CIRCULAR BUILDINGS COALITION

TOWARDS A CIRCULAR ECONOMY IN THE BUILT ENVIRONMENT

OVERCOMING MARKET, FINANCE AND OWNERSHIP CHALLENGES

Metabolic · WORLD GREEN BUILDING COUNCIL · CIRCLE ECONOMY · wbcsd · ELLEN MACARTHUR FOUNDATION · ARUP

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Metabolic

“The circular economy is a new economic model for addressing human needs and fairly distributing resources without undermining the functioning of the biosphere or crossing any planetary boundaries.” “We don’t just want [...] materials to be theoretically possible to recover – it has to happen on a time-scale that is relevant to people.”

https://www.metabolic.nl/news/the-seven-pillars-of-the-circular-economy/

Circle Economy

“We believe the built environment should be a ‘living’ system in which building materials and products are optimally used and reused— a system that operates within the boundaries of our planet, preserves the (business) value of its resources, and ensures the wellbeing of its inhabitants.”

https://www.circle-economy.com/programmes/built-environment

Ellen McArthur Foundation

“By applying the principles of the circular economy to the way we design buildings, infrastructure and other elements of the built environment, we can reduce greenhouse gas emissions, while creating urban areas that are more liveable, productive and convenient.”

https://ellenmacarthurfoundation.org/

World Green Building Council

“We believe it is time for a peace treaty with nature. We envision a future where the built environment not only does less harm, but actively regenerates our planet, climate, and human health, and offers the highest wellbeing and quality of life to all.”

https://worldgbc.org/wp-content/uploads/2022/08/Sustainable-Buildings-for-Everyone-Everywhere_FINAL.pdf

World Business Council for Sustainable Development

“There needs to be an acceleration of the transformation towards a net zero carbon, circular, healthy, inclusive and resilient built environment. This transformation to succeed will have to involve the full building value chain, from materials and equipment suppliers, architects, construction companies, utility and service companies to developers, investors, owners and users and urban planners.”

https://www.wbcsd.org/Programs/Cities-and-Mobility/Sustainable-Cities/Transforming-the-Built-Environment/Resources/The-business-case-for-circular-buildings-Exploring-the-economic-environmental-and-social-value

ARUP

“Since 2016 Arup has been the knowledge partner for the built environment with the Ellen MacArthur Foundation, combining our 75 years of deep built environment delivery expertise with over 10 years defining and framing the conversation on the transition to a circular economy. We are thrilled to continue supporting the Foundation in the Circular Buildings Coalition, and looking forward to collaborating with the partners in accelerating the adoption of circular economy principles in the European built environment.”

https://www.arup.com/perspectives/publications/research/section/first-steps-towards-a-circular-built-environment

CIRCULAR BUILDINGS COALITION

The circular buildings coalition is an initiative by Metabolic, Circle Economy, World Business Council for Sustainable Development, World Green Building Council, Ellen McArthur Foundation and Arup to accelerate the transition to a circular economy in the Built Environment.

Learn more here:
www.circularbuildingscoalition.org

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Carbon trust	Ramboll	City government of Heidelberg	BPIE	Healthy Building Network
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GearCraft Real estate	Brightworks Sustainability	Bain & Company	Bankers without Boundaries	ACO Serbia & Montenegro
Dutch Green Building Council	Signify	Deloitte	Foster + Partners	Erion
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Green Building Council Finland	Art-er	Cushman and Wakefield	Prague city hall	Knauf Insulation
Chainable	Edge	Holcim foundation	ECOS	U.S. Green Building Council
Chatham House	SystemIQ	Cembureau	Kingspan	WSP
Stibbe	AlKondor	REDEVCO B.V.	NHS (ELFT)	
Department for Community Planning and Housing, Government of Sweden				

Table 1: Stakeholder interviews

EXECUTIVE SUMMARY

This report examines the obstacles to accelerating the circular transition that are faced by the European construction industry, and what can be done to overcome them. It is a collaborative research effort by the Circular Buildings Coalition (CBC), which has been set up to coordinate built-environment stakeholders working towards this transition. The CBC is an initiative of Metabolic, Circle Economy, World Green Building Council, World Business Council for Sustainable Development and the Ellen MacArthur Foundation in collaboration with Arup, funded by the Laudes Foundation. The report is based on extensive consultations with industry leaders on the circular economy from the construction and finance sectors.

Our pre-study research identified three areas in which systemic challenges impede the scaling of circular-economy methods: markets and supply chains, financing circular buildings, and ownership models. Over the course of six months, CBC researched these three systemic challenges through a literature review, desktop research and interviews with 50 stakeholders in all parts of the construction value chain, including asset owners, real-estate investors, financial institutions, contractors, designers and NGOs. These interviews focused on what the interviewees see as the main pain points of the transition. Conclusions were tested and discussed in four workshops, occurring between August and December 2022. The research was further supported by bottom-up modelling of material flows of the construction sector (see page 26, Rationale and Methods of Research) aimed at understanding the scale of the challenge across Europe.

WHY THE CONSTRUCTION SECTOR NEEDS TO CHANGE

The construction industry is a key engine of economic activity, directly creating 18 million jobs and accounting for roughly 9% of the EU's GDP.[1]

However, the industry is facing pressure to change, as its current way of operating is unsustainable for our climate and the planet.

The EU27+UK's carbon budget for construction is depleting quickly.

The industry contributes approximately 277 Mt (million metric tonnes) CO_2e per year, representing almost 9% of the EU's annual greenhouse gas (GHG) emissions. We estimate that in a 'business-as-usual' scenario, the EU27+UK's construction sector will exceed its allocated carbon budget for limiting global warming to 1.5°C in 2026. Furthermore, the budget for 1.7°C and 2.0°C will run out in 2029 and 2031 respectively, if no action is undertaken.

As the sector is implementing the 'Renovation Wave', it should ensure this is done using materials with low embodied impacts, such as secondary materials.

To achieve climate neutrality in 2050 for use-phase emissions, the EU's Renovation Wave strategy targets a 3% annual renovation rate. The embodied carbon impacts of these renovations will be increasingly important as the Renovation Wave is being implemented. If current renovation practices in the EU27+UK continue as usual, the energy and non-energy-related renovation activities will consume 918 megatonnes of virgin materials between 2022 and 2050, resulting in the emission of 978 Mt of embedded GHG emissions. In a policy-compliant scenario – i.e. if renovation activities increase in line with the 3% rate – this would increase to approximately 1500 Mt.

Globally, the construction sector accounts for approximately one third of total material consumption, contributing to a threefold increase in global material extraction since 1970.[2]

In Europe, the sector consumes about 1094 Mt of materials, with the residential sector consuming almost three times the amount of the utility sector.

In the EU, demolition, including renovation, generates roughly 124 Mt of waste a year, which comes close to the weight of 12,277 Eiffel Towers.

After this demolition, a huge amount of value is being lost by discarding or low-value recycling of construction materials and products. Western

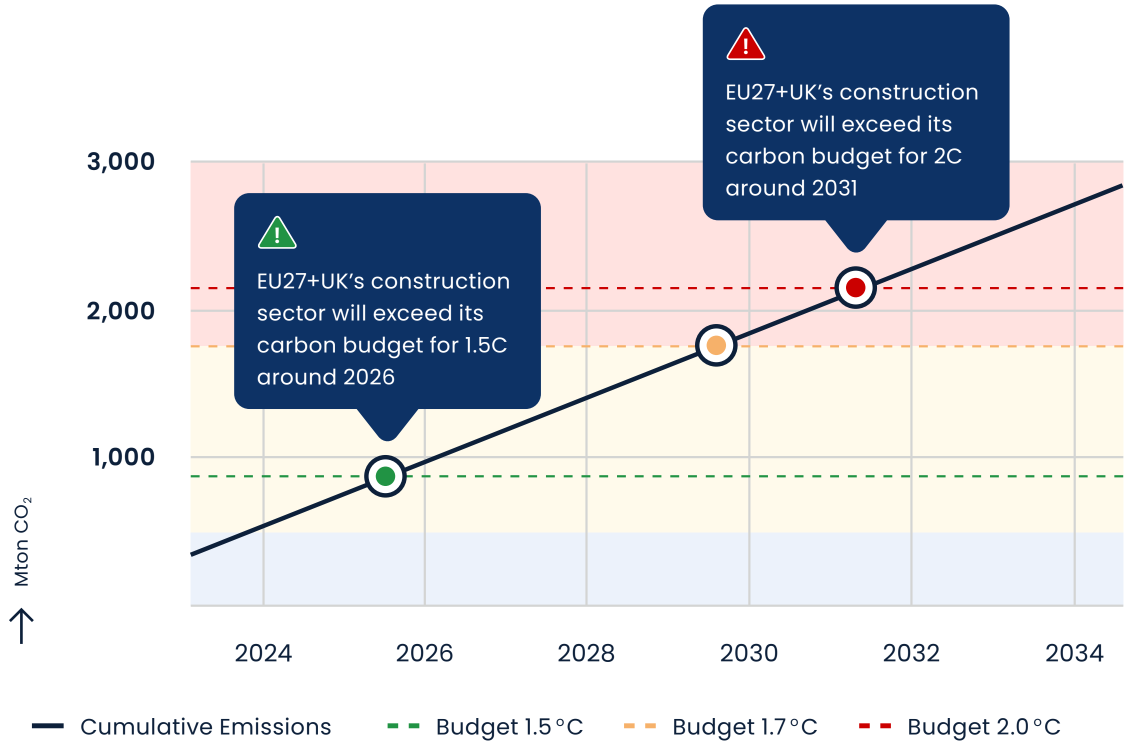

Figure 1: CO_2 budget of the residential and utility construction sector.

European countries furthermore produce almost twice as much demolition waste per inhabitant compared to other EU regions. Much of this could have retained its value when re-used.

A few materials have an outsized impact on this: concrete without steel reinforcement bars accounts for 74% of the total mass of resources consumed and is responsible for 36% of all carbon emissions. Steel, with only 3% of the total mass, accounts for 30% of the total impact. Combined, they make up more than 5% of the EU27+UK's total emissions.

While incremental change is the conventional approach in the construction industry, radical change is necessary to guarantee that humanity can remain within the planetary boundaries. The construction sector will need to face up to this reality, as the European Green Deal and its ambitious decarbonisation targets are pushing the industry to reduce its carbon footprint. Transitioning the industry from a linear model to adopting the principles of a circular economy is increasingly being recognised as the best way forward to face those challenges.

CIRCULAR PRINCIPLES IN CONSTRUCTION: CREATING VALUE, REDUCING IMPACT

Building according to circular principles creates value for businesses while reducing environmental impact.

The traditional model of resource consumption in the built environment is based on extracting raw materials, transforming them into buildings, infrastructure and construction products, and later demolishing them. This linear approach, often referred to as the 'take-make-waste' model, has been the dominant approach since the industrial revolution.

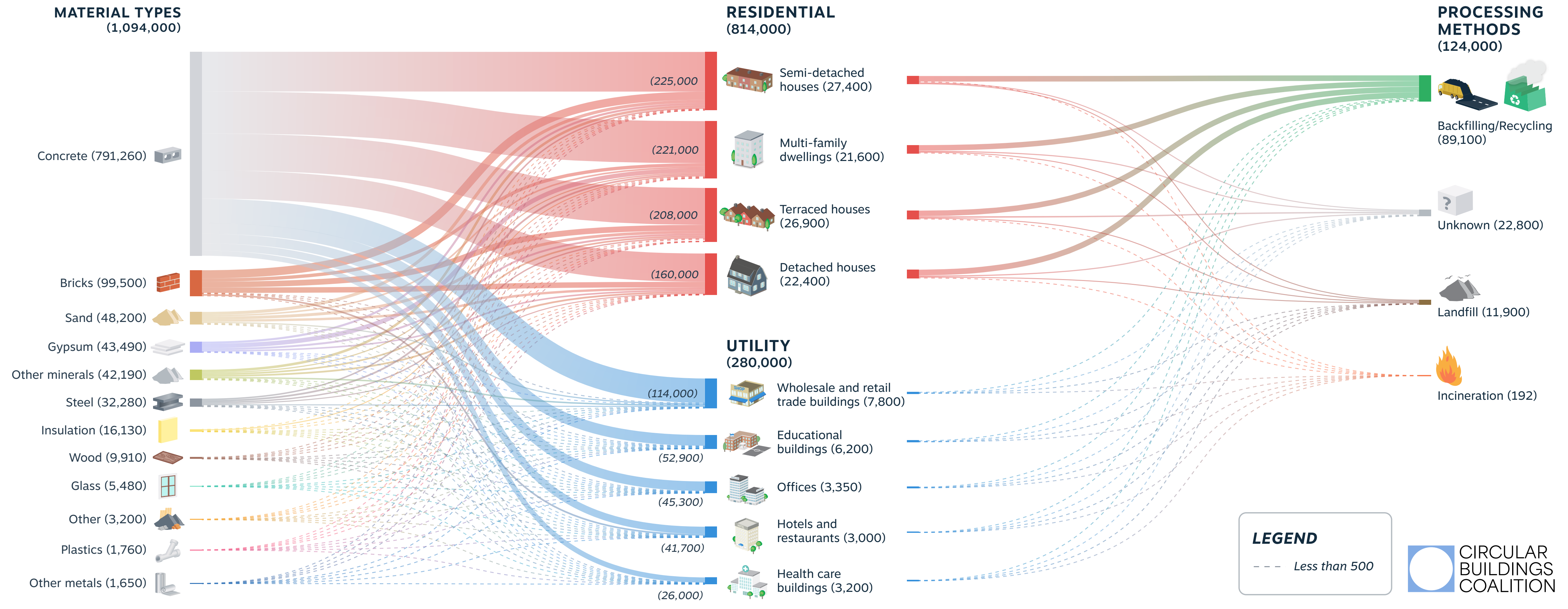

Figure 2: A material flow analysis (MFA) of material consumption and usage in Europe. Figures are in kilotonnes.

Adopting circular economy principles in the built environment represents a transformative approach to resource management that can generate economic, environmental and societal benefits. At its core, a circular economy has two objectives: ensuring that humanity continues to live within planetary boundaries, and creating new forms of value by keeping existing resources at their highest value for as long as possible while minimising virgin resource use and waste. The implementation of circular principles is also an important tool for the decarbonisation of the built environment.

For all actors in the construction industry, implementing circular principles can increase resource productivity, asset utilisation and value.

Environmental benefits: if the EU27+UK's construction industry were to become 'zero-waste' while current demand remained unchanged, secondary materials could replace up to 12% of virgin materials (in an ideal scenario). Circular interventions such as optimising resource use by utilising the existing building stock through maintenance and retrofitting would further reduce virgin material demand.

Economic benefits: In the EU, transitioning to a circular economy could generate a net economic gain of €1.8 trillion per year and an increase of up to 7% in the region's GDP, made possible through the improvement of resource productivity (of about 3%), which would generate cost savings as high as €600 billion a year and an additional €1.2 trillion in other benefits.[3]

Societal benefits: Applying circular principles in the construction sector will demand a new approach to building and deconstruction and could create new job opportunities, strengthening local labour markets.[4]

WHAT DOES BUILDING ACCORDING TO CIRCULAR PRINCIPLES ENTAIL?

There are four top-level strategies for building according to circular principles. The first is to **build nothing**, avoiding the intensive material use associated with constructing a new building. Stakeholders should reimagine and strive to carefully assess buildings that have not yet reached the end of their technical life. At the same time, 'build nothing' is also an injunction for policymakers. One in three people in the EU live in under-occupied dwellings, while 16% live in overcrowded dwellings and are driving demand for new construction.[5] Policy should interrogate such disbalances and ensure that the existing building stock plays a more significant role in addressing existing demand.

The second strategy is to **maintain buildings and build for long-term value**. In order to achieve a circular state, simply redirecting material outflows back into construction is not sufficient. While secondary materials could replace some of the current EU27+UK's demand for virgin materials – up to 12% – the demand needs to be reduced too. Here, the most immediate, high-impact strategies are retrofitting and maintenance programmes that utilise the existing building stock. This strategy will be one of the most high-impact methods to decarbonise the built environment and fulfil the EU targets for reducing CO_2 emissions, as 85-95% of the existing stock will still be in use in 2050.

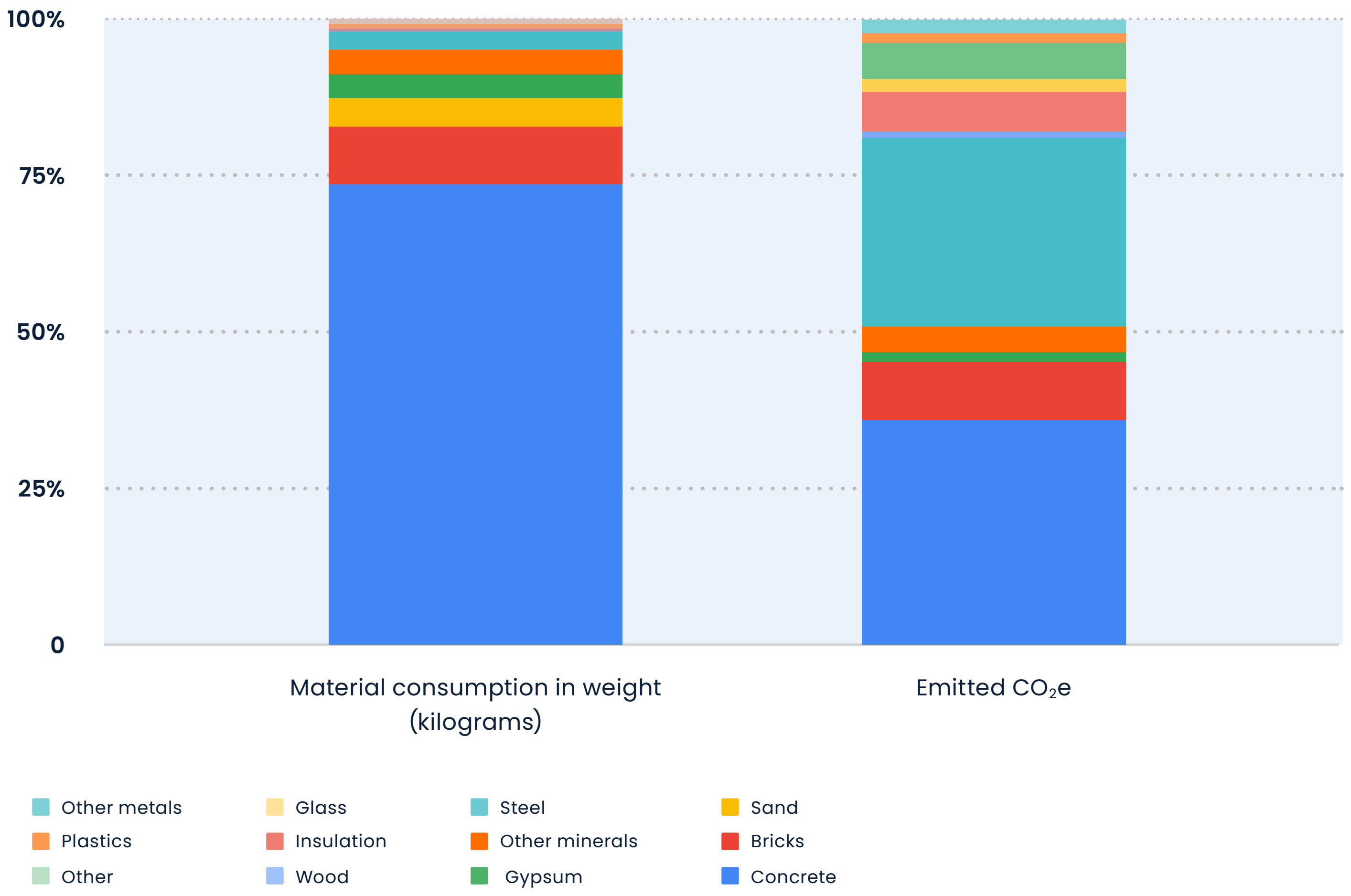

Figure 3: Impact of material consumption in weight and emitted CO_2e

Building for long-term value is essential both for societies and for asset owners who fear the deterioration of their portfolios and stranded assets. Using circular principles as the basis for both the design and business model of buildings creates buildings that are more resilient: it supports constructing buildings in a way that makes them easier to maintain, disassemble and adapt when market or climate conditions change.

The third and fourth strategies entail **building more efficiently and building with the right materials**. On the technical side, this includes creating simple designs that consider the actual need for components and materials. The strategy also calls for reducing the use of virgin materials and high-intensive carbon materials while prioritising the use of re-used, recycled and renewable materials.

Combined, these four strategies allow building according to circular principles; however, to be able to implement these circular principles at scale, a range of systemic obstacles must be overcome. The report's ensuing chapters on markets, finance and ownership examine these challenges and what strategies exist to surmount them.

DRIVERS FOR AND BARRIERS TO A CIRCULAR BUILT ENVIRONMENT

The policy landscape is already moving in favour of building according to circular principles.

This includes setting standards for measuring and reducing virgin material use, reducing embodied carbon impact and reducing waste. Stakeholders in the construction industry who anticipate these changes by adopting circular principles will be well-positioned to lead resilient organisations. They also reduce the risks to their businesses associated with the transition.

Energy prices are volatile and impact the cost of construction products dependent on energy-intensive processes. In 2022, energy prices soared as a result of the war in Ukraine and ensuing trade embargos.[6]

This led to an increase in the once-stable prices of concrete, cement and bricks, because the production processes of these materials are energy intensive. Higher transport costs drove the prices up even further. Even though the direct impact of this war may prove to be transitory, it illustrates the risk of the construction industry's reliance on energy-intensive products. Well-functioning and stable markets for secondary materials could take some of the pressure off these markets by enlarging the pool with materials that are less exposed to such energy price risks.

Despite the good intentions of many construction stakeholders, legal, economic and policy barriers create an uneven playing field that favours virgin materials.

As a result, secondary material markets still occupy a small niche in the overall value chain. As one example of a barrier, many contractors and developers are hesitant to use secondary materials, citing higher risks such as storage costs, difficulty in insuring the materials, and unpredictable supply, which ultimately suppresses demand. On the supply side, the physical and local infrastructure for processing is not yet forthcoming at scale to truly facilitate a secondary market that can compete at cost with virgin materials.

The various practices of calculating the costs of construction entrench linear construction practices.

For example, the cost calculation for the construction of buildings built in the current linear system does not take into account the external costs incurred (externalities), which, if priced in, would increase their relative costs compared to circular buildings. Besides the reduced externality costs, current valuation methods do not fully capture the additional value of circular buildings compared to linear buildings, such as their salvage value, their increased adaptability and potential for disassembly, or the cost savings stemming from their ease of maintenance. Because these concepts are still relatively new and not applied at scale, there is a limited track record for capitalising on circular value. Both financial institutions and developers perceive this as a risk factor and do not yet see sufficient justification to direct significant financial flows towards circular buildings.

ASPECTS OF THE CIRCULAR TRANSITION IN THE BUILT ENVIRONMENT

A digital, physical and legal transformation of our supporting infrastructure.

In a future circular built environment, buildings are not static material deposits, but banks of potential secondary materials that can be reutilised in continuous cycles. A well-functioning market for secondary materials is a critical component of this future. To achieve this, the policy and infrastructure landscape of the construction sector needs to undergo a significant transformation, with important roles to play for both the public and the private sector.

The private sector is instrumental for developing businesses to access these urban material banks through 'urban mining',[7] and it should support setting up platforms to aggregate demand and supply. This is needed to create a safe, reliable and predictable flow of materials for professional and private customers alike. While builders and developers are currently still hesitant to use secondary materials, citing higher risks and difficulties in insuring their projects, the policy landscape is changing rapidly, potentially creating a more profitable secondary material market that rewards businesses that are prepared for the transition.

The public sector must create the supporting infrastructure required on a municipal and regional level, including, for example, waste processing and storage infrastructure available at local and regional scale to limit transport costs. The public sector also has a critical role to play in creating a supportive policy environment that mandates the generation of data through reporting requirements on all phases of the building lifecycle. This includes the creation of policy levers for decarbonisation policies by imposing increasingly stringent obligations on the overall carbon embedded in buildings.

Revisiting business and ownership models

Combined, policy, data and physical infrastructures are critical to laying the ground for the emergence of a new generation of circular business and ownership models. These models will be able to compete with linear business models not only on 'image' but also on value, making it possible for 'regular' construction players to choose to build in line with circular principles without incurring significantly higher costs than when building according to linear tradition.

However, it might also be necessary to revisit existing ownership and business models. The ownership models that are prevalent in our current linear system hamper sustainable construction due to a misalignment between the costs and benefits among stakeholders. This 'split-incentive problem' occurs when two parties have conflicting interests, and one is unable to act in response to its own incentives because it has no control over the actions of the other party.

In addition, decision-making on construction products – a point-of-sale business – is often based on lowest cost, short warranties and discarding after use, reducing the incentive to make long-living, repairable construction products.

Even so, there are many ways to overcome such split-incentive obstacles. For example, early indicators suggest that some ownership models, such as cooperative developments, land trusts or other types of developments that keep a building asset in perpetuity – meaning that the asset is not bought with the intention of selling it at a later stage – could be used to overcome the split-incentive problem by incentivising a whole-life outlook on a building.

These ownership models may pertain to land tenure, to entire buildings and to building components/ construction products. In other cases, implementing circular economy principles with new business models or building design strategies requires a different configuration of ownership structures. For example, open building concepts may contribute to the construction of fundamentally more adaptable and reusable buildings, while in some cases dividing the ownership of a building into owners of different building layers. Alternative business models also offer promising opportunities for overcoming split-incentive problems. For example, Product-as-a-Service (PaaS) models, in which essential building services are provided by specialised providers, can create more collaborative and enduring relationships between product manufacturers and service providers. As the service provider keeps ownership of the product throughout the whole product lifecycle, these models can potentially enhance the product's operational performance, increasing its longevity and boosting the recovery of materials.

Parallel evolution of financing models

All of the above will only be made possible by a simultaneous evolution of the financial system. To increase financial flows towards circular construction, it needs to offer a higher value, lower risks and more transparency. Ways to promote transparency include the widespread adoption of tracking tools and measurement frameworks, complemented by knowledge-sharing platforms that disseminate information on circular building tools and practices.

The industry has ample opportunity to capture circular value and should be challenged by the private and public sector alike to develop novel financial models, incentives and insights that contribute to the creation of successful business cases, allowing the financial sector to become a key player in the transition towards a sustainable built environment. This can be achieved by revisiting existing accounting practices to account for actual depreciation per building layer, for the inclusion of the salvage value of buildings in investment considerations, and for the inclusion of all costs of an asset over its lifetime to provide a complete financial assessment.

Addressing the risk associated with investing in circular buildings requires deliberate but manageable efforts on the side of financial institutions. A diverse group of stakeholders could explore various forms of blended finance, which mitigate risk and leverage financing opportunities within one fund or financial vehicle by combining concessional financing (from investors investing with a philanthropic or development intention under favourable terms) and commercial funding provided by conventional financiers. Guarantees and insurance products can further reduce risk. For example, governments can introduce guarantees for secondary materials, such as Contracts-for-Difference (CfDs). Through these, public funds would cover the cost difference between secondary and virgin materials, making them equally priced.

THE MAINSTREAMING PHASE

The policy landscape is changing rapidly in favour of circular principles. Upcoming changes to EU legislation, such as the Construction Product Regulation (CPR) and the Extended Producer Responsibility (EPR), could address some of the issues regarding transparency, safety and quality.

In addition, the European Green Deal and its ambitious decarbonisation targets are pushing the industry to reduce its carbon footprint. Stakeholders in the construction industry who anticipate these changes by adopting circular principles will be well-positioned to lead resilient organisations.

The landmark EMF report 'Towards a Circular Economy' posited that a five-year pioneering phase would roll over to a mainstreaming phase, so that by 2025 we would be in the position to reach material cost savings of up to one-fifth of the current material use. The large body of existing case studies, pilot projects and technical and policy innovations that have emerged in recent few years indicate that the pioneering phase is well underway – and the industry is ready to look towards mainstreaming the innovative practices.

CALL FOR FUNDED COLLABORATION WITH THE CIRCULAR BUILDINGS COALITION

As we are nearing this mainstreaming phase, we invite industry frontrunners to share their ideas on how to overcome existing barriers to scale or create demand for their solutions that accelerate the transition to a circular built environment. Organisations that submit blueprint projects are keen to contribute to enlarging the market for their solutions or solutions like them to benefit all, while contributing to the public good of accelerating the transition towards a circular built environment. Furthermore, engaging the blueprint project process will help increase recognition for their work and increase visibility.

Express your interest following the link below.

circularbuildingscoalition.org/ open-call

GLOSSARY

Embodied carbon
The carbon emissions associated with the production and transportation of building material.

Operational carbon
The emissions caused by the energy use of a building.

Secondary materials
Material recovered from previous use or from residual flows from another product system which substitutes primary materials or other secondary materials.

Mt CO_2e
Million tonnes of carbon dioxide equivalent.

Backfills and backfilling
A recovery operation whereby suitable waste is used for reclamation purposes in excavated areas or for engineering purposes in landscaping, and whereby the waste is a substitute for non-waste materials. The backfilling of materials is not considered a sustainable or circular practice in this report.

EU27+UK
EU27+UK is the abbreviation for the countries of the European Union (EU) operating as an economic and political block, plus the United Kingdom, which left the union on 1 February 2020. The EU27 consists of Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, Finland, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia and Sweden

Northern Europe (EU)
Sweden, Finland

Southern Europe (EU)
Cyprus, Greece, Italy, Malta, Portugal, Spain

Central and Eastern Europe (EU)
Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia

Western Europe (EU27+UK)
Austria, Belgium, Denmark, France, Germany, Ireland, Luxembourg, Netherlands, United Kingdom

Carbon credit
In greenhouse gas emissions trading, a credit granted to a country that counts towards its emission targets as agreed in the Kyoto Protocol.

Total Cost of Ownership (TCO)
A financial measure that takes into account all of the costs associated with owning and using a product or service over its lifetime. This includes not only the upfront purchase price, but also ongoing costs such as maintenance, repairs, upgrades, and disposal. TCO helps organisations to understand the full economic impact of a product or service and make more informed purchasing decisions.

