CIRCULARITY ACCELERATOR

THE CIRCULAR BUILT ENVIRONMENT PLAYBOOK

WORLD GREEN BUILDING COUNCIL

About the World Green Building Council

The World Green Building Council (WorldGBC) is the largest and most influential local-regional-global action network, leading the transformation to sustainable and decarbonised built environments for everyone, everywhere.

Together, with 75+ Green Building Councils and industry partners from all around the world, we are driving systemic changes to:

- Address whole life carbon emissions of existing and new buildings
- Enable resilient, healthy, equitable and inclusive places
- Secure regenerative, resource efficient and waste-free infrastructure

We work with businesses, organisations and governments to deliver on the ambitions of the Paris Agreement and UN Global Goals for Sustainable Development (SDGs).

Find out more **www.worldgbc.org**

WorldGBC's Circularity Accelerator is kindly supported by:

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CEO Foreword

In the natural world nothing goes to waste. It is undeniable that humans, with our current linear systems which extract, transform, use and waste materials, are causing immeasurable damage to ourselves and to the planet.

The use and waste of materials and products is trending in a dangerously unsustainable direction. Our homes, localities and infrastructure cover less than 2% of the earth's surface, yet our cities consume almost half the resources extracted globally[1]. Current estimates calculate that the world is only 7.2% circular, and continually overshooting planetary boundaries[2].

A circular economy is an essential part of the sustainability solution. All governments and the building and construction sector must prioritise the massive material and waste footprint of our current linear system and embrace a circular transition that leverages social value for all. The transition to a circular economy within the built environment brings opportunities to decouple economic growth from carbon emissions and could yield up to US $4.5 trillion in economic benefits between today and 2030[3].

Through the Circular Built Environment Playbook, we hope to make the complex principles of the circular economy easy to understand for every actor in the built environment value chain. We have mapped out more than 20 strategies of implementing circular design, construction and operation for the built environment, illustrated with best practice case studies from all over the world. We hope this will be an invaluable resource to guide the much needed system change from linear to circular.

I would like to thank our Circularity Accelerator programme partners and Green Building Councils whose shared ambition and collaboration has brought this important resource to fruition. Their innovation and case studies, which form the basis of this report, demonstrate that together we can close material loops in the built environment and drive the transition to a more sustainable future. We hope that the launch of this report will accelerate change within the built environment and demonstrate the urgency to scale sustainable solutions, now, and shape a future and circular economy that we are proud to live in.

Cristina Gamboa
CEO, World Green Building Council

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Executive Summary

Why a circular economy?

Globally, our linear take-make-waste systems are putting us on track to environmental, social and economic disaster, with the use of materials and products trending in a dangerously unsustainable direction – 2023 estimates predict the world is only 7.2% circular[4] (a reduction from 8.6% in 2020 and 9.1% in 2018)[5]. Today, high-income countries are generating more than one-third of the world's waste, yet they only account for 16% of the world's population. In lower-income countries an estimated 93% of waste is illegally dumped[6], and by 2050 waste generation in Sub-Saharan Africa is expected to more than triple from current levels[7].

An estimated 2 billion tonnes of municipal solid waste was generated in 2016, and in 2050, this number is expected to grow by 70% globally to 3.4 billion tonnes[8]. In 2022, a year's worth of biological resources were used in just seven months, which means the equivalent of 1.75 planet Earths would be required to supply this level of demand per year[9]. Today, five of the nine key 'planetary boundaries' that measure environmental health across land, water and air have been broken[10].

Today's efforts to combat climate change have focused predominantly on the critical role of renewable energy and energy-efficiency measures within the built environment; these measures would address 55% of emissions from the sector. However, meeting climate targets will also require tackling and prioritising the remaining 45% of emissions associated with the things we make, including building materials[11].

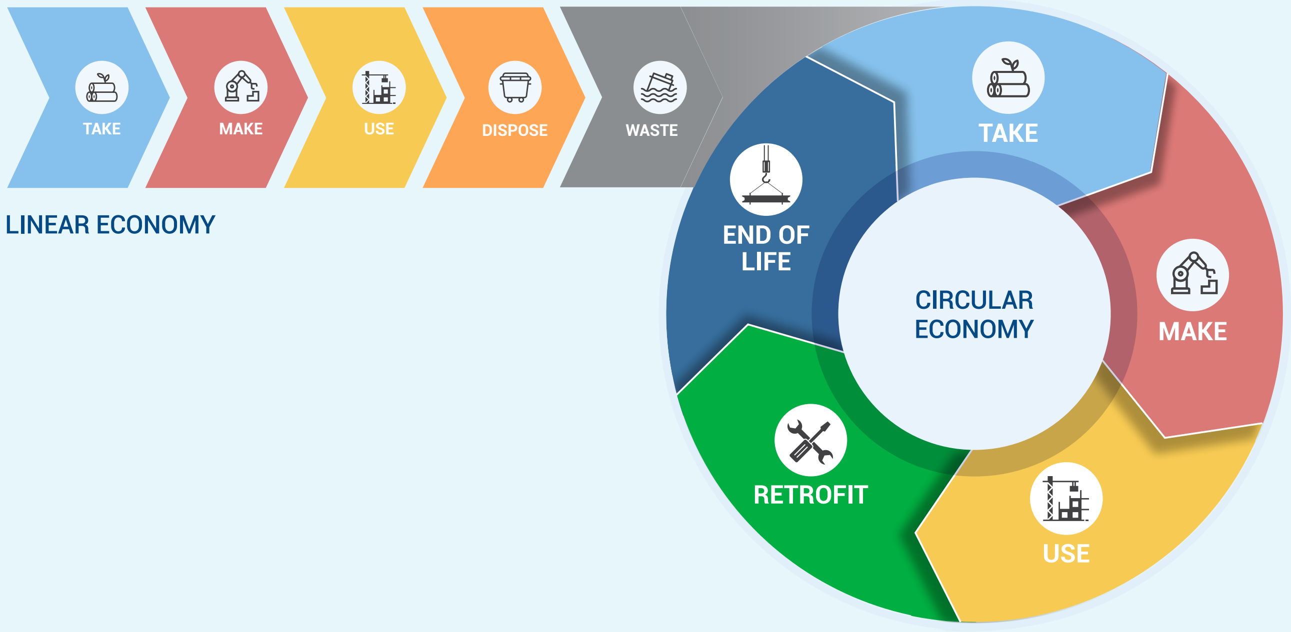
The path to a better future is clear – a circular economy is an essential part of the sustainability solution.

Through the publication of **The Circular Built Environment Playbook**, the WorldGBC network aspires to increase awareness and accessibility of circular economy solutions, by guiding all stakeholders within the built environment value chain towards sustainable, circular decision-making.

Through this work our global network is driving action towards our guiding goals for resource efficiency and circularity; **"A built environment that facilitates the regeneration of resources and natural systems, whilst providing socio-economic benefits through a circular economy."**

Image Credit: Patrick Ward

The Fundamental Principles of a Circular Economy



A Definition for a Circular Building is:

A circular building optimises the use of resources whilst minimising waste throughout its whole lifecycle. The building's design, operation and deconstruction maximise value over time using:

- Durable products and services made of secondary, non-toxic, sustainably sourced, or renewable, reusable or recyclable materials
- Space efficiency over time through shared occupancy, flexibility and adaptability
- Longevity, resilience, durability, easy maintenance and reparability
- Disassembly, reuse or recycling of embedded material, components and systems
- Lifecycle assessment (LCA), lifecycle costing (LCC) and readily available digital information (such as building material passports)[12].

WBCSD (2021) The business case for circular buildings: *Exploring the economic, environmental and social value*

The core principles of a circular economy for the built environment are:

- **Reduction in consumption of materials and resources**
- **Optimisation of lifespan for material and product use**
- **Design for disassembly, reuse and recycling, and the elimination of all waste**
- **Regeneration of nature.**

The strategies underpinning these themes through all building stages are examined in detail throughout this report.

Tackling these sustainability issues will require a systemic transformation across the entire built asset value chain. The principles of a circular economy must be implemented at all building scales and across all geographies and regions, whilst being applicable to assets of all typologies, both new and existing buildings and infrastructure

Call to Action

All stakeholders in the built environmental value chain have a role to play in enabling circular solutions at scale. Circular design and construction offers extensive environmental opportunities and socio-economic benefits if the appropriate design and construction strategies are implemented. In practical terms, it requires all stakeholders including investors, clients, developers and design teams to take a longer-term view, considering the past, present and future use of a building's products and parts.

Leadership from both private and public sector actors will be essential in guiding the large-scale circular economy transition. **WorldGBC calls all actors from across the value chain to embrace the necessary actions to become 'circular-ready' as the necessary market conditions are put into place to create a thriving regenerative economy operating in alignment with planetary boundaries.**

More detail in the measures that practitioners can take to implement the calls to action can be found in the **checklist**.

For more information on WorldGBC's Circularity Accelerator global programme, please visit worldgbc.org/circularity-accelerator

WorldGBC's global network of Green Building Councils are committed to driving a sustainable built environment for everyone, everywhere — by convening industry, knowledge dissemination, developing best practice standards and certification tools across different markets, and driving national and international policy change.

For more information please reach out to your local **Green Building Council**.

01 Introduction

In this report, WorldGBC examines the circular economy in the built environment, recognising its essential role in tackling the global climate and biodiversity crises, regenerating resources and accelerating socio-economic development.

We are living in a period of environmental breakdown: a climate emergency, mass biodiversity loss, pollution and extinction, the over-utilisation of natural resources and a global waste crisis. There are an increasing number of complex global risks accelerating our planet's breakdown, and it is undeniable that our current linear systems which extract, transform and use materials are causing immeasurable damage to the planet and its people.

This report presents an overview of circular economy strategies for the built environment, and features market leadership and solutions from across the WorldGBC global network. The case study evidence in this publication showcases existing solutions that could be implemented at scale. Through this report, WorldGBC demonstrates strategies that will help the built environment transition towards a closed-loop system, and calls for mass-market collaboration to make our circular economy aspirations business as usual for all built assets.

1.1 Global Context

Building operations and the materials used in the construction of buildings are estimated to account for around 37% of global CO_2 emissions[15].

Our homes, localities and infrastructure cover less than 2% of the earth's surface, yet our cities produce an estimated 70% of all global greenhouse gas emissions[13] and consume almost half the resources extracted globally[14]. Once a city is built, its physical form and land-use patterns can be locked in for generations, leading to unsustainable sprawl. Projections suggest this trend is only accelerating, with estimates stating that 68% of the world's population will live in cities by 2050. Today, the expansion of urban land consumption outpaces population growth by as much as 50%, which is expected to add 1.2 million km² of new urban built-up area to the world by 2030[16].

High-income countries are generating more than one-third of the world's waste, yet they only account for 16% of the world's population. In lower-income countries an estimated 93% of waste is illegally dumped, and by 2050 waste generation in Sub-Saharan Africa is expected to more than triple from current levels. **An estimated 2 billion tonnes of municipal solid waste was generated in 2016, and in 2050, this number is expected to grow to 3.4 billion tonnes[19] – that represents an increase of 70%.**

The transition to a circular economy within the built environment will bring together resource efficiency and opportunities to decouple economic growth from carbon emissions. **Globally, the circular economy could yield up to US $4.5 trillion in economic benefits between today and 2030. In Europe alone it is estimated that a transition to a circular economy could generate a net economic gain of €1.8 trillion per year, this represents a potential 7% increase in the region's GDP[20].**

Image Credit: Dave Herring

The way we currently utilise resources in the built environment is unsustainable for three core reasons:

1. Depletion of finite resources:

The Earth does not have an infinite supply of the resources on which we have built global economies, particularly fossil fuels, heavy metals, soil and water. **We operate in a world where more than 90% of all materials extracted and used are wasted.** Between COP21 in Paris and COP26 in Glasgow, the global economy consumed 70% more raw materials than the Earth could safely replenish[21].

2. Greenhouse gas emissions accelerating climate change:

The emissions resulting from the way buildings and materials are produced, used and disposed of, are causing unprecedented climate change and environmental damage.

3. Inequities and human rights challenges:

The building and construction sector employs at least 7% of people worldwide[12]. However the socio-economic structures surrounding the extraction, trade, construction and use of these materials are unjust. Forced labour and inequality at all stages of the supply chain must be tackled. **We must address 'embodied injustice' alongside embodied carbon emissions.**

Our Network's Guiding Goals

The World Green Building Council global network's guiding goals for a circular, resource-efficient built environment is:

A built environment that facilitates the regeneration of resources and natural systems, whilst providing socio-economic benefit through a circular economy.

2030 Goal:

The sustainable management and efficient use of natural resources within the built environment, achieving zero waste to landfill targets and working towards a built environment with net zero whole life resource depletion.

2050 Goal:

A built environment with net zero whole life resource depletion, working towards the restoration of resources and natural systems within a thriving circular economy.

