recycled concrete have been built for 20 years. In an average building, the proportion of concrete makes up more than 50 per cent of the building fabric and is, therefore, an influential factor. Zirkulit® concrete gives the opportunity to make this influential factor more sustainable by reducing the primary resource share and CO_2 emissions. The recipe allows for the reduction of the cement fraction to a minimum, and innovative technology turns the secondary material fraction into a storage of CO_2.

SMARTCRUSHER – THE NETHERLANDS

SmartCrusher[63] has developed a technique for recovering sand, gravel and cement from concrete. The high emissions from concrete are caused mainly by the production of cement from $CaCO_3$. This means that for every kilogram of cement produced, one kilogram of CO_2 is released. The SmartCrusher can decompose concrete rubble into its constituent parts, and the cement fraction can also be removed. The recovered sand and gravel can be reused immediately without loss of quality. The recovered cement can serve as a CO_2-free raw material to make new cement and can also be used as a concrete improver.

REBRICK PROJECT – COPENHAGEN

The Rebrick project[64] has a very simple but very efficient business model of restoring and reselling old bricks from demolition sites. As the production of bricks is an energy and resource-intensive process, the reused bricks save the environment 0.5 kg CO_2 per brick. The Danish SME Gamle Mursten has developed technology for the automated sorting of demolition waste and repurposing of old bricks. The bricks are cleaned using vibration rasping.

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