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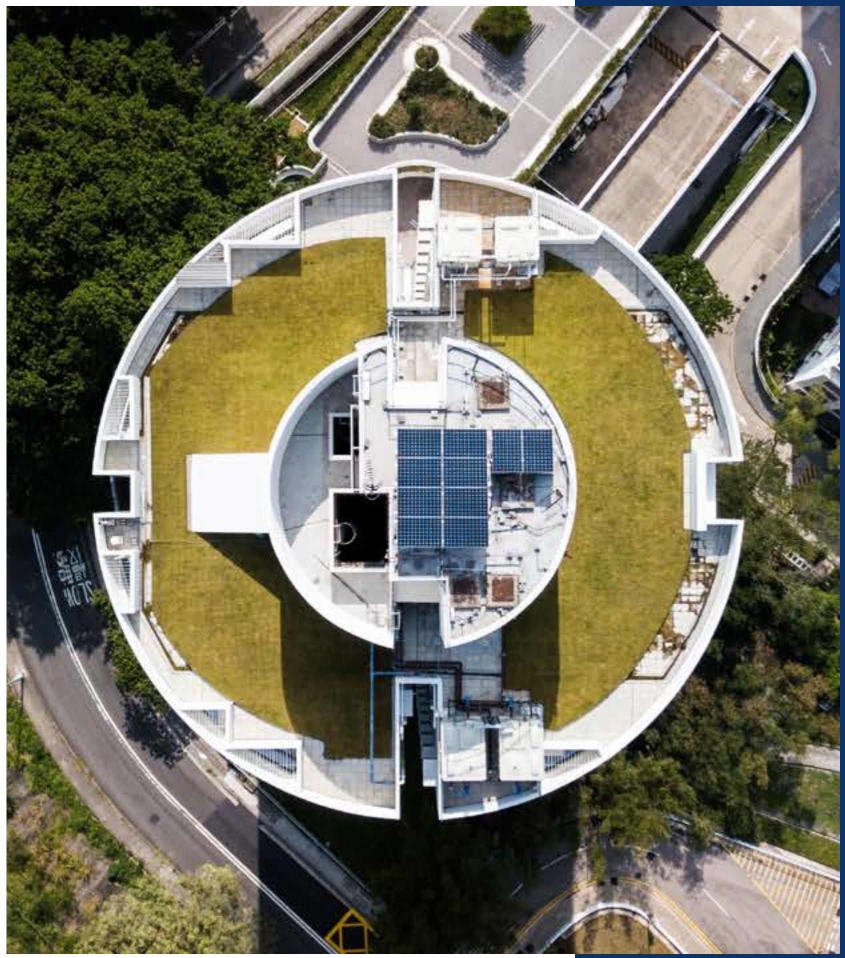
How alternative ownership models aligned with circular economy principles can overcome split incentive problems while maintaining both economic and environmental value, and what barriers hinder their adoption.

Product-as-a-Service p. 94

How Product-as-a-Service, as one of the most mature circular business models, provides value to businesses.

WHAT IS CIRCULARITY IN THE BUILT ENVIRONMENT?



The traditional model of resource consumption in the built environment is based on extracting raw materials, transforming them into buildings, infrastructure, and construction products, and eventually disposing of them.[8] This linear approach, often referred to as the 'take-make-waste' model, has been the dominant approach since the industrial revolution. This linear model can be seen in construction in ways that include:

- The design and execution of constructions such that the full value of their constituent materials and building components cannot be easily recovered, leading to downcycling or discarding;
- The demolition of complete buildings while they still function technically either in part or as a whole;
- The execution of building designs that are inflexible and unable to accommodate economic change;
- The design of buildings that are inefficient in their material use.

Adopting circular economy principles in the built environment disrupts these models and creates economic, societal and environmental value.

At its core, a circular economy has two objectives: ensuring that humanity continues to live within planetary boundaries, and creating new forms of value by keeping existing resources at their highest value for as long as possible while minimising virgin resource use and waste.. A building developed according to circular principles optimises the use of resources while minimising waste throughout its whole life cycle, including construction, renovation and demolition.[9]

Importantly, for all actors in the construction industry, implementing circular principles can increase resource productivity, asset utilisation and value, keeping assets and materials at the highest possible value for as long as possible. This can generate real value for businesses; for example, detailed modelling has shown that applying circular principles can increase internal rates of return for real estate owners.[10]

On a basic level, circularity in the built environment is about designing and managing buildings, infrastructure, and other constructed spaces to imitate the closed-loop systems found in nature.

To help explain this concept, in 2012, the Ellen MacArthur Foundation created the butterfly diagram, which shows the various stages of resource use and waste production in the resource cycle. The model suggests that strategies of sharing, maintaining, reusing, refurbishing, remanufacturing, and recycling should be employed in order to keep the monetary, social, and environmental value within the system. Loops that are smaller (such as sharing) have preference over larger loops (such as recycling) as they maintain value more efficiently. Overall, employing these strategies reduces the input of finite resources and minimises systematic losses, such as the loss of materials or resources that could be reused, recycled, or repurposed.

APPLYING CIRCULAR ECONOMY PRINCIPLES TO BUILDINGS

Every building is different, and the application of the four circular principles is influenced by various factors such as market demands, environmental conditions, available resources, and cultural context.

Furthermore, buildings are a distinctive asset as they can be understood as being composed of building layers. Each layer has characteristics that vary, such as lifespan, technical and economic function, and the expertise required for production and maintenance, as illustrated in Figure 4 on the following page. By viewing buildings as a combination of layers, we can gain a more granular understanding of how circular principles potentially affect them. For example, compared to the cycling of a load bearing construction, the cycling of materials belonging to a facade can follow different speeds, fall under the purview of different owners, and create different business cases.

Front-running organisations have formulated four top-level strategies for building design and development based on these circular principles: build nothing, maintaining buildings, build efficiently, and build with the right materials:[12]

1. Build nothing

Refusing to build can help avoid the intensive material use associated with constructing a new building by first evaluating whether a physical building is necessary to meet the envisioned requirements, and if it is, determining whether an existing building can be used instead. The focus is on using what already exists and optimising the current building stock.

2. Build for long term value, and maintain buildings

- ***Increase building utilisation*** to reduce the amount of resources used at the start of a project by making the most of available spaces and avoiding periods of inactivity in the building's life.
- ***Design for longevity*** to maximise the value of the building and its parts for the long term, helping to ensure that the value of the building is retained and can be recovered if needed. This also allows for reduced embodied carbon emissions, material extraction and costs in the long run.

- ***Design for adaptability*** to ensure that buildings can be adapted to new functions over time, so that they retain their value. This focuses on two design principles for adaptability: versatility and convertibility. These principles are best suited for sites and building types for which changes of use are likely. By enabling adaptability, this strategy helps to ensure that buildings can remain valuable and useful for longer.
- ***Design for disassembly*** to enable the disassembly of components at the end of their service life. Some components in buildings can have a longer useful life than their service life as part of a system. To maximise the residual value of these components at the end of their service life, it is essential to design them for practical disassembly

3. Build efficiently

- ***Refuse unnecessary components*** by using the least amount of materials possible while meeting project requirements. This encourages simple designs that carefully consider the actual need for components and materials. It also encourages architects and designers to consider whether certain components can be eliminated without compromising the project's ability to perform at the desired level.
- ***Increase material efficiency*** by striving to maximise performance while minimising material usage at every level. This encourages the avoidance of inefficient types of structures, such as high-rise, transfer, long-span, cantilever, and deep underground structures, and instead selects efficient systems and forms.

4. Build with the right materials

- ***Reduce the use of virgin materials*** by reducing the use of non-renewable resources, such as critical raw materials, by promoting the use of reused products, recycled materials, renewable resources, and biobased materials.
- ***Reduce the use of carbon-intensive materials,*** for example by prioritising suppliers that use reused products, recycled materials, renewable and biobased materials or products, and that use energy from clean sources in their manufacturing processes.
- ***Design out hazardous/polluting materials by preventing the use of materials*** that could have a detrimental effect on the environment beyond contributing to global warming. This supports the reduction of environmental impacts that are addressed in international life cycle assessment guidelines.

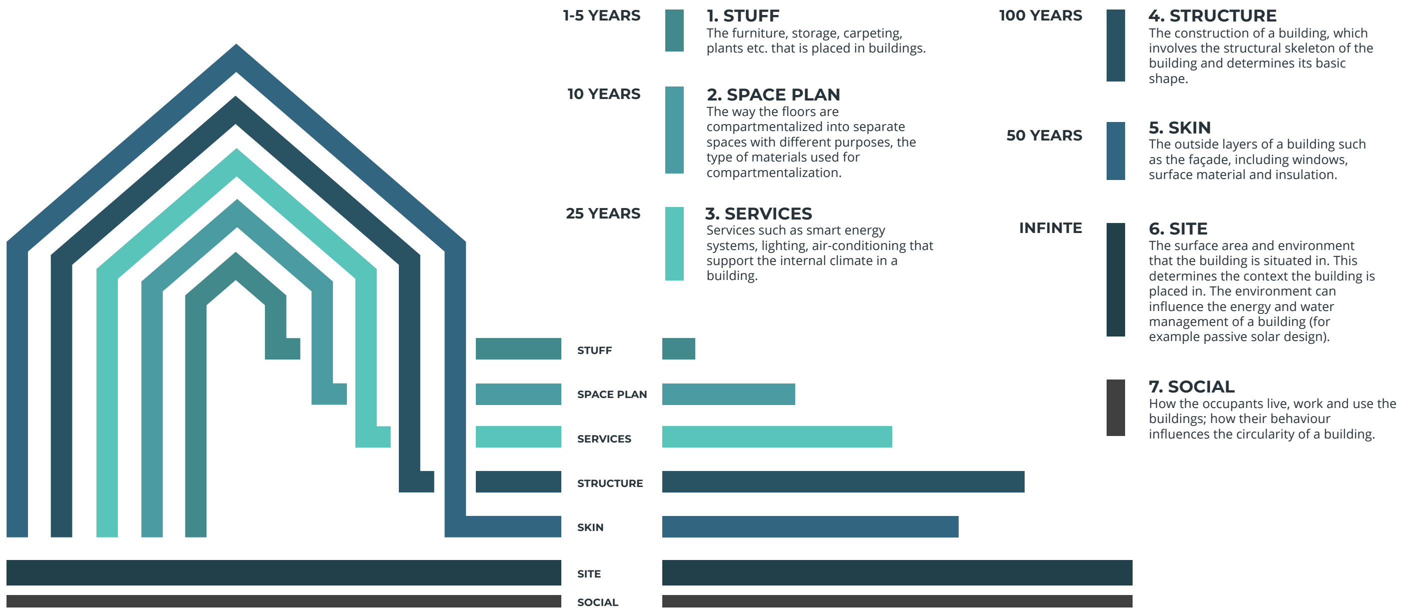


Figure 4: Building model consisting of six material layers (after Steward Brand [1994] and David Bergman [2011]) and a seventh social layer.[11]

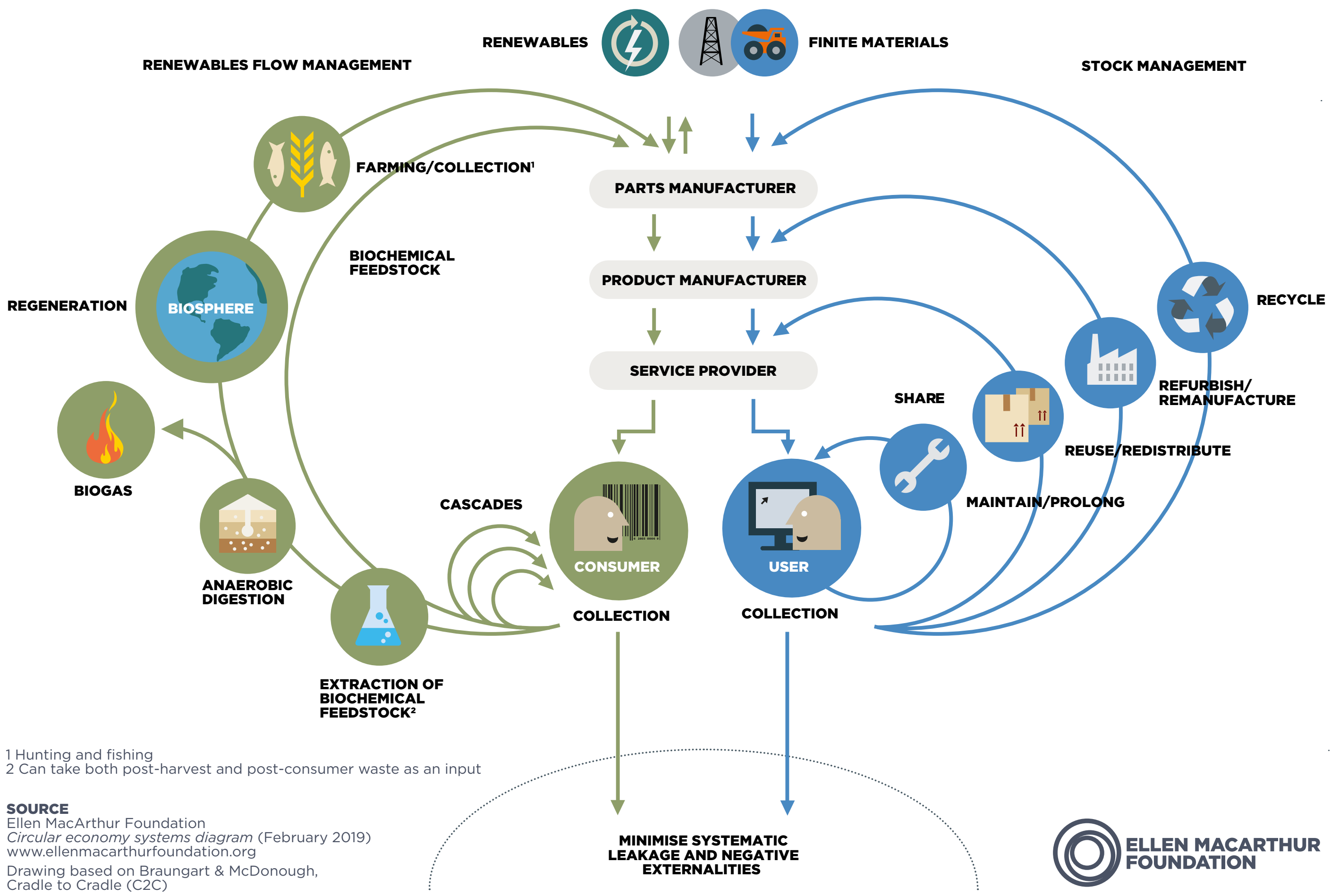


Figure 5: Butterfly Diagram

DRIVERS FOR THE TRANSITION

Adopting circular principles is essential to achieving our climate goals and staying within planetary boundaries. But at least as important, for organisations in the construction industry, these principles are increasingly no longer just desirable, but need to be considered seriously to ensure the continued viability of their businesses due to a number of emerging trends:

The circular economy has the potential to provide significant economic benefits, while also addressing climate change.

In the EU, transitioning to a circular economy could generate a net economic gain of €1.8 trillion per year and an increase of up to 7% in the region's GDP. This would be possible through the improvement of resource productivity (of about 3%), which would generate cost savings as high as €600 billion a year and an additional €1.2 trillion in other benefits. In the building sector, the adoption of circular economy principles could halve construction costs, and contribute to reducing the sector's embodied CO_2 emissions by a third.[13]

The construction industry plays a critical role in achieving our climate ambitions.

Greenhouse gas emissions from energy use in buildings in the EU in 2019 stood at 979 Mt CO_2e, declining by about 17% compared to 2009.[14] CO_2 emissions from material extraction and manufacturing, as well as the construction and renovation of buildings, also sometimes referred to as 'embodied carbon',[15] can be estimated at 277 Mt CO_2 in 2020, or around 8% of total emissions in the EU.[16]

The total emissions in the EU are still more than 70% above the target set in the EU's 'Fit for 55' plan, announced in 2020, which aimed for a reduction of EU emissions to about 2000 Mt CO_2e

by 2030, representing a reduction of 55% compared to 1990. As an industry that is responsible for almost 40% of these emissions, the construction sector urgently needs to implement reforms to achieve these goals.

The construction industry is exposed to high prices, extended linear supply chain disruptions and global volatility.

Even though materials only constitute one of the inputs in the construction process, in recent years, their prices have very closely correlated with construction output prices in the EU. After a relatively stable period between 2011 and 2016, the costs for input materials escalated in 2020 (see Figure 6; between the first quarter of 2021 and the second quarter of 2022, construction costs increased by more than 16%, affecting the profitability of the projects[18]). Furthermore, in Germany and France, the price of steel increased by more than 70% between November 2020 and March 2021 due to disrupted supply chains, market misuse and the war in Ukraine.[19] Starting with price hikes caused by the Covid-19 crisis, 23% of EU construction companies reported production issues in August 2022, due to a shortage of building materials stemming from pandemic-induced supply-chain disruptions.

Carbon price – A carbon price is a cost applied to carbon pollution to encourage polluters to reduce their emissions.[20] Not only are the prices of virgin materials volatile and rising, the price for EU carbon also reached a historic high of €100 per tonne in February 2022 (up 150% from a year before), and is expected to rise further, as the EU will continue to reduce the yearly supply of emission allowances. This is relevant because the EU Emissions Trading System (EU ETS) covers the main industrial sectors producing construction materials, and the European Commission (EC) will establish a new EU ETS for buildings and road transport fuels. In this new EU ETS system, the regulated entities (fuel distributors) will need to report the amount of fuels, starting in 2024 for commercial buildings and in 2029 for private buildings. [21,22] The cap on emissions would be established in 2026 and would gradually decrease, resulting in a 43% reduction of emissions by 2030.

Energy prices – In 2022, energy prices soared as a result of the war in Ukraine and ensuing trade embargos. This led to an increase of the once stable prices of concrete, cement and bricks, because their production processes are energy intensive.[23] Higher transport costs, partly the result of the increase in energy prices, and the disruption of usual transport routes drove up these costs even further. Even though the direct impact of this war may prove to be transitory, it illustrates the risks of the construction industry's reliance on energy imports.

Category	% of total emissions in the EU	CO_2 emissions	Year	Source
Energy use + construction and extraction	36%	1256 Mt CO_2e	2019/2020	Combined
...of which construction and extraction	8%	277 Mt CO_2e	2020	Metabolic modelling
...of which operational energy	28%	979 Mt CO_2e	2019	European Union
Total emissions EU all sectors	100%	3456 Mt CO_2e	2020	UNFCCC17

Table 2: CO_2 emissions in Europe

EU construction prices and costs 2005-2022, unadjusted data (2015=100)

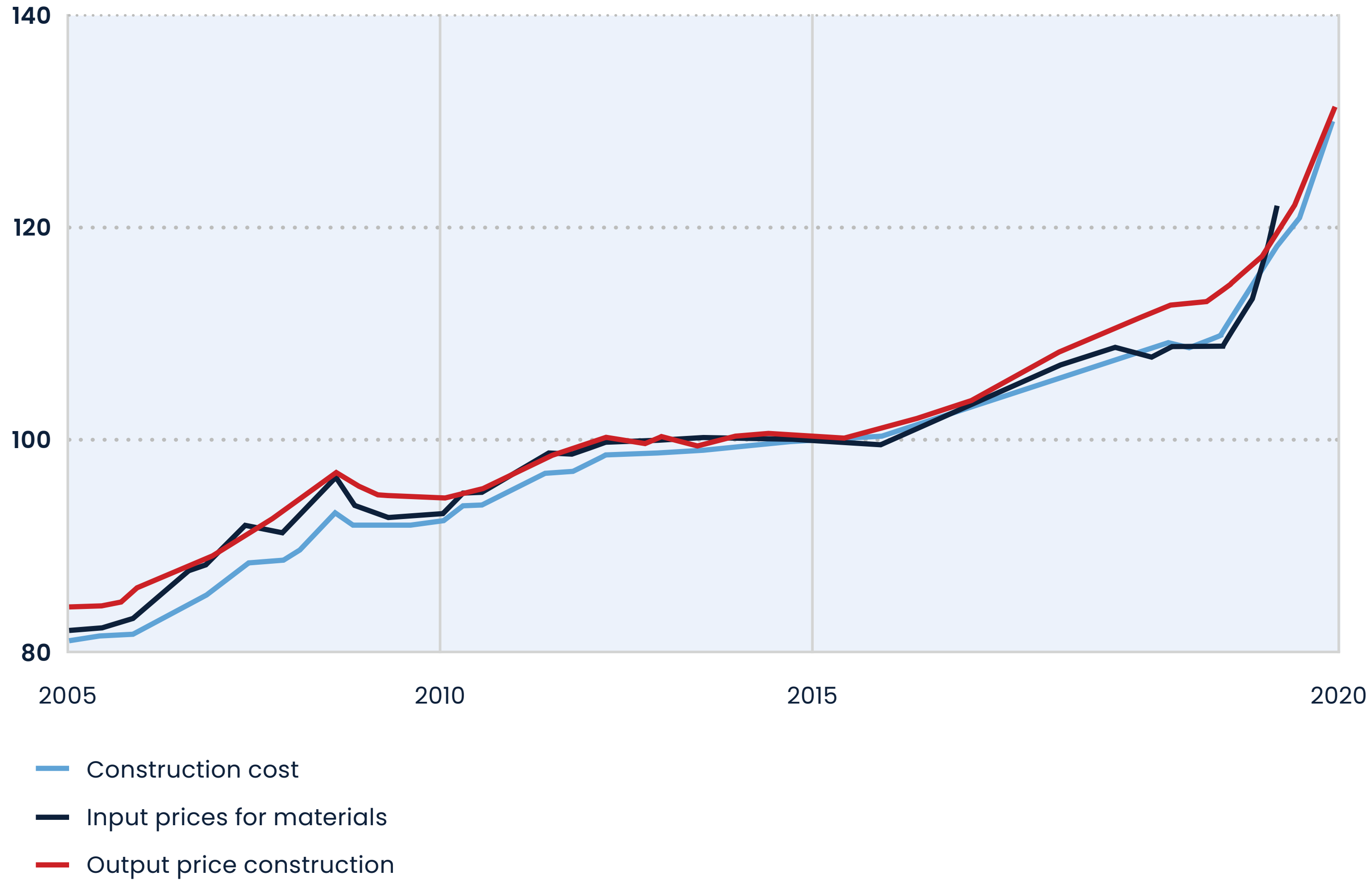


Figure 6: EU construction data prices and costs 2005 - 2022
Official source: Eurostat. (2022). Construction producers cost indices.

Climate ambitions and impacts – In some cases, the EU climate ambitions indirectly affect construction commodities markets. For example, the production of synthetic gypsum (FGD gypsum), now being used in 30% of plasterboard,[24] is expected to drop from 15 million tonnes per year in 2010 to 5 million tonnes per year in 2050, as it is produced as a by-product of the operation of coal-fired power plants, which are set to close. This seven-billion-euro industry is already looking ahead and investigating how it can transition some of its business models to circular ones.[25]

With the growth of populations and urbanisation, coupled with resource extraction shifting towards more difficult-to-reach locations, it is probable that prices and volatility will persist at high levels.[26] Additionally, as the depletion of natural capital increases, the associated environmental costs are likely to escalate as well. By design, the aim of adopting circular principles is to decouple revenues from material inputs by designing buildings for long-term value, and using vast amounts of material reclaimed from end-of-life products as the foundation for economic growth.

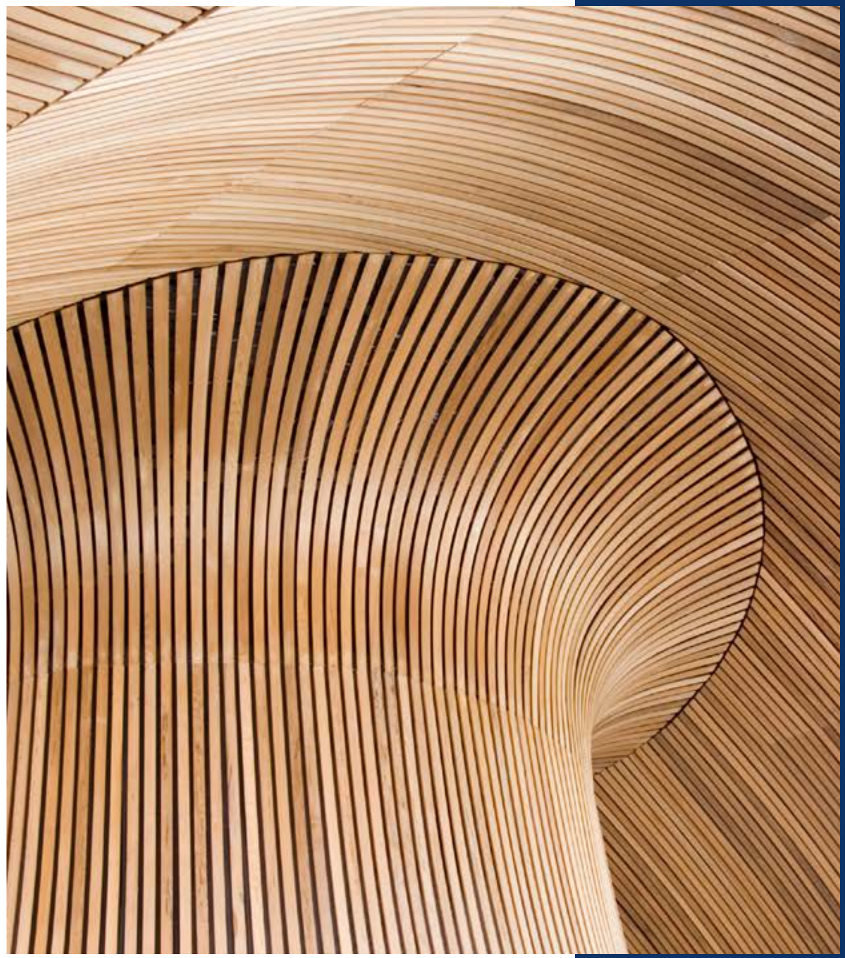
The process of developing legislative instruments in the EU and implementing them in national legislation moves at a slow pace, but once completed, it changes the competitive landscape.

As the world's third-largest emitter of CO_2, the EU and its member states have in many ways taken a leadership role in policies aimed at cutting CO_2 emissions.

The Energy Performance for Buildings Directive of 2002, for example – a key instrument to promote the improvement of the energy performance of buildings – follows an eight-to-ten-year update cycle. The recast directive was voted on in March this year, and calls for an EU-wide framework for calculating life-cycle Global Warming Potential (GWP) and for Member States to publish roadmaps that include limit values and targets on life-cycle GWP. This will ensure that high-quality data on embodied carbon will be accessible to the many actors in the buildings sector. Aided by the establishment of the setting of mandatory targets, this information could potentially lead to an increase in the production and use of low-carbon construction materials[27] and make secondary materials more attractive.

The Construction Products Regulation was introduced in 2011 and is under review for 2023 (see page 61, Policy for better markets). The next revision round will be the last opportunity to introduce effective EU-level tools to push the building sector towards the 2030 climate goals. Considering the potential impact this will have on wasteful linear construction models, and the incentives it may contain to move towards circular models, businesses should look ahead and anticipate EU legislation.

RATIONALE AND METHODOLOGY OF THE REPORT



WHY WE FOCUS ON THREE SYSTEMIC CHALLENGES

A pre-study mapping and outreach revealed numerous examples of circular economy principles, such as buildings that adhere to circular principles, policy initiatives to promote circular construction, city-wide circularity action plans, and circular material markets. Despite these initiatives achieving some success on a local level, we have yet to observe a widespread transition to building practices aligned with circular principles. Our pre-study research identified three areas in which systemic challenges impede scaling:

Markets and supply chains–Stagnant market dynamics make the emergence of secondary and renewable materials very complex. In a future circular built environment, the sources of inflow of secondary materials is distributed throughout the built environment in buildings acting as material banks, and construction products and materials are drawn from and re-embedded in continuous cycles. A well-functioning market for secondary materials is therefore an essential component of this future.

Financing circular buildings–The finance sector plays a significant role in all aspects of the property value chain. However, currently it does not prioritise investments in the development of the circular building industry. Increasing the funding for circular construction projects is critical if they are to compete with traditional, linear construction practices. This applies to investment funds looking at residual value, risk management, and value retention in the long term, as well as commercial developers, land owners, and public actors looking to minimise cost in the short and medium term.

Ownership models–There is a lack of a track record of financially sustainable ownership models that align the interests of building investors, users and developers with long-term climate and circularity goals. In the construction industry, the ownership of buildings and infrastructure (and the products and materials they are made of), does not generally lie with the organisation that designed and developed them in the first place. This leads to a split incentive, making sustainable and circular design difficult and financially less attractive.

The construction sector continues to be hindered by outdated rules and regulations that fail to address circularity in the built environment, perpetuating traditional construction models with little consideration for their environmental impacts. Policy and regulation intersect all three systemic challenges, and, as part of the systemic analysis, the coalition has reviewed European policy areas relevant to these challenges to identify leverage points that could accelerate circularity in the built environment in Europe.

METHODOLOGY FOR DEVELOPING INSIGHTS IN THE REPORT

The coalition conducted an extensive literature review and interviewed 50 stakeholders across the construction value chain over six months to gain insight into the systemic challenges. Stakeholders included asset owners, real estate investors, financial institutions, contractors, designers and NGOs. Their perceptions of the primary pain points in the built environment were established through interviews (see Table 1). The insights gathered from the interviews, literature review, and desk research were analysed to identify patterns and draw conclusions.

To validate and refine the conclusions, the coalition conducted four workshops between August and December 2022. They were attended by representatives from relevant industries and experts who provided feedback on the conclusions derived from the interviews. The workshops enabled the coalition to test the conclusions reached from the stakeholder interviews and identify any gaps or inaccuracies.

BOTTOM-UP MODELLING TO DEVELOP THE BUSINESS-AS-USUAL SCENARIO

The report was further grounded by bottom-up modelling of material flows in the construction sector, with the aim of gaining an understanding of the scale of the challenge across Europe. The benefits of the circular economy in terms of the use or reduction of material used can best be appreciated when compared with a baseline scenario of material use in the scale of the EU27+UK's. Bottom-up modelling is based on inventories of individual items and their material intensities. This approach typically involves dividing the stock into categories (such as housing and business premises) and then applying material ratios or intensities, such as kilograms per metre.[28,29]

A model was developed to evaluate the material flows and their impacts in the EU27+UK's construction and demolition sector. The model consists of 144 reference buildings: for four different regions in Europe, four different age cohorts and nine different building types. The model takes into account the geographic and historical differences in building methods within the different regions in the EU27+UK's. The reference buildings were created using multiple data sources, including online drawings of buildings and interviews with experts.

EASTERN, WESTERN, NORTHERN AND SOUTHERN EUROPE

Much of the data that is used for this report includes pre-Brexit data. Consequently, where there are references to the EU in this report, data analysed relates to the current 27 EU member states plus the United Kingdom (EU27+UK), unless indicated otherwise. The European countries studied were divided into four regions (Northern, Southern, Central-Eastern, and Western Europe) to create homogeneous areas with similar climatic conditions. The reference country or countries for each region is indicated by white diagonal lines. These hatched countries are used as representatives for their region in regard to construction materials and methodologies used. The bottom-up modelling of material consumption for the EU27+UK's is based on representative housing typologies from these countries.