Find out more: WorldGBC's 'Circularity Accelerator' Global Programme

02

The Fundamental Principles of a Circular Economy

2.1 A Circular Economy for the Built Environment

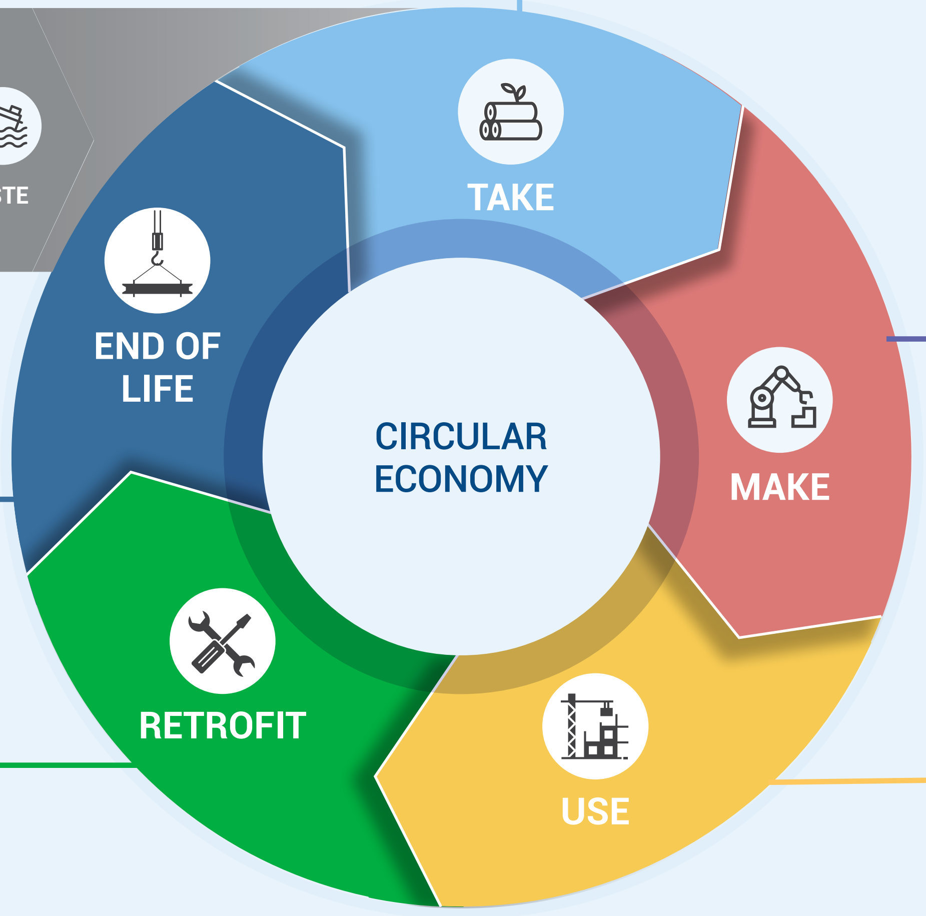
Circularity has become a popular word in recent years, but the truth is that buildings have been circular for millennia.

Urban mining, buildings as material banks, and design for disassembly may sound like new ideas, but in fact, people have been reusing and repurposing building materials and products throughout history. It's only in our relatively recent history that we've overlooked some of these building principles and begun to inflict severe environmental damage. Today the circular use of materials and products is not trending in the right direction – 2023 estimates calculate the world is only 7.2% circular[13] (a reduction from 8.6% circular in 2020 and 9.1% circular in 2018)[14].

What is a Circular Economy?

Unlike linear economic models - in which resources are disposed of at end of initial functional use - a circular economy optimises the use of resources whilst minimising waste throughout its whole lifecycle. In the built environment, these stages are:

LINEAR ECONOMY



At **MANUFACTURING** stage, make use of local, alternative and reused materials (particularly those deconstructed from existing buildings or assets), prioritising the use of renewable energy sources and operating with efficient use of natural resources, such as water.

At **DESIGN** stage, prioritise energy efficiency, make use of passive design strategies, prioritise renewable energy generation and utilisation, facilitate water harvesting and regeneration of nature, and prioritise use of locally sourced, reused or alternative materials. Design for ease of maintenance, disassembly and deconstruction and ensure non-toxic material choices to allow future reuse and circulation.

At **CONSTRUCTION** phase, low embodied carbon construction processes are utilised — such as modular construction — and higher performance standards are implemented around construction waste. The use of sustainable materials and products is a priority through all decision making processes.

During the **OPERATIONAL** phase, buildings are well maintained — enabling a longer life of assets and their parts. Waste creation is minimised, and natural capital is restored and protected on site.

Throughout the operational life of a building, maintenance and adaptability allows for the extended lifespan of an asset. At the **RETROFIT** stage all assets are retrofitted according to higher sustainability performance standards. Reuse is prioritised over demolition, with preference for alternative, renewable, reused or recycled material use for asset renovations.

At end-of-life stage, prioritise full disassembly and **DECONSTRUCTION** to allow for reuse of all building materials, products and components. Demolition and sending building components to landfill should be avoided.

Globally, there are numerous definitions of a circular economy being utilised across all sectors. A few of the most prominent and widely used definitions include:

"An industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems, and business models."

The World Economic Forum

"The circular economy is a new and inclusive economic paradigm that aims to minimise pollution and waste, extend product lifecycles, and enable broad sharing of physical and natural assets. It strives for a competitive economy that creates green and decent jobs and keeps resource use within planetary boundaries."

UNECE's Economic Cooperation and Trade Division (ECTD)

"The circular economy refers to an industrial economy that is restorative by intention; aims to rely on renewable energy; minimises, tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design."

Ellen MacArthur Foundation

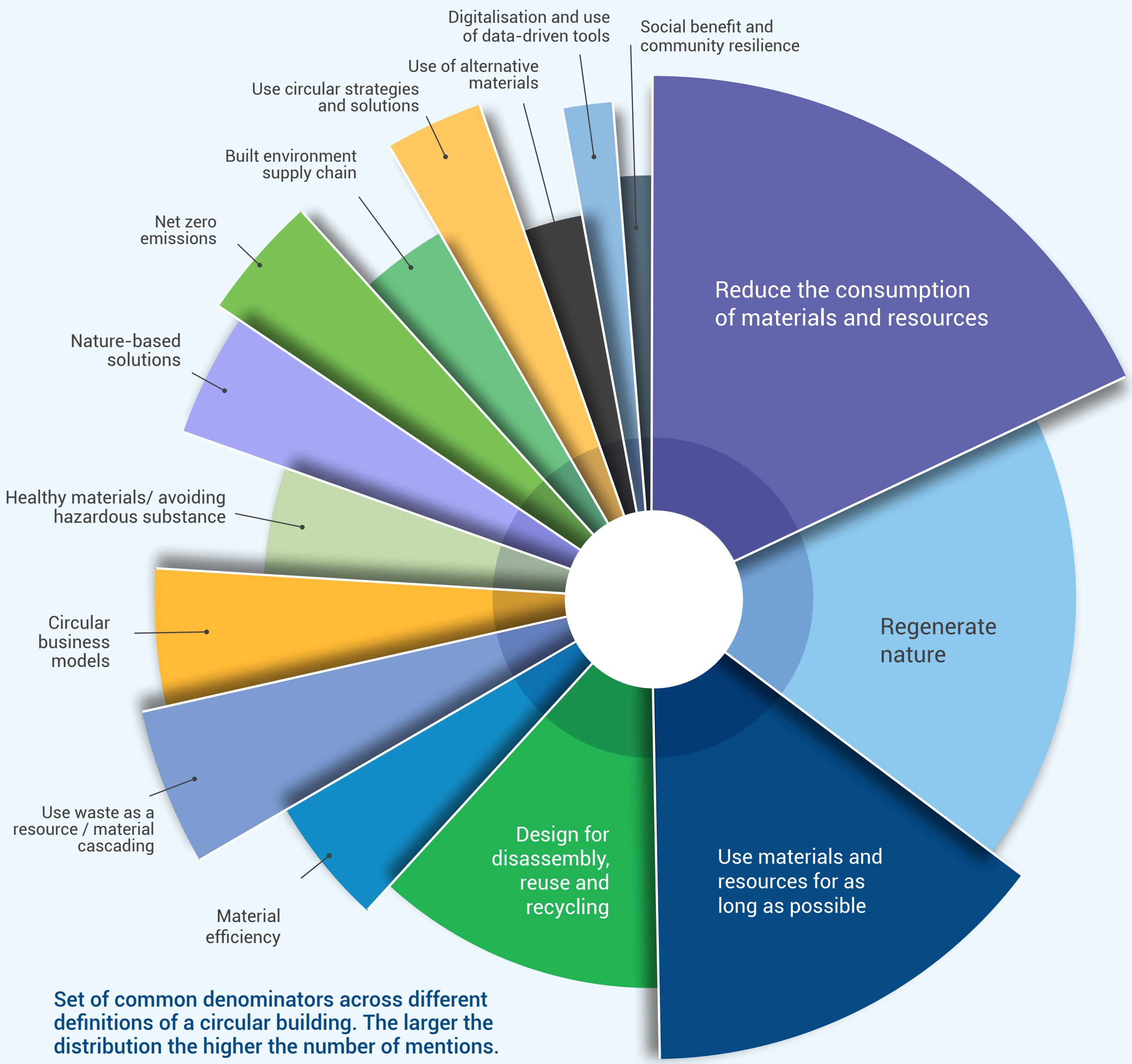
A Definition for a Circular Building is:

"A circular building optimises the use of resources whilst minimising waste throughout its whole lifecycle. The building's design, operation and deconstruction maximise value over time using:

- Durable products and services made of secondary, non-toxic, sustainably sourced, or renewable, reusable or recyclable material
- Space efficiency over time through shared occupancy, flexibility and adaptability
- Longevity, resilience, durability, easy maintenance and reparability
- Disassembly, reuse or recycling of embedded material, components and systems
- Lifecycle assessment (LCA), lifecycle costing (LCC) and readily available digital information (such as building material passports)[22]."

Despite the challenge of multiple definitions in use, there are clear overlaps between different definitions, frameworks and academic literature in circulation today. Across numerous publications a common set of 'core' circular economy principles emerge. For the purpose of providing clarity and overview in this document, an analysis of prominent sources from within the built environment has been conducted.

Analysis of Circular Economy Definitions



Set of common denominators across different definitions of a circular building. The larger the distribution the higher the number of mentions.

Based on WorldGBC's market analysis the most common themes and core principles of a circular economy in the built environment can be summarised as follows:

- **Reduction in consumption of materials and resources**
- **Optimisation of lifespan for material and product use**
- **Design for disassembly, reuse and recycling, and the elimination of all waste**
- **Regeneration of nature.**

Within the context of the built environment, the core principles of the circular economy must be implemented at all scales:

- Product, building, neighbourhood, infrastructure, city and system
- All geographies and regions; and applicable to buildings of all typologies, encompassing new and retrofitted buildings.

The design and construction strategies underpinning these themes are examined in detail in the subsequent sections of this report.

Sources:
ARUP, BAMB, C40, Circle Economy, CIRCuIT, DGNB, Chatham House, EEA, Ellen MacArthur Foundation, GBCA, GBCItalia, Haupt et al (2017), Hobson (2016), Metabolic, Moreau et al (2017), NorwegianGBC, OECD, PACE, PBL, PolishGBC, Ramboll, Singh and Ordonez (2016), SITRA, WBCSD, WEF, World Bank, WRI, UKGBC, UNECE

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2.2
Creating a Circular Value Chain in the Built Environment

All stakeholders across the built environment value chain have a role to play in enabling circular solutions at scale.

Addressing existing gaps in education and skills development will be crucial, as the circular economy is a concept that requires all stakeholders to think and act differently. Transitioning to a fully circular economy within the built environment will require urgent and large-scale action from all parts of society, particularly supported by both regulatory enforcement from the public sector and leadership of the private sector.

The call to action and key outcomes for the **Circular Built Environment Playbook** report can be analysed in detail within the industry-specific WorldGBC **'Circular-Ready Checklist.'**

WorldGBC calls all actors from across the value chain to embrace the necessary actions to become 'circular-ready' as the necessary market conditions are put into place to create a thriving regenerative economy operating in alignment with planetary boundaries.

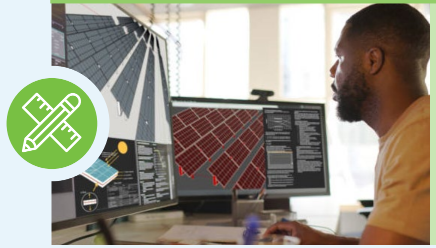
DEVELOPERS AND INVESTORS:

Set circular economy requirements as part of ESG and sustainability strategy. Mandate use of lifecycle assessments alongside digital modelling to guide planning and decision-making, including allowances for use of alternative materials where possible.

MANUFACTURERS AND SUPPLIERS:

Consider and target the use of alternative materials, prioritising reused materials and exploring product take-back business models. Start collecting and disclosing data to stimulate market transparency and create a ripple effect across the supply chain.

DESIGNERS:



Prioritise the implementation of key circularity principles through design and retrofit, such as adaptability, disassembly and for-nature generation. Specify materials with passports and EPDs, including the use of alternative and reused materials, to stimulate the market for secondary and bio-based materials.

CONTRACTORS:

Construct assets that are able to be adapted, maintained and disassembled. Implement sustainable procurement practices that prioritise locally sourced materials, with low embodied carbon, no hazardous substances and storage, over-ordering, and supplier take back schemes. Develop a plan to minimise construction waste.

ASSET OWNER/OCCUPIERS, USERS AND MANAGERS:

Innovate practices to utilise sharing business models, and champion adaptation of assets to other use types. Protect and enhance nature and natural resources on-site. Develop a plan to minimise operational waste generation and disposal to landfill.

DECONSTRUCTION:

At the end of asset functional use, take back all materials and facilitate reuse / repair / recycling to keep products and materials in extended useful life and avoid demolition waste. Where products or materials can't be repurposed, employ material cascading hierarchy to downcycle materials for further functional use.

POLICY MAKERS:

Policy makers can enable and facilitate the implementation of circular design principles through appropriate regulatory change that incentivises the use of circular services and products.

The Circular Built Environment

A circular built environment will require action at every stage of the building and construction lifecycle.

1. MANUFACTURING

Materials are manufactured locally using local skills and resources. Focus is placed on reducing all emissions and waste, using alternative, bio-based and renewable materials and reducing the dependence on mining and manufacturing of new materials. Manufacturers provide material passports for products, assemblies and fabricated elements which align with best practice guidelines and rethink business models to use less materials or adopting product take-back schemes.

2. DESIGN

Holistic circular design approach makes use of passive design, renewable energy, water harvesting and local materials to mitigate emissions and allow for regeneration of natural resources. Designing for operational needs is considered upfront, focusing on the multi-use of spaces, design for flexibility, adaptability, disassembly and longer lifecycles. All materials including alternative, bio-based and renewable materials are sustainably sourced and procured.

3. CONSTRUCTION

Buildings are constructed to higher sustainability performance standards and modular elements in construction are used, making buildings easier to repair and maintain, disassemble and relocate or refurbish for reuse. Construction waste is eradicated as far as possible, whilst supporting improved quality and timelines for construction.

4. OPERATION

Buildings are resource efficient and well maintained, enabling a longer life of buildings and their parts while reducing all waste and carbon emissions. Technology is used to enhance operational efficiency, and all materials that are part of existing assets are considered resources for the buildings of tomorrow. Building facilities are shared and contribute to the resilience of communities.

7. REUSE AND RECYCLING

End-of-life considerations are part of the full design process enabling opportunities for reuse and recycling. The value of recovered building products is fully understood, and upcycling opportunities are available. Buildings are deconstructed and the materials are reused again and again.

6. DECONSTRUCTION

End-of-life considerations are part of the full design process enabling opportunities for disassembly and deconstruction. The value of recovered building products is fully understood, whereby buildings are deconstructed and building products are reused again and again.

5. RETROFIT

All assets are retrofitted according to higher sustainability performance standards. Reuse is prioritised over demolition, and disassembly and deconstruction are a part of standard building practices. The majority of materials are locally sourced and procured which supports the economic resilience of the local community.

2.3 Measuring Circularity in the Built Environment

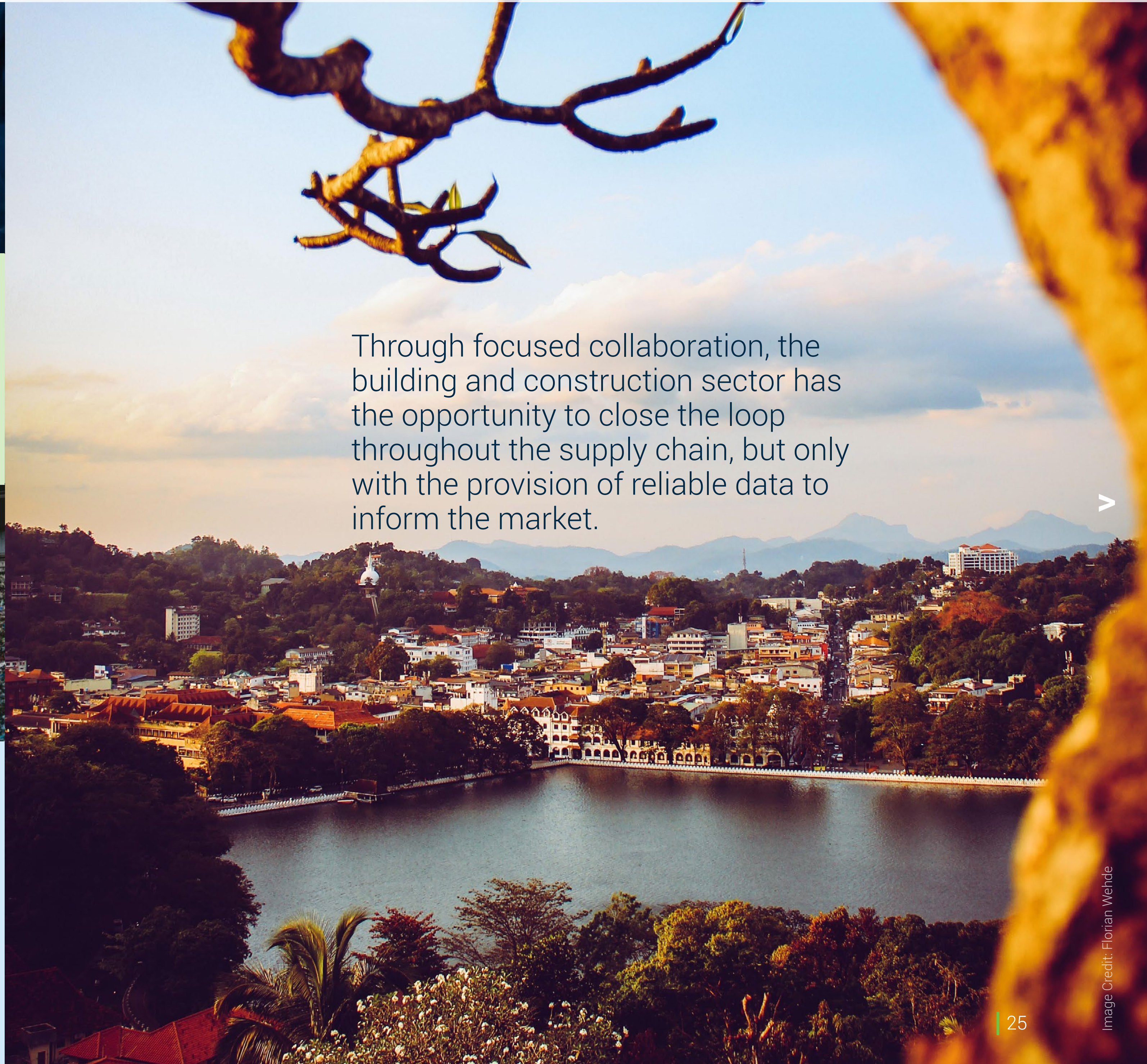
Measuring the progress of a circular economy is essential to the actual implementation of a functioning circular economic system.

We can't improve what we don't measure. The implementation of strategies that retain an asset's value and usefulness requires long-term planning. Through focused collaboration, the building and construction sector has the opportunity to close the loop throughout the supply chain, but only with the provision of reliable data to inform the market.

The measurement of a circular building or asset is a question that remains unresolved across the industry. However strategies and frameworks covering a broad range of topics such as product availability and quality, material storage location, reusability, and including circularity ratings for an entire asset, are enabling leadership within the market.

Digital material passports are a key strategy for tracking the circulation of building and construction materials in a closed loop system, by hosting open-source data defining the characteristics of materials in products used, and enabling the identification of value for recovery, reuse and recycling.

How can we measure the circularity of materials? Whilst the circularity of a building cannot be fully measured until the end of its life, the following indicators have been proposed to establish quantifiable goals and indicators at different stages.

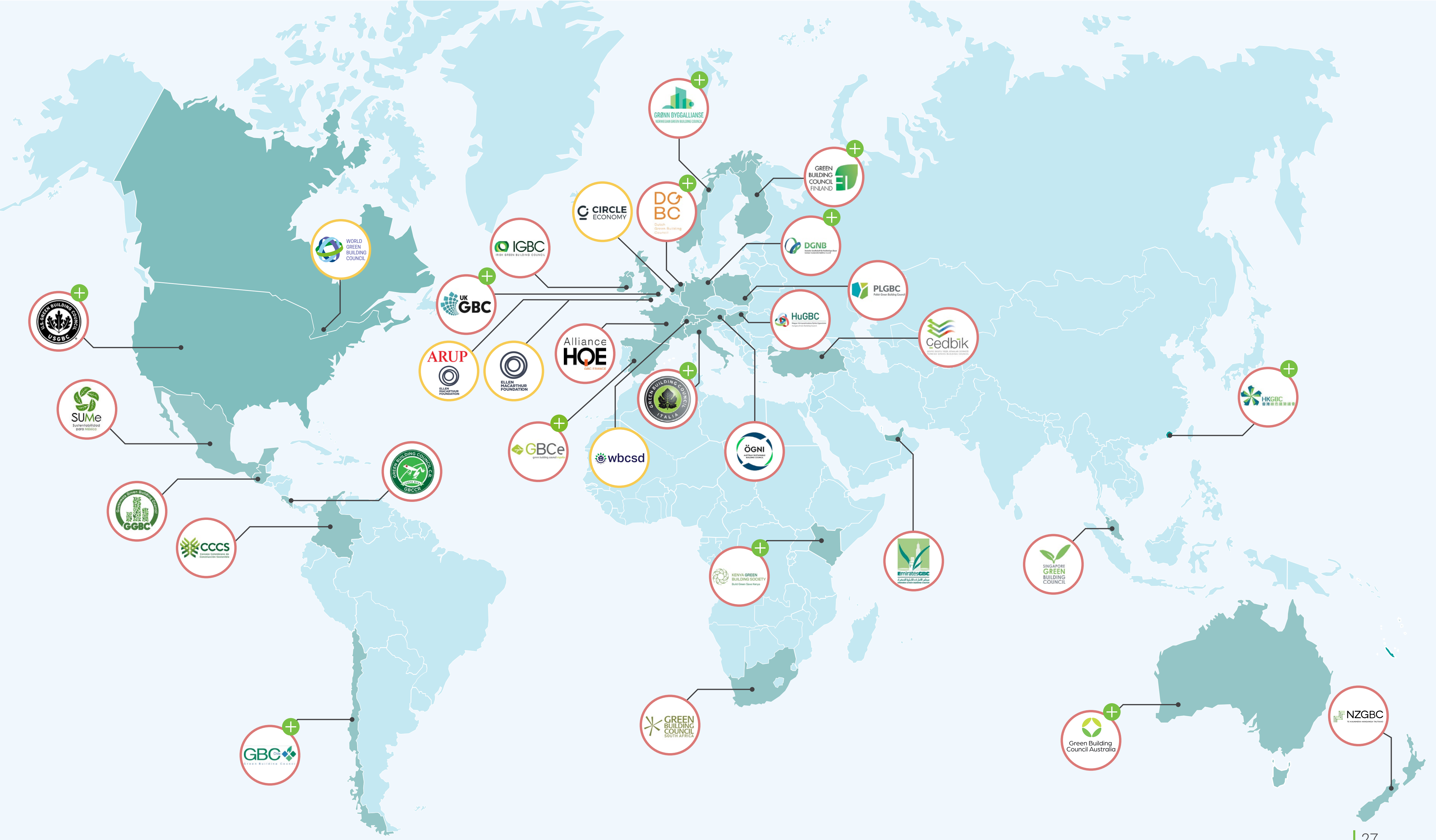


Through focused collaboration, the building and construction sector has the opportunity to close the loop throughout the supply chain, but only with the provision of reliable data to inform the market.

Image Credit: Florian Wehde

Circular Built Environment: Resources for the Global Industry

The WorldGBC global network aspires to increase awareness and accessibility of circular economy solutions for the built environment. This interactive map features market leadership from Green Building Councils who participate in the Circularity Accelerator global programme, in addition to industry partners.



WorldGBC Circular Accelerator Steering Committee

Industry Partners

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INTRODUCING **KEY THEMES** FOR THE CIRCULAR ECONOMY IN THE BUILT ENVIRONMENT

BUILDING AND CONSTRUCTION MATERIALS

DESIGN AND RETROFIT

REGENERATE NATURE

LEVERS FOR CHANGE

Image Credit: Matthew Henry

03 BUILDING & CONSTRUCTION MATERIALS

This chapter examines building and construction materials, and presents best practice circular economy examples from across the global built environment.

"We have a long tradition of reusing materials. Right up until the 1960s, there were strong traditions of sorting and reusing building materials in Norway, such as notched logs, joists and beams, roof structures, bricks, roof tiles, windows, and doors. Materials were expensive and there was money to be saved by reusing them. A major shift in material recovery occurred in the 1950s when we moved from using lime mortar to cement mortar. From that point, it became possible to produce very cheap building materials through industrial processes. Efficient building methods, fewer requirements regarding the service life of buildings, and lower material costs made material recovery less important for many."