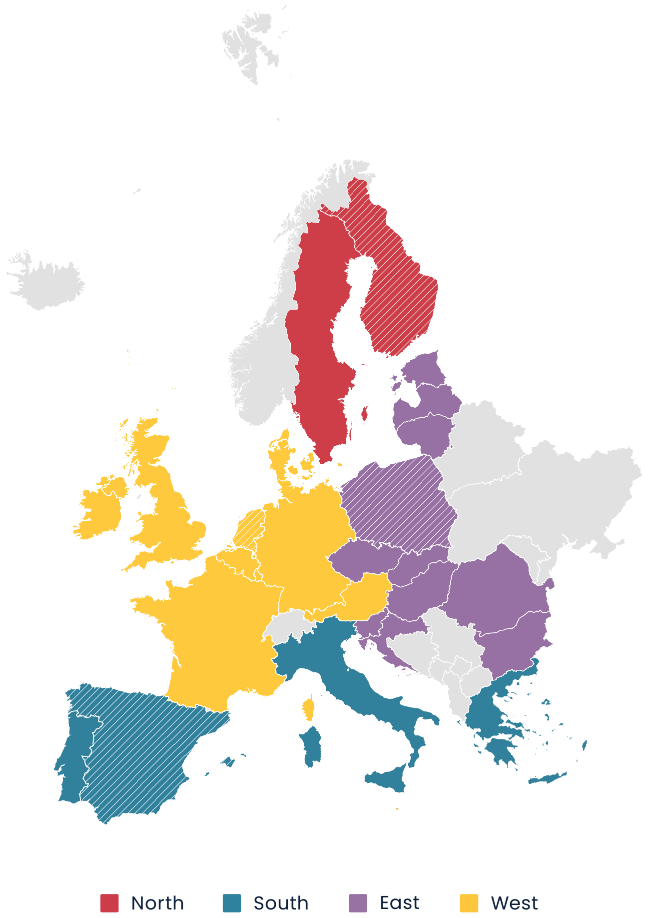


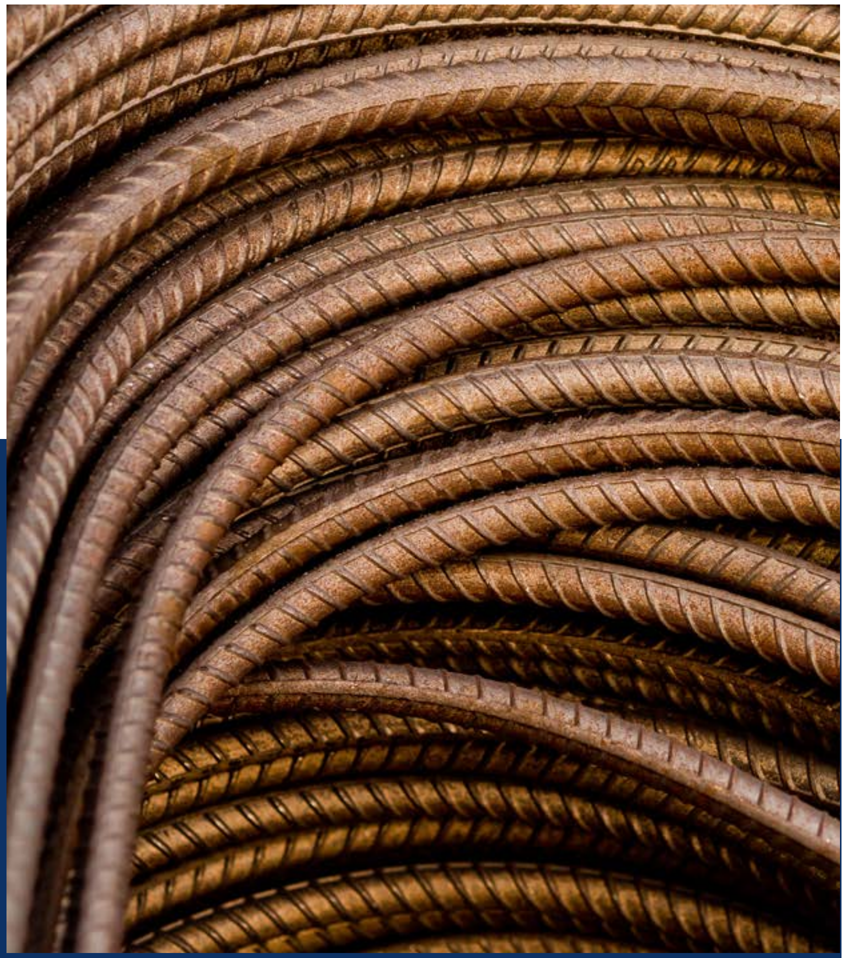
Figure 7: The division of EU Countries into four regions for the purpose of modelling material consumption, demolition waste and environmental impact. Countries used as reference are hatched.

RENOVATION MATERIAL FLOWS, AND IMPACTS

Based on the reference building model described in the previous section, a selection of building products is used to create material intensities sets for different renovation types. For example, for the renovation type 'Renovation/installation of the bathroom or toilet' the building products applied in a bathroom or toilet for a specific building typology are selected and assumed to be replaced. This means that the materials related to the products replaced are modified, and therefore the mass, lifespan, or environmental impact of that building product – and therefore, the renovation type – are different. The quantity of renovations of each type that are modelled is based on a variety of factors, such as the age of the building stock in a certain country or the percentage of the building stock in a country that is renovated yearly.

The full methodology behind the modelling used for the current research is further described in the report 'Modelling the Renovation of Buildings in Europe from a Circular Economy and Climate Perspective'.[30]

SYSTEMIC CHALLENGE: MATERIALS AND SUPPLY CHAIN



At 277 Mt CO_2e emissions annually, the construction sector in the EU is a major carbon emitter. Concrete and construction steel in themselves account for more than 5% of the EU's annual emissions. Western Europe, which contains the largest share of the European building stock, is responsible for 66% of the total material consumption, and has almost 1.5 to 3 times as much demolition waste per inhabitant compared to other regions of the EU.

Demolition activities (including renovation) in the EU generate roughly 124 Mt of waste, a large part of which ends up in backfills (e.g. used as road foundations) or landfills. Increasing the uptake of secondary materials requires more storage space, logistical infrastructure and information on the availability, quality and quantity of secondary materials. It also requires better certifications and warranties for the safety and quality of secondary materials to reduce the perceived risks associated with their use. However, even in a theoretically ideal scenario, secondary materials could only replace approximately 11% of virgin material demand. For the construction industry to reach a sustainable state, biobased materials, such as timber and natural insulation products, need to be considered.

The environmental impact of the construction industry in the construction phase amounts to approximately 277 $MtCO_2e$. We estimate the remaining CO_2 budget for new construction of utility and residential buildings in the EU27+UK's from 2023 onward will be 783 $MtCO_2e$. Reviewing this in comparison to the current emission of carbon because of construction, we can estimate that in a business-as-usual scenario, in 2026 the EU27+UK's construction sector will exceed its allocated carbon budget consistent with limiting global warming to 1.5°C. Furthermore, we estimate that the budget for 1.7°C and 2.0°C will run out in 2029 and 2031.

This also makes it abundantly clear that for the construction industry, a sustainable state cannot be achieved without a reduction in the demand for new construction. As one in three persons in the EU live in under-occupied dwellings,[31] a system combining mandatory and voluntary instruments is an important lever to improve efficiency. Extending the lifetime of buildings through renovation is another. The EU Renovation Wave targeted a 3% annual renovation rate. As we are accelerating this renovation wave, the embodied carbon impacts of these renovations will be increasingly important. If current renovation practices in the EU27+UK continue as usual, the energy and non-energy-related renovation activities will consume 918 Mt of virgin materials from 2022-2050, resulting in the emission of 978 Mt of embedded GHG emissions. An additional demand driver has proven to be an increase in the average number of square metres of living space per person. It is therefore essential to promote urban planning that creates denser housing typologies and thus reduces the net material consumption of buildings without compromising the quality of life of their inhabitants.

To achieve a circular construction sector, a mindset shift is needed. At the same time, new business models will have to be developed throughout the sector to make this new economy financially feasible. Currently, the construction industry mainly focuses on constructing new assets. This has been socially justified by the fact that new construction makes up the majority of the sector's employment and financial contributions to GDP in the EU, while less than 2% is generated by deconstruction, material reprocessing and careful dismantling of buildings with the reuse of materials in mind (urban mining). To accelerate the adoption of circular economy principles in the built environment in the EU at scale, we need to adopt policy levers (fiscal policy, incentives, planning guidance, rules and regulations) that change the economics of material use in favour of retaining or cascading them at high values. These levers will allow us to create jobs and at the same time to value existing materials not only financially, but also socially and environmentally.

To offer a better understanding of the construction market and the market for secondary materials, our market and supply chains analysis examines both the quantity of construction materials annually needed in the current linear construction market, the amount of construction material becoming available through demolition, the systemic drivers that have an influence on the construction and demolition process, and the influence of specific policy frameworks.

As the circular economy strongly depends on when and where materials become available, this analysis divides the EU into four regions, thus highlighting the differences between inflows and outflows of materials and the potential of a regional approach in tackling the transition toward a circular construction sector.

As material consumption in the construction industry contributes to approximately 8% of total greenhouse gas emissions and also has a significant impact on other planetary boundaries, such as land-use change, water consumption and ecotoxicity, tackling the demand for raw resources is of paramount importance. Applying the principles of a circular economy is one way to tackle this impact. In this chapter, we examine the consumption patterns of different geographical regions and the import and export dependences of materials.

THE FLOW OF MATERIALS FROM BUILDINGS TO WASTE

The following is an overview of the quantities and environmental impact of the residential and utility construction sector in the EU based on a bottom-up data analysis of construction activities in different EU member states. This analysis provides the following insights:

Box 1

What is a material flow analysis?

A material flow analysis (MFA) quantifies the materials that 'flow' through a demarcated system for a set period of time. Usually, the analysis is presented in the form of a Sankey diagram, in which the width of each stream shown is proportional to its mass. The diagram is read from left to right, and shows incoming flows on the left, the various processing or process steps in the middle and outgoing flows on the right. For the Sankey diagrams in this report, we employ a timeframe of one year. Sankey diagrams can be used to assess the material consumption and circularity of a process, sector or a system. It shows the type and quantity of materials that are being consumed by what typology and/or process and what happens to materials at the end of their life.

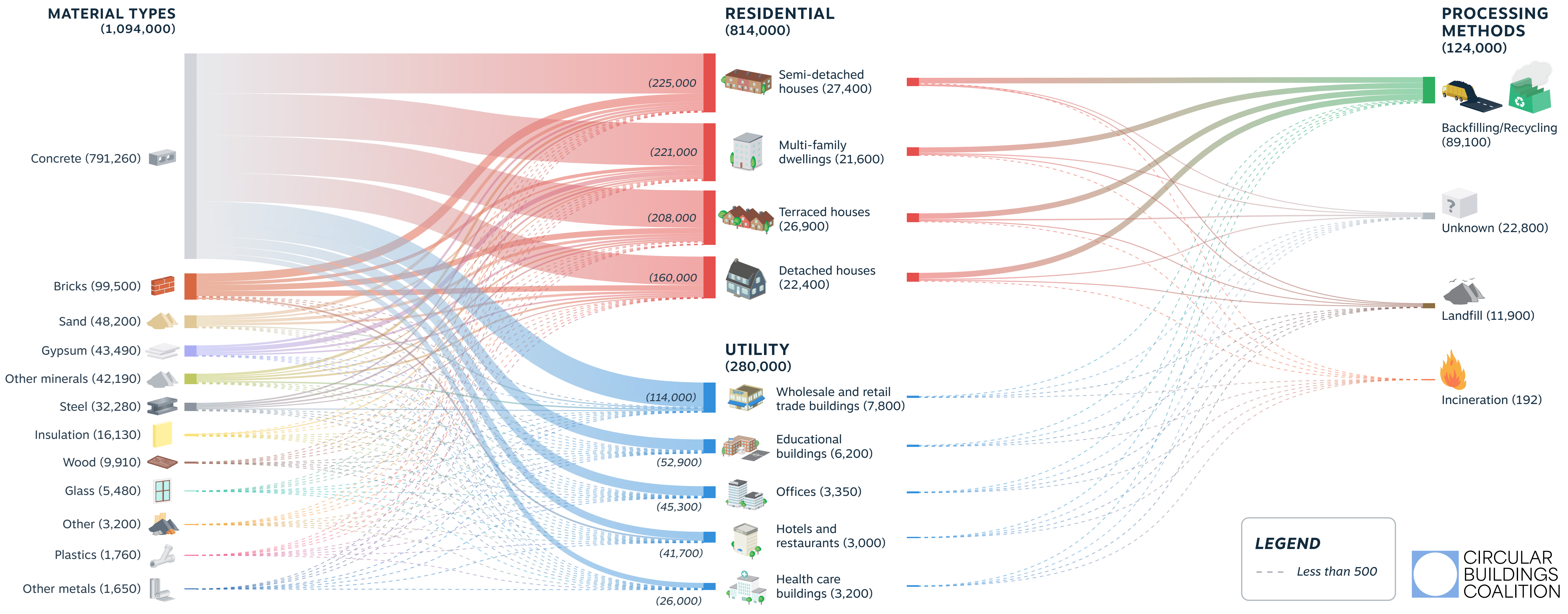


Figure 8: A material flow analysis (MFA) of material consumption and usage in Europe. Figures are in kilotonnes.

On an annual basis, the EU construction sector consumes approximately 1,090,000 kilotonnes of material.

Concrete is the most widely used material, comprising roughly 72% of all materials used in the EU (see Figure 8).

Through renovation and demolition activities, the EU generates 124,000 kilotonnes of demolition waste. Of all the materials that are processed as waste, roughly 71% are recycled or backfilled. Backfilling involves crushing construction waste and using it as a base layer for roads. From a circular perspective, this is a low application of material, as it is not used to its full potential. For example, a beam of concrete could be used to span 20 meters or to form the foundation of a skyscraper, but by crushing it and putting it under a road, it is used in the same way as sand. This also prevents it from being reused as concrete in the future, 'locking' it in place. This is known as downcycling. As there is no uniform classification system for the end-of-life phase of materials in the EU, it is impossible to determine which member states recycle the materials and which ones downcycle them to be backfilled. Approximately 10% of construction waste is landfilled, and 0.2% is incinerated.

WHERE MATERIALS ARE SOURCED FROM

The EU construction sector is part of an intercontinental supply chain. From the analysis of both import and export movements related to the construction sector (see Figure 9), the following points can be derived.

1. **Between 1 and 10% of all material used in the EU construction sector is imported from outside the EU.** As import and export data do not take internal trading into consideration, and the EU is also a trading point in global resource flows, an exact percentage of dependence on external resources is hard to determine.
2. **Of all material imported to the EU, about 54% comes from non-EU countries in Europe.**[32] As these countries are not EU members, they are not necessarily bound by the same policy targets. Therefore, EU policy tools should take this into account and potentially impose import

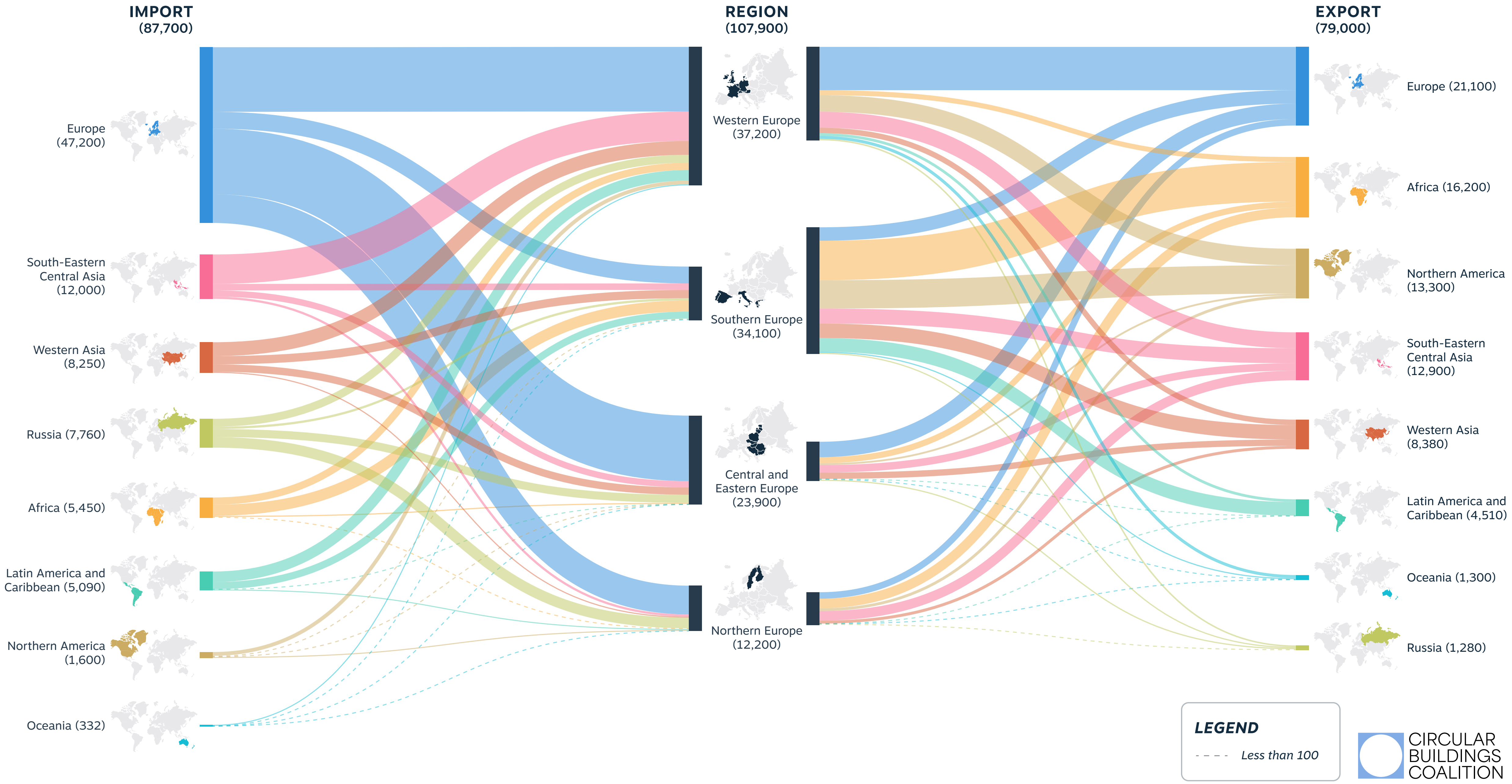


Figure 9: Import and export of construction materials to and from the EU.
Figures are in kilotonnes. Source: Metabolic Data Cluster

requirements and enforce environmental standards to ensure that the external impact is included in the EU's decarbonisation strategies.

3. **The EU's construction sector is a net importer of materials.** On an annual basis, 8.6 Mt more material is imported than is exported. This makes the European Union a material sink that is dependent on the natural resources of other territories.

4. **Southern Europe is a net resource exporter of materials,** as it appears to export 2.4 times more materials than it imports. This indicates that many natural resources are extracted for export outside the EU.

5. **The majority of exported construction materials go to Africa, North America and South-eastern and central Asia.** These three export regions represent roughly 53% of the offset market of EU construction market products. Export to these regions is dependent on highly impactful means of transport and as such complicates the achievement of the EU's carbon neutrality targets. Understanding this impact and the implications that further decarbonisation efforts might have on trade are key to a healthy and resilient market.

JOBS AND VALUE-ADDED IN CONSTRUCTION SECTORS

The EU construction industry is responsible for 18 million direct jobs,[33] and adds roughly 9% to the EU's GDP. Applying circular principles in the construction sector will demand a new approach to working. For example, the disassembly of existing buildings and the reuse, repair and recycling of non-virgin materials will lead to a sharp increase in demand for skilled (manual) labour. Planning, commissioning, designing, and delivering buildings for a circular built environment requires changes in how we work. The ILO predicts that a circular economy will change global employment in four ways: [34]

1. Emerging fields such as urban mining and green roof installation will generate new job opportunities;
2. Jobs that replace existing roles such as reprocessing secondary steel and wood into new materials will emerge;
3. Industries such as mining and extraction will experience a decline in jobs without vacancies opening up in other sectors;
4. Many existing jobs will undergo redefinition as they adapt to new business models, regulations, and demand patterns.

To accelerate this shift and safeguard jobs, a labour market that anticipates and plans for these changes is crucial. Despite playing a central role in the circular economy, the contributions of workers, employers, and education and training providers are often overlooked. Without engineers and tradespeople, buildings cannot be constructed or renovated. Most of the jobs needed to drive circular strategies and business models already exist in the workforce but may require upskilling. For some new functions – such as digital modelling or the sourcing of sustainable building materials – different approaches can be taken: new work may be taken on by existing occupations or split across different ones, and new specialist occupations with new skills will also emerge.[35]

A comparison of the percentage of material added to the EU's building stock per region with the relative percentage of employment reveals a small variation (as shown in Table 3).[36] It is notable that the proportion of construction workers in Northern Europe is relatively high compared to the amount of material used in this region.

If we compare the percentage of the working population employed in construction per member state (see Figure 10), we see that countries in Southern Europe have the lowest percentage. Informal employment in the construction sector, which is significant, has not been accounted for in these figures.[37]

Figure 11 shows the employment per phase of the construction process.[38] Roughly 69% of people working in the construction industry are employed in the construction of assets (this data does not differentiate between construction activities for housing, utilities and infrastructure). Eastern Europe and Northern Europe have a relatively low share of employment in the waste and reprocessing sector.

Region	Percentage of total material consumption in the EU	Percentage of employment of total (all of EU) construction sector
Northern Europe	2.3%	4.4%
Eastern Europe	14.5%	20.4%
Southern Europe	16.8%	21.5%
Western Europe	66%	54%

Table 3: Material consumption in the four European regions.

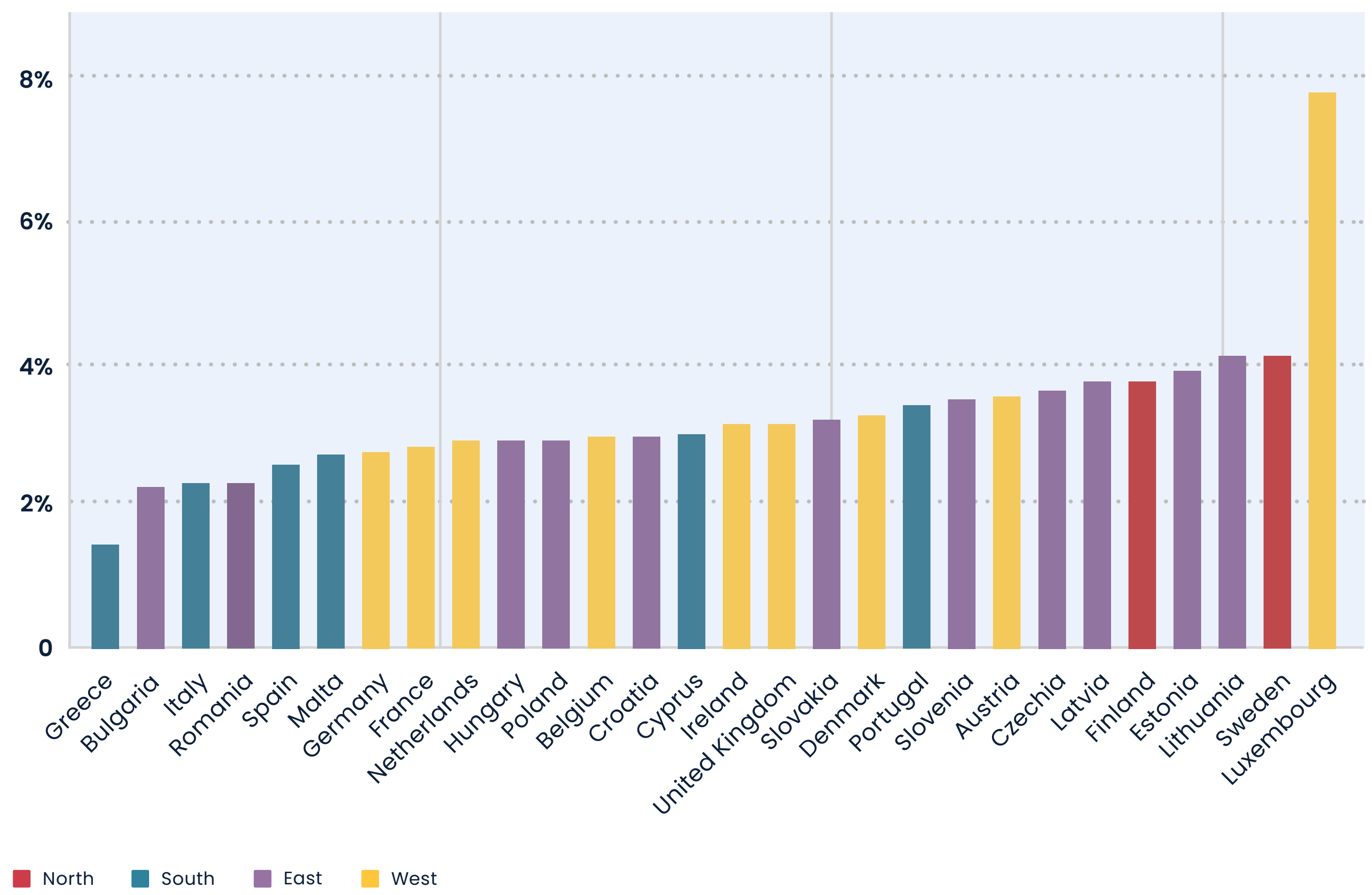
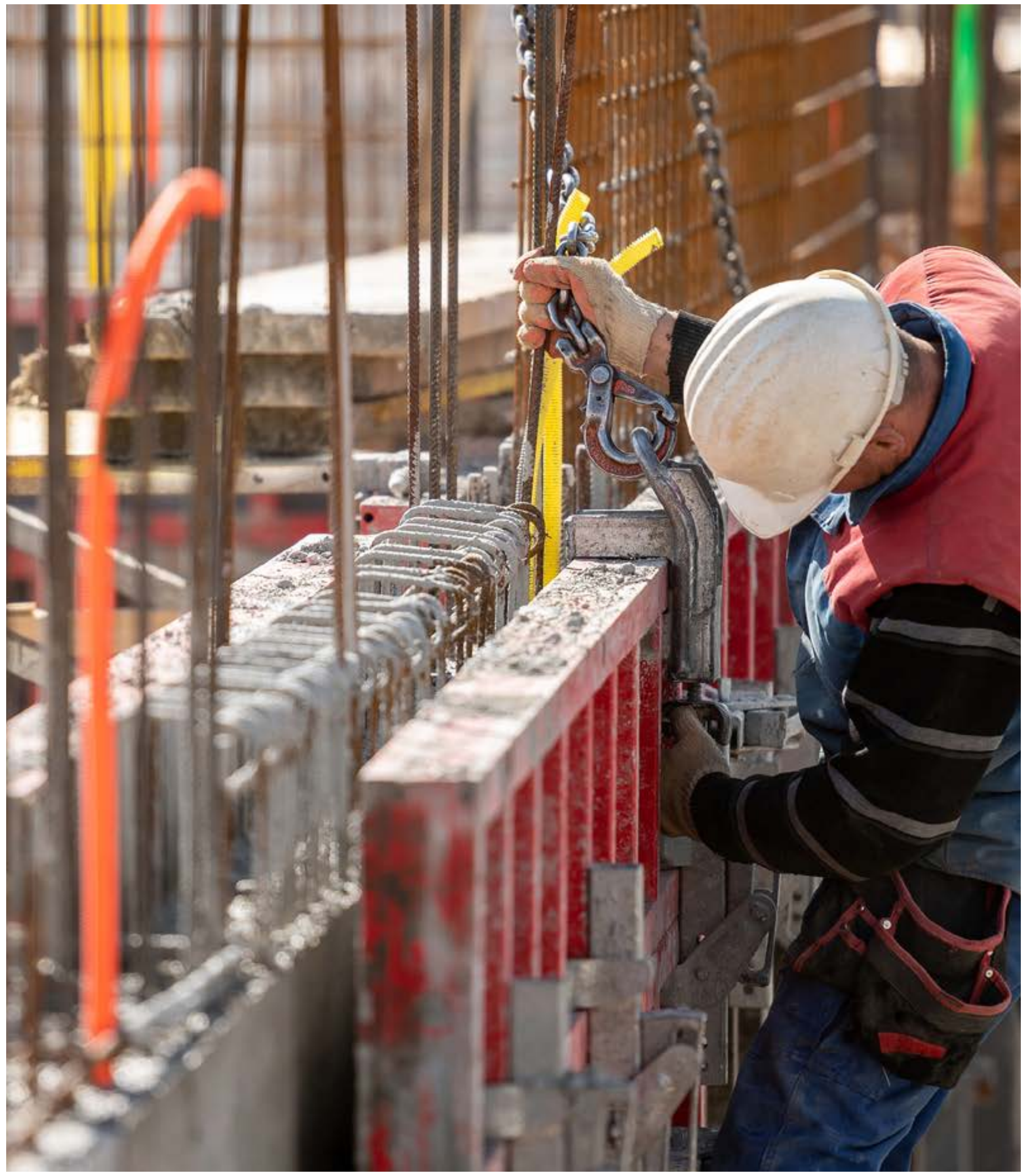


Figure 10: Percentage of the working population that works in the construction sector. Colours indicate the EU regions. Based on employment data by Exiobase. https://www.exiobase.eu

The need for reskilling and training in the construction industry grows as the sector shifts towards more sustainable and technologically advanced practices.

According to the European Commission,[39] retraining and reskilling of the EU's workforce is necessary in order to meet the demands of the Green Deal and the Renovation Wave (see Box 2, Renovation Wave), which aim to transform the region's building stock to be climate neutral. The EC has predicted that the transformation towards more sustainable construction practices will create new job roles, such as specialists in deep building renovation and installers of advanced technological solutions. The industry is already facing a shortage of qualified workers, due in part to an ageing workforce and a lack of young workers entering and remaining in the industry. In addition, the construction industry has often relied on cheaper, precarious labour rather than investing in training and good working conditions, making it less attractive to workers.[40]

In all regions, the construction of assets adds a significantly higher percentage of value to the economy than do other activities. From the perspectives both of value added and of overall employment, reprocessing of construction products and waste processing make up only around 2%.



Box 2

Renovation Wave

The term 'Renovation Wave' originates from the 2020 European Commission Strategy 'A Renovation Wave for Europe – Greening our buildings, creating jobs, improving lives'. Following the Energy Performance of Buildings, this strategy sets out to increase the renovation speed of buildings while improving their energy efficiency. Specific instruments are decarbonisation, lifecycle assessment and accessibility, and the focus lies on three areas: (1) tackling energy poverty, (2) improving public buildings and social infrastructure and (3) decarbonisation of heating and cooling.

CONSTRUCTION

DEMAND DRIVERS FOR CONSTRUCTION

The construction sector's ecological impact and greenhouse gas emissions are driven by annual growth of roughly 0.3% in the EU's building stock, as well as continued growth in urban land consumption. Between 2012 and 2018, the urban areas in the EU grew by 4,646 km², which is equivalent to twice the total land surface of Luxembourg.[42] We have identified the following drivers of this demand for construction.