Think-twice-before-demolishing, Grønn Byggallianse (Norwegian Green Building Council)

3.1
Building and Construction Material Use in Industry

All materials and buildings have a carbon footprint as a result of the embodied carbon emissions generated when we extract resources and materials, or when we repurpose existing products and building parts.

Material usage in the construction industry is set to increase exponentially over the coming decades, yet it is vital that the sector does not exceed the global carbon budget based on planetary boundaries[23]. By 2050, the global demand for conventional materials, such as steel, cement and aluminium, is projected to increase by a factor of two to four[24]. Even with ambitious net zero strategies, emissions from the production of conventional materials alone will reach, cumulatively, 649 billion tonnes of CO_2e by 2100[25].

Materials and products with circular properties (including both conventional and alternative materials) are typically non-toxic, minimise natural resource depletion through use of renewable resources and/or secondary materials (encompassing reused, recovered and recycled materials).

Research demonstrates that circularity principles are not being utilised at scale in many of the primary materials markets[22]. Therefore the materials market has huge untapped potential to embrace the benefits of more sustainable material use. With around 30% of the carbon emissions for the construction sector being generated at the product stage, we cannot ignore that faster action across the whole value chain is needed. A focus on safety, healthier products and disclosure will enable faster decarbonisation as well as new business opportunities. The production and use of materials with circular properties, whether conventional or alternative, are essential in reducing carbon emissions from the built environment.

With around 30% of the carbon emissions for the construction sector being generated at the product and construction stages, we cannot ignore that faster action across the whole value chain is needed.

Global ABC Global Status Report 2018 EIA

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3.2 What are the Key Concepts?

Digital Material Passports

A material passport document describes the characteristics and value of building materials and products for recovery, reuse and recycling purposes in larger volumes in open markets[26]. The concept of the material passport is currently being developed by multiple parties, particularly in European countries [27]. There are several existing market tools linked to material passports, which include the measurement and declaration of impacts on social and environmental indicators, such as Lifecycle Analysis (LCA) and Environmental Product Declarations (EPD)[28]. The information about products used in a building can be mapped and recorded in digital databases, both for new and existing buildings. The information about the material resources of a building can be useful for refurbishment purposes, or when a building is deconstructed and the products become available for other buildings or uses. Material databases need to be transparent to facilitate comparison whilst demonstrating the residual value of materials at the end of a building's life. **Digital material passports enable all built assets to function as material banks.**

For more information and examples of material databases: Common Materials Framework, Transparency Catalog, Cradle to Cradle (C2C) Certified Products Registry, Energy Efficient Products for Consumers, SPOT, Ecoinvent, Global Green Tag.

CASE STUDY:

Pasaporte de materiales y activos sostenibles (P+MAS) — a pioneering material passport platform in Latin America.

The "Sustainable Materials and Assets Passport: P+MAS" is a project developed and managed by Chile Green Building Council (Chile GBC) and the Technological Center for Innovation in Construction (CTeC), both being non-profit organisations and specialists, promoting sustainability and innovation in the construction sector in Chile. This initiative is part of the circular economy challenges for the construction sector of CORFO (agency of the Ministry of Economy) and is co-financed with contributions from renowned material manufacturing and real estate companies.

Image Credit: Ricardo Gomez Angel

Buildings as Material Banks

Every brick, wall, door, and window pane in a building has a value. When buildings are refurbished or demolished, these materials are often disposed of in landfill sites or used in energy recovery. With the concept of buildings as 'material banks', buildings are seen as places that store materials that can be reused, recycled, or upcycled for new products[48]. **In a circular economy, materials that are part of existing buildings are considered resources for the buildings of tomorrow. This creates demand for reused, recycled or repurposed building parts; however, to achieve these accurate material databases, records and bills of quantity are needed.**

The pledge for transparency and performance in materials

The call for Environmental Product Declarations (EPDs) has exponentially increased in the last couple of decades as a result of the call for more transparency from users, developers and authorities. In fact, the EPD credit is the most popular Materials & Resources credit in the LEED rating system and several manufacturing companies, such as Saint-Gobain have embraced this movement and are raising the bar in the circularity goals.

CASE STUDY:

The Recycled Houses; Denmark.

'Are recycled materials as durable as new materials?' Between 1990-1994, three apartment buildings, known as 'The Recycled Houses', were built from 80-90% recycled materials in Horsens, Odense and Copenhagen. The aim was to employ full-scale, traditional construction methods making the greatest possible use of recycled materials.

CASE STUDY:

Delivering steel´s full reuse potential.

Steel reuse is now a viable low-carbon option for all parties to implement; from the perspectives of contractor, steel producer, fabricator, engineer to the client, as it is demonstrated by the Elephant and Castle regeneration project in London, UK.

Locally Sourced Materials

Localising the supply chain represents a tremendous opportunity to help the environment and the local economy. The amount of energy it takes to produce and transport materials should be considered crucial in the selection process of materials, as these factors are reflected in the embodied carbon emissions of an asset. Materials and products vary in the amount of energy they require for production, as do various transportation modes.

When transportation and energy consumption are reduced, emissions that cause climate change and impact human health are also lowered. **Procuring materials locally can enable entrepreneurial activity, with the potential to provide employment to traditionally underserved branches of society, such as women and young people entering labour markets and facing unemployment[41].**

CASE STUDY:

Xiao Jing Wan University, China – a history of locally sourced brick masonry buildings.

The complex nature of university buildings was designed and constructed to respect the area's vernacular heritage whilst minimising the environmental impact of construction by sourcing and manufacturing materials locally.

Responsible and Healthy Materials

Key global organisations are encouraging the use of environmentally responsible, healthy, low carbon products ready for a circular economy by delivering a common language and multi-attribute criteria that can be used to select better products.

Existing frameworks, such as 'Mindful Materials' and GBCA's 'Responsible Products Framework', have significant commonalities, including setting out criteria relevant for building products and materials based on their impact on people, place, and planet. These are based on established industry protocols such as EPDs and HPDs. While there may be some differences between tools and systems, there is a growing consensus on the core attributes of a responsible product.

CASE STUDY:

Creating Circular Materials, Compatible with Life: A compilation of leading industry resources to guide healthy, non-toxic material use in buildings

For years, circularity practitioners have needed to develop an advanced knowledge of toxicology to be able to ask the right questions of their supply chain to exclude anything suspected to be harmful to life. To increase the accessibility of circular, sustainable and healthy materials, experts at Brightworks Sustainability have partnered with visionary leaders through years of stakeholder engagement and material vetting to offer the following free and comprehensive resources.

Image Credit: Zeeshan Wani

Urban Mining and Material Cascading

Urban mining is the process of reclaiming materials from various waste streams. It considers the waste generated by cities as a valuable resource, allowing for the monetisation of any material and product from any waste stream. However when demolition is adopted by project teams, it often makes the separation of material streams difficult.

Material cascading maximises resource effectiveness by re-using products to create the most economic value over multiple lifetimes This approach to production and consumption states that energy recovery should be the last option, ideally with efficient incineration processes, minimising carbon emissions.

This concept is often associated with the forestry sector, in which cascading use can be effectively demonstrated. For example, a resource effective cascade may start with recently harvested, solid wood that goes into veneer wood products. After one lifecycle, if direct reuse is not technically feasible, then becomes particle-based products, which then becomes fiber-based products, which then becomes bio-based chemical products, which then becomes energy for electricity and heat[30]. The principle of consecutive functioning uses of a material or product is equally relevant for the built environment, in particular for construction materials.

SOLID WOOD
⇩
VENEER WOOD PRODUCTS
⇩
PARTICLE-BASED PRODUCTS
⇩
FIBRE-BASED PRODUCTS
⇩
BIO-BASED CHEMICAL PRODUCTS
⇩
ENERGY FOR ELECTRICITY AND HEAT

CASE STUDY:

Cross-laminated secondary timber (CLST).

Solid timber waste is typically chipped and downcycled into products such as particle board and animal bedding with limited reclamation of solid timber through salvage yards. In a circular economy, biological materials should be cascaded through reuse and high-value recycling, which increase the built environment's capacity to store biogenic carbon, before downcycling to lower-grade products and eventually returning to the biosphere. An example of high-value recycling is using recovered wood in mass timber products like CLT and glulam, which can displace the need for carbon-intensive virgin materials. Upcycle waste timber to retain its sequestered carbon over the long term, and allow local production of mass timber products[29].

Material Take-Back

Material take-back in today's markets is often organised by a manufacturer or retailer to collect used products or materials from consumers and reintroduce them to the original processing and manufacturing cycle. A company may implement this programme in collaboration with end-of-life logistics and material processing firms[45]. The process of material take-back reduces the requirement for new materials in product creation and incentivises better design for disassembly and reuse by the manufacturer.

There are multiple benefits for implementing a take-back programme, including: stronger customer relationships, lower cost of goods sold due to secondary material supply, alternative supply of critical raw minerals, mitigated risks associated with hazardous materials handling and reduced environmental impacts. These benefits can result in lower cost or discounts to consumers when they participate. However these programmes can be complex to implement as it may be a major challenge to convert end products back to raw material, and the cost of recycling may be high. **The support of governments is required to assist in creating the necessary infrastructure, incentives and waste regulations to accelerate the implementation of take-back programmes at scale[45].**

CASE STUDY:

Product take-back models in use in the commercial real estate sector

The built environment has a significant potential to reduce carbon emissions through circular practices in fit-outs. A building fit-out is a process whereby interior building materials and components are installed, including flooring, wall and window coverings, partitions, doors, furniture and equipment. On average, fit-outs happen every eight years and are responsible for a third of emissions over the life of a building.

CASE STUDY:

Hungary leading innovation of the circular economy by enabling the trade of reclaimed refrigerants

Through amendments to the current legislation, the Hungarian Government is encouraging unit owners and service companies to choose reclamation as an alternative to disposal for recovered fluorinated greenhouse gases (F-GHG), so that they only become waste when absolutely necessary.

The role of the Extended Producer Responsibility (EPR)

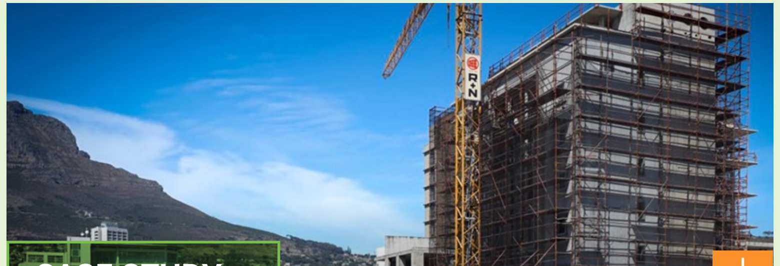
Extended Producer Responsibility (EPR) is an environmental policy approach under which producers are given a significant responsibility – financial and/or physical – for the collection and treatment of post-consumer products. Assigning such responsibility in principle provides incentives to prevent waste at the source, promote product design for the environment and support the achievement of public recycling and materials management goals[30].

Carbon-Storing Materials

Carbon storage in construction materials is essential to achieving net zero carbon targets within the built environment[31]. The use of embodied carbon accounting tools to measure emissions can help prioritise carbon-storing materials instead of offsetting carbon-emitting materials.

Carbon dioxide can be stored within materials, including those used for buildings and construction in a number of ways. Two prominent methods include:

- **Bio-based materials and products** – which are derived from living organisms: when a plant dies and decays, some of the carbon is stored in the soil while the rest is released back into the atmosphere. If these plant resources are instead harvested and converted into a building product, the carbon is effectively stored for the life of the building.
- **Mineral carbonation or weathering process** – where dissolved carbon dioxide reacts with the minerals in rock to produce carbonate, which is stable over a long period of time and can be used in construction. This technique is being used by industry-leading companies to develop products including cement bricks and plaster boards[32].



CASE STUDY:

84 Harrington Street in Cape Town, South Africa, named world's tallest hemp built building

84 Harrington Street in Cape Town, South Africa is a 12-storey building featuring a total of 50 apartments built using hempcrete blocks and hemp construction materials. Hempcrete sequesters about 108kg of CO_2 which can be locked away as biomass per cubic meter of hempcrete for the lifespan of the building.

CASE STUDY:

Cutting-edge technologies towards carbon-neutral concrete

Concrete is a widely used material in the built environment as it is a strong, durable, and versatile material that can withstand great stresses without yielding. Apart from providing structural strength, concrete can contribute to energy efficiency of buildings when providing thermal mass for the appropriate applications. Technologies to decarbonise concrete include the carbon capture in minerals to be used as low emission raw material in green cement and the Carbon Capture Utilisation and Storage projects (CCUS). Holcim, a global leader in the sector is partnering with research organisations to find globally scalable technologies to accelerate industrial decarbonisation.

3.3

Overcoming Challenges:

How Can We Mainstream the Use of Circular Materials?

Analysis from *'Towards a circular built environment in Europe – A Systems Analysis', by the Circular Buildings Coalition.*

Although materials with circular features are recognised as essential elements, in support of sustainable economic growth and the decarbonisation of the built environment[54], when compared to traditional materials and products, such materials face key challenges that include:

- **Complex certification processes and lack of appropriate regulations –** the current policies and mandatory measures do not incentivise the use of alternative materials at scale. Traditional products´ standards and assessment methods do not recognise all product performances. Furthermore, the lack of standardisation usually results in the need for more than one certification, which is costly and time consuming.
- **Cost competitiveness –** current markets experience high costs for the production and certification of alternative materials, low profit margins and low cost of virgin materials, which makes it difficult for builders to justify using them, even if they are more sustainable.