There has been an increase in single-adult households

The growth of the EU's housing stock has not been consistent with household growth over the past decade. While both the overall number of housing units and the population of the EU, and also the UK, have increased by 0.3% on average, the increase in the number of households has been much greater: 9.5% between 2009 and 2021. The majority of this increase has been due to the growth in single-adult households,[43] which make up 27.4% of all households.[44] At the same time there is very little investment in public housing throughout the EU (0.6% of GPD).[45] This together with tax incentives has increased property value in the EU by more than 40%,[46] contributing to a housing crisis, with affordable housing unavailable to many EU inhabitants.[47]

In the past decade, the population growth across the EU has not been uniform. While Western European countries have experienced a slight increase in population (0.09 to 0.97%), Eastern European countries have seen a slight decrease (-0.1 to -1.3%). Among the Western European countries, Portugal is an exception, having seen a small decline.[48]

A large proportion of the population lives in low-density areas.

Approximately 60% of EU citizens live in low-density areas such as suburbs, small towns and rural areas.[49] About 53% of all EU citizens live in detached single-family homes, which are, on average, more resource-intensive in terms of materials and energy. These dwellings typically use more materials due to the lack of shared surfaces (i.e. walls, roofs etc.) and also have higher energy consumption, as they have more surfaces through which heat can escape. The need for infrastructure to support these housing typologies also contributes to resource consumption. While energy consumption and infrastructure are not part of this analysis, they are important to keep in mind when considering sustainable alternatives.

In recent decades, the average living space per person in the EU has increased significantly, currently standing at around 40 square metres per person.

There is significant variation in living space across different regions: the average is higher in Scandinavian countries (47.5 square metres) and lower in Southern and Eastern European (ranging from 25 to 38 square metres).[50]

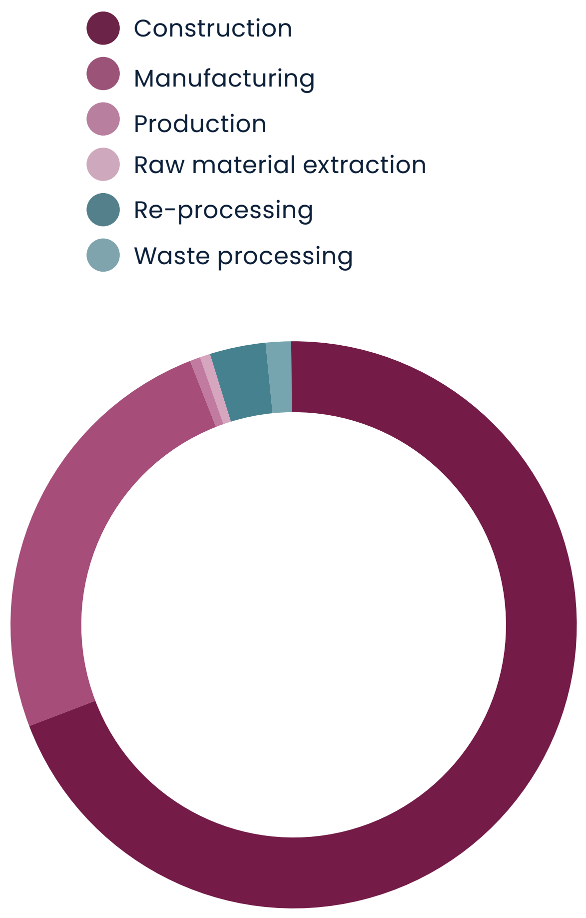


Figure 11: Employment per subsector of the construction industry.

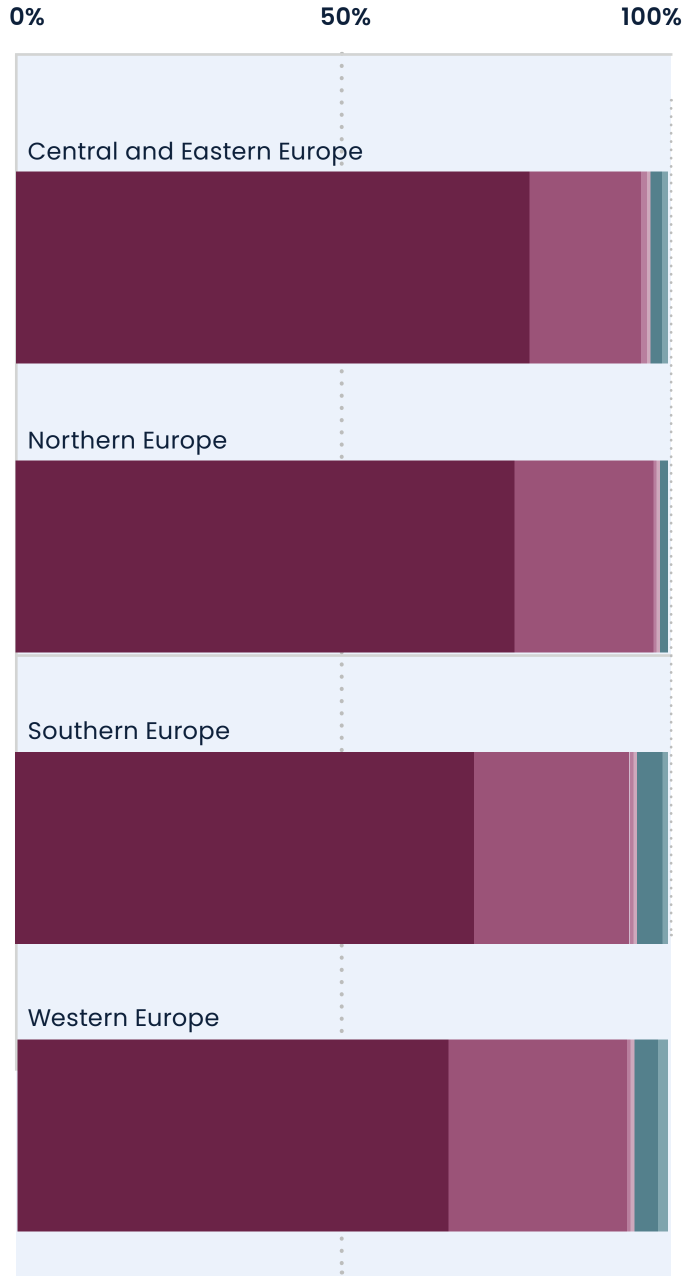


Figure 12: Employment per subsector of the construction industry per region.

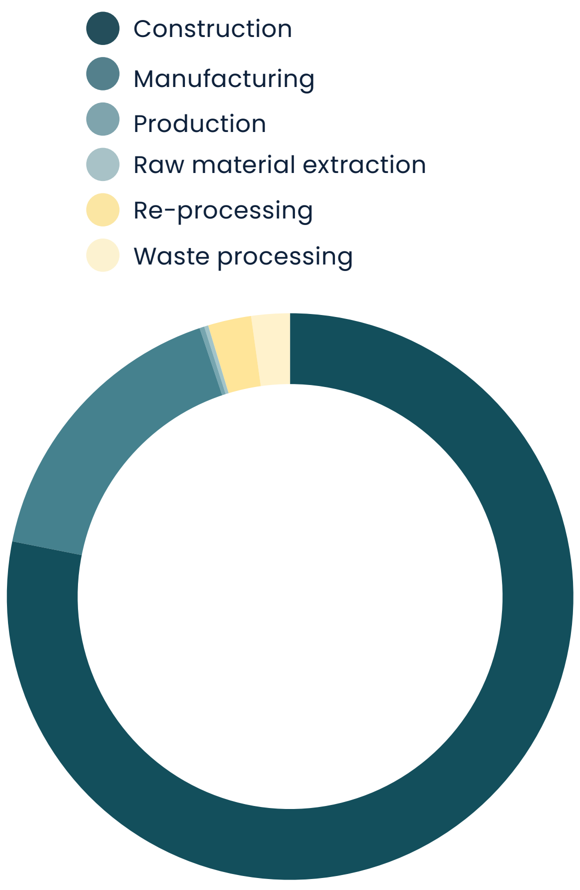


Figure 13: Financial value added to the economy per subsector of the construction industry.[41]

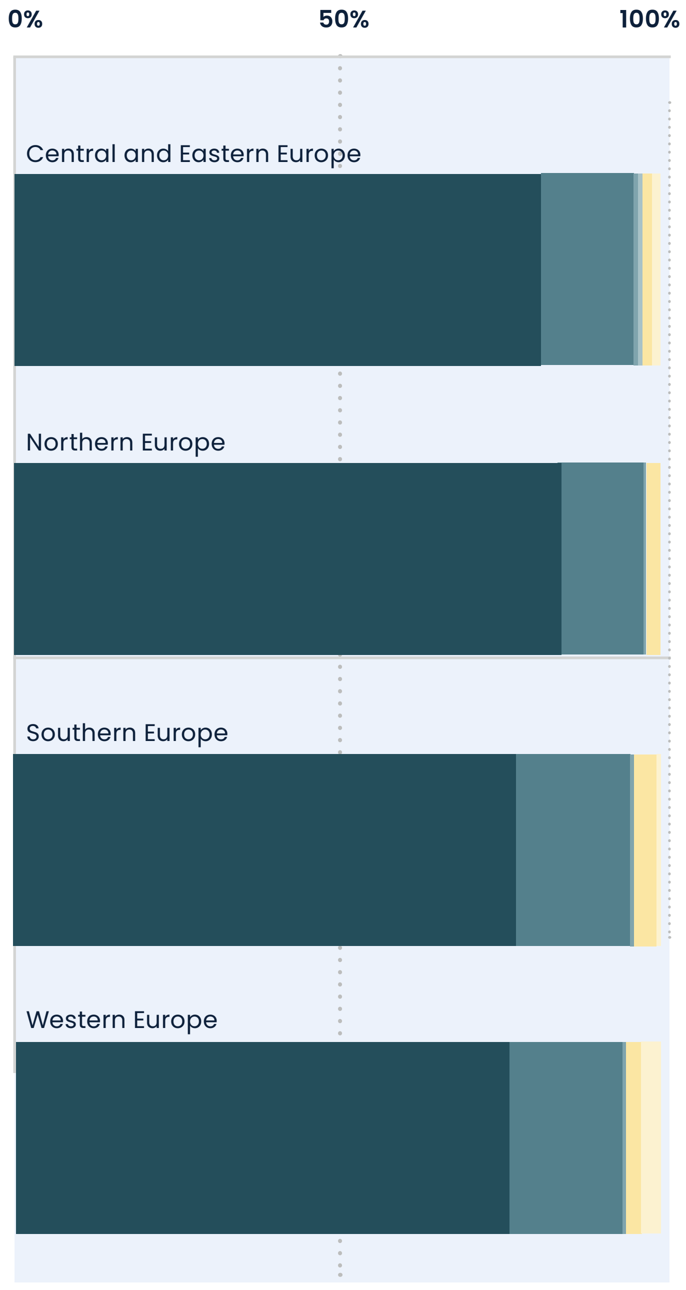


Figure 14: Financial value added to the economy per subsector of the construction industry. per region

A large proportion of the EU housing stock is underused.

In 2019, roughly 30 million houses were uninhabited, and 35% of all dwellings in the EU were under-occupied, in the sense that they had unused bedrooms and were deemed to be too large for the needs of the occupant household.[51]

Despite this underuse, access to affordable and appropriate housing remains a problem.

In 2016, 16% of the EU population lived in overcrowded dwellings and suffered from serious housing quality issues (such as the lack of a bath or a toilet, a leaking roof or lack of daylight).[52,53] There are wide national divergences, with Greece, for example, reaching nearly 30% overcrowding in 2020.[54] Moreover, homelessness has been on the rise in the EU, with numbers increasing consistently in most member states over the past decade. Studies estimate that on any given night in the EU, at least 700,000 people are sleeping rough or in emergency or temporary accommodation – 70% more than a decade ago.[55] This has coincided with an emerging housing affordability crisis, driven primarily by a 30% increase in housing prices at EU level and an increase in rents of 14.8%.[56]

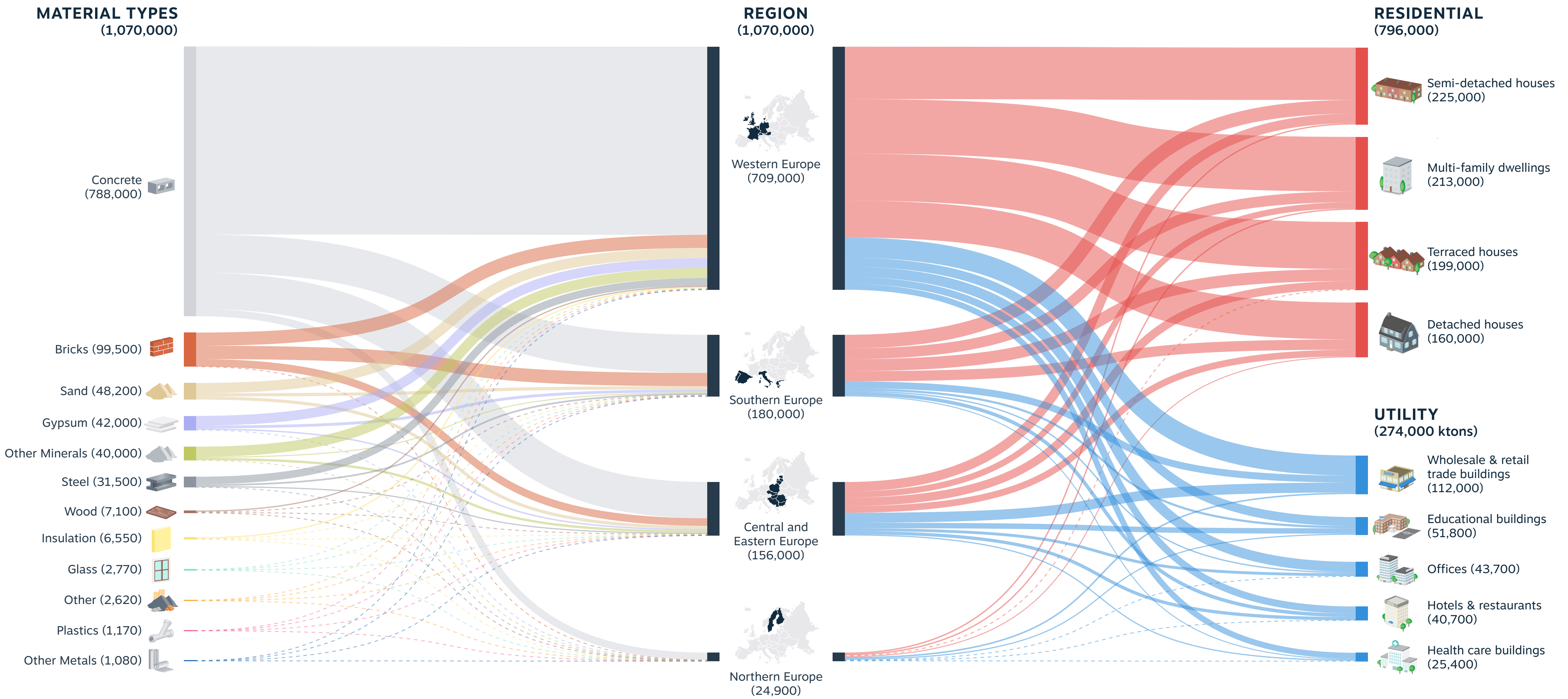
MATERIAL CONSUMPTION IN THE CONSTRUCTION SECTOR

To better understand the magnitude of material consumption within the EU27+UK construction market, a material flow analysis has been executed. This first insight includes a detailed breakdown of materials, geographical region and typology, as shown in Figure 15.

The modelling exercise yielded the following results:

Concrete

Concrete is the most widely used construction material in the world, not only in the EU. According to the material flow analysis (see Figure 15), by weight, concrete comprises roughly 75% of all materials used. Concrete is a common building material in all types of buildings, often used for foundations, structural elements and interior walls. The cement industry, which produces concrete's key ingredient, is responsible for 5% of all human-caused CO_2 emissions.[57]



LEGEND
Less than 5,000

Figure 15: A material flow analysis that shows the use of construction materials per region and building typology. All figures are in kilotonnes.

CIRCULAR BUILDINGS COALITION

Bricks and ceramic products

Bricks and ceramic products also account for a large share of materials used (9.5%), with a particularly large proportion used in Southern Europe (about 22%, compared to around 5% in the rest of Europe).

Steel

Steel is also a widely used construction material, mostly used as rebar for concrete, but also in direct structural steel applications. The iron and steel industry is responsible for about 4% of CO_2 emissions in the EU and 9% worldwide, due to its intensive use of coal.[63] The application of structural steel sections varies a lot between typologies: predominantly non-residential buildings and high-rise residential buildings are built with structural steel sections.

Biobased materials

As shown in Figure 15, timber constitutes less than 1% of all construction materials by weight used in the EU, with the majority used in Northern and Western Europe. As 'mineral' materials (such as concrete) are much heavier then biobased materials (such as wood and flax) this percentage is relatively low. As the application of biobased insulation materials (such as wood fibre or flax) is still relatively small, and contributes very little material as a proportion of weight, such materials were not included among the typologies used for this modelling exercise.

Regional differences

The type and quantity of materials used in construction can vary by region, with Western European building typologies typically using more materials per square metre of gross floor area, often due to greater use of concrete. This may be attributed to a range of factors, including local building codes and regulations, cultural preferences and the availability and cost of different materials. The particular materials utilised and the amount of each material used can significantly affect the embodied CO_2-impact of a structure.

CONSTRUCTION'S SHARE OF CO_2 IMPACTS OF MATERIALS

Our analysis suggests that the environmental impact of the construction industry in the construction phase amounts to approximately 277 Mt CO_2e. This equates to almost 9% of the EU's annual greenhouse gas (GHG) emissions.[68] Two materials, cement and steel, emerge as significant drivers of this impact, contributing a combined 66% of all emissions. Concrete without steel reinforcement bars accounts for 74% of the total mass of resources consumed and is responsible for 36% of all carbon emissions. Steel, on the other hand, represents only 3% of the total mass, but its CO_2 emissions are relatively high, at 30% of the total impact. Combined, they make up more than 5% of the EU's total emissions. This is largely due to the high environmental impact of steel reinforcements, which are used to strengthen concrete structures.[69,70]

CONSTRUCTION AND OUR CARBON BUDGET

The concept of planetary boundaries outlines a group of nine boundaries that define a safe operating space for humanity to thrive on our planet for future generations.[71]

To ensure sustainable development and thriving communities, a group of scientists proposed quantitative limits on these processes. Crossing these boundaries may trigger catastrophic and irreversible changes in the environment. The most famous planetary boundary is 'climate change'. To avoid its devastating effects, there is a limit to the amount of CO_2 that can be released into the atmosphere. This limit is known as the 'carbon budget,' which represents the maximum level of emissions that can be sustained in the future. In this chapter, we explore the carbon budget in greater detail to better understand how it applies to the European construction industry.

Box 3

At a glance: The cement industry in the European Union

Main players

The premier companies who dominate the EU's market include Buzzi Unicem (Italy), Heidelberg Materials (Germany), Holcim (Switzerland), TITAN (Belgium) and VICAT (France). The EU cement market is formed by around 170 small and medium-sized companies.

Stated intentions of the industry

The cement industry in the EU aims to achieve net-zero emissions along the cement and concrete value chain by 2050.[58] The roadmap considers several technical and political recommendations at each stage of the value chain, from the production of cement, concrete, construction and ultimately recarbonation (the process whereby concrete reabsorbs CO_2 during its lifetime). The industry demonstrates several examples of industrial symbiosis through using by-products from other industries as supplements for cement clinkers or alternative fuels during production. Certain waste and by-products containing useful elements such as calcium, silica, alumina and iron can be recycled as raw materials in the kiln.[59] There is also a focus on fuel substitution and net zero emission fuel by replacing fossil fuels with alternative waste streams, as well as the avoidance of incineration emissions, or methane emissions from landfills.[60]

Notable initiatives

The Concrete Initiative[61] aims to engage with stakeholders on the issue of sustainable construction, and in particular the barriers and solutions to harness its multiple benefits. It examines the economic, social and environmental implications of sustainable construction and the need for a balanced approach among these three pillars.

The European Cement Research Academy (ECRA)[62] was founded in 2003 as a platform for the European cement industry to support, organise and undertake research on the production of cement and its application in concrete.

Box 4

At a glance: The steel industry

There are more than 500 steel production sites in the EU, located in 23 EU countries.[64] Germany is by far the largest crude steel producer, accounting for more than a quarter of all crude steel produced within the EU. Within the EU as of 2020, Italy was the second-largest producer, accounting for nearly 15 per cent of the production. The European Steel Association (EUROFER), which represents almost the entire steel industry in the EU, is calling for EU support to put 60 major low-carbon projects in place across the EU by 2030.

Steel for Europe is an initiative to foster steel security within the EU.[65] It aims to secure a reliable domestic supply of sustainable steel and its source materials. Sustainable Steel Region is an innovation platform focusing on supporting innovation aimed at promoting industrial transition in North Middle Sweden by developing existing companies and creating new ones.[66]

Green Steel for Europe supports the EU in efforts to meet the 2030 climate and energy targets and the 2050 long-term strategy for a climate-neutral Europe, with effective solutions for clean steelmaking.[67] The project consortium, made up of 10 partners, draws on a combination of skills and expertise and allows for full coverage of the EU member states and steelmaking installations.

The rate of climate change is accelerating rapidly, resulting in severe consequences such as droughts, floods, and the loss of biodiversity. The United Nations' Intergovernmental Panel on Climate Change (IPCC) has developed scenarios to illustrate the amount of warming that occurs at different CO_2 concentrations in the atmosphere. Based on these scenarios, a carbon budget has been established that outlines the maximum level of global CO_2 emissions that can be released to limit climate change to 1.5˚C, 1.7˚C, and 2.0˚C. Exceeding this budget would cause further warming beyond what is considered acceptable.[72]

Between 1850 and 2019, the world emitted approximately 2390 gigatonnes of CO_2. To maintain a 67% likelihood of limiting global warming to 1.5˚C, the global CO_2 budget from 2020 onwards is 400 gigatonnes; to limit warming to 1.7˚C with 67% certainty, the budget is 900 gigatonnes; and to limit it to 2.0˚C with 67% certainty, the budget is 1150 gigatonnes. However, with annual global emissions currently hovering around 3Mt, this budget is rapidly dwindling.[73]

To determine a CO_2 budget for the EU27+UK construction industry, it is not possible simply to divide the global carbon budget by country or sector. The method used, such as historical emissions, population, or gross national product, can significantly influence the available budget. According to New Climate, Western countries like the Netherlands have already exceeded their 'fair' CO_2 budget based on historical emissions and financial capacity.[74]

In establishing a CO_2 budget for the EU27+UK construction sector, several choices were made resulting in three budgets for limiting global warming to 1.5˚C, 1.7˚C, and 2.0˚C, each with a 67% chance of preventing exceedance. The allocation of the budget to EU27+UK was based on population numbers, consistent with previous CO_2 budget calculations for the construction industry. The year 2020 was selected as the starting point for the reduction targets under the Paris Climate Agreement.[75]

To determine the remaining CO_2 budget for the construction of housing and utility buildings in the EU27+UK, the total budget (starting from 2020) was reduced by the combined CO_2 emissions between 2020 and 2022, which are estimated at approximately 107.6 gigatonnes. Consequently, the remaining CO_2 budget from 2023 onward is 292 gigatonnes for limiting global warming to 1.5˚C, 792 gigatonnes for limiting it to 1.7˚C, and 1042 gigatonnes for limiting it to 2.0˚C.

The budget for the construction sector was then allocated based on population numbers, consistent with previous CO_2 budget calculations for the construction industry. This leaves 6.6% of the remaining global budget. To determine the specific CO_2 budget for the construction of housing and utility buildings in the EU27+UK, the budget is further divided based on the sector's historic CO_2 emissions as a percentage of the total economy, which is roughly 11%. The distribution of this 11% across the different activities in the construction sector, applying the same methodology as presented in the report by the Dutch Green Building Council and NIBE, leaves 29% of the aforementioned 11% for the construction of new residential and utility buildings, with the rest of the budget going to infrastructural projects and renovations of the existing residential and utility stock.

This means that the remaining CO_2 budget for new construction of utility and residential buildings in the EU27+UK from 2023 onward is 783 Mton for limiting global warming to 1.5˚C, 1762 Mton for limiting it to 1.7˚C, and 2252 Mton for limiting it to 2.0˚C.

Reviewing this in comparison to the current emission of carbon caused by construction (see Figure 18), it can be assumed that the EU27+UK's construction sector will exceed its carbon budget for limiting global warming by 1.5˚C in 2026. The budgets for 1.7˚C and 2.0˚C will run out in 2029 and 2031 respectively.

Figure 16: Average kilograms per square metre of gross floor area of buildings constructed in each geographical region

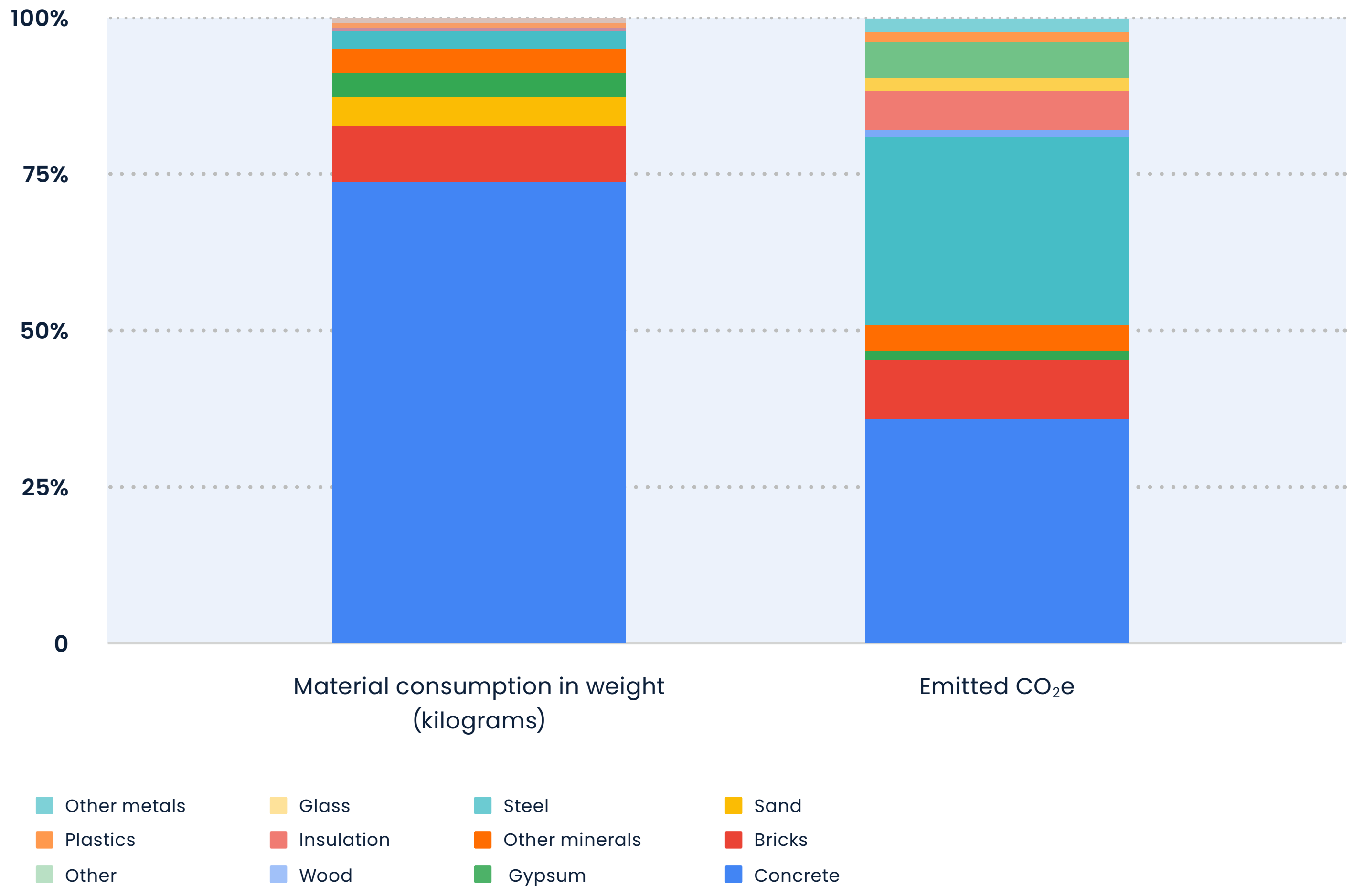


Figure 17: Impact of material consumption in weight and emitted CO_2e

Conclusion

To meet the targets in the Paris agreement and to reduce the chance of reaching a tipping point in one of the planetary boundaries, we have three years to act. Applying circular economy material principles can significantly reduce the environmental impact - the Coalition is currently modelling the pathways.

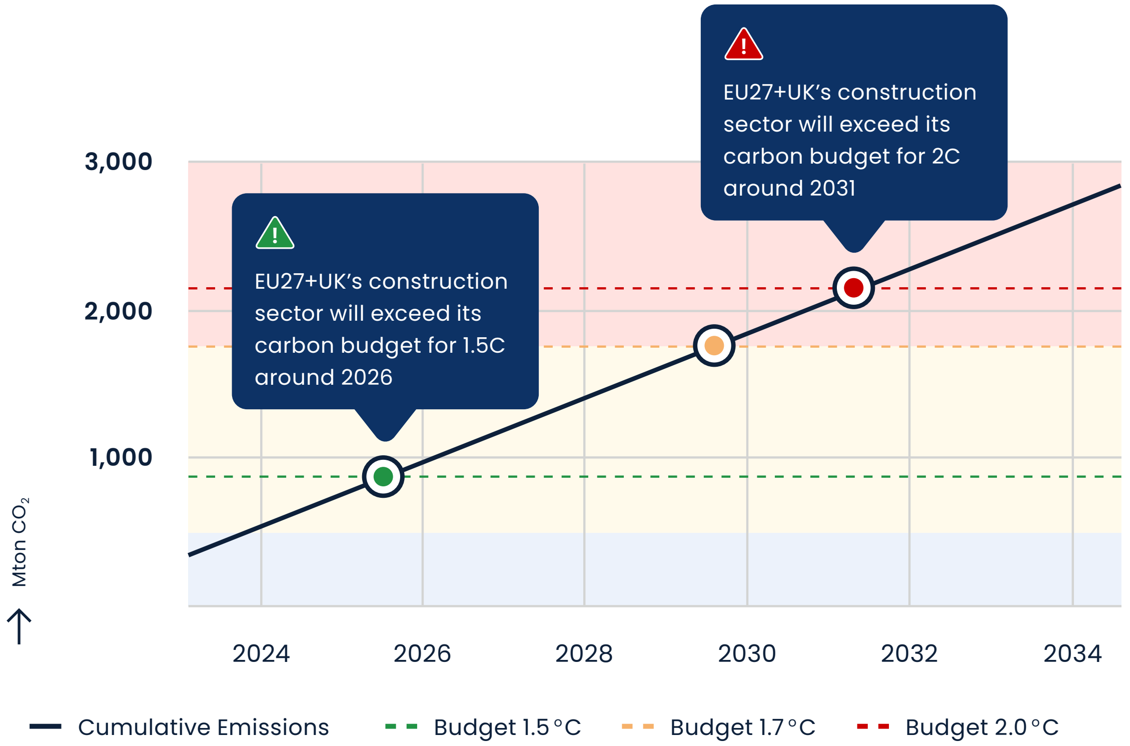
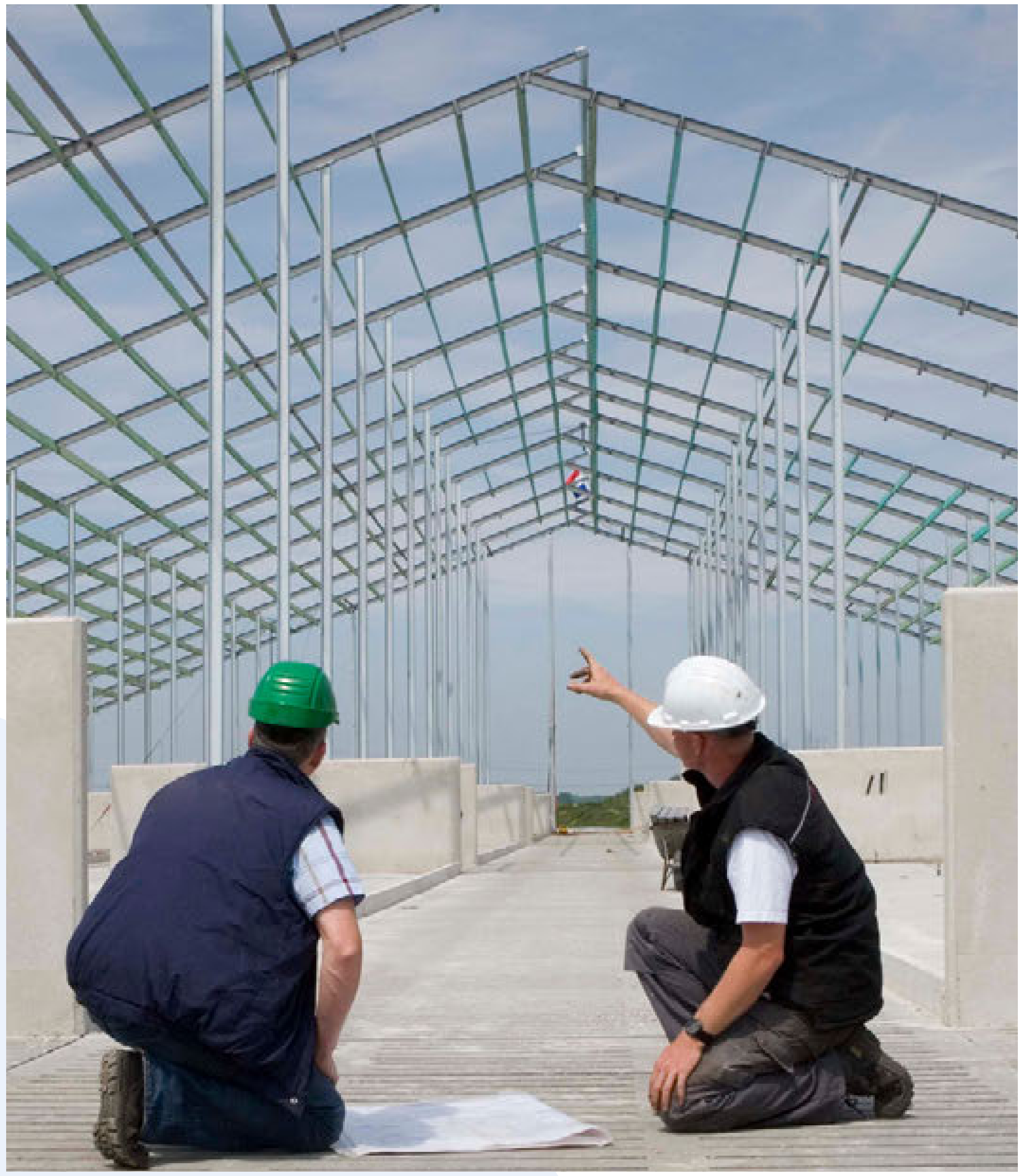


Figure 18: CO_2 budget of the residential and utility construction sector.



RENOVATION AND MAINTENANCE

DRIVERS FOR RENOVATION AND MAINTENANCE

As a result of the slowed and high-impact production of new housing, the ageing housing stock has drawn increasing attention. In particular, in recent years, there has been a strengthening focus on reducing not only the emissions caused by the energy use of buildings (operational carbon), but also the embodied carbon (see glossary) associated with the production and transportation of the materials used in their construction. Buildings play a significant role in achieving the goals of environmental policies such as the circular economy and climate change mitigation.

However, given that 85-95% of the EU's current building stock is expected still to be in use in 2050, the majority of opportunities for reducing carbon emissions lie in the renovation of existing buildings.[76] Common reasons for renovating existing buildings include creating more space, improving energy efficiency, preserving cultural heritage and bringing buildings up to current technical standards. Renovation activities also reduce material use for new construction, since they extend the lifespan of existing building stock.

Renovations can be divided into energy renovations (deep, medium, and light intensities) and non-energy renovations (complete, partial, and particular).[77,78] Non-energy renovations may include upgrades to building systems, finishes or structural elements.

The drive for both energy and non-energy renovations is directly linked to the ownership model of the property.

Individual homeowners who also inhabit their own property are preoccupied with thea energy efficiency of their homes to save money, improve comfort and decrease environmental impact.[79] To increase this energy efficiency, homeowners can carry out different type of energy renovation projects. However, both the available capital and the complexities in executing such renovations are seen as barriers.

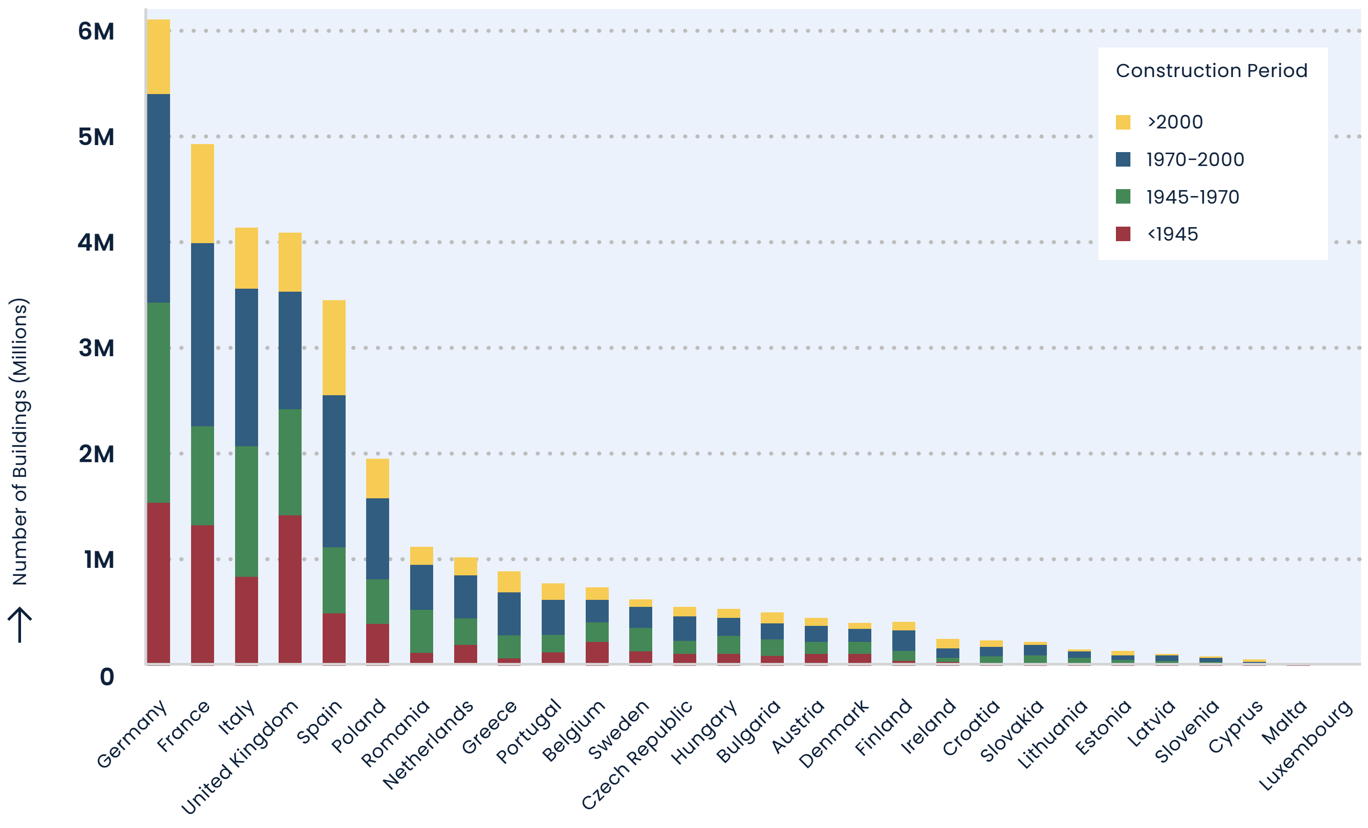


Figure 19: number of buildings per construction period. Source: JRC, Graphic - Metabolic https://www.eea.europa.eu/publications/building-renovation-where-circular-economy/modelling-the-renovation-of-buildings/view.

Despite support programmes put in place at EU member state level, a number of factors make private consumers reluctant to invest in renovating their houses. These include a lack of trust in market actors in the construction industry,[80] split incentives – which occur when two parties involved in a construction project or building have conflicting interests – and a sense of overwhelming complexity. Corporate homeowners and landlords such as housing corporations are often viewed as key players in the effort to decarbonise the building stock in the EU. In current policy directives from the EU (such as the Renovation Wave) large corpoarations are seen as the most important stakeholder to lead the way in the large-scale renovation activity to meet climate goals.

MATERIAL INFLOW IN RENOVATIONS

In all renovation projects combined (both energy- and non-energy-related), insulation materials are the most commonly used, accounting for 39% of all materials applied in renovation in the EU (see Figure XXX). These materials are typically used for energy efficiency and soundproofing purposes. Most of the materials used in renovations are for residential projects (74%). However, only 23% are used for renovations designed to improve energy efficiency. EU policy objectives such as the Renovation Wave (see Box XXX, Renovation Wave) are expected to raise this percentage in the future. Within the EU, Western Europe accounts for the majority of materials used in renovations in absolute terms. This is partly due to the fact that the region has the largest proportion of building stock. In addition, a higher proportion of the stock is renovated annually in Western Europe compared to Southern and Eastern Europe. While concrete is used extensively in construction, it is less prominent in renovations.

Box 5

More financial flows towards the EU's renovation markets are needed

Investment in renovation represents just under a third of the total investment within the EU's construction market. Renovation served as a stabiliser in the aftermath of the 2008 financial crisis and has proven to be the least volatile section of the market over the last decade. In the EU, investments in renovation further increased by 5.7% in 2021, despite a dire macroeconomic state.[81] The growth in the renovation market may have a positive impact on the energy retrofitting submarket as well. The European Commission (EC) estimates that in order to achieve the target of a 55% reduction in greenhouse gas emissions by 2030, an additional €275 billion in annual investments will be necessary to renovate and decarbonise the existing building stock.[82,83]

According to a 2020 survey, awareness of the environmental and climate crisis is on the rise in the EU, with citizens, businesses and communities experimenting with new ways of living and working.[84] Residents and homebuyers already seem to be willing to pay for sustainable features and energy-efficient solutions. Results from a 2021 survey carried out in the Czech Republic, Germany, Italy, Spain and commissioned by the European Climate Foundation, indicate that a large percentage of end users support energy efficiency improvements: 89% of the respondents think that it is important to buy or rent a property that is energy efficient, and 64% say there are too few energy-efficient properties available on the market.[85] One may assume that this increased environmental consciousness and the enhanced commitment to the sustainability of younger generations will likely further increase the demand for circular construction.[86]

MATERIAL OUTFLOW FROM RENOVATIONS

Insulation material makes up the largest share of materials removed from buildings during renovations, accounting for 52% of all materials removed. This includes both soundproofing and insulation for energy efficiency. This insulation is often removed because it does not meet current or future energy standards. As the quality of the material cannot be guaranteed, it is removed and replaced with new resources, rather than adding a minimal amount of new insulation material to existing layers. Wood, which is often sourced from residential buildings, is the second most common material removed, comprising 15% of the total. Glass used in windows (for example, when replacing single with double glazing) is the third largest category, at 9%.

Impact of renovations

Based on the Material Flow Analysis shown in Figure XXX, the reuse of products and recycling of materials do not create a sufficient flow of building products and materials to close the circularity loop with renovation materials alone. This implies that the material flows from renovations will always be deficient in terms of quantity; more material will enter than leave. Therefore, a broader scope must be adopted to look for more solutions beyond simply closing material cycles within renovation activities, such as preventing the need for material altogether and using less impactful and more regenerative materials.

If current renovation practices in the EU27+UK continue as usual, energy- and non-energy-related renovation activities will consume 918Mt of virgin materials from 2022-2050, resulting in the emission of 978 Mt of embedded GHG emissions.

Inflow of materials

The majority of material demand comes from countries within Western Europe, which will demand 447 Mt of all material consumption related to renovation activities in the EU27+UK per year; this is 48% of all material consumption. This comes as no surprise, since the majority of buildings are also located in this region. The top four materials entering the EU27+UK building stock are insulation materials (28%), ceramics (16%), wood (12.5%), and concrete (12.2%), which together make up 68.7% of all materials entering the building stock, and 38% of all GHG emissions related to the renovation of the EU27+UK building stock (978 Mt). Only 21% of all material consumption is associated with to energy-related renovation activities, with the other 79% applied in non-energy renovations.

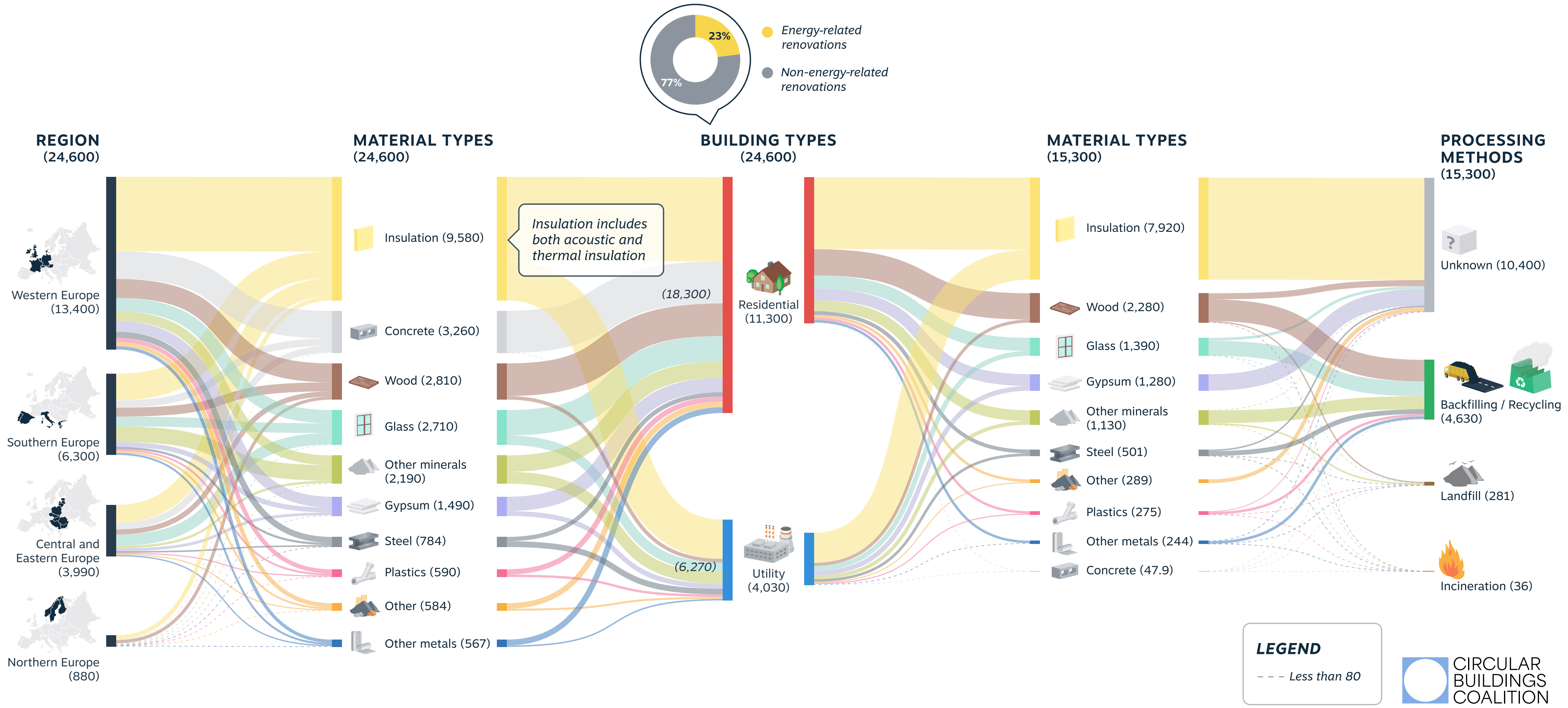


Figure 20: Figure XXX: Material consumption per geographic region for energy and non-energy-related renovations. All figures are in kilotonnes. Source: Metabolic Data Cluster. Source: JRC, Graphic - Metabolic.

Outflow of materials

Based on the modelling, it can be assumed that less material is leaving the EU27+UK building stock due to renovation than is entering; in total 386 megatonnes of mass was removed from the EU27+UK building stock during the time scope of this research. The materials flowing out of the building stock because of renovation are insulation (39%), wood (16%), gypsum (10.6%), and glass (10.1%).

The Material Flow Analysis is executed based on the business-as-usual scenario, which shows the materials needed for current renovation activities. However, if different states comply with European directives such as the Green Renovation Wave, the annual renovation rate will increase by roughly 300%. This analysis also does not include the reduction of GHG emissions due to a more energy-efficient housing stock.

DEMOLITION

DRIVERS OF DEMOLITION

While the deconstruction of a building involves taking it apart while carefully preserving valuable elements for reuse, in demolition, little or no attention is generally paid to preserving materials. Limited data is available about demolition processes and the decision-making processes leading up to demolition. While a significant amount of information is recorded about the initial construction of buildings, including the planning, design and construction process, less information is available about the utilisation phase, including management, renovation and redesign, and even less is known about the end of a building's lifecycle. This lack of knowledge derives partly from a focus on mass housing production in the past, following World War II, when policymakers' priority was to address housing shortages rather than the maintenance and longevity of existing housing stock.[87]

The fact that knowledge about demolition is limited is partly due to the small volume of demolitions – on average between 0.1 and 0.2% of the existing residential stock annually in Western Europe until 2008.[88]

Research suggests three main factors that affect the decision to demolish a buildings are:[89]

1. **End of technical life.** Motives here strongly depend on the year of construction of the building typology. For example, the majority of demolition motives (88%) of post-war constructions are related to defining features of the building, such as structural, climate-related or technical shortcomings. The prospect of houses no longer meeting climate-related standards is becoming a pressing issue. This can be attributed to a variety of factors, such as inadequate construction of buildings or their lack of adaptability to changing social expectations and climates.

2. **End of economic life.** The end of the economic life of a building refers to the point at which the costs of maintaining and operating the building are no longer financially justifiable based on its expected future revenues. This can be due to various factors, including changes in the market, technological advancements and the condition of the building itself.

3. **Market Demand for building typology:** The availability of similar properties in the vicinity of a building increases the likelihood of its demolition. This factor has a strong relation to the economic life of the building as the willingness to invest might shift the economic balance of a property. This theme has a strong link with economic geography. A decrease in economic activity can result in a decrease in employment, leading to dereliction and demolition. Conversely, an increase in employment can lead to rising property values and increased economic and social demands for densification.

The three influencing factors are:

1. **Ownership model.** Who owns the building and the type of building are key factors. Non-residential buildings constitute a large majority of demolition by floor area. In addition, non-residential buildings are usually much larger and newer at the time of demolition than residential buildings. Rental homes are, on average, demolished sooner than owner-occupied homes. Multi-family homes are much more likely to be demolished, especially if they are in the rented social housing sector.

2. **Geographic location.** Demolitions tend to be concentrated in urban areas, with cities accounting for 76% of the total demolished floor area. A study in Finland suggested that 44% of all demolition by floor area is in city centres.[90] This suggests that the majority of demolitions derive from the expiry of economic rather than technical lifecycles. Reasons for demolitions in cities include high land prices and high demand for floor space. This could also point towards an empty or underutilised building stock outside of high density urban city centres, in areas where demolition and reconstruction is not common or financially feasible.

3. **Internal and external value.** A further factor in determining the decision to demolish a building is its value in terms of functional or aesthetic qualities as perceived by the owner ('internal value'), or as a landmark or cultural asset as perceived by the surrounding community ('external value'). A lack of these qualities might incentivise an early demolition.

DEMOLITION WASTE

The construction sector in the EU is responsible for about 36% of the total mass of generated waste.[91] On average, the recovery rate of construction and demolition waste (CDW) in Europe has been increasing, reaching 76% in our analysis.[92] However, it is important to note that this indicator includes backfilling in the statistics of recovered CDW, although backfilling is in fact ranked lower than recycling in the waste hierarchy framework (see Box XXX, The EU Waste Framework Directive and the waste hierarchy framework). In this report, 'secondary materials' refers exclusively to the CDW that is reintroduced into the value chain through high-quality recycling or reuse in such a way that it can prove to be an alternative to virgin raw materials.

The majority of the materials that are disposed of during demolition practices are mineral-based, such as concrete or bricks, which make up over 80% of the total by mass.

Wood is also a significant contributor, accounting for 7% of the total by mass.

About 64% of the materials that are disposed of during building demolition are supposedly recycled, but as there is no standardised reporting system across Europe, it is difficult to compare material availability and end-of-life scenarios.

Furthermore, most of the larger streams of materials, such as concrete and mixed mineral waste, are not recycled according to circular principles and are instead used as foundation for roads, backfilled (not considered a sustainable or circular practice in this report), landfilled, or used as a substitute for gravel in new concrete mixes. From a circular perspective this is a waste of environmental impact because through disassembly (rather than demolition) these products could be reused as a replacement for virgin construction products (higher on the waste hierarchy, see Box XXX, The EU Waste Framework Directive and the waste hierarchy framework). For 12% of the materials that are disposed of, the processing method is unknown. This includes materials like sand, which is often reused, and insulation, which is often incinerated.

Box 6

The EU Waste Framework Directive and the waste hierarchy framework

The Waste Framework Directive lays down some basic waste management principles.[93] It requires that waste be managed:

- without endangering human health and harming the environment
- without risk to water, air, soil, plants or animals
- without causing a nuisance through noise or odours
- without adversely affecting the countryside or places of special interest

It explains when waste ceases to be waste and becomes a secondary raw material, and how to distinguish between waste and by-products.

The Directive also introduces the 'polluter pays principle' and the 'extended producer responsibility'.

The foundation of EU waste management is the five-step 'waste hierarchy', established in the Waste Framework Directive, which establishes an order of preference for managing and disposing of waste.[94]

Construction materials and building designs should follow the waste hierarchy; the first step is to prevent the unnecessary use of resources, including raw materials, water and energy.

Recovery has to keep in mind the management principles whereby special attention is required for potentially harmful substances for both human health and the environment.

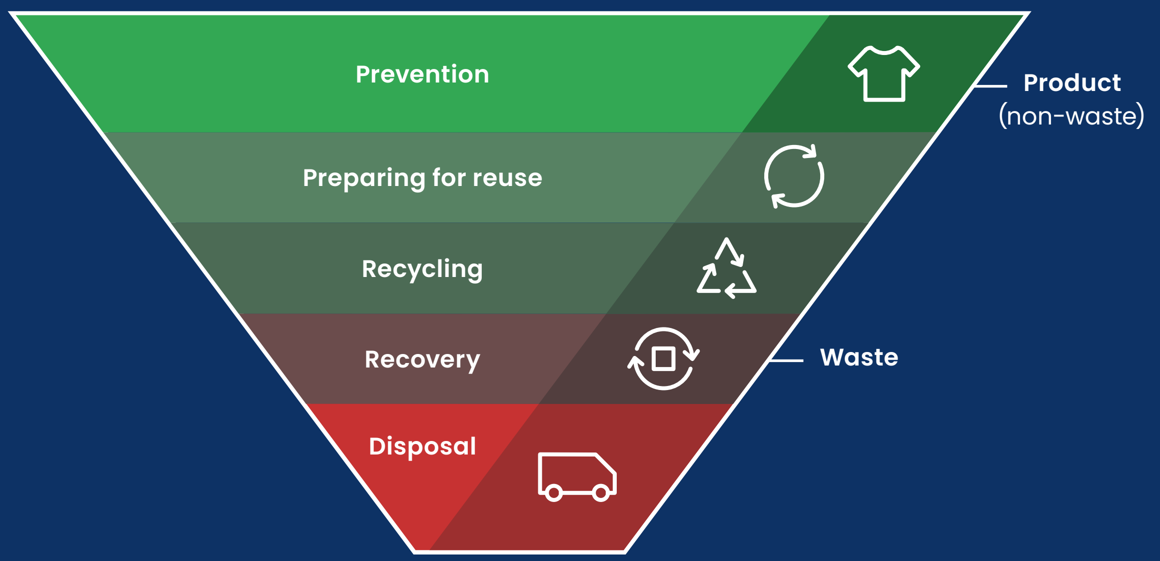


Figure 21: European Commission. Waste Framework Directive. Retrieved November 2022, from https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

Western Europe produces 1.5 times as much demolition waste per inhabitant compared the EU average and more than 3 times as much compared to Central and Eastern Europe or Southern Europe. Moreover, it consumes 66% of all construction materials, even though it only has about 44% of the population. There are several possible explanations for this, including the high density development model in Western Europe, which may lead to the economic life of buildings depreciating more rapidly, and a preference for demolition rather than expansion into greenfield land.

Region	Kilotonnes Modelled	Tonnes per Capita
Central and Eastern Europe	9,290	0.09
Northern Europe	3,179	0.20
Southern Europe	12,480	0.09
Western Europe	81,337	0.30
Total	106,000	0.20

Table 4: Supply of secondary material (theoretical maximum)

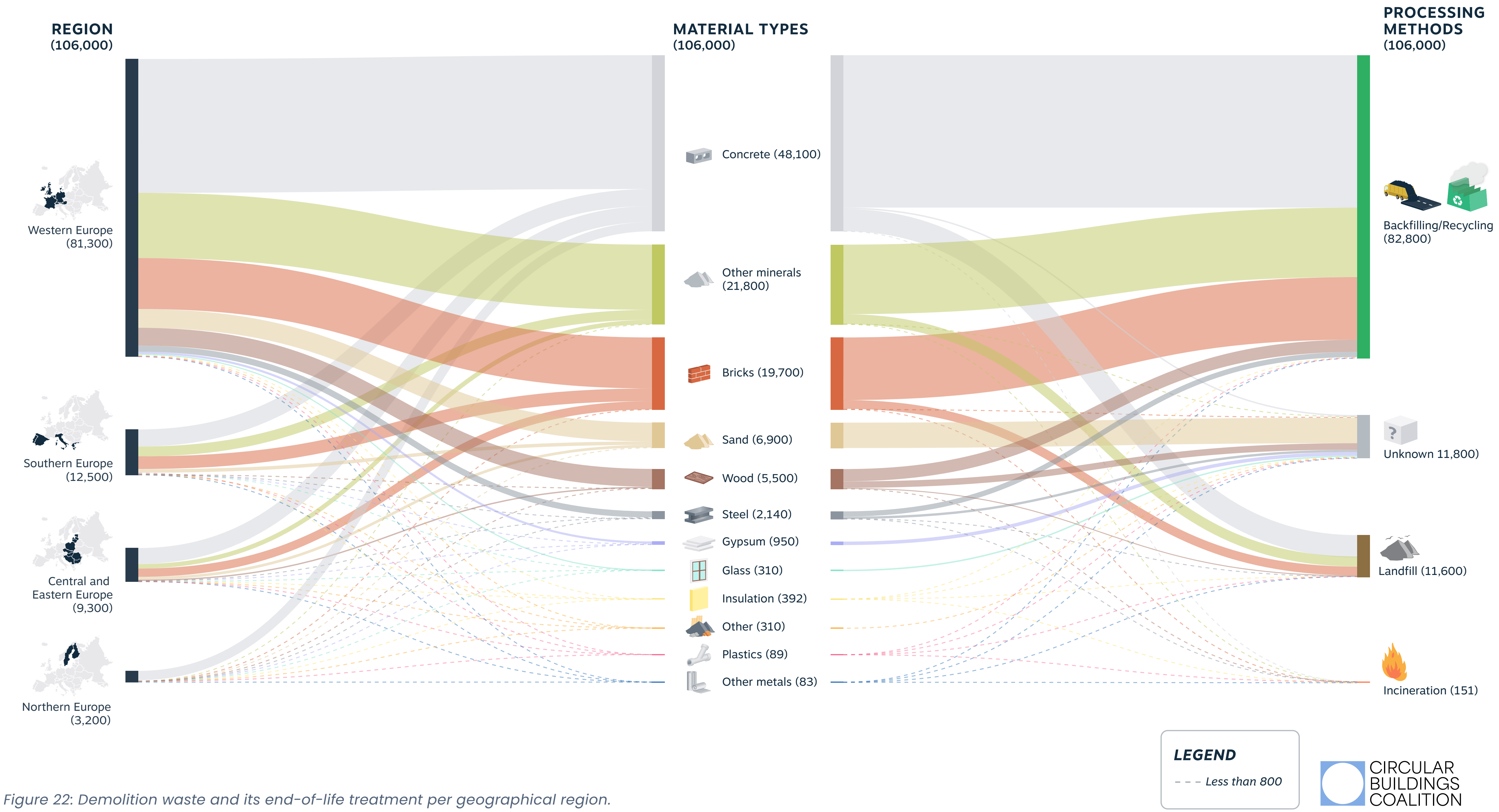


Figure 22: Demolition waste and its end-of-life treatment per geographical region.
All figures are in kilotonnes.

MARKETS FOR MATERIALS

WHAT HINDERS THE UPTAKE OF SECONDARY MATERIALS?

If all materials coming out of the existing building stock could be reused without considering technical barriers, it is estimated that 11% of total virgin material demand could be replaced (see Table XXX).

This highlights the potential of an increased uptake of secondary materials to reduce environmental impact, as well as the potential of developing sustainable alternatives to current building materials. It also highlights the limitations: covering all demand for new constructions with secondary materials is currently impossible, and other interventions such as reusing the existing building stock and biobased materials are needed to move the construction industry to a sustainable state.

More importantly, however, even this 11% of potential recovery is challenging to realise. As yet, the secondary material market struggles to compete with conventional construction materials, which are perceived as safer and more reliable due to the uncertainties, risks and associated costs involved in using secondary materials. Interestingly, technological innovation for recovering construction and demolition waste is not considered an important barrier.[95] Barriers in realising the potential recovery include:

A lack of available information on quality, quantity and time of availability of secondary materials, which can make it difficult for builders and developers to plan and budget for their use.