To overcome these challenges, collaboration and commitment of the entire value chain is required:

- Manufacturers have expressed the need for more financial support. This could come from additional credit lines for the development and implementation of green products or incentives from local and national governments, or incentives for the certification processes.
- The competitiveness of alternative materials could also increase by incorporating externalities into the prices of construction materials. Traditional and new materials usually do not reflect the environmental impact and the carbon emissions, which is why some countries are exploring the idea of extending carbon and health-related taxes[55].
- The manufacturing sector must develop certified alternative materials with competitive costs while the demand side needs to be sufficiently motivated. For instance, the public sector could lead by example by showcasing exemplary circular buildings using third-party certifications or aligning with best-in-class initiatives such as the upcoming EU Taxonomy.
- The demand for circular solutions to be supported by databases, platforms, and the appropriate logistics to connect manufacturers with developers. Databases provide designers and constructors with the availability of local, certified alternative products, making it easier for them to include into their specifications and decrease costs and carbon emissions due to transportation. Platforms could support the connection between providers and contractors, and certain services (such as storage warehouses) could decrease the amount of waste and facilitate the construction process.
- Once databases and platforms are in place, mass data capture of material use can occur, where Environmental Product Declarations (EPDs) and Lifecycle Assessments (LCAs) promote transparency.

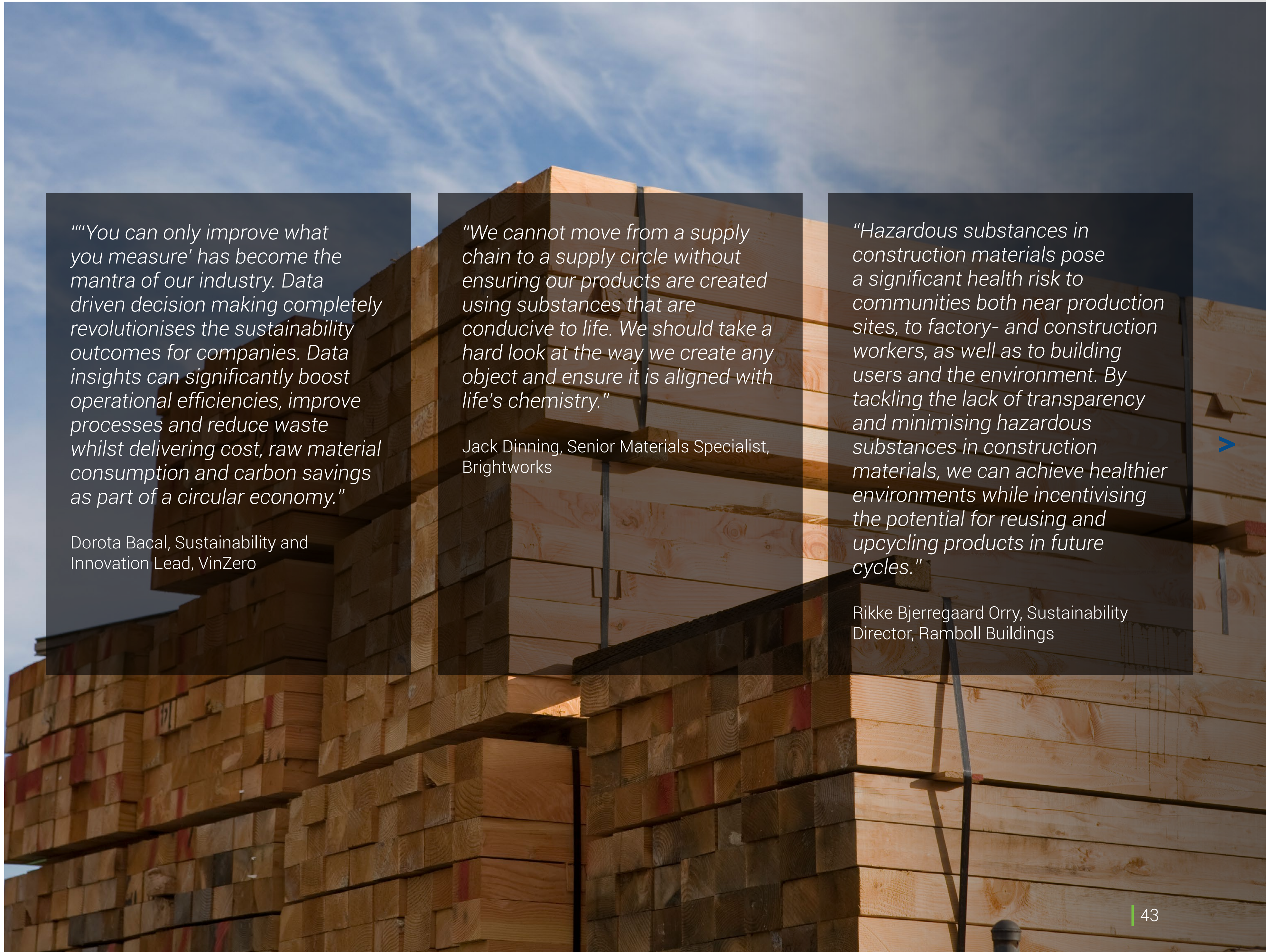
3.4 Call to Action

This chapter examines the role of building and construction materials in order to demonstrate the feasibility of circular economy approaches within the built environment, with the following calls to action for industry:

DRIVE CIRCULAR MATERIAL USE: increase the demand for sustainably sourced and procured materials and products which preserve biological diversity in nature, whilst ensuring it sustains economic viability.

REDUCE THE CONSUMPTION OF RESOURCES: materials that are part of existing buildings are considered resources for the buildings of tomorrow. Avoid the production and use of new building materials as well as the construction of new built assets.

LOCALISE THE SUPPLY CHAIN: localising the supply chain and procuring materials and products locally represents a tremendous opportunity to help the environment and the local economy.



""'You can only improve what you measure' has become the mantra of our industry. Data driven decision making completely revolutionises the sustainability outcomes for companies. Data insights can significantly boost operational efficiencies, improve processes and reduce waste whilst delivering cost, raw material consumption and carbon savings as part of a circular economy."

Dorota Bacal, Sustainability and Innovation Lead, VinZero

"We cannot move from a supply chain to a supply circle without ensuring our products are created using substances that are conducive to life. We should take a hard look at the way we create any object and ensure it is aligned with life's chemistry."

Jack Dinning, Senior Materials Specialist, Brightworks

"Hazardous substances in construction materials pose a significant health risk to communities both near production sites, to factory- and construction workers, as well as to building users and the environment. By tackling the lack of transparency and minimising hazardous substances in construction materials, we can achieve healthier environments while incentivising the potential for reusing and upcycling products in future cycles."

Rikke Bjerregaard Orry, Sustainability Director, Ramboll Buildings

04 DESIGN AND RETROFIT

This chapter examines design and construction practices in the circular economy, analysing and presenting strategies in action from across the global built environment.

Designing a circular building will principally mean that no building asset at the end of its lifecycle will become waste, but will instead remain incorporated in the supply chain.

"Circularity in the built environment refers to the concept of designing and operating buildings, infrastructure, and other constructed spaces in a way that mimics the closed-loop systems found in nature."

Towards a circular built environment in Europe - A Systems Analysis, Circular Buildings Coalition

4.1 Circular Building Design and Construction Strategies

Designers of buildings and infrastructure are well-placed to challenge business-as-usual approaches and unleash forward-looking designs that consider the entire lifecycle of an asset.

Circular design and construction offers extensive environmental opportunities and socio-economic benefits if the appropriate design and construction strategies are implemented. In practical terms, it requires all stakeholders including investors, clients, developers and design teams to take a longer-term view, considering the past, present and future use of a building's products and components – including how to procure, maintain and retain their value and usefulness over multiple lifetimes.

Linking Net Zero and Circularity:

The implementation of circular design principles is an essential part of the solution for a net zero carbon future. While industry has traditionally focused on addressing operational carbon, increased efforts to tackle embodied carbon emissions at a global scale must now be equally prioritised.

WorldGBC's Whole Life Carbon Vision calls for all new buildings to be net zero carbon in operation and all new buildings, infrastructure and renovations to have at least 40% less embodied carbon with significant upfront carbon reduction by 2030. By 2050, all new buildings, infrastructure and renovations must have net zero embodied carbon.

Design for Reuse Over Multiple Life Times

In built environment design, building reuse (also called adaptive reuse) refers to the repurposing of an existing building or structure for a new purpose, avoiding the use of new building components and parts when more sustainable approaches are achievable. Building reuse strategies minimise emissions and material use, reduce construction waste while mitigating social challenges related to urban sprawl. During design, considering the adaptability potential of the building during its operational phase is essential, as the functional life span of buildings is relatively short versus its physical capacity to exist in a safe manner[57]. Design must consciously facilitate the longer functional use and ease of maintenance of building products and parts to keep them at a high value over multiple lifetimes.

Materials which pose a potential risk to human health are likely to prevent the reusability of building products in the future, thus impeding on the value retention potential. Preventing the use of materials and products that have a negative impact on the health and wellbeing of building occupants and workers is fundamental to circular design. Existing buildings may contain hazardous materials, presenting long-term human health risks; hazardous materials must be identified in advance of construction to prevent accidental exposure for the occupants. Hazardous materials include: asbestos, lead, polychlorinated biphenyls (PCBs), chlorofluorocarbons (CFCs) and heavy metals among others[58].

Modular Construction

Modular construction is a key component of design for reuse through a circular built environment, as standardised building parts are easier to repair and maintain, disassemble and relocate or refurbish for reuse. The demand for raw materials and energy is reduced during the production of new units within a closed factory environment rather than at an open construction site (which could be prone to external disturbances) and as a result the production waste is more easily reduced due to more control over material recycling and the protection of building materials. The refurbishment of modular building units and their parts rather than the replacement of the entire unit (or building) leads to extended product lifetimes, reducing the number of building products disposed of prematurely.

CASE STUDY:

Quay Quarter Tower, Sydney Australia - setting a global benchmark for adaptive reuse

Designed and constructed to have a net-positive or at least a net-zero impact on the environment, rather than being demolished, the existing commercial skyscraper was upcycled, retaining more than 60% of its existing structure and extending the asset's design life by 50 years. In 2022, the project won the World Building of the Year award at the World Architecture Festival in Lisbon.

CASE STUDY:

Burwood Brickworks Shopping Centre, Australia - an industry leading sustainable retail design and construction

Developed by Frasers Property Australia, the Burwood Brickworks Shopping Centre project team conducted 'healthy' materials research to create a freely available resource known as the Greensheet for the Australian market.

CASE STUDY:

Canada's largest heritage rehabilitation project

Canada's100-year-oldparliament building, Centre Block in Ottawa, is undergoing an extraordinary retrofit that blends heritage conservation with sensitive contemporary interventions including seismic upgrades, modernised building systems, and new spaces to support parliamentary operations.

Design for Disassembly and Deconstruction

It is important at an early stage in the design process to design for the disassembly and deconstruction of the building in order to recover the residual value of the asset at its end-of-life stage. Designing for disassembly should create buildings that function as material banks, eliminate waste, and are easy to maintain, retrofit, and reuse.

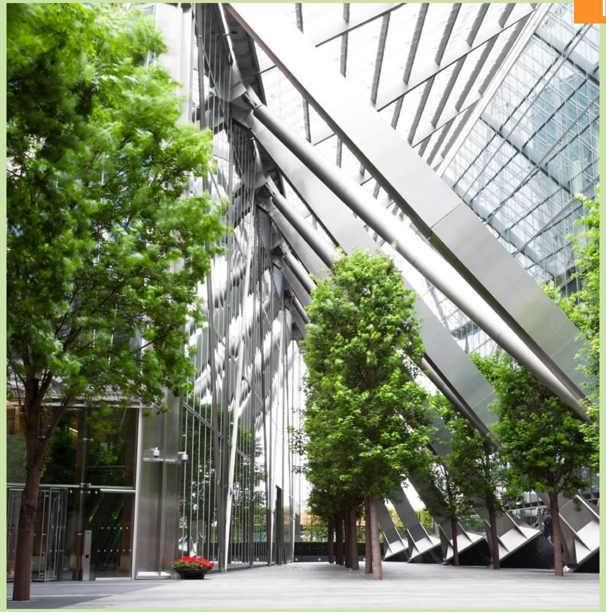
Demolition is commonplace in the construction industry and the waste it generates is catastrophic, making the separation of material streams, and the consequent reuse of them difficult to facilitate.

Strategies that promote the reuse, repurposing and recycling of products and components must be prioritised over demolition on a principle basis. Deconstruction is a more resource efficient alternative as it involves the selective dismantling and removal of materials and products from buildings while retaining the original value of building components.