This information gap can also create financial obstacles for companies seeking to invest in infrastructure and reuse technology to support the use of secondary materials.

A lack of suitable storage space and infrastructure, which makes it difficult to transport and store materials that could be reused or recycled.

Improving the connection between demolition and new construction projects as well as increasing the availability of storage space and logistical infrastructure could help to reduce waste and improve the sustainability of the construction industry. Throughout Europe there are many small scale storage spaces of secondary material that usually do not reach critical scale to be a financially viable alternative to virgin material suppliers.

Low gate fees for the disposal of construction materials in most countries, constraining the possible financial advantage of using reused materials.

Countries with higher recycling rates have high landfill taxes in place. For example, the landfill tax for construction and demolition waste in Romania amounts to €11 per tonne, whereas in Denmark, the landfill tax is €49/€64 per ton depending on construction materials – five to six times higher than in Romania.[96]

Region	Incoming (kilotonnes)	Outgoing (kilotonnes)	Supply of secondary material (theoretical maximum)
North	25,800	3,900	15.1%
East	162,300	12,900	7.9%
South	186,900	16,700	8.9%
West	724,600	90,00	12.4%
Total	1,099,660	124,000	11,3%

Table 5: incoming (kilotonnes), outgoing (kilotonnes)- Supply of secondary material (theoretical maximum)

Low availability of certifications and warranties that validate the safety and quality of secondary materials, which can be required by safety regulations.

This lack of validation can make it difficult for builders and developers to use secondary materials and can create uncertainty and risk for those who do. The administrative costs around instruments such as the Environment Product Declaration and the Life Cycle Analysis are also perceived as a barrier among several stakeholder groups who are solely focused on financial value.

A common language and clear definitions of waste types and recovered materials as well as more information about certifications are needed. This would also help in providing a basis for understanding the different requirements of the market and financial investors.

To boost circularity in waste management, the EU has set a revision for the Waste Framework Directive for 2023. Specific management guidelines and definitions for more product groups and waste types will be discussed during this revision.

POLICIES FOR BETTER MARKETS

Market forces have a significant impact on driving markets towards desired societal objectives. Nevertheless, markets are also significantly influenced and steered towards these objectives by policies formulated by governments, organisations, and institutions. Policy in the EU's construction sector is developed under the auspices of the European Commission (EC) and combines with multiple legislative instruments that determine how the sector is regulated by different government bodies. EU member states are then responsible for transposing EU law within their jurisdictions, typically through dedicated ministries and regional or local governments. National governments may also choose to set more aggressive policy targets. Regional and municipal governments are key players in tightening, implementing and monitoring policy from the bottom up. Lobby groups also play a significant role in influencing decision-making in the EU's construction sector.

The European Green Deal seeks to align the European construction and real estate sectors with greenhouse gas emission reduction trajectories that are in line with the 1.5°C target set out in the Paris Agreement. While there are of course eight other planetary boundaries (see Construction [pages 40-49] and our carbon budget), climate change is currently ranked as the highest priority for focus.

This vision has been communicated through several workstreams, policies and frameworks, which are presented in Figure 23. As part of this ambition, the EC has framed a circular economy strategy, the Circular Economy Action Plan (CEAP),[97] around ambitions towards the reduction of waste, GHG emissions and material extraction.

In order to realise these ambitions, construction industry stakeholders have called for the harmonisation and standardisation of policies and for the simplification of administrative and legal processes for construction materials.

They have also expressed the need to lower risks for suppliers, investors and asset owners, reduce information gaps, increase transparency and boost R&D and the competitiveness of circular products and materials. In order to implement the CEAP, the EC has embarked on a series of revisions and the introduction of new tools. These include:

- improving the standardisation of measuring the sustainability of products and obtaining their certification (see Box XXX);
- potentially introducing recycled content requirements, or minimums per construction product (Construction Products Regulation)[98]
- revising minimum performance requirements for the energy efficiency of buildings, introducing mandatory measurements of global warming potential, as well as mandatory setting of targets (Energy Performance Directive for Buildings);
- introducing mandatory material passports and digital logbooks for buildings (see Box XXX, Data storage and tracking tools);
- Revising material recovery targets for construction and demolition waste (Waste Framework Directive)[99].

A lack of safety standards for recycled and alternative materials is a barrier for some clients or insurers to adopt them widely.

Through the revision of the Construction Products Regulation, the EU aims to address the environmental aspects of construction products and to certify the safe use of secondary materials.

The EC's circular economy ambitions are strongly tied to the wider industry-supported decarbonisation agenda.

For both, a significant funding gap still needs to be addressed. The EC estimates that in order to meet the target of a 55% reduction in greenhouse gas emissions by 2030, an additional €275 billion in annual investments will be needed to renovate and decarbonise the existing building stock. This funding will be critical to achieving the necessary emissions reductions and transitioning to a more sustainable and low-carbon economy.[100]

For a comprehensive overview of the relevant EU policy instruments, see WorldGBCs Whole Life Carbon Roadmap.[101]

Although the EU recognises the importance of transitioning to a circular economy, existing policies and regulations do not sufficiently encourage investment in circular principles. High taxes on labour ensure that the opportunity cost of its use is significantly higher than that of resources, which remain largely tax free. At the same time, the limited Extender Producer Responsibility (CPR) initiatives fail to hold manufacturers in the construction sector accountable for materials at end-of-life. It is therefore a challenge for cities and local governments to prompt the private sector, even if they have more ambitious sustainability goals than their national governments. The path to circular construction is less established and requires significant coordination, funding, capacity and regulatory flexibility, while the path to linear construction is well established. Even where circular construction has a similar cost to a linear process, lower administrative risks may still make the latter more attractive. Approximately 74% of cities and regions report a need for additional support from national governments to achieve their sustainability goals at scale.[102] To address this, the EU and national governments should implement policies and regulations that create a level playing field, making it more competitive to invest in circular projects.

Box 7

Revision of Construction Products Regulation

Currently, the main framework covering construction products in the European Union is the Construction Products Regulation (CPR). The CPR evolved from the Construction Products Directive (CPD) and aims to establish uniform rules for the CE marking of construction products in Europe. It harmonises the methods of assessment, the means of declaring product performance and the system of conformity assessment of construction products, but does not directly influence national building regulations. This flexibility allows local contexts, the market, and regulatory bodies to set their own sustainability requirements as needed. However, in jurisdictions that require additional sustainability indicators through national schemes, manufacturers of construction products must invest in both a CE marking and national certification, which can be costly and reduce the competitiveness of their products.

The evolution of the CPR reflects the need for constant review and adjustments of the regulatory frameworks in view of market transformations and the need for faster action to tackle climate change. The current revision of the CPR is an opportunity to increase not only the ambition, but also the applicability and the inclusion of innovative materials. With a focus on safety and healthier products and buildings, it is necessary to adopt schemes that promote transparency as well as methods and models that level the market for products that take all the pillars of sustainability into consideration.

Regional, national and supranational regulations (including the CPR) should be updated so they truly support a circular economy, while continuing to ensure that construction material manufacturers operate on a level playing field. The regulations need to ensure that mechanisms are available for manufacturers to prove structural and environmental performance and safety for the construction materials they produce.

The current taxation system incentivises resource use while disincentivising labour.

On one level, this is a direct incentive to maximise the use of resources and minimise the use of labour in any given construction project—a clear stimulus for linear projects over circular ones. Aside from this, one of the biggest bottlenecks for upscaling circular practices is the development of skills and affordability of labour required for activities such as disassembling and repair, which can evidently be attributed to misaligned tax incentives.

Manufacturers are not responsible for the end-of-life phase of their materials so residual value is not accurately accounted for in development projects.

Several national Extended Producer Responsibility (EPR) policies exist, but not yet at EU level for construction (see Box XXX, Extended Producer Responsibility (EPR) and the Waste Framework Directive). A sufficient EPR approach would require developers to better maintain and manage projects both during and at the end of life.

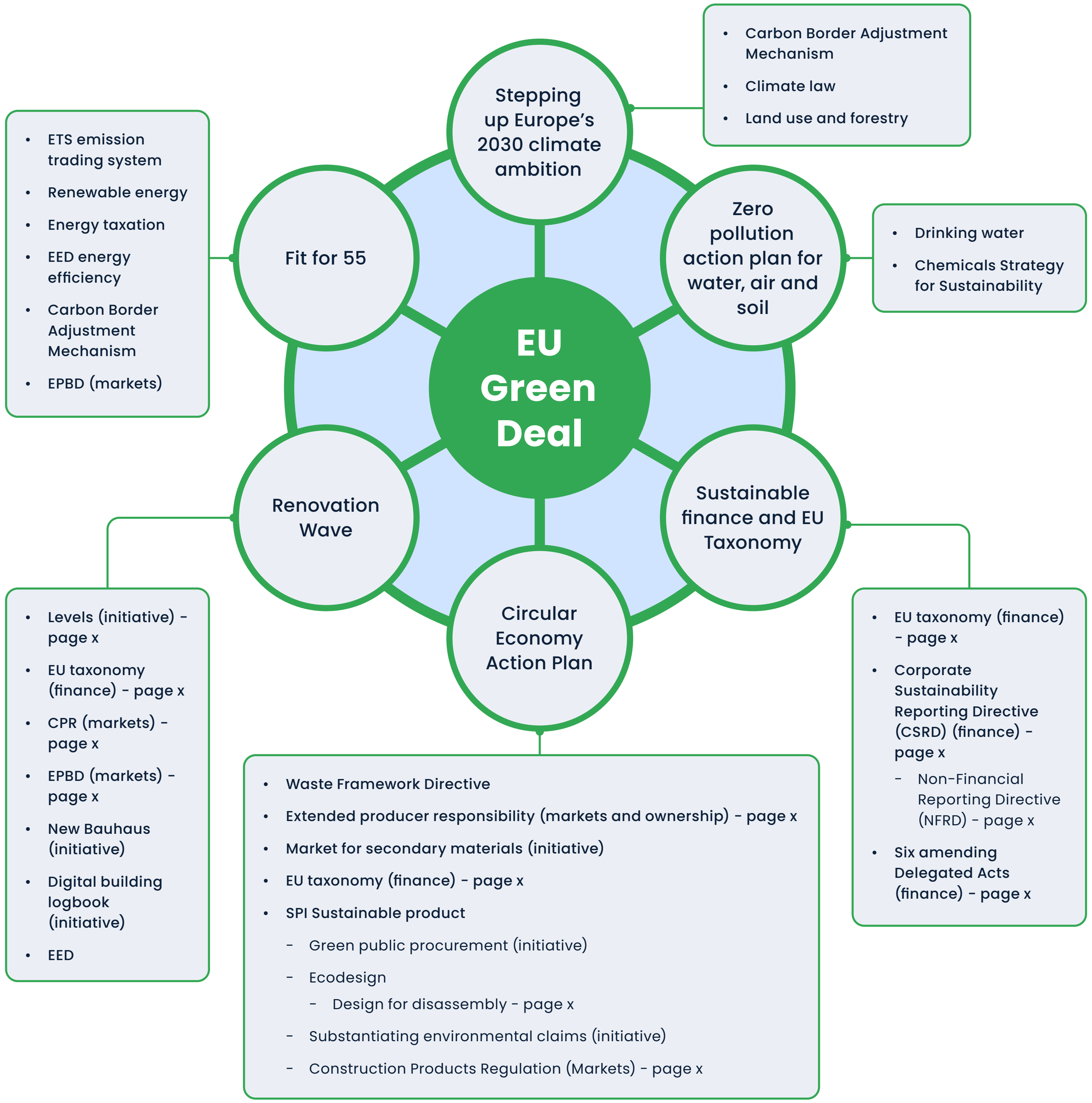


Figure 23: EU Green Deal. Adapted from www.construction-products.eu.

SYSTEMIC CHALLENGE: FINANCING BUILDINGS ALIGNED WITH CIRCULAR PRINCIPLES

Within the finance sector, there is still limited knowledge and understanding of circularity; the sector has much to learn about what circular projects are, how to fund them and how to write loans against them. Within many financial institutions that aim to invest in new builds, the application of circular principles in constructions are considered risky, expensive and complex. Funds are being channelled into promoting circular construction through public funding streams, but when private sector actors make independent decisions to develop circular buildings, they mostly need to draw on internal budgets.

As key barriers, financial institutions cite a lack of proof of viable business cases or clear and convincing asset valuations. Moreover, there is no uniform standard the circularity of a project, which complicates the identification of what counts as a circular building for an investment portfolio. Even though speculative ways exist to capture the potentially higher value of circular buildings, a lack of historical track records to validate such estimations elevates buildings with 'circular value' to a higher risk category.

If circular construction is to attract increased financial flows, it needs to offer higher value, lower risk and more transparency. Ways to increase transparency include the wide adoption of tracking tools and measurement frameworks, supported by knowledge exchange platforms that disseminate information on circular building practices.

There are ample opportunities to capture the 'circular value' of a building, for example by changing existing accounting practices to account for actual depreciation per building layer (see introduction). Other ways include capturing the salvage value of buildings and accounting for the positive externalities presented by the long-term positive social, environmental and economic impacts of buildings aligned with circular principles.

Ways to reduce risks might include various forms of blended finance, which mitigate risk and leverage financing opportunities within one fund or financial vehicle by combining concessional financing (from players investing with a philanthropic or development intention under favourable terms) and commercial funding provided by conventional financiers. This can be done through the provision of additional guarantees, or alternatively by pooling several projects and investors' resources in investment funds and vehicles to reach the right scale and diversify risk, or tokenising real estate to spread risks among a wide range of investors.

Increasing the funding for circular construction projects is critical if they are to compete with traditional, linear construction practices. The finance sector plays a significant role in all aspects of the property value chain. It has a wide range of stakeholders and markets, including public entities such as development banks and government funding sources, and private entities like banks and private investors. The finance sector's influence can be direct, for example through investment in buildings and projects, or indirect, through the financing of projects, buildings or companies, or through the risk mitigation of buildings or construction projects.

Furthermore, as the focus on sustainability grows, the finance sector is under increasing pressure to report on and account for carbon emissions and other environmental, social and governance (ESG) considerations. The process of accounting for scope 1, 2 and 3 emissions (see Box XXX, Scope 1, 2 and 3 emissions) has revealed the significant risks that the sector is facing, including transition risk due to changing policy and regulations, and adaptation risk due to a changing climate. These risks, along with shifts in market demand drivers such as occupier demand, public sector demand signals, and volatile economic conditions are causing changes in the basis of valuation and strategy for the finance sector.

While there are risks involved in the transition to a more sustainable and low-carbon economy, there are also opportunities for innovation, support and investment. The consultancy firm McKinsey has estimated that in order to meet the targets set in the Paris Agreement, global annual financing for the transition to net zero will need to increase by an additional € 3.1 trillion per year on average between 2021 and 2050.[103,104]

Box 8

Scope 1, 2 and 3 emissions

Scope 1, 2 and 3 emissions are categories used to classify and quantify the greenhouse gases (GHGs) emitted by an organisation or entity. These categories were developed by the Greenhouse Gas Protocol, an international accounting tool for GHGs.

Scope 1 emissions are direct GHG emissions from sources that are owned or controlled by the organisation. These include emissions from fuel consumption in company-owned vehicles, emissions from on-site boilers and generators and emissions from refrigeration and cooling systems.

Scope 2 emissions are indirect GHG emissions from the consumption of purchased electricity, heat or steam.

Scope 3 emissions are all other indirect GHG emissions that are a result of the activities of the organisation, but are not included in Scope 1 or 2. These include emissions resulting from business travel and from the use, disposal or recycling of the organisation's products. 'Financed emissions' also fall under scope 3, comprising any emissions that are generated as a result of investments, lending, and financial services.

Box 9

Speaking the language of the financial sector

The establishment of a common language and clear definitions is often seen as crucial to enable communication and understanding between different industries and stakeholders. A shared language can help to promote transparency, alignment, standardisation and benchmarking. The finance sector has its own particular language and terminology, and the translation of technical aspects of the built environment to this language is not always easy or unambiguous. Moreover, literature research and interviews suggest that references to 'circularity' are relatively rare within the finance sector, with terms such as 'green finance', 'sustainable finance', 'decarbonisation' and 'net zero' being mentioned more frequently.[105] In short, the application of circular concepts is still very new in the world of real estate finance and investments.

Our outreach to finance-sector stakeholders returned conflicting views on the need for a shared language. Some saw shared language and definitions as essential to creating measurements that could support standardisation and to helping incorporate circular concepts into strategies, policies and regulations. Others, some of whom were not yet familiar with the terminology, noted that some of the technical language is obscure and inaccessible on first encounter. It should be noted that this follows the same path as the introduction of the language associated with 'decarbonisation'. Some have suggested that circular concepts could be adequately described using existing language already familiar to the finance sector in order to convince stakeholders of the benefits of circularity and encourage them to adopt it.[106]

HOW CIRCULAR BUILDING PROJECTS ARE CURRENTLY FINANCED

SOME CONTRIBUTION BY CONVENTIONAL FINANCIAL PLAYERS

Little aggregate data is available to compare the financing flows allocated to buildings adopting circular principles. However, desk research and interviews with sectoral experts have revealed that the role currently played by conventional players such as private banks are as yet limited; this is one of the areas in which improvement is needed in order to bring circular principles in construction to scale. Our review charted the main sources of finance flows towards adopting circular principles in the built environment.

Public funding, with municipalities playing a crucial role.

We found that municipalities often serve as the primary funding source for circular construction projects, or play a crucial role. Interviews confirm that the public sector is the key stakeholder that drives higher expectations from the supply chain through public procurement, and has the scale to trigger wider market action. The provision of equity support for projects that adopt circular principles fosters the establishment of a circular building track record and helps to alleviate lenders' concerns regarding non-traditional construction financing. These projects often involve intermunicipal cooperation to facilitate project financing. At regional level, neighbouring municipalities pool resources to realise specific projects. Thousands of EU municipalities – and even some cities outside of the EU – have also joined the Covenant of Mayors for Climate & Energy, which is involved in initiatives aimed at promoting circular economy principles in cities and regions.[107,108]

Internal budgets to invest in circular buildings as a prestige project.

A number of financial organisations, including banks, have demonstrated circular construction in practice by constructing their own office buildings according to circular principles.[109] While this is a positive development, it appears that the same organisations may be hesitant to provide financing for external circular building projects. According to some financial institutions interviewed, the screening criteria used by financial institutions do not align with the specific characteristics and financial cycles of circular buildings, which could be a barrier to their financing. The exact nature of this mismatch requires further research.

SOME USE OF CONVENTIONAL FINANCIAL INSTRUMENTS

We have seen some use of conventional financial instruments to finance circular buildings, such as equity financing through funds, debt financing through bonds or loans, and direct investments. However, with some justification, most investors see circularity as a risk rather than an opportunity.

Blended finance is sometimes used to provide buffers and guarantees.

Blended finance mitigates risk and leverages financing opportunities within one fund or financial vehicle by combining concessional financing (from investors investing with a philanthropic or development intention under favourable terms) and commercial funding provided by conventional financiers (see Figure 24, A blended finance structure [page 78]). Although it still appears to be rare in the financing of circularity, blended finance is often cited as a solution to match investors' diverging risk profiles, incentives and appetites within one vehicle. For example, retail banks, in collaboration with national governments or the European Investment Bank, sometimes play a role in providing buffers and guarantees that lower the interest rate of 'green loans' for improvements to buildings that reduce their environmental impact or contribute to the circular economy. Our interviewees mentioned that more adapted instruments are needed to cover for the additional risks that may come with circular building.

Green mortgages and home improvement loans, providing finance under preferential terms.

Under a green mortgage, a bank or mortgage lender offers homebuyers preferential terms if they can demonstrate that the property against which they are borrowing meets certain environmental standards or will reach a certain level through renovation.[110] While these advantageous terms are often based on the energy label (A) or Energy Performance Coefficient (neutral [0] to 0.4) of the property,[111] more innovative criteria are gradually being developed and applied, such as discounted offers for the use of biobased materials.[112]

Similarly, **home improvement loans** have the potential to scale up the financing of circular building retrofits in houses. This is a debt instrument that allows homeowners to improve their environmental impact while saving energy costs through insulation and other energy efficiency improvements. Even more than with energy-related renovation, home improvements according to circular principles need to prove that they can be earned back. Several national governments provide funding for renovations and retrofitting. Some prominent examples of national public investments in energy efficiency retrofitting include those by Italy and France. The French government, for example, is providing €7 billion for energy efficiency improvements in private homes, office buildings and public buildings such as schools and town halls.

Besides meeting the sustainability commitments of financiers, financial institutions sometimes offer **discounted mortgage rates terms** for buildings with high energy efficiency because these buildings have often proved to have a reduced credit risk, and a lower probability of mortgage default.[113] This most likely relates to lower utility bills (leaving more room for lenders to repay their loans) and the increasingly higher prices that energy-efficient housing can demand on the market.[114] Buildings constructed according to principles of circularity will only receive a similar premium if they prove similar additional direct or benefits, or better compliance with rules and regulations.

Box 10

EU grant programmes for circularity

Several EU grant programmes and financing initiatives exist for circular projects or companies.[115 116] For example, existing circular building projects have benefitted from Horizon 2020 funding and the European Regional Development Fund. The European Investment Bank provides finance to circular economy projects/promoters through loans and risk-sharing instruments benefiting from EU guarantees. This is done through the Joint Initiative on Circular Economy, a partnership between the EIB and the EU's largest National promotional banks and institutions (NPBIs).[117] More novel project types with medium-to-high levels of risk may be assisted by the European Fund for Strategic Investments, InnovFin and other special financial instruments designed to handle greater risk.[118]

BARRIERS TO FINANCING CIRCULAR BUILDINGS

Even though there are a few tentative explorations of the use of existing financial instruments to finance buildings adopting circular principles, as yet, the financial sector does not broadly embrace and support circularity in the built environment. Partner research has concluded that investors identify significantly more barriers than opportunities when considering funding circular buildings.[119 120] In the sections below, we explore these barriers and challenges in more detail.

LIMITED KNOWLEDGE, LIMITED TAXONOMIES, AND LACK OF TRACK RECORD OF THE ADDED VALUE OF CIRCULAR PRINCIPLES

A challenging environment for broad innovation.

The property value chain is complex and compartmentalised, with limited interaction, communication and shared knowledge among the construction, finance and real-estate sectors.[121] Structured around linear business models, the industry perceives circularity as complex, technical and unrelated to their key performance indicators.

Limited knowledge of circularity within the building and finance sector.

Circularity, along with other sustainability topics, is not yet mainstream in education and professional training, so real-estate and finance professionals lack necessary knowledge to integrate circular principles into their day-to-day work.[122] For example, their understanding of circularity is often restricted to designing out waste, while ignoring other circular principles such as keeping products and materials in use and regenerating natural systems (see 'What is circularity in the built environment?').

Lack of track records and proof of a business case.

According to interviewees, one of the greatest barriers for the finance sector to financing circular buildings was the lack of a solid track record of business cases for such projects.[123] Despite thought leadership on this topic (such as WBCSD's Business Case for Circular Buildings),[124] there are few practical examples to show the viability of circular building business models or whether easily achievable circular principles are ready for scaling. There are a number of key aspects to this challenge:

- There is a lack of understanding about how to implement circular business models and how this impacts project assumptions, analysis, management and operations.
- There is not enough data and evidence on risk management and other core assumptions required for decision-making, raising the risk profile of circular interventions.
- Data transparency and sharing is a longstanding issue in the industry, and between progressive companies that have implemented circular buildings there is a hesitancy to share potentially sensitive data.

A need to consider all aspects of circularity in policy

Currently, the most impactful EU policies focus primarily on renovation and energy performance, with less attention paid to material use and embodied carbon. Level(s), the European framework for sustainable construction, is a step in the right direction, as it provides a more holistic approach to measuring and labelling circular buildings (see Box XXX, Level(s) Framework).[125] The labelling of circular projects will help identify projects to invest in, especially via the EU taxonomy and disclosure requirements. The technical screening criteria are still in development, and data will only start to become available in 2023, when companies and financial institutions need to report on circular economy indicators. Furthermore, as the regulatory landscape changes, businesses will require specific frameworks on which they can base change themselves.

Adjusting processes and developing new products requires significant investment, and businesses need to know that such changes will not become redundant as policy becomes increasingly stringent.

Box 11

Level(s) Framework

Level(s) is an EU non-compulsory reference method to assess and report on the whole-life sustainability of buildings. Actors across the building chain are thus informed about a building's sustainability performance, and the approach automatically links it to EU targets.[126]

Lack of circular frameworks and metrics.

Current sustainability frameworks and metrics used by investors do not sufficiently capture circularity principles, although the EU Taxonomy will change this. According to the 2020 survey by the United Nations Environment Programme Finance Initiative (UNEP FI), a lack of uniform metrics for circularity was seen as the number-one barrier preventing the scaling of circular initiatives in the finance industry.[127] There is no standardised technical assessment system to benchmark.[128] There is a recognition that the basics need to be consistent, somehow predictable and accepted by the market as a whole for the industry to push forward and accelerate the transition. This could include agreed definitions, standards and measurements/metrics to quantify the impact and feed into circular business model analysis and certification.[129] Despite efforts to achieve these industry-agreed standards, and best intentions to gain the necessary knowledge, it has become clear that the current process is moving far too slowly to achieve a timely transition.

Box 12

EU Taxonomy

The EU Taxonomy is a key part of the European Green Deal that aims to encourage the financial sector to invest in sustainable projects. The Taxonomy defines and classifies sustainable activities for the following environmental objectives: climate-change mitigation and adaptation, sustainable use and protection of water resources, transition to a circular economy, pollution prevention and control, and protection and restoration of biodiversity and ecosystems. By setting performance thresholds, investors can use the Taxonomy to identify which activities in this sector are environmentally friendly and where improvements are needed.[130]

The latest proposal for the amount of virgin materials in a building to be able to classify it as 'contributing to the transition to a circular economy' is:[131]

A. Concrete - natural or agglomerated stone: maximum 70%;

B. Brick, tile, ceramic: maximum 70%;

C. Biobased products: maximum 80%;

D. Glass, mineral insulation: maximum of 70%;

E. Non-biobased plastic: maximum 50%;

F. Metals: maximum 30%;

G. Gypsum: maximum 65%.

Box 13

Reporting directives

CSRD and the NFRD

The Non-Financial Reporting Directive (NFRD) is an EU directive that requires large companies to report on non-financial information, including their sustainability practices. The NFRD follows a 'double materiality' perspective, which means that companies are obliged to disclose information about sustainability issues that affect them and their impact on society and the environment. The Corporate Sustainability Reporting Directive (CSRD) is an amendment to the NFRD that will expand reporting requirements to include more information about companies' operations and management of social and environmental challenges. The CSRD aims to include more companies and set stricter reporting requirements, including the requirement for assurance of reports and their digitalisation.[132]

SFDR

Adopted in 2019, the Sustainable Finance Disclosure Regulation (SFDR) is intended to provide more insights into the sustainability of financial products, and applies to financial market participants and financial advisers. The regulation includes requirements for both products and company policies to ensure sustainability risks are accounted for. Ultimately, this increased transparency is aimed at reducing greenwashing and enhancing sustainability in the financial sector.[133]

STILL DEVELOPING UPDATED VALUATION AND RISK-ASSESSMENT MODELS

Mismatch between asset valuation and sustainability risk: sustainability aspects are not yet priced in.

Until now, the market has not fully reflected sustainability concepts in the valuation of the buildings as a whole, whether through the so-called 'brown discount' or through the 'green premium'. However, there is growing evidence that the market is starting to reflect a shift in the demand and policy drivers that influence property value by integrating energy transition and climate risks. An example is the Minimum Energy Efficiency Standard (MEES) in the UK, which sets minimum energy levels for domestic private rented properties.[134] Since 1 April 2018, landlords must ensure their properties have an Energy Performance Certificate (EPC) rating of E. Similar regulatory instruments should be adopted for other circular principles.

Mismatch between costs and benefits of different owners.

There is often a change of ownership at key transition points, for example when developers hand over finished buildings to the end investor, and this leads to underinvestment by the initial developer. Investments for the long term (such as in disassembly) are unlikely to be highly valued until they are valued market-wide (see 'Systemic challenge: Ownership Models').

Current focus on indefinite growth.

This means the current system does not naturally support or encourage circularity. For example, even though reduced costs are attractive to some stakeholders, investment managers have a mandate to invest in order to generate returns. Similarly, asset managers' fees are based on the size of their portfolios, so they have an incentive to increase the size of their portfolios, while in some cases it may be better for the environment not to build anything at all.

THE WAY FORWARD TO UNLOCK THE POTENTIAL OF FINANCE TOWARDS CIRCULAR BUILDINGS

With the market slowly shifting towards sustainable buildings, there are opportunities for smart investors who understand the advantages of buildings in line with sustainability principles such as lower operating and maintenance costs, lower default rates, and reduced risk of becoming unutilised and unremunerative assets.[135] Buildings with higher sustainability levels have been shown to be higher-value, lower-risk assets compared to standard structures.[136 137] However, the shift is not happening fast enough to meet Paris-aligned targets, and the introduction of circular principles is an important way to accelerate and capitalise on this momentum. The following high-level pathways offer some potential to unlock greater finance towards circular buildings.

MAKE IT MORE VALUABLE

Capturing circular value.

Accounting standards and principles were designed for the linear economy, and fail to capture the financial and non-financial added value of adopting circular principles. For example, allowing assets to be depreciated to zero fundamentally contradicts the principles of the circular economy, in which resources are meant to be used in ongoing cycles. Circular economy principles reframe waste as a resource, so previously worthless assets have a residual value. The positive externalities presented by the long-term positive social, environmental and economic impacts of circular building models should also be accounted for and included in both financial and sustainability reporting. Finally, circular approaches reduce systemic, transitional and physical climate risks, which could also be accounted for when monitoring the value of assets, for instance with alternative discount rates.

To attract investors in the circular built environment, it is crucial to showcase this additional value with innovative accounting and investment practices. Below are a few possible accounting practices to capture circular value.

Accounting for salvage value to improve solvency ratio and decrease default risk[138]

The salvage value of an asset can be calculated as the remaining value minus the dismantling costs and other costs related to reuse. Although it can be compared to the 'residual' value in linear accounting, which estimates the resale value, it differs by accounting for potential end-of-life costs. Entering the salvage value of products and materials that will remain at the end of a building's lifecycle improves the solvency ratios of a project and thus decreases the risk of default in the eyes of the financiers.[139] Aside from higher solvency, determining the salvage value of materials means that businesses may financialise and trade these materials in future contracts. As a result, building suppliers are incentivised to limit dismantling costs through innovative designs, such as modular design, to maximise the salvage value of their building. Appropriate pricing for the salvage value of building materials requires information about the applications and markets available for residual resources.[140] Circular value chains and collaboration are vital for the pooling and upcycling of different residual resources. The market dynamics of supply and demand then determine the price of these salvage materials by their usefulness in other upcycled products.

Accounting for actual depreciation per building layer to increase the value of circular buildings over time.