Designing for disassembly and deconstruction involves some straightforward tactics: the fewer parts you use, the fewer parts there are to take apart, and additionally the use of common and similar fasteners (e.g. screws) will require only a few standard tools, simplifying and improving the speed of disassembly. **Importantly, upskilling and and training around disassembly and deconstruction will help contractors understand how best to disassemble and reassemble building components[33].**

According to the ISO 20887[61]: **Sustainability in buildings and civil engineering works — Design for disassembly and adaptability,** the following principles should be considered when designing for:

- **Disassembly:**
  1. Ease of access,
  2. Independence,
  3. Avoidance of unnecessary treatments and finishes,
  4. Supporting reuse business models,
  5. Simplicity,
  6. Standardisation,
  7. Safety of disassembly
- **Adaptability:**
  1. Versatility,
  2. Convertibility,
  3. Expandability



WORLD GREEN BUILDING COUNCIL

CASE STUDY:

Pyörre House, Finland - the first Finnish building designed and constructed to test the EU's design criteria for adaptability, disassembly and recyclability

Pyörre House is a steel-framed single-storey detached house built for the Lohja Housing Fair in 2021. The building has 227 m^2 of floor space and the primary construction is made of steel. The house has been designed and constructed to embrace low-carbon circular principles and strategies and of all the materials used on the project, it is made up of 22.1% recycled, 15.3% renewable and 62.6% non-renewable materials. The design team carefully mapped the use of materials and building components for the project, exploring ways in which the building could retain its value and usefulness over the long term.

CASE STUDY:

Minimising waste at deconstruction, Kāinga Ora – Homes and Communities

Construction and demolition waste may represent up to 50% (6 million tonnes per year) of all waste to landfills in New Zealand. Consequently, the municipality of Kāinga Ora established an ambitious deconstruction and demolition programme, which aims to reuse or recycle up to 80%, or more, of uncontaminated materials by weight in Auckland and Northland development areas, and 60% of uncontaminated materials in all other regions.

Design Out Waste

Implementing circular economy principles and approaches is essential when designing out waste. By using resources efficiently from the design stage, the aim is to plan to use available materials as efficiently as possible in order to minimise the amount used during an asset's construction and operation[34].

Sustainable waste management closes the loop through the reuse and recycling of as much waste as possible, allowing it to re-enter the economy instead of being sent to a landfill. A circular economy depends upon using materials to their most efficient extent, and waste management is the last step in that process[61].

Where waste is inevitable and products are not practically reusable, careful consideration must be given to achieve optimum use of all waste streams. Best practice waste management plans for construction must be prepared in the early stages of a project, considering waste as a valuable resource. Environmental impacts are reduced when the contractor diverts a targeted percentage of construction and demolition waste from landfill. Equally, an appropriate plan for operational waste should be prepared that ensures the building design includes adequately sized waste storage areas to facilitate efficient, safe separation, collection and recovery.

A circular economy is not possible without sustainable waste management systems. Adopting a zero-to-landfill approach is a specific, measurable and achievable target. However it is also essential to have transparent, published data on the recovery and destination markets available for all materials and products.

The Waste Hierarchy:

In order to minimise negative impacts of waste, the Waste Hierarchy was proposed as a model to establish preferred programme priorities and evaluate processes that protect resources.

The European Commission, for instance, developed a five-step "waste hierarchy" for the EU Waste Framework Directive, in which preventing waste is the preferred option, and sending waste to landfill should be the last resort[35]:

CASE STUDY:

You can't improve what you don't measure, the Petinelli headquarters in Brazil leads by example:

The Curitiba headquarters of Brazilian engineering and green building consulting firm Petinelli, was the first building to certify using LEED Zero, a programme which tracks net zero performance in the categories of waste, water, energy and carbon. In addition to achieving LEED Zero Waste, the building has also achieved ambitious net zero targets set for energy and water.

CASE STUDY:

JP Morgan Chase HQ - New York City's first all-electric, circular and net-zero skyscraper

Located at the heart of Manhattan, Foster + Partners conceptualised this building as the city's first all-electric tower, with a programme that prioritises employee wellness and sustainability.

4.2 Overcoming Challenges when Designing a Circular Building

There are unavoidable barriers to be faced in terms of designing and constructing a circular building or asset, with prominent examples including:

- **Tackling linear mindsets:** Designing to close loops is a relatively new concept for market stakeholders. Clients, designers and contractors have the challenge of culturally embracing *not-brand-new* assets and products, promoting understanding that quality is not compromised, and meeting project timings and budget.
- **Appropriate tools:** Circular building design requires the support software and modelling tools that incorporate lifecycle data, including performance (structural, thermal, etc), life spans, maintenance and replacement requirements, embodied carbon, etc. While many Building Information Modelling (BIM) tools are working on incorporating this information, they are still exemplary and not yet a common practice.
- **Supporting regulations:** Current regulations can be an obstacle to designing with certain materials, which discourage the transition to a fully circular mindset. Furthermore, they often do not foster local markets to achieve ambitious circular and environmental targets.
- **Cost competitiveness:** The lack of cost competitiveness of alternative materials, the need for additional tools to design and the lack of expanded knowledge on circular practices can increase the cost of circular projects. Circular economies include additional labour costs for deconstruction, sorting and reuse, and there are typically additional storage costs when project timing is not aligned.

To overcome these challenges, the following recommendations are provided to the manufacturing industry, designers and developers to offer guidance around common challenges faced when looking to develop a fully circular building:

1. **Setting aligned interim targets:** The public sector can promote the development of circular buildings at scale by setting up targets and facilitating the collaboration of the value chain. Regional attempts, such as the Taxonomies, are sending signals on the quantitative goals and the timelines that public authorities should aim for. Local authorities may reference and adapt these to align with the local needs on climate mitigation, adaptation and sustainability goals.
2. **Financial support:** Financial products for innovation and incentives can support the development of platforms, simulation tools, training programmes and more exemplary projects to boost circular buildings at scale.
3. **Sharing knowledge and data:** Upskilled professionals, as well as creating a society that embraces circularity, are essential to avoid unnecessary new products and assets and minimise waste. Professionals can support data collection and report transparency.

4.3 Call to Action

This chapter has examined strategies for circular building design and construction, presenting the following calls to action for industry:

CHALLENGE SHORT-TERM THINKING:
All stakeholders including investors, clients, developers and design teams must take a longer-term view, considering the past, present and future use of a building's products and components – including how to procure, maintain and retain their value and usefulness over multiple lifetimes.

DESIGN FOR REUSE OVER MULTIPLE LIFETIMES:
Design must consciously facilitate the longer functional use and ease of maintenance of building products and parts to keep them at a high value over multiple lifetimes. Modularity is a key component of design in a circular built environment, as standardised building parts are easier to repair and maintain, disassemble and relocate or refurbish for reuse.

DESIGN FOR DISASSEMBLY AND DECONSTRUCTION:
Designing for disassembly and deconstruction should create buildings that function as a material bank, eliminate waste, and are easy to maintain, retrofit, and reuse.

DESIGN OUT WASTE:
Implementing circular economy principles and approaches is essential when designing out waste. By using resources efficiently from the design stage, the aim is to plan to use available materials as efficiently as possible in order to minimise the amount used during an asset's construction and operation. Adopting a zero-to-landfill approach is a specific, measurable and achievable target.

"Adopting circularity in the built environment is essential to achieve a regenerative balance, by facilitating the decarbonisation of the industry, limiting finite raw materials extraction and waste production all while staying within planetary boundaries."

Chris Trott, Partner Head of Sustainability, Foster + Partners

"A circular built environment can, not only drive environmental stewardship by reducing the negative impacts linked to overconsumption of building materials, but also it will foster social equity by upskilling local workforces and support sustainable growth and resilience of the sector."

Helene Carpentier, Global Head of Circular Economy & Zero Waste, CBRE

05 REGENERATE NATURE

Image Credit: Chris Lawton

This chapter examines how the built environment can gain inspiration from natural systems to implement circular economy solutions at scale.

A regenerative model emulates natural systems, prioritising both people and planet, and supports natural processes which allow nature to thrive.

Species are dying out at a rate not seen since the last mass extinction 66 million years ago[36], and our growing world population and resource-intensive economies are having a vastly negative impact on the planet's biodiversity, land use, and renewable freshwater resources[37]. Every year the planet's safe environmental limits are exceeded. The Circular Gap Report 2023 provides a simple message, "Our current development is not safe. Not for the planet, nor for people". Today, five of the nine key 'planetary boundaries' that measure environmental health across land, water and air have been broken. A circular economy could substantially address this by reducing global material extraction and use by one-third.

Growing public awareness is putting pressure on businesses to help reverse the global biodiversity crisis. Many regions are addressing biodiversity through local planning policies and requirements, such as biodiversity net gain and offsetting regulations, green roof bylaws and urban ecology targets[56]. At the UN Biodiversity Conference COP 15 2022, the participating nations adopted the Kunming-Montreal Global Biodiversity Framework agreeing to conserve and manage at least 30% of the world's lands, inland waters, coastal areas and oceans, with emphasis on areas of particular importance for biodiversity and ecosystem functioning and services[38].

THE PLANETARY BOUNDARIES:

The planetary boundaries concept presents a set of nine planetary boundaries within which humanity can continue to develop and thrive for generations to come. Crossing these boundaries increases the risk of generating large-scale abrupt or irreversible environmental changes[39].

5.1

Inspiration from Nature and Nature-Based Solutions

The built environment has used nature as an inspiration for many applications. Cities and buildings could extend the use of nature-based principles even further, by developing solutions inspired by natural cycles.

Nothing is wasted in nature. The avoidance, or significant reduction, of waste in our cities is key to achieve the sustainable development that will guarantee a healthy future.

Recent studies have quantified the value provided by nature in the built environment, using natural capital as a tool that enables us to place a financial value on the invaluable natural services provided by our planet. Natural capital is valued at USD $145 trillion/ year, twice as much as the global aggregate GDP[40]. In the real estate sector, there is an opportunity to enhance natural capital by supporting Nature-Based Solutions (NBS). NBS are sustainable planning, design, environmental management and engineering practices that weave natural features or processes into the built environment to promote adaptation and resilience.

A circular built environment aims to integrate nature-based solutions in order to close resource loops and reduce new resource consumption.

Nature-Based Solutions can also lower energy demand for buildings, when passive design approaches minimise the requirements for heating, cooling and ventilation. At a neighbourhood scale, green corridors in urban areas could mitigate the urban heat island effect while improving air quality. NBS should be integrated into climate resilience measures as well. Notably in coastal locations; by using vegetation the shoreline is stabilised, soil erosion is reduced and the risk of flooding is minimised whilst safeguarding ecosystem services and allowing nature to regenerate and thrive.

Biomimicry -
Bringing Nature's Best Practices to the Built Environment

Five centuries ago, Leonardo da Vinci urged his students to "seek their lessons in nature". Today, this approach is a structured methodology: biomimicry. It is both a school of thought and a scientific and technological discipline: it is based on the principle of using nature as a model to meet sustainable development challenges, and a combination of biology and technology to solve human problems by transferring models from living organisms. Indeed, these models have been tested and validated by 3.8 billion years of evolution and selection.

Biomimicry is not only about learning from the results of evolution (such as form, function, or relationship), but also about learning from the process of evolution (such as collective intelligence), and the evolution success parameters (such as permanent reuse). It is a systemic approach that places us within our ecosystem.

The biomimetic approach applies the principles of living things' effectiveness to the design of products, buildings, services, or even organisations. For example:

- **Nature uses only the quantity of matter necessary.** For instance, the alveolar structures of bones allow them to be both solid and light, while drawing locally from renewable and abundant resources; as bones are renewed from the remnants of their old structure. Buildings can mimic these features and instead of extracting huge amounts of rare and/or non renewable materials at great distances from where they are required, analysing which structures are more efficient requires fewer materials that can be locally sourced.

- **Prioritising resilience rather than maximising performance.** Living things use multifunctional solutions (the leaf of the tree is both a solar panel, an evaporator, and an insulating parasol), that are redundant (trees do not have a single, super-efficient leaf), and decentralised (a leaf does not need the tree to sign an order form for it to capture solar energy). If we design according to these principles, our buildings will have a longer lifespan and will even be able to have several successive lives (offices today, homes tomorrow, shops the day after tomorrow) because they will be multi-purpose.

- **Nature tends to use simple materials to promote decomposition at the end of life.** Conversely, human kind produces objects composed of sophisticated and heterogeneous mixtures that are difficult to reuse and recycle. Imagine that the fibres and the matrix of our composites were made of one and the same material, but organised in different ways, so that at the end of their life, products would once again become raw material and reusable.

- **In nature, resources are used and reused over and over.** When winter comes, tree leaves - having fulfilled their multiple functions - do not just become waste but, on the contrary, a stock food for local animals whose excrement will feed the symbiont micro-organisms of the tree, while, after several lives, the constituents of the leaf will return to the tree, following complete cycles. We dream of a human production systems which is capable of doing the same: making things that can be disassembled, reused separately for new uses, and then recycled to provide a stock of raw materials.

Examples of biomimicry innovations are already numerous, from velcro to aircraft winglets and glue for surgical use. The construction sector could well be where biomimicry will have the most impact tomorrow.