Linear (or straight-line) depreciation applying to a building as a whole is still the norm for long-term asset valuation. This method often obscures the true value of assets, as it assigns 'useful lives' (after which buildings are meant to be fully depreciated) of 25 to 50 years to buildings. This means that beyond this time, only a fraction of the value of buildings – or merely the value of the land – is captured in the balance sheets of property owners.

'Layered depreciation' would involve the depreciation of the building according to different building layers (see page XXX, applying circular economy principles to buildings) that have different lifespans. Such an approach is also applied in some cases, for example by housing associations. It has also been utilised by some asset owners in New Zealand between 2010 and 2020, when due to legislative changes buildings were no longer depreciable as a whole. In response, asset owners sought ways to continue to depreciate

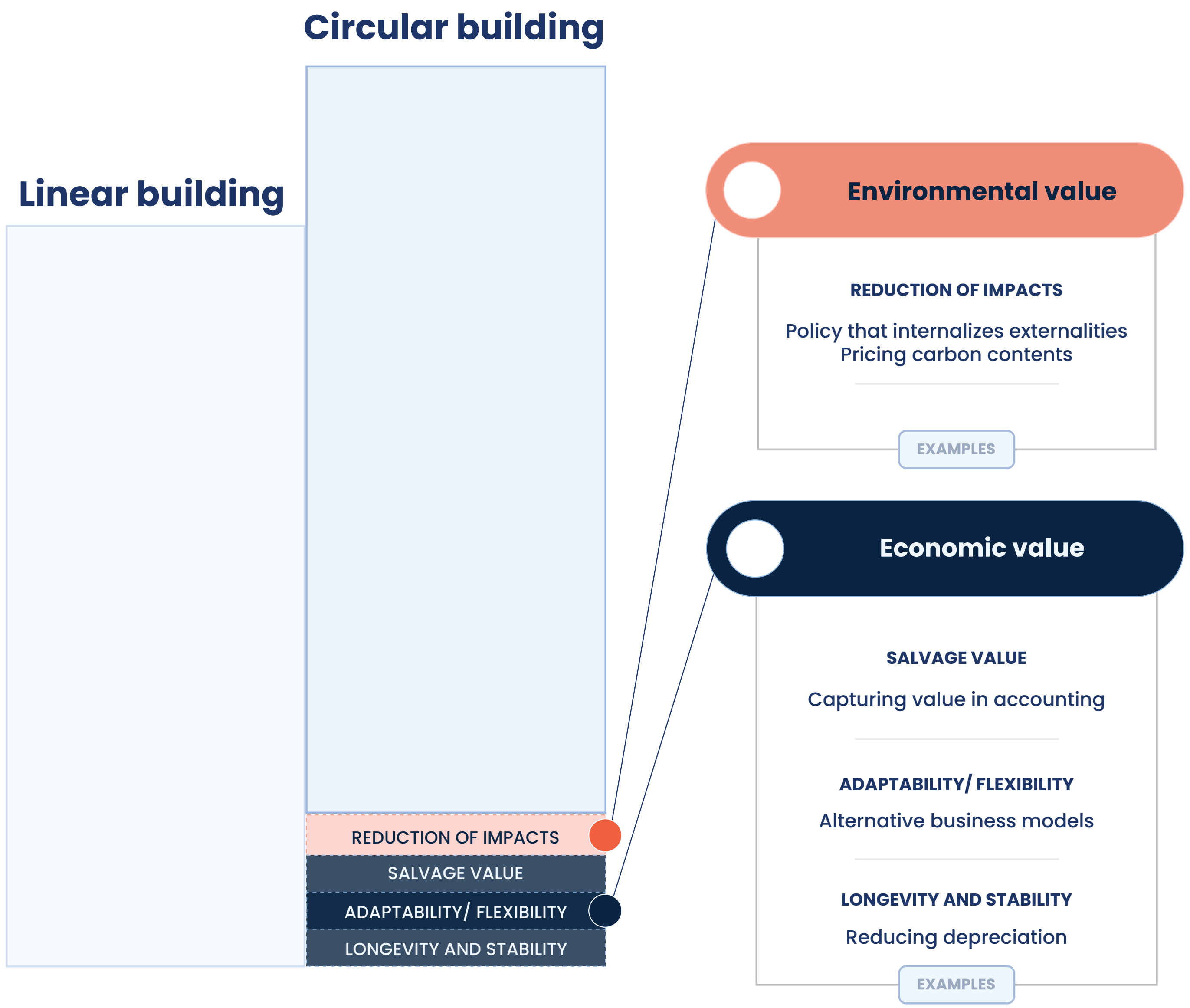


Figure XXX: Capturing Circular value

'non-building' fixtures (such as wiring or piping) for tax purposes. If layered depreciation were applied as a principle, furniture, storage or carpeting would be depreciated based on a useful life of one to five years, whereas the useful life of the hard structure of the building (which usually comes at a high value) would be extended to 100 years or more. Facades could be valued for 50 years, and the useful life of the site would be indefinite. Space plans and services such as smart energy systems could also be modelled and added to the value of a building.

From an accounting perspective, this results in a more interesting balance between assets and liabilities (solvency ratio) and lengthens the value over time of real-estate projects capturing circular value.

Accounting for all costs of an asset over its lifetime provides a more complete financial assessment.

Whole life costing (WLC) – sometimes also referred to as 'lifecycle costing' and not to be confused with whole life carbon – provides a holistic appraisal of the cost of an asset over its entire life. Besides the explicit construction costs, which are typically accounted for, WLC includes more implicit costs that eventually impact the financial viability of a project. These include maintenance, operational costs incurred while managing the facility, occupancy costs (i.e. costs that support the occupier's stay, such as security and mail room staff), end-of-life costs, non-construction costs such as land acquisition, fees, rental costs, relevant tax liabilities, and externalities such as sunk costs.[141] These costs are often not considered when evaluating real estate opportunities, and this is to the detriment of circular developments. Incorporating them could tip the scale in the favour of circular buildings, given that they are designed for ease of maintenance and to have extended lifetimes, which is likely to result in lower overall costs over the lifecycle.

Accounting for environmental impacts mitigates transition and physical risks.

In a free-market economy, market price equilibrium usually disregards the externalities of products and services. Marginal social and environmental costs need to be measured to better account for positive and negative externalities. By editing their usual assessment model (either voluntarily or in response to regulation), to price in or at least capture these environmental effects, investors can make climate-friendly products and services more attractive than their counterparts with a negative environmental impact and eventually shift market dynamics (see Box 14, Pricing in externalities in construction).

Using business models that incentivise the capture of circular value.

As well as up- and downcycling and end-of-life solutions, we also see the development of innovative ownership business models that represent additional sources of circular revenues. For example, Product-as-a-Service (PaaS) models incentivise service providers to extract more value from products and materials than they do in the linear economy (see 'Product-as-a-Service').[144] In PaaS models, suppliers become service providers: they retain ownership of the products themselves and source revenues related to their responsibility for the maintenance, repair, upgrade, repurposing and/or disposal of the products. Every additional use cycle saves replacement costs and increases profit margins per unit. As a result, service providers are incentivised to use products that were designed to be circular by default. This product innovation may also increase the salvage value of the materials – given the lower dismantling costs – and therefore may result in investors viewing circular building projects more favourably. The shift in project business models will also require novel financing structures to address the new context. In the case of PaaS, for instance, where revenue is spread across the lifetime of the asset and the asset value fluctuates with regular repair, traditional leasing arrangements that assume linear depreciation become redundant, and more innovative approaches are required, often involving multiple stakeholders.

Using carbon credits or climate dividends to improve the business case for renovations in line with circular principles.

Renovations adopting circular principles can produce carbon credits or climate dividends for the CO_2 emissions they avoid compared to a conventional building. The investor is able to account for the emissions avoided or captured. Carbon credits reward green buildings for their environmental performance, which improves their business case. For investors, carbon traded in cap-and-trade or voluntary carbon markets can be viewed as an attractive asset class with well-understood risk premium drivers.[145] Although carbon credits are still evolving as a distinct asset class, carbon markets are starting to take better form as regulators and industry groups help to codify rules around them.[146] For new builds, it is more difficult to develop carbon credits based on avoided emissions although this is an area that merits further exploration.

MAKE IT MORE TRANSPARENT

Collaboration and knowledge sharing to unlock investment.

The transition to a circular economy will require collaboration across all stakeholders that influence the value chain of products and materials. While acknowledging that data sharing can be a competition-sensitive topic, vertical and horizontal stakeholder coordination is imperative to build momentum, raise awareness, scale action and share best practices and track record required for the transition.

Digital tools to improve transparency.

Digital tools to track and store environmental data in the built environment are already improving, yet access to this data still faces obstacles. Accounting for intellectual property sensitivities is key for data to become accessible to the right parties without damaging the competitive position of companies. (See also Box XX, Data storage and tracking tools, page XX).

Box 14

Pricing in externalities in construction

Carbon budgets and internal carbon pricing

Carbon budgets can be used by organisations to decarbonise their operations and activities, whether applied at product, department or supply-chain level. Firms can allocate carbon budgets to reach company-wide net zero emissions targets and align with the 1.5°C scenario roadmap.[142]

Carbon budgets can be useful to mobilise efforts to implement internal and external changes; some companies even align employee benefits with set budgets. Usual changes may entail a focus on sustainable procurement (switching to renewable sources for internal electricity usage, for example, or altering car lease and mobility practices) but can also address emissions hotspots within the value chain. Companies may also implement an internal carbon price.[143]

Lifecycle assessment (LCA)

LCAs are used to assess the environmental impact of a product, process or service across all the stages of its life cycle. Calculations involve matching data based on the inputs needed for a product, process or service with the estimated emissions they produce, or with other impact categories such as resource depletion (clean air, water, soil). An impact score corresponding to the degree of their effect in each category is then calculated, and can be taken into consideration within innovative investment frameworks.

While assessing environmental impact should not be reduced to assessing carbon, it is one of the most urgent factors to tackle, and tools and methodologies that assess carbon emissions within the built environment are already at an advanced stage. The whole life carbon approach is a holistic assessment of the carbon emissions caused by a building project and can easily be integrated within the LCA approach.

The shadow price

An LCA impact score can be translated with a shadow price method, so that the scores are merged into a single comparable number and expressed in monetary terms: the Environmental Cost Indicator (ECI), a single-score indicator in euros. The shadow price shows the highest acceptable cost level per unit of emission control, as it unites all relevant environmental impacts. By linking weighted environmental impact category outcomes to a monetary value, the ECI enables actors to objectively assess and compare the environmental performance of different contractors. Due to their reduction in materials, energy use and emissions, circular construction projects should receive a low ECI score; this may be attractive to investors looking to make their portfolio more circular, and for investments that suffer from minimal transitional and physical climate risks.

Box 15

Data storage and tracking tools

Data storage tools are essential to track the inputs and environmental impact of construction projects efficiently, while retaining data ownership. Although many of the existing tracking tools still involve the manual entry of large quantities of data, some promising developments in this area are emerging, such as WBCSD's framework Circular Transition Indicators (CTI),[147] which focuses on circular and linear mass flows and enables the monitoring of actions toward circularity goals.

Madaster

Madaster is another online registry tool that stores data on all materials, products and services that are used in a building or infrastructure object. Businesses can create a unique material passport for a project, which shows all materials, products and services used in the project, their impact on circularity and the environment, and the potential residual value they represent.[148] It should be noted that the tool requires data owners to send data requests to other actors within the value chain; data access is therefore not open by default.

LCA Databases

The Dutch National Environmental Database Foundation (Stichting Nationale Milieu Database) is an independent environmental database that stores LCA environmental data about building materials and their processing, and determines the environmental performance of projects.[149]

Despite the barriers to openly accessing the data, the collation and processing of circularity-related data carried out by these tools is certainly a step in the right direction. The next step would be to increase access to such tools, paving the way toward true circularity. The European Commission is currently developing Digital Product Passports (DPP) as part of its Circular Economy Action Plan (CEAP). By gathering and storing product-specific information that can be electronically accessed by the relevant stakeholders in the supply chain, DPPs can help improve data tools similar to the initiatives mentioned above.[150]

Blockchain for transparency of the performance of real estate assets.

Blockchain technology can allow for more transparency regarding the environmental performance of real-estate assets. For instance, accumulated emissions can be recorded and made accessible to investors, and smart contracts can be programmed for transactions to be executed once products or materials meet a certain threshold of remanufactured material.[151] Research has shown that environmental data transparency facilitated by blockchain could increase the pace at which high-emission companies redesign their business models and supply chains to make them more circular.[152] Blockchain-facilitated data transparency can further incentivise stakeholders to employ circular practices, as seen with Coca-Cola's use of blockchain to record and reward the work of informal recycling collectors in Africa.[153] Through its ability to record material flows along the supply chain, blockchain technology could also help implement Extended Producer Responsibility schemes, whereby companies pay a fee to cover the cost of end-of-life recovery.[154] Self-executing smart contracts, for instance, could minimise free-riding behaviours by explicitly establishing the extent to which each party in the supply chain is responsible for end-of-life costs. In this way, the end-of-life burden would not fall only on ecologically responsible companies and/or end-users.[155]

Knowledge-exchange platforms to distribute and share information on circular building practices.

Various knowledge-sharing platforms, such as the European Circular Economy Stakeholder Platform (ECEP) circulate studies, reports or position papers on circular building practices.[156] They are crucial to scaling the emerging and ever-evolving circular built environment.[157] For finance specifically, such platforms can also help to initiate public-private partnerships that ideate and action methods to de-risk private investment.

Frameworks and metrics to make informed decisions.

The majority of the interviewees and partners recognise the significance of stakeholder collaboration for the development of a broadly accepted vision and agreement on circularity metrics, methods and standards. Collaboration is needed to integrate standardised circularity metrics into leading existing frameworks, such as the TCFD and the SASB (see Box 16, TCFD and SASB).[158] Investors should agree on collectively adopting a few selected frameworks and metrics that are fit-for-purpose for the business at hand. While specialised real-estate investors may benefit from using detailed circular building metrics and frameworks, many investors with a diversified portfolio may find these too complex and lack expertise in real-estate specifics. To avoid introducing a new concept with its own metrics and framework to institutional investors, circular-building principles can be integrated into existing decarbonisation or Paris Agreement alignment tools and frameworks. In this context, investors should examine the Level(s) framework closely to determine if it can be utilised in their investment decision-making process (see Box 11 [page 70], Level(s) Framework).

In developing these frameworks, caution is required.

Reporting frameworks for financial institutions do not always incentivise the right behaviours. For example, banks are not required to report changes in the energy efficiency of the real estate they are financing, and they are generally required to treat construction (including substantial renovation projects) as higher risk than loans against stabilised, income-producing buildings. Climate reporting may reward a bank for financing a brand new, low operating carbon building (regardless of whether it was built on the ruins of a perfectly serviceable building that should have been renovated and retrofitted), while disincentivising the financing of any kind of retrofit renovation (circular or otherwise). We need to scrutinise the way financial regulators focus on sustainability, not assume that they are encouraging banks and other regulated firms to deploy capital in ways that actually support sustainable investment and development.

Box 16

TCFD and SASB

The TCFD (Task Force on Climate-related Financial Disclosures) is a voluntary, standardised and internationally recognised set of recommendations on the way companies should disclose climate-related financial information to investors, lenders and insurance underwriters. The SASB (Sustainability Accounting Standards Board) is a non-profit organisation that develops and maintains industry-specific sustainability accounting standards for publicly listed companies in the United States. Both the TCFD and SASB aim to provide financial market participants with standardised, relevant and useful information about a company's sustainability performance.

MAKE IT LESS RISKY

To scale finance to circular buildings, we need to unlock new and larger flows of investment. While conventional financial instruments are available and are being used to finance circular buildings, additional risks of circular project include, for example, the expected salvage value of various building layers which will only be realised in the future.

Guarantees and insurance instruments to reduce risk.

Currently, conventional investors view investments in some circular products as risky.[159] Additional insurance products and warranties are needed to cover the risks accompanying the use of secondary materials. An example could be price guarantees for secondary materials to reduce the cost. For instance, a Contract for Difference could be employed, whereby public funds would cover the cost difference between secondary materials and virgin materials thus, making the two equally priced.

Blended finance to reduce risk and to attract and mobilise capital.

Blended finance mixes different types of investments and loans to meet the needs of investors who want different levels of risk, return, and time to invest. In this context, blended finance refers to the use of a combination of public and private financing to achieve a particular development goal. Public financial institutions can play a role here by providing the de-risking capital, instrument or mechanism. When public resources are deployed strategically, a previously unbankable project can attract and mobilise capital from commercial and institutional investors. Public or philanthropic actors could play a role and provide loan guarantees and first-loss equity tranches within blended finance vehicles to act as buffers and reduce the risk accompanying circular building projects.[160] Given the complexity of such vehicles, blended finance is conventionally more attractive to finance large-scale projects, although investment vehicles can be set up as blended products to feed into smaller projects.

Pooling smaller projects by investment funds to reach the right scale to attract mainstream finance.

To stimulate the development of new financial products that support circular building projects, there is a need for either larger project sizes or a larger volume of projects. One solution to this issue is bundling projects, which can provide the scale needed to attract investment.[161] Only a small number of investment funds currently focus on the circular economy and green building themes. These funds can help pool smaller companies and circular building projects and attract funds based on circularity criteria. However, these circular-economy-themed funds are small in size. To increase uptake within the financial industry, it may be beneficial to combine the strengths of circular economy fund management with mainstream management techniques, such as sensitivity to risk and return and the use of circularity criteria for security selection.[162]

Tokenisation of real estate to spread risks among a wide range of investor types.

A new development in the EU financial sector is the use of blockchain technology. Circular construction financing can use this development to its advantage. Converting real-estate assets into tokens makes them available to a wider group of investors, including individual or retail investors, by reducing minimum investment levels and upfront investment costs.[163] Moreover, it lowers barriers to investment, reduces transaction costs and transforms direct investment in property into indirect investment, which increases liquidity by making it tradable.[164] Tokenisation also allows for smaller investments and the opportunity to 'test' investments in circular buildings while spreading the risk among multiple investors.

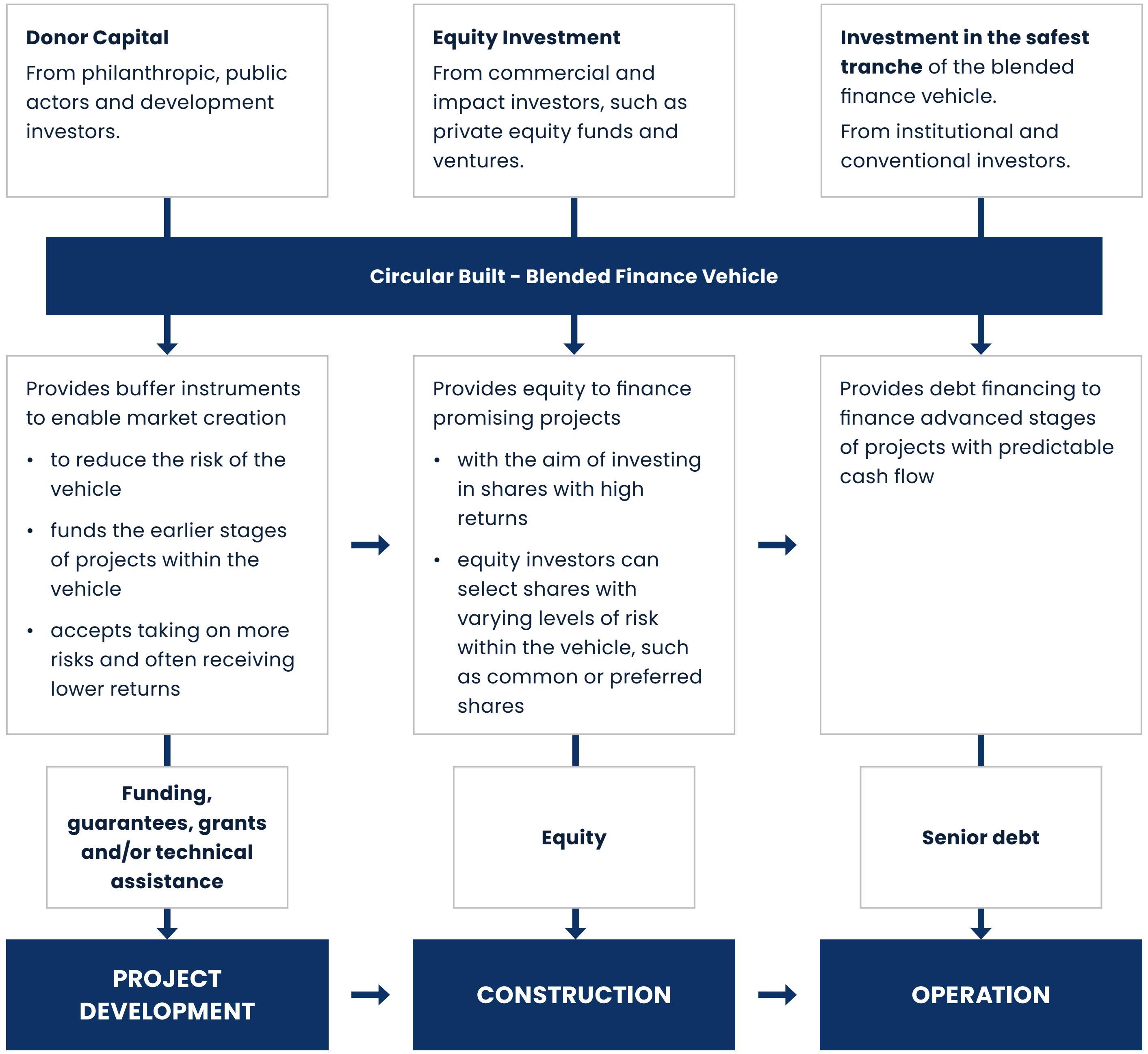


Figure 24: A blended finance structure

Crowdfunding to finance smaller projects or to be combined with other sources of financing.

Crowdfunding is considered an alternative form of financing that involves establishing relationships with a large base of people and creating widespread awareness about the project. At present, there are multiple online crowdfunding platforms that allow members to provide financial capital to circular building projects. On the platform OnePlanetCrowd, for example, the circular buildings companies Robuusteiken and Greenhuus have received funding of €600,000 each. Although these initiatives are a good way for progressive individuals to contribute to the development of a tentative track record for circular buildings, government-supported interventions will still be required to alter the approach to construction at large.

SYSTEMIC CHALLENGE: OWNERSHIP MODELS

We understand ownership in the built environment as the legal right to use, possess and sell land, buildings, building products or construction materials. The models of ownership in the built environment are intrinsically linked to the decisions made throughout the built environment, and have the potential to significantly impact the way our built environment is constructed. Furthermore, different property development models (build to sell, build to rent, owner occupier etc.) regard the ownership of design, construction, operation, asset management and end-of-life in different ways. Whoever holds ownership at both the asset and operational level has the capacity to create value financially, socially and environmentally.

In the lionshare of the construction industry, the ownership of buildings and infrastructure (and the products and materials they are made of), does not lie with the organisation that designed and developed them in the first place. This leads to a split incentive, making sustainable and circular design difficult and financially less attractive.

There are some ownership models that in themselves overcome the split incentive problem by incentivising a whole-life outlook on the building. They include creating community land trusts for land ownership, or including circular criteria in planning permission and procurement processes. Cooperative developments can soften the industry's focus on maximising returns, and open building concepts may contribute to the construction of fundamentally more flexible and reusable buildings.

In other cases, the implementation of circular economy principles to new business models, or building design strategies requires a different configuration of the ownership structures during different construction phases, for example, or of building layers. For example: Open building concepts may contribute to the construction of fundamentally more adaptable and reusable buildings, while in some cases divvying up the ownership of a building into owners of building layers. Other business models, such as Product-as-a-Service, as one of the most mature business models aligned to circular principles, reduces maintenance costs and transfers the accountability for the performance of services to service providers, guaranteeing a level of service and reducing operational risks. This business model can pose real questions as to who is the right actor (from a business perspective) or legal actor (as prescribed by prevailing rules and regulations) to own building assets, such as a facade in the case of Facade-as-a-Service.

Several barriers prevent the adoption of circular ownership models, including technical barriers, organisational complexity, established legal, insurance and taxation systems, perceived risk, and cultural preferences towards traditional ownership models. Even so, there are many ways to overcome such barriers and a move towards alternative ownership models that are more conducive to a circular economy.

OWNERSHIP IN A LINEAR SYSTEM

The holder of ownership in the built environment has, within the framework of applicable regulation, a strong influence to decide how it is designed and whether the materials within it are used, recycled, reused or landfilled.

The ownership of the built environment is closely linked to decision-making power, and those who possess assets in the various stages of a building's life (design, construction, and end-of-life) have an incentive to maximise its value during their ownership. However, maximising value in one phase (e.g. installing a low-cost, inefficient insulation during construction) may come at the expense of value in subsequent phase (e.g. operational costs and value loss during use), resulting in a loss of value in the broadest sense, both for the next owner and for society as a whole. For instance, in the ownership practices associated with the linear built environment, users of buildings have little influence over their design, development, and construction, leading to underinvestment in, among other things, performance and longevity. In consecutive building phases in which direct value can be shown to transfer, this problem is less pressing; however, there are still costs, such as environmental costs, that all owners are content to externalise. For instance, users and owners who are not invested in the building for its entire lifespan are unlikely to invest in ensuring that the building meets circular standards, unless compelled by regulation.

To achieve a circular economy, ownership models that align the incentives of builders, owners, users and society need to be adopted more widely. Such ownership and business models can facilitate a more sustainable distribution of costs and benefits across the lifespan and value chain and therefore influence the implementation of circular economy principles in the built environment. For example, if a circular principle such as 'total cost of ownership' (TCO, a measure of the cost of a project throughout its life cycle, see glossary) becomes a business consideration (for example through legislation), new business models will likely emerge that more effectively align incentives.

In this section, we will review how many 'linear qualities' are entrenched in the most common property development models in the built environment by examining four typical phases in the property development process:

Phases:

1. **Land acquisition and planning phase:** During this phase, the developer acquires land or a building, and conducts market research and feasibility studies to determine the viability of the project. Once the relevant authority grants development rights, the land is prepared for construction, which may involve clearing the site, installing infrastructure and obtaining necessary permits.
2. **Design and construction phase:** This phase involves the design and construction of the building on the land. The owners or developers work with architects, engineers, and contractors to design and construct the building.
3. **Operation and maintenance phase:** After construction is completed, the property is managed and maintained by its owner.
4. **End-of-life phase:** At the end of its technical or economic life, the building may be refurbished, renovated, demolished, deconstructed, or repurposed for other uses.

Linear valuation models are entrenched from the onset in many land development processes

Land acquisition phase: land is immobile, fixed in quantity and deeply embedded in a particular society: its location, its surrounding economy, the administrative system that governs it, and its public and private facilities. Three main drivers for increasing land value are changes in land use or planning permission, the addition of infrastructure, and an increase in market demand. A common strategy among speculative, high-risk investors is to acquire a plot of land on the assumption that either land use (and thus development rights) will change, public investments will be forthcoming, or that demand will increase to capture the land's increase in value.

Such strategies, aimed at extracting maximum profits from the exchange of land can entrench linear construction models even before any construction has taken place. Specifically, the value of the land is determined by the future market value, such that once the transaction is complete, the budgets are locked in. As a result, after land acquisition, the financial space for a property developer to invest in constructions that require more up-front investments becomes limited if these additional costs have not been accounted for.

All land acquisitions that do not price in the additional costs for circular construction in the land value will likely have a hard time in freeing up the required budget to build according to circular principles. There is a role for public authorities (e.g. municipalities) to ensure circular criteria are part of this valuation process, for example, by including circular criteria in area development or land-use planning.

How split incentives in building ownership inhibit investments in circularity

In each ensuing phase after land acquisition, split incentives may inhibit investments in building according to circular principles.

Construction phase: In most development models, during this phase there is little incentive for developers to create buildings in line with circular principles, such as adaptable buildings that are easy to disassemble. Although it is the construction client that pays for this quality, the additional value only accrues to the owner at the end of life, or become apparent as a reduced externality cost. This is referred to as the 'split incentive'. As a result, the cost of recovering reusable materials at the end of a building that was not designed for it can preclude a viable business case for material recovery. In addition, a lack of adaptability in a building's construction may result in its demolition while it is technically still sound. The same split-incentive problem occurs in some development models between designers, engineers and contractors who are responsible for executing most of the decisions regarding how the building will be constructed, but do not have a stake in the building during its use phase and at the end of its life.

Operation phase: This phase matters because it is when a significant share of a building's CO2 impact is generated. During this phase, value can be lost in some development models if owners who are able to reduce operational costs are primarily interested in reducing their capital expenditures on the building. Occupants, regardless of their ownership status, have an interest in reducing operational costs such as heating, lighting, and water usage but may not be in the position to invest in such reductions. In build-to-sell development models, for example, this can lead to underinvestment in maintainability, and in build-to-rent models, to underinvestment in climactic performance. Even though tools such as energy labels exist to overcome some of those split incentives, they are imperfect and only account for a limited set of impacts, such as climate performance, without addressing issues such as maintainability, ease of disassembly, or embodied carbon. A split incentive may even occur within the same organisation if budgets between capital expenditures and operational expenditures are not commutable.

Additionally, in the use phase, there is a risk of existing spaces not being used optimally. This can be due to commercial leases that provide consistent rents to landlords even if the building is not being used, leases that prohibit subletting, or tenants who are reluctant to share working spaces with others.

Maintenance phase: During this phase, building owners are faced with the decision to improve their asset. However, the value of renovation is not always immediately apparent; current tenants may have to endure disruptions during the renovation process and may not fully benefit from lower utility bills if their rents are raised to compensate for the improvements. Future tenants might enjoy the benefits of lower utility bills without shouldering the full cost, as their rents will be determined by the market rather than the historical capital expenditures. Moreover, they will have avoided the inconvenience caused by the renovation process. For the landlord, the benefit of having a better building depends on how the market values it in the future – and building circularity and performance may not be the main factor driving value.

Given the complexity, disruption, and uncertainty associated with the renovation process, landlords, tenants, and owner-occupiers may be hesitant to invest in circularity-focused improvements. Owner-occupiers will likely prioritise convenience, practicality, and their own financial preferences over the building's long-term sustainability or financial value. As a result, opportunities to enhance the building's circularity and sustainability through renovations are frequently not seen as an option, leading to suboptimal use of the building's potential and a higher environmental impact.

End-of-life phase: At this point, ownership of the materials and components of the building typically transfers to a renovation or demolition company, which disposes of the construction material and pays treatment or disposal fees dependent on the material type. Demolition and investment decisions are commonly based on the building's economic life (the time period over which assets are depreciated to zero on company balance sheets) and opportunity cost (unlocking the income generation potential of the site) rather than the building's technical life (the time period that a building and its structural materials could last), leading to an accelerated onset of the end-of-life phase.