CASE STUDY:

MODULATIO' designs biomimicry solutions for industry.

Within a structure, stress is not distributed evenly: some areas must withstand considerable loads, while others have moderate or little force exerted upon them. So, the question is: why use the same density of material everywhere? Inspired by this question, MODULATIO' created a solution inspired by nature and replicable with different materials: ***The Alveolar and Lattice Structures with Variation of Effort and Density (SALVED).***

CASE STUDY:

Apple Park - A campus to promote creativity, innovation and wellbeing.

The Apple Park, in Cupertino California, was conceived as a project fully connected with nature - its landscape and buildings are all encompassed by flowing parkland that enhances the buildings as places to socialise, exercise and work. The campus is powered by 100% renewable energy, and is the largest LEED Platinum-certified office building in North America.

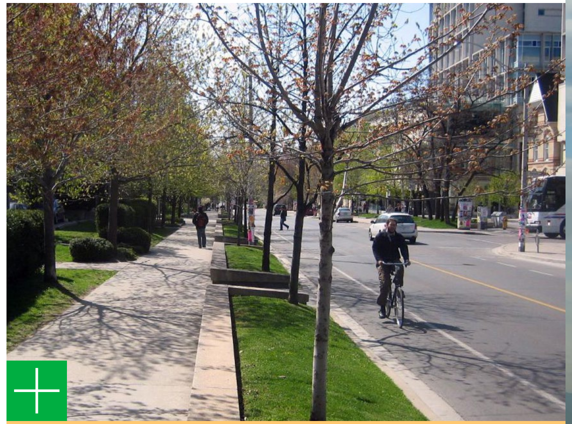
Image Credit: Carles Rabada

5.2
Regenerative Cities

Urbanisation is growing at an unprecedented rate, which contributes significantly to the climate crisis and biodiversity loss. Cities hold many potential solutions to reverse these trends.

Cities account for an estimated 80% of global GDP and consume almost half the resources extracted globally[40]. Sustainable cities must be regenerative, with the ability to regenerate the natural resources consumed. For example, food supplies could be supplemented through urban agriculture, energy through solar rooftops, geothermal and bio-waste, and water through storm water collection at the neighbourhood scale. This enhanced ecosystem service infrastructure within the urban area improves the city's self-sufficiency as well as its resilience. Instead of urban sprawl and expanding on virgin land, regenerative urban development should allow for denser cities by redeveloping and regenerating the existing urban fabric, restoring the relationship between resource-dependent cities and the natural systems.

Urban regeneration projects should focus on making cities more people-centred, and increasingly functional for the community[42]. When our cities are planned well and with ambitious policies, they can reduce humanity's environmental impacts as they meet human needs more efficiently and find synergies between urban development and nature conservation.



The Green Factor Method

Many cities in countries like the UK, Germany, Sweden, Finland and the US are using the Green Factor Method to ensure that urban regeneration projects maximise the multiple benefits of green and blue infrastructure in delivering resilient, healthy and environmentally friendly cities. The Green Factor Method is a tool used to mitigate the effects of construction by ensuring sufficient quantity and quality of green and blue infrastructure.

CASE STUDY:

Making the case for clean construction: Mexico City.

Implementing clean construction principles is part of the solution to create greener, more equitable and liveable cities. Since signing the C40 Clean Building Accelerator in 2020, Mexico City has integrated ambitious clean building strategies which inclusively address the impacts of our built environment on our carbon footprint, and climate and social resilience. Rigorous equity assessments, citizen engagement and data analysis has been conducted and in turn are creating enabling conditions for the city to scale up its clean construction efforts.

CASE STUDY:

La Borda social housing complex in Barcelona.

Co-operative involvement was crucial for defining the project's environmental strategies; the participation of the building occupants in all phases, from the design to the construction and further operational management, was essential. La Borda social housing complex in Barcelona was driven by its focus on community, proposing a new paradigm in social housing focussing on the basics of social, communal spaces. The building is the highest constructed building from cross-laminated timber (CLT) in Spain. CLT is well-known for its carbon sequestration benefits and typically shorter construction period required.

Image Credit: Alexis Tostado

5.3
Regeneration of Nature - Understanding the Key Challenges

There are unavoidable barriers to be faced in terms of designing and constructing a circular asset for the regeneration of nature, prominent examples include:

Knowledge Gaps:
There are knowledge gaps regarding the long-term effectiveness of nature-based and regenerative solutions for climate change mitigation and adaptation. Current research is still inconclusive and incomplete on a series of aspects, including the effectiveness of nature-based solutions (for instance, as regards to positive effects on human health and wellbeing or the comparative merits of various approaches in the long term)[42].

Implementation:
An important element in an integrated approach to scaling up solutions are measures to ensure that other unwanted social and environmental consequences are avoided over the long-term. Standards should be considered when implementing solutions at scale, outlining the requirements that need to meet a certain level of quality and serve as a basis for assessing compliance or quality, including respect for the rights of indigenous peoples and local communities, including to land and natural resources[43].

Financing and funding:
Cities often lack funds, potentially as a result of the structure of municipal revenues and spending. A report by the Organisation for Economic Co-operation and Development (OECD) highlights the role private investments can play to fill funding gaps provided certain conditions are met[44].


Image Credit: Alex Galperin

5.4
Call to Action

This chapter examines how the built environment can support regeneration of natural systems through the implementation of circular economy solutions at scale and in alignment with calls to action for industry.

Gain inspiration from nature:
nothing is wasted in nature. By implementing nature-based solutions our cities can close material loops while restoring the relationship between cities and natural systems.

Protect water resources: promote water efficiency and quality at all stages of the building lifecycle, and include water use within the reporting conducted during a building's construction and operation phases.

'It is vital that all stakeholders embrace a circular economy and whole life carbon principles to disrupt existing wasteful practices at all stages of a project – the opportunities to innovate are endless...'

David Leversha, Leader of WSP Property & Buildings Global Net Zero Carbon network, WSP

WORLD GREEN BUILDING COUNCIL

06 LEVERS FOR CHANGE

Image Credit: Mark Stoop

This chapter presents a high-level summary of the value proposition for a circular built environment, alongside an analysis of the enabling strategies and actions required across the value chain to close material loops.

WORLD GREEN BUILDING COUNCIL

6.1
Building the business case

In order to stimulate a large-scale transition, stakeholders from across the entire supply chain must be 'circular ready' to play their part in a wider systemic change. This will require a compelling value proposition for all built environment actors, in both public and private sectors.

A key part of the business case for circular economy - as well as being an enabler of a closed-loop future - is the use of innovative business models, such as Product as a Service.

Product as a Service (PAAS):

Service-based business models can increase the utilisation of underused products, components and buildings[81]. Rather than procuring a product, businesses and governments can also procure the 'use' of a product. This can incentivise the supplier to lengthen the lifespan of a product and reuse it multiple times.

CASE STUDY:

Lighting as a Service

Lighting as a Service (LaaS) is a business model in which lighting is treated as a service and a contract is set based on a subscription. The model enables customers to reduce installation and maintenance cost while significantly reducing CO_2 emissions.

To support these goals, Signify, a world leader in lighting, created *"ALight"* - a project designed specifically to help reduce the building carbon footprint of the company Air Liquid, while achieving economical savings, and improving the workspace environment with high quality lighting.

Image Credit: Sebastiano Piazzi

The value proposition for a circular built environment

Benefits to government, business and citizens from transitioning to a circular economy

GOVERNMENT	BUSINESS	CITIZENS
Reduced waste from construction and demolition works	Assigning value to existing processed materials, creating a new market for otherwise disposable products and new jobs in the sector	Enable future tenants to adapt the space to their anticipated needs
Social value creation through development of take-back infrastructure, material storage and employment opportunities	Benefits of modular design as an improvement to the efficiency of the construction process (less waste, faster = cheaper)	Reduced costs over the whole life
Reduced embodied carbon emissions from the building and construction sector	Recovery of an asset's value at end of service life, enabling future reuse of building components and lower extraction costs	Contributes to improved health and wellbeing for building users through material ingredient transparency and optimisation
Compliance with environmental and social legislation	Removal of hazardous substances in products contributes to improved health and wellbeing in the material production industry and to the future reusability potential of materials	Benefits from green and blue infrastructure, reduced air pollution, reduced hazardous materials in buildings
Build a sustainable supply chain for the future	Recognition through sustainability benchmarking schemes	
Reduced material extraction and more efficient use of natural resources by the building and construction sector	Control of costs by adopting a wider approach to whole life costing	
Sustainable procurement intiatives	Effective management of risk and reputation	
	ESG reporting opportunity	

For more information on the business case for circular economy in the built environment, please see *'The business case for circular buildings: Exploring the economic, environmental and social value'* report (WBCSD, 2021).

WORLD GREEN BUILDING COUNCIL

6.2
Enabling Value Chain Action for a Circular Future

Everyone can catalyse action towards a circular economy.

Consumers have the power to make choices that embody core circularity principles, such as purchasing reused or recycled products, or selecting non-toxic products that can be kept in a closed-loop system. However, in order to stimulate a large-scale transition, a compelling value proposition must be created for simultaneous and ambitious action from governments, businesses and citizens.

The private sector can implement and execute sustainability actions that go beyond local and national policy requirements, making fast, independent decisions for their own value chains. This makes them innovation drivers, and one of the reasons why businesses around the world have been early adopters of the circular economy model[82].

The public sector can create an enabling environment for a circular economy by catalysing action along the supply chain, expanding the economy on both the supply and demand side. All governments can encourage circular economy innovations in products and services by providing regulatory and financial support especially for research, business innovation, as well as early-stage and high-risk projects that need additional financial support[83]. **Procurement provides a unique and large-scale opportunity for governments to mainstream circular economy principles.**

Circular Procurement

The public sector can create a thriving environment for a circular economy. This can also generate local employment, by establishing procurement policies and practices that call primarily for the use of circular products. **City governments have large purchasing power which gives them the ability to create demand and shift the market to new ways of providing products and services.** In Europe, public procurement makes up 14% of GDP (EUR 2 trillion annually), whilst in developing countries it is around 30%[44].

Localising the supply chain and procuring materials and products locally represents a tremendous opportunity to help the environment and local economy, particularly in less-developed countries. The development of a circular economy could provide employment to traditionally underserved branches of society, entering labour markets and facing unemployment.

Image Credit: Ragnor Vorel

CASE STUDY:

Arden Precinct – circular economy embedded into masterplanning and building design.

Through the adoption of circular economy principles, a pioneering precinct-wide waste management plan has been developed for the Arden Precinct in the north of Melbourne, Australia. This 44.6-hectare development will accommodate 34,000 jobs and 15,000 residents. It aspires to set the standard for best practice in sustainable urban renewal, aiming to become Melbourne's first circular and toward zero waste precinct, in line with net-zero carbon emissions targets by 2040.

CASE STUDY:

A City´s Leadership to unlock full circularity potential – San Francisco.

With the goal to be a net zero carbon city by 2040 without the purchase of offsets, the City of San Francisco has seen in circularity an opportunity to optimise resources and tackle climate change. The vision was key: while the private sector is a key innovator and developer, the public sector needs to be a facilitator to overcome obstacles.

San Francisco co-led the development of the advancing toward zero waste declaration in 2018, which aims to reduce disposal to landfill or incineration by 50% by 2030, using a 2015 baseline and reduce the generation of materials by 15%. After prevention, the City believes that material reuse and markets are critical for circularity. Therefore, the goal is to ensure that there is infrastructure in place to support any requirements. The approach is to bolster three distinct areas:

1. The network of suppliers and receivers
2. A virtual inventory and asset management platform
3. Physical storage space.

Private Sector Leadership towards a Circular Economy

The private sector has been the source of much of the progress made to date in implementing circular economy models[45]. Measurable circularity strategies can demonstrate the socio-economic benefits associated with resource efficiency and waste including; material cost savings, reduced price volatility, improved security of supply, employment creation, as well as the reduced environmental impacts. This data can create a compelling business case, and trigger mass-market interest through knowledge-sharing and reporting. Businesses can also use ESG to normalise and enhance ambition around the circular economy.

Sustainable finance catalysing ESG disclosure

The investment landscape is changing – sustainable finance is no longer a trend but a groundswell. The flow of capital towards ESG oriented funds has experienced a steep exponential increase; in the third quarter of 2021 global sustainable funds hit a record high of $3.9 trillion, more than doubling in less than 12 months[45]. This trend reflects growing interest from private firms in sustainable and energy transition projects. One of the main reasons is that companies that can demonstrate sustainable supply chains and good human rights records are less vulnerable to environmental shocks or reputational damage. Additionally, climate change and other societal challenges also pose significant investment risks that are increasingly recognised by the financial sector, and transformative action can be taken to future-proof assets and reduce portfolio risk from both regulatory and physical climate damage drivers.

The Role of ESG Frameworks in the Circular Economy

Environmental, social and corporate governance (ESG) are becoming a priority for mainstream finance, as investors start to understand the 'true' value of sustainable solutions. **ESG investment has increased significantly to over USD 40 trillion in 2020, up from USD 23 trillion in 2016[46].** Renewable energy, waste generation and resource, energy and water consumption are all factored into ESG ratings. A growing number of financial institutions and investors have identified the circular economy as a positive framework to address global issues.