When there are different owners in the life phase of buildings, the creation of long-lasting products is not incentivised

Building materials, construction products, and building services offer relatively novel opportunities for the implementation of innovative ownership models in the built environment. Alongside other strategies, these assets provide granular chances to apply new ownership models. The classic split incentives that were once present for safety criteria, such as fire resistance, are also applicable to circular product properties. For example, without regulation, cost-minimising incentives during the design phase tend to encourage designs that can be produced in large quantities while minimising production costs, prioritising cost-efficiency over qualities that are essential for a circular economy, such as durability, quality, and the potential for disassembly and reuse. During the construction phase of a building, without further regulation, there is little motivation for the owners to keep installation records or select products that can be easily disassembled in the future. And in the use phase of a product, replacement may be cheaper and more convenient than repair, even though product repairs may retain more value for society at large.

STRATEGIES AND ALTERNATIVE OWNERSHIP MODELS TO ADDRESS SPLIT INCENTIVES

As the preceding chapters have made clear, policy and regulation are necessary to ensure linear approaches no longer go unchecked. From a market perspective, this will likely result in the adoption of alternative ownership models that can factor in these costs while still demonstrating their economic viability. However, to accelerate the transition once the regulatory incentives are in place, parallel exploration, evolution and support of strategies and ownership models that adhere to circular principles will be essential.

Tools and strategies to overcome split incentives

There are many possible strategies to address split-incentive problems in the building industry. For example, to address the problem of underinvestment in building performance improvements, approaches include financial innovations in the form of special loan schemes (for example 'Green Mortgages', as co-developed by the Romania Green Building Council),[168] or the establishment of energy service companies (ESCOs) that arrange financing and earn their revenue based on energy saved.[169] Strategies to increase investments towards other circular principles, however, such as increasing reuse and repairability, are less mature, even though we see increasing interest and adoption. Examples include:

- Open Building Design: According to these principles building components are divided into layers (or levels) that have different functions and life cycles, giving flexibility for independent disassembly, flexibility and repair. The ownership, and thereby control and responsibility, is distributed according to the level of various stakeholders, from producer to user, offering forms of co-ownership and co-making. One example is the Superlofts building in Amsterdam, which has a flexible and open framework that allows for a change of use and for elements to be swapped in and out.[170] For example, while the structure will likely remain the same, the facade can be updated in cycles of 25 years, while the interior and heating, ventilation and air conditioning systems may be replaced every five years with relative ease. Designing flexible floorplans is therefore a key part of this concept.

  This design and construction strategy can reduce the impact of split incentives; for example, if in the construction phase, contractors used poorly performing materials, these can now be changed more easily and at lower costs. It can also enable the implementation of services aligned with circular principles, such as Product-as-a-Service (see 'Product-as-a-Service').

- Disassembly scores and the tracking of materials in material passports: A disassembly score is a dimensionless scoring of the deconstruction potential of a building. This can include factors such as ease of recovery, ease of reuse and ease of recycling.[171] Buildings designed with Open Building Design principles would be expected to have high disassembly scores. Material passports in the construction industry are digital documents that track the lifecycle of a building material, from its production to its disposal. They provide detailed information about the material, including its origin, properties and performance characteristics, as well as its environmental impacts and sustainability credentials. In a circular future with well-functioning markets for secondary materials, complemented by policies that financially incentivise reuse of materials, buildings that can be disassembled more easily and whose products are well documented using material passports should be more valuable. This can reduce the impact of the split incentive problem by incentivising owners in the construction phase to invest in material passports and to design buildings for disassembly.

Box 17

Considerations for a large-scale uptake of the Open Building Design concept

Commercial buildings, office buildings, healthcare and educational facilities and retail buildings are common examples of building typologies built using Open Building Design principles. Applying the concept to residential buildings on a large scale requires attention to the following areas:

- Feasibility of the distributed ownership model for large-scale commercial developments.
- Examination of the total cost of ownership (TCO) of Open Buildings to understand and demonstrate the financial benefits to building owners and their tenants.
- Dedicated suppliers or manufacturers for interior fit-outs, depending on the demand for customisation.
- Development of building standards for the interface between the permanent and changeable parts of the building's mechanical system.
- A mindset shift from builders, inhabitants and designers to create acceptance in the sector.

Creating space for investments through alternative land and building ownership models.

Most business models aim to maximise profits at their specific point in the building value chain. This does not necessarily need to run against circular principles. For example, if legal and policy instruments ensure that costs to the environment are not externalised, or a level playing field is ensured through tendering processes, a profit maximisation motive may move in tandem with ambitions to shift to a circular economy. However, in the current legal and policy environment in most countries in the EU, profit-maximising motives leave little room for circular investments in buildings that may not directly improve returns. The following not-for-profit business ownership models remove this motive and instead act as stewards of the asset:

- **Community land trusts (CLTs)** are non-profit organisations that function as landowners (shared equity ownership) as well as land stewards that encourage equity and sustainability while maintaining local ownership.[172] As the ownership of the land remains in the hands of the CLT, it is relatively well protected from market volatility. The CLTs can determine the usage of the land and can ensure affordable long term housing, turning the land and buildings into urban commons. By preventing financialisation of building assets, CLTs can free up capital for investment solutions more aligned with circular principles. Owners of the housing built on the land enter into a long-term lease agreement with the CLT. The land can be managed by the CLT, community residents or government officials, or a combination of the three, through public-private partnerships. Foreclosure rates for land trusts have been as much as 90 percent lower than for conventional home mortgages, because homeowners are not overextended.
- **Housing cooperatives** own housing rented by their individual members. In limited equity cooperatives, assets and surplus value stay within the cooperative. By design, housing cooperatives aim to meet the needs of members while ensuring long-term value through shared resources, and are thus incentivised to consider the total cost of ownership (TCO), in line with circular principles. Cooperatives can thus function as political agents for a sustainable, circular and affordable housing market.[173 174] An example of such a cooperative housing project is the Co-Operate initiative in Amsterdam, aimed at creating an inclusive, shared and circular neighbourhood with affordable housing built on land owned by the community land trust CLT H-Buurt.[175 176]

Incentivising longer-lasting, more often reused and better maintainable products.

Alternative ownership models and business practices for construction products can create a more collaborative and enduring link between product manufacturers and product owners (in some cases even eliminating the separation between them) in order to increase the manufacturer's stake in the performance, longevity and potential for product disassembly. There are several models, regulations and policies that can facilitate this, including:

- **Product-as-a-Service (PaaS):** The provider of the service retains the ownership of the product and the user takes a subscription to access a certain performance of the product, thereby incentivising the service provider to reuse or re-purpose their products (see 'Product-as-a-Service'). The model has the most potential for performance-based services.[177 178] In recent years, asset owners and providers have been exploring use cases for PaaS in a growing number of building sectors (see Box XXX, Everything-as-a-Service).
- **Extended Producer Responsibility (EPR):** The producer's responsibility for a product, material or service is extended to the stage of a product's end of life cycle model. Due to the long lifespan of buildings, implementation of extended producer responsibility is rather complex, as the provider of the material or product may no longer exist at the time of deconstruction. In addition, tracking materials across various use phases is difficult, although with a combination of technologies such as blockchain and Building Information Modelling (BIM) this challenge can be overcome (see Box XXX, Extended Producer Responsibility (EPR) and the Waste Framework Directive).[179]
- **Life extension through functional guarantees:** Products are given a lifetime warranty to ensure they are used according to their original purpose for as long as possible through maintenance, repair and refurbishment by the manufacturer.[180] Unlike PaaS models, in which the service provider retains ownership of the product, here the customer/user owns the product.
- **Buy-back programmes:** Manufacturers and producers are able to reclaim building materials, products and services. Such programmes have already been widely applied for electronic equipment. In the construction industry, buy-back programmes are slowly emerging. For example, the Swedish engineering group Sandvik has implemented a buy-back programme for high-alloy steel, and the mineral wool manufacturing company Rockwool offers a take-back system for their insulation products. At the end of one lifecycle, the ownership of the building materials products and services returns to the original manufacturer or producer.[181 182]

Box 18

Considerations for a large-scale uptake of the Open Building Design concept

EPR was first implemented through an amendment of the EU's Waste Framework Directive on electrical waste and electronic equipment (2012/19/EU), and covers the equipment itself as well as packaging, batteries and vehicles.[183] Functioning as a connective instrument between legislation and policy, EPR follows the polluter pays principle. Producers, rather than consumers or public entities, are responsible for financing and organising the production, maintenance facilitation and disposal of electronics.

This approach internalises environmental externalities and nurtures circular waste management, as producers are incentivised to take repair, disassembly and recycling into account during design and production. Successful results have led to amendments to the 2012 Waste Framework Directive, tightening the minimal requirements for EPR as well as broadening the products to which the EPR approach applies. To date, the European Commission has not proposed EPR for the construction industry.[184] This might be due to the complexity of buildings, the longevity of their components and their many different products and owners. However, through the use of digital technologies like Building Information Modelling (BIM) or material passports, the complexity might be more manageable, and EPR for building products could be introduced.[185]

Box 19

Everything-as-a-Service in buildings

Across the construction industry, we note the emergence of 'product service systems' across a wide range of domains. This has also been called 'Everything-as-a-Service' (X-as-a-Service or XaaS). In these models, producers typically maintain product ownership and lifecycle responsibility and are consequently incentivised towards adopting circular economy strategies. Combined, these services promote a shift to a 'performance economy' in which the emphasis is on maximising the value and utility of products and services.[186] Of the capabilities required of buildings, very many can be transformed into services. Possibilities include:

- **Space/Office-as-a-Service**, providing flexibility for organisational growth and functional change. Examples include companies such as Oxxer, Regus, Spaces, Tribes, Seats2Meet, WeWork and HNK, as well as more local initiatives such as B. Amsterdam, Spring House and Microlab. These parties redevelop obsolete and often vacant offices into workplaces with new energy, entrepreneurship and creativity.
- **Heating-as-a-Service, Cooling-as-a-Service or Light-as-a-Service**, providing traditional building operations. Examples include Philips and the Finnish company Valtavalo, which both provide lighting as a service.
- **White Goods-as-a-Service or Kitchens-as-a-Service**, providing food preparation and cleaning areas. More generally, this can fall under the heading of Appliance-as-a-Service, as for example provided by Electrolux.[187]
- **Facade-as-a-Service**, providing protection from wind and weather by transforming major building components into service.

RESIDENTIAL OWNERSHIP: A MAJOR IMPACT AREA

The 'residential building' impact category is by far the largest, as it makes up 75% of total floor space in the EU.[188]

Here, the tenure status of occupiers in privately owned houses has a great impact on what obstacles are relevant, and what circularity strategies would be impactful. For example, while owner-occupiers have a stake in increasing the energy efficiency of their building, private owners that do not occupy their building are not liable for its operational cost and will tend to reduce investments in building improvements if they do not directly yield a return.

In many EU regions, access to finance is a more important obstacle to extending building life and energy efficiency than are split incentives.

On average, almost 70% of all EU residents live in owner-occupied property, with stark regional differences – in EU member states such as Romania, Slovakia, Croatia, Lithuania, Portugal and Italy, the proportion is more than 90%.[189] Innovations to increase access to finance are more important drivers for building improvements than are tools to address split incentives.[190] On the other side of the spectrum, countries such as Germany, Austria and Denmark stand out; in these countries, around half of the population rent their homes, and may experience split-incentives as an obstacle.

The impact and specific design of financing instruments (such as mortgages) to invest in circular buildings or green building improvements will likely differ in Europe.

EU data shows a wide divergence in the ways owners have acquired their buildings. For example, in Romania and Croatia, 94% and 84% of the population respectively have no mortgage or loan. In Western European countries where owner-occupancy is much less common (principally in the Netherlands and Ireland), owner-occupiers mostly purchase their homes using a mortgage or loan. In Denmark only about 10% of the homeowning population does not have a mortgage or loan.

Residential buildings typically have a longer lifespan than commercial buildings, which means that building improvements are particularly important for this category.[191]

Such improvements can have a significant impact on operational costs over the building's lifespan. Parties interested in design for disassembly for these buildings need to utilise instruments that allow them to operate on a much longer time-horizon – and with more uncertainty. On the other hand, non-residential buildings have a shorter lifespan on average and can typically be written off at higher depreciation rates. For example, in New Zealand, commercial constructions have a depreciation life of 50 years, while residential buildings cannot be depreciated at all.[192] Therefore, commercial constructions, flexibility in design and a focus on disassembly are more relevant. Incorporating modular construction, movable walls, and adaptable mechanical systems can also ensure that these buildings can be easily repurposed and reconfigured as needed.

Non-private ownership of residential buildings comprises a limited part of the building stock.

These are buildings for which split incentives can inhibit investments; the stewardship of these buildings needs to be directed, by law or by mandate, to the public good or for the well-being of its inhabitants in order for it to take action towards building improvements. Again, here the picture differs significantly across the EU. Although there are wide differences across the EU, social housing still accounts for around a quarter of the total housing stock in some countries, including Austria (24%), the Netherlands (29%) and Denmark (21%). Some countries, including Germany (3%) and Greece (0%), have little or no social housing sector, although they may support affordable housing using other means, such as rent caps.[193] However, not all social housing is publicly owned, as Europe-wide liberalisation drives in the last two decades have privatised much of the social housing stock.[194] In the Netherlands, for example, social housing is now almost entirely in private hands, owned by housing corporations, although these are still heavily regulated by the government.

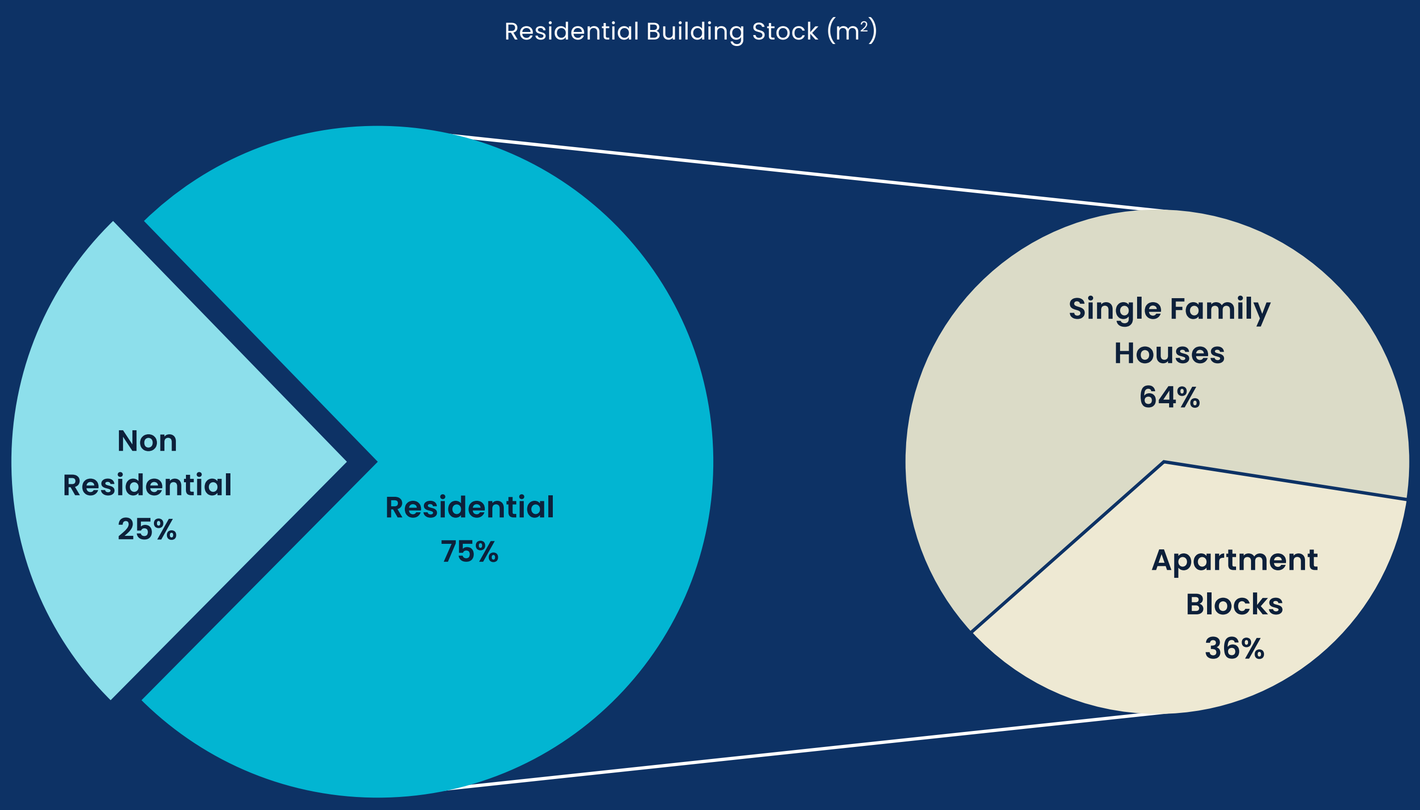


Figure 27: Floor space and population in major regions, floor space per building type

Source: adapted from BPIE (2011). Europe's Buildings under the Microscope

BARRIERS TO THE ADOPTION OF ALTERNATIVE OWNERSHIP MODELS

In the previous chapter, we explored the different phases of ownership in the built environment and the ways in which ownership can influence its circularity. Not all models are necessarily easy to adopt, and various barriers impede the scaling of some models to a level at which they would have a significant impact.

Legal, policy and financing challenges

A wide range of legal obstacles can hinder the adoption of circular business models.

For example, estate law in some countries can pose a barrier to a circular economy when it legally defines fixed objects (such as windows and doors) as a part of the building, and the ownership of the objects is thereby accredited to the owner of the building (see Box XXX, Products as fixtures). This poses a problem when trying to implement Product-as-a-Service models. Superficies agreements or other legal arrangements that permit one party to use and develop the surface of another party's property can be applied to facilitate PaaS models.[195 196 197] These arrangements can be useful in implementing PaaS models by allowing for the use of physical assets without ownership.

Another example of lagging legal and policy definitions throwing up obstacles is the case of housing cooperatives.

In many places these are not yet perceived as viable investment partners, and this reduces their access to finance (see 'How circular building projects are currently financed'). Furthermore, as yet there is no recognition and formalisation of collective-driven models at EU level, which is essential to establish linkages to EU agendas (housing, urban planning, circular economy and climate change) and tap into associated funding streams.[198]

Individual ownership takes precedence over the collective stewardship of resources.

Specific implementations of EU property laws that allow everyone the right to 'use, dispose of, and bequeath of his or her lawfully acquired possessions' are sometimes unaligned with circular economy principles.[199] For example, a building owner has no obligation to facilitate the reuse of building materials when demolishing a building, while this could have a great environmental benefit for society at large. Although mechanisms exist to suspend some rights where this is in the public interest, environmental sustainability is generally neglected in this context.[200]

Collective-driven models face legal and regulatory challenges, inhibiting their adoption.

Collective-driven models take property out of the financialised profit-maximisation 'rat race', and are often mandated to satisfy both the interest of the property's inhabitants and the public good. Currently, on average, 5% of the building stock is managed through models that are not strictly public or private, such as community land trusts, housing associations or cooperatives. Cooperative ownership models already represent a significant proportion of the housing market in some European countries, such as Poland (19%) and Sweden (17%)[201]. Others, such as Spain (6%) and Portugal have much smaller shares owing to different legal or cultural contexts.

Certain ownership models that aim to provide positive social impact, such as community land trusts (CLTs), can encounter challenges with existing tax systems that do not account for their unique nature.

In many cases, estate taxes are calculated based on the market value of the land, which doesn't align with the restricted resale value imposed by CLTs to maintain affordability. Consequently, the tax burden on CLTs might be disproportionately high relative to the actual value of the house for the owners, considering the resale limitations.[202] As another example, in the UK, value-added tax (VAT) is levied at a zero rate for new construction, while repair, maintenance and refurbishment of existing buildings attract 20% VAT, discouraging stewardship of the existing building and promoting new builds.[203]

Box 20

Products as 'fixtures'

One legal barrier that complicates the adoption of circular-ownership models is rooted in laws regulating legal and economic ownership. In many legal systems in the EU, the products attached to a building are considered fixtures, and therefore legally part of the building. This legal and physical binding may complicate the reuse or recycling ('multi-cyclical behaviour') by tenants of different building elements, from facades to windows, at different rates.[204] A comparative scan of ownership rights in three EU member states based on the available information yields the following:

- Netherlands: Economic ownership follows legal ownership.[205] Any new building element added to a rental property by the user is automatically transferred to the owner of the building.
- Belgium: Legal ownership follows economic ownership. The user or the tenant retains the ownership of any new elements added to the rented property and the elements can be removed after the expiry of the rental contract. The ownership can be transferred to the building owner only through appropriate financial compensation.
- France: There is a legal provision for the opportunity to reclaim ownership of building components after demolition, provided they are registered through the appropriate legal channels.

Standardisation and coordination challenges

The approach of tracking materials through material passports encounters a number of obstacles.

In the Netherlands, Switzerland, Belgium and Norway, a material passport service is provided by Madaster, which offers digital documents containing information on all parts of a building. Another commercial organisation that provides this service is the German company Building Material Scout, which so far has documented more than 100 construction projects. Challenges that material passports face include:[206]

- Lack of a unified approach: if many different types of material passports are developed, exchanging data between them could be difficult;
- Difficulty in keeping data in the material passports up to date;
- Concerns about privacy and security.

Finally, to ensure that data will still be relevant and processable at the time of demolition, a highly standardised approach is needed to track products and materials using digital material passports.

Perceived risk of alternative ownership models

Alternative ownership models can seem complex when first introduced. They may result in the involvement of a large number of stakeholders, for example, as different building products and materials can have different owners. Managing long-term assets and agreements will require changes to structures and processes that are fixed around linear business models across phases and stakeholder groups. A real willingness is needed from businesses and other asset owners to explore new structures and processes to manage long-term assets.

ENABLING BUSINESS MODELS TO BUILD IN LINE WITH CIRCULAR PRINCIPLES

National governments should consider revising property tax regimes in favour of green and circular construction.[207]

In a future in which investments in the circularity of a building leads to an increase in the value of the property, measures should be taken to ensure the owners do not face an increased tax bill. Reform options include tax exemptions for green buildings, as well as reductions and rebates.[208] A progressive property tax could support the accomplishment of environmental objectives, such as carbon reductions, while also reducing inequality.[209]

Local governments should consider the inclusion of circular criteria in land use in planning frameworks.

This can be a way to reduce land values of vacant land on the speculative market, creating financial space for building developers to pay for buildings aligned with circular principles. Another example would be allocating space to cooperative developments in urban plans, reducing the high capital costs of land acquisition for such projects.[210]

The private sector, with public support and guidance, should continue the alignment of data standards and data storage.

Furthermore, the transfer of ownership of the material passport needs to be well organised to ensure data is not lost. One of the initiatives that could lead to a more unified approach is the recently announced Digital Product Passport (DPP). In a proposal for an Ecodesign for Sustainable Products Regulation (ESPR), the EC announced the DPP as a key regulatory element to enhance the traceability of products and their components. DPPs could also be applied or be complementary to the Environmental Product Declaration (EPD) and Building Information Modelling (BIM) in the construction sector, because these are already used by architects and designers.[211]

Stakeholders throughout the value chain should continue innovating in technologies and design strategies that allow buildings to be divided into building layers more easily.

Examples of such innovative approaches included open building concepts or design-for-disassembly principles that enable materials, products and services with different life cycles to be serviced, owned and replaced separately.

PRODUCT-AS-A-SERVICE

Product-as-a-Service (PaaS) is a business model in which a company provides a product to customers on a subscription basis, rather than selling the product outright. This model can incentivise producers to design durable, high-performance systems, and it aligns business success with positive environmental outcomes. As such, PaaS can both be an important tool for a transition towards a circular economy and a way to create value for businesses.

PaaS offers four notable advantages:

Longevity and stability

PaaS offers long-term and more stable client relationships. For users, it shifts capital expenditures to operational expenditures, reducing the need for a large initial cash outlay. Furthermore, maintenance costs and activities shift to service providers, creating a guaranteed level of service and reducing operational risks, allowing users to focus on their business activities. As a more predictable model, it can help companies and customers reduce exposure to changing prices for goods, materials and services.

Focus on outcome

PaaS offers the service provider commercial incentives and the scale to invest in systems that help users make their consumption more efficient. Examples include close monitoring with sensors to track the performance of a facade, the creation of monitoring dashboards to give better insights into consumption, or the use of machine learning to predict the need for maintenance.

Supplier risk and profit opportunities

	Point of Sale	Hire Purchase Agreement	Leasing	Performance Contracting	Product-as-a-Service
Ownership transferred to user	✓	✓			
Regular fee paid by user		✓	✓	✓	✓
Payment for meeting key performance indicators				✓	✓
Maintenance and operational costs managed by service provider					✓

Table 6: Differences between PaaS and other models for the supply of products. Source: Literature review and expert interviews.

Better operational performance

PaaS models align the search for value with the search for efficiency, giving an incentive to implement the performing technologies for as long as possible, and thus leading to a reduction in overall operational costs. Furthermore, as the PaaS provider maintains a longer relationship with the product manufacturer, it can give direct feedback on the performance of the system and play a role in improving its design.

Better utilisation and recovery of materials

As the ownership of the product is maintained by the PaaS provider, this incentivises the provider to invest in – or demand from manufacturers – upgradeable, repairable products. It also incentivises the provider to reuse a product for different purposes ('cascading use'), or to disassemble the materials and reuse or sell the product's components at the end of its life.

		Longevity and Stability	Outcome Focused	Operational Performance	Material Recovery
		Lifespan with reasonable investment period (30-50 Yrs) High volume-to-value ratio	Ability to monitor direct impact of performance High rate of obsolescence	Use phase consumes resources (energy, water, materials) Requires regular maintenance and repair	Potential residual value Does not compromise functional completeness
Stuff	M-H	Medium	High	Mid-High	Mid-High
Space Plan	M	Mid-High	Mid-High	Low	Medium
Services	H	High	High	High	High
Structure	M	Mid-High	Low	Medium	Mid-High
Skin	M-H	High	Low-Medium	Mid-High	Mid-High
Site	L	Low	Low	Low	Low

Table 7: Suitability of PaaS for different building layers.
Source: Literature review and expert interviews

In the building sector, PaaS models are most suitable for products with a lifespan within a reasonable investment period (30-50 years), and a high volume-to-value ratio. For PaaS to be most effective, it should also be possible to monitor the direct impact performance (including consumption of resources), and the rate at which products usually need to be replaced ('obsolescence rate') or maintained should be high. PaaS has the most potential for products for which performance can be measured, such as mechanical and electrical installations, which have one of the largest impacts in buildings rated to their weight.

Another benefit of PaaS is that it enables greater access to operational resources for businesses that have tighter cash flows and that may struggle to cover large upfront costs. By requiring lessees to pay for an asset for as long as they use it, the operating leasing model leads to more consistent, evenly distributed and flexible cash flows. As balloon payments and purchasing assets outright become rare, costs are spread out over a longer period, thus narrowing the discrepancy between monthly revenue and expenditure. By including weekly or monthly operating lease payments in the cash flow statement, companies can better predict future cash flows and hence be better equipped to assess the feasibility of other future expenditure.

Some challenges for widespread adoption remain.

For example, contracts and agreements are currently not designed with PaaS in mind. Standardised legal frameworks need to be developed to establish trust and confidence in new ownership models for the relationships between suppliers of services and customers, and for issues such as foreclosure, liability and termination clauses. Furthermore, new governance arrangements, such as portfolio-wide contract management, accounting procedures, and more collaborative approaches among actors in product ecosystems will need to be adopted.

There are huge opportunities for the implementation of PaaS models in the different construction sectors.

For privately-owned residential buildings, whether they be occupied by the owner or rented out, current PaaS models address items such as furniture or kitchen appliances, but other parts of the buildings, such as heating services could be explored. Here, PaaS support could potentially be extended through mortgages. For social housing, budgeting may need to be changed to allow for total expenditure accounting to implement PaaS. For the public sector, leaders may need to be educated about PaaS models, followed by changes in public procurement processes and an increase in their capacity to manage PaaS contracts. For the private sector, the attractiveness of PaaS will depend on the development model of the asset owner. Important enablers in this respect are the creation of appealing investment packages and clarity on legal challenges (for example, making it clear that PaaS will not block the sale of the asset). Creating space for facility managers to have a voice in construction teams is also an important enabler.

Example: Facade-as-a-service

A Facade-as-a-Service (FaaS) provider retains ownership of the asset, the facade, which is provided to a client as a service. The service provider is responsible for the facade, its performance and its maintenance. This service model incentivises the provider to develop a sustainable, future-proof facade, while taking into account technological innovation and adaptability in the design phase. The facade will be better maintained and can be optimised during its lifespan, and will therefore last longer. Standardisation and modularity of facade components ensure that the parts can be easily adapted or replaced. At the end of the facade's life, the materials can be recycled; this is already taken into account in the design and choice of technology and materials.

In some cases, FaaS requires novel contract structures, for example through combining rental and service agreements to bypass accession, a legal event in which a smaller, in itself independent physical object becomes part of a larger physical object, and thus problematic for FaaS providers. In this new structure, the legal ownership will lie with the owner(s) of the building, but the economic ownership will stay with the service provider, who retains the right to take back the product. This contractual structure does not solve the accession problem as such, but bypasses the issue altogether. In some cases, the facade builders (service providers, contractor and manufacturer) create a special purpose vehicle (Facade Service Company or FSC) to prevent the balance sheet extension by transferring economic ownership to the FSC.

FaaS models promote early cooperation between the developer, construction company, architect and the service providers. The property owners receive high quality services from the facade supplier and are relieved of the responsibility for maintenance. This reinforces the trust factor for the customer. Benefits include:

1. **Cost savings.** The high residual value may positively influence the production costs and the periodic payment, which ultimately results in a more attractive proposition for the customer. Secondly, the residual value can potentially serve as security for financing.
2. **Possibility for a discount.** The monthly service fee may be reduced if maintenance costs are lower thanks to careful use of the facade.

However, there are also some limitations:

1. Due to the novelty of this rental/service structure, financiers have trouble translating it into adequate risk models. Financial regulators should also be included in the assessment and recognition of this structure in order to support a broad implementation.
2. It is difficult to estimate the value of a modular facade after a certain number of years of use. The future residual value strongly depends on demand and the existence of markets for materials to facilitate trade. The inclusion of residual value in the balance sheet of the facade builder is therefore to some extent speculative.
3. Where in traditional models, buildings are financed by an asset as mortgage security, the situation here is more complicated. Facade builders have argued that guarantees should come from contracts, sustainability, high residual value and the security of the property owners associations rather than from the facade as an asset. There is no policy framework yet to assess this type of application. In addition, financial institutions find it hard to determine the appropriate risk and return model for this product.

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This report examines the obstacles to accelerating the circular transition that are faced by the European construction industry, and what can be done to overcome them. It is a collaborative research effort by the Circular Buildings Coalition (CBC), which has been set up to coordinate built-environment stakeholders working towards this transition. The CBC is an initiative of Metabolic, Circle Economy, World Green Building Council, World Business Council for Sustainable Development and the Ellen MacArthur Foundation in collaboration with Arup, funded by the Laudes Foundation. The report is based on extensive consultations with industry leaders on the circular economy from the construction and finance sectors.

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