Using innovative data-driven, digital tools ESG reporting has the potential to strongly support the faster adoption of circular economy practices across different sectors. Businesses are encouraged to use ESG to normalise and enhance the circular economy by:

- Reporting on whole life carbon emissions, circularity strategies implemented, and new business models utilised
- Driving innovation in industry by targeting ambitious net zero strategies and certifications for ecology, emissions, water, and waste
- Improving the ESG report process by collaborating and sharing lessons learned within industry.

6.3 Call to Action

This chapter examines enabling strategies and actions that must be pursued in order to scale up circular economy solutions, in alignment with calls to action for industry.

Implementation of new business models: a number of innovative business models have the potential to create value from implementing circular principles. Examples include product as a service, virtualisation, remanufacturing and material marketplace schemes.

Improve data availability and reporting: participation in circular value chains should be incentivised and taken into account through Environmental, Social and Governance (ESG) reporting and assessment of Scope 3 emissions-specific challenges.

Evolve certification and labelling schemes: certification and labelling schemes should provide the appropriate guidance and indicators to align with circularity principles, for example, the certification of reused products.

Upskill and educate: globally addressing existing gaps in education and skills development will be crucial as the circular economy is a concept that requires all stakeholders to think and act differently.

Collaborate and build partnerships: whole value chain collaboration is an essential lever for catalysing the circular economy, which must be undertaken in a spirit of knowledge sharing, transparency and commitment to progress.

Circularity in the construction sector requires collaboration. We see the Extended Producer Responsibility scheme in France to be really important to the collection and sorting of construction waste – and to finding new secondary uses for these materials at the highest value.

Jonna Byskata - Head of EU Public Affairs, Kingspan

07 OUR CALL TO ACTION

Image Credit: Michele Bitetto

In this report, WorldGBC has examined the circular economy within the built environment, recognising its essential role in tackling the global environmental crises and providing an unparalleled opportunity to regenerate resources and accelerate socio-economic development.

A circular economy can enable humanity to thrive in partnership with the Earth, within planetary boundaries.

The only way to produce a circular closed-loop system is through transformative action from every actor across the supply chain. All stakeholders must take action and help transition the sector toward circularity becoming business-as-usual. Every actor in the supply chain must prioritise and implement circularity principles - collaborating with sustainability professionals and member organisations to overcome barriers towards a circular future. WorldGBC's network aspires to see leadership from all governments and businesses. A circular economy is an essential part of the sustainability solution - providing a foundation for future policy change and business innovation.

7.1 The 'Circular-Ready' Built Environment Checklist

	STRATEGY	RESPONSIBILITY	CIRCULAR-READY CHECK		OUTCOME	BUILDING STAGE
BUILDING & CONSTRUCTION MATERIALS	**Drive alternative material use** Increase the demand for sustainably sourced and procured materials and products which preserve biological diversity in nature, whilst ensuring it sustains economic viability.	National Government and Local Authorities	**Has a centralised material database been established?**	**Yes / No**	National government establishes a nationwide material database, building on city-level networks, to reflect the latest material information available. Additionally, pre-demolition and pre-redevelopment surveys are introduced nationally, to identify building products and parts for reuse and recycling, with local authorities providing locations where they can be stored.	Planning
		Manufacturers	**Are digital material passports available for all building materials, products and parts?**	**Yes / No**	Manufacturers provide digital material passports for all materials and products, in alignment with best practice guidelines to facilitate the procurement and specification of (circular) materials and products and the development of a material inventory for a project.	Manufacturing
		Developers and Architects	**Has circular performance-based procurement criteria been included in contract specifications?**	**Yes / No**	Developers and architects examine the use of material passports on projects and engage early with contractors and manufacturers to incorporate circular performance-based procurement criteria (e.g. design for reuse, avoiding the use of raw materials through the inclusion of reused materials and recycled content) into contract specification documentation.	Planning & Design
		Quantity Surveyor and Design Team	**Does the cost analysis identify cost-saving opportunities for the project when alternative or regenerative materials and products are procured?**	**Yes / No**	All stakeholders share material use information with the quantity surveyor (QS) and identify cost-saving opportunities for the project i.e. cost benefit of material reuse. This is factored into the overall cost analysis by the quantity surveyor and the information demonstrates energy and carbon savings. The output from the QS and design team includes targets for alternative material use, and on previously developed sites, a comparison between reusing the entire asset versus reusing building parts is provided.	Planning & Design
	Reduce the consumption of resources Materials that are part of existing buildings and infrastructure are considered resources for the built assets of tomorrow. Avoiding the production and use of new building materials, as well as prioritising retrofit and adaptation over the construction of new built assets, is key to reducing emissions from the sector and implementing a circular economy.	National Government	**Has an extended producer responsibility policy been developed?**	**Yes / No**	National government develops an extended producer responsibility policy ensuring take-back schemes and Product as a Service (PAAS) initiatives are in place.	Planning
		Manufacturers and Contractors	**Have take-back schemes been created for the refurbishment, recycling and the resale of building products?**	**Yes / No**	Manufacturers and contractors create takeback schemes for the refurbishment, recycling and the resale of building materials, products and parts or work with third parties locally to provide these services.	Manufacturing
		Developers and Contractors	**Has a material inventory been created for the asset? If not, has a pre-refurbishment/ pre-demolition audit been conducted?**	**Yes / No**	Developers prioritise the reuse of existing building structures, wherever possible, and start the process of commissioning a pre-refurbishment/ pre-demolition audit, if a material inventory has not been prepared for the building. Pre-demolition surveys are key to identifying reuse and retention opportunities. Contractors carry out detailed pre-refurbishment and pre-demolition audits, to ensure that existing materials can be kept at their highest value.	Design & Retrofit
		Design Team and Contractors	**Does the Operation & Maintenance manual include technical guidance for an asset's refurbishment and deconstruction?**	**Yes / No**	The proposed asset refurbishment and deconstruction methodology is included in the Operation & Maintenance manual, along with a material inventory listing and providing data and documentation (material passports) for all building materials, products and parts. Documentation is handed over to facility management, owners, and occupiers at the end of the construction stage and updated throughout the building's life.	Design & Construction
	Localise the supply chain Localising the supply chain and procuring materials and products close to site represents an opportunity to reduce embodied carbon of any built asset and stimulate the local economy	Local Authorities and Developers	**Have local authorities and developers worked together with supply chains to collate information on material availability and storage?**	**Yes / No**	Local authorities and developers work together with supply chains in order to drive the growth of circular services and products (i.e. PAAS and material take-back schemes). Local authorities collate information on material availability and storage, as part of a public database illustrating supply potential.	Planning & Design
		Quantity Surveyor, Design Team and Contractors	**Has local sourcing been prioritised based on availability, considering material passports and LCA's, when materials and products are procured?**	**Yes / No**	Quantity surveyor and design teams produce technical specifications that prioritise procuring building materials and products locally. Contractors work with the supply chain to identify opportunities for procuring reused materials and ensure products are installed to enable future reuse.	Planning, Design & Construction
		Manufacturers and Contractors	**Have embodied carbon reduction plans for products and operations been developed?**	**Yes / No**	Material manufacturers develop embodied carbon reduction plans for their products and operations, focusing on reducing materials, energy usage, manufacturing waste, and transport needs. Contractors work with their material manufacturers and supply chains to set carbon intensity reduction targets, require mandatory disclosure of supply chain data, and track and reduce construction site emissions. Carbon is evaluated alongside cost in all value engineering exercises.	Manufacturing

DESIGN AND RETROFIT

STRATEGY	RESPONSIBILITY	CIRCULAR-READY CHECK		OUTCOME	BUILDING STAGE
Challenge short-term thinking All stakeholders including policymakers, investors, clients, developers and design teams must take a longer-term view, considering the past, present and future use of a building's products and components – including how to procure, maintain and retain their value and usefulness over multiple lifetimes	National Government and Local Authorities	**Has a national circular economy planning framework policy been developed?**	**Yes / No**	A national circular economy planning framework policy is developed, and national government incentivises the use of circular design principles, and works with local authorities to support further policy development.	Planning
	Asset Owners	**Have Whole Life Carbon targets been set within contracts and has progress been monitored at every building stage?**	**Yes / No**	Clients set out clear Whole Life Carbon targets and evaluate circular economy approaches using circularity-related metrics (e.g. the reduction in raw material use, construction waste to landfill, use of alternative or secondary materials and biodiversity on site).	At every building stage
	Developers and Architects	**Have circular performance-based procurement criteria been included in contract specifications?**	**Yes / No**	Developers and architects examine the use of material passports on projects and engage early with contractors and manufacturers to incorporate circular performance-based procurement criteria (e.g. design for reuse, avoiding the use of raw materials through the inclusion or reused and recycled content) into contract specification documentation.	Planning & Design
Design for building reuse, disassembly and deconstruction Design must consciously facilitate the longer functional use and ease of maintenance of building products and parts to keep them at a high value over multiple lifetimes. Modularity is a key component of design in a circular built environment, as standardised building parts are easier to repair and maintain, disassemble and relocate or refurbish for reuse. Designing for disassembly and deconstruction should create buildings that function as material banks and eliminate waste.	Investors	**Have the benefits of implementing circular economy approaches been conveyed to asset owners?**	**Yes / No**	Financial sector agents engage with the local authorities to support and promote the implementation of circular principles in construction projects. Investors and agents understand and report on the benefits of a zero-to-landfill approach, building reuse, design for disassembly, and recycling.	Planning
	Developers, Clients, Contractors and Design Team	**Have demolition contractors or deconstruction experts been appointed as part of the design team? If yes, has the contractor conducted a pre-refurbishment or pre-demolition audit?**	**Yes / No**	Clients appoint demolition contractors or deconstruction experts as part of the design team, early enough so pre-refurbishment or pre-demolition audits can be considered. Structural engineers proactively identify opportunities to utilise reused structural elements and identify opportunities to design for disassembly. Contractors carry out detailed pre-refurbishment or pre-demolition audits to ensure that existing materials can be kept at their highest value. The demolition/refurbishment contractor reviews the material inventory data and provides comments and updates. The products and materials identified for reuse within the development are specified to be carefully disassembled and stored. Developers ensure the programme planning allows for materials to be removed, stored, and retrieved for reuse.	Planning, Design & Construction
	Developers and Architects	**Have material passports been examined for the project considering end-of-life options?**	**Yes / No**	Developers and architects examine the use of material passports on projects to make materials and products easily identifiable and traceable when disassembling buildings or for future fit-outs. The material inventory is developed and updated to inform design teams of future material availability. This principle can also be applied to refurbishment projects, storing data so that deconstructed elements can be used in the near future.	Planning, Design & Construction
	Asset Owners, Facilities Managers and Occupiers	**Do contractual requirements related to acquisition, ownership and rental, such as green leases, include clauses related to circular economy approaches?**	**Yes / No**	Owners should embrace green contracts and leases for their assets. These might include clauses on fit-out, waste avoidance, restrictions on material selection, or responsibilities for deconstruction at the end of the lease. Based on a green lease and tenancy agreement, the tenant must notify the facilities manager of any changes that will be made to the building during the lease.	Operation, Retrofit, Recycling and Deconstruction
Design out waste Develop strategies to prevent unnecessary waste generation by creating a zero-to-landfill plan with specific, measurable and achievable targets.	Owner, Design Team and Demolition Contractors	**Has a zero-to-landfill approach been targeted and adopted across all stages of the building lifecycle?**	**Yes / No**	Owner, design team and contractors target and adopt a zero-to-landfill approach across all stages of the building lifecycle and the demolition contractors recover products and building parts for reuse as identified in the contract documents.	At every building stage

	STRATEGY	RESPONSIBILITY	CIRCULAR-READY CHECK		OUTCOME	BUILDING STAGE
REGENERATE NATURE	**Gain inspiration from nature** Nothing is wasted in nature. By implementing nature-based solutions our cities can close material loops while restoring the relationship between cities and natural systems	National Government and Local Authorities	**Have biodiversity-enhancing policies been established with incentives to implement circular design approaches and nature-based solutions?**	**Yes / No**	National government and local authorities establish biodiversity-enhancing policies which incentivises the use of circular design principles and the implementation of nature-based solutions.	Planning
		Asset Owners, Design Teams and Contractors	**Are biodiversity-enhancing nature-based solutions and circular design approaches implemented?**	**Yes / No**	Asset owners, design teams and contractors adopt circular economy design principles and construction processes to implement nature-based solutions, for residential, commercial, and major infrastructure projects (e.g. green corridors in cities).	Design & Construction
	Protect water resources Promote water efficiency and quality at all stages of the building lifecycle, and include water use within the reporting conducted during a building's construction and operation phases.	Owner, Design Team and Contractors	**Has a net-zero water approach been targeted and adopted?**	**Yes / No**	Owner, design team and contractors target and adopt a net-zero water approach for all stages of building (i.e. a net zero water building, constructed or renovated, is designed to: i) minimise total water consumption: ii) maximise alternative water sources; and iii) minimise wastewater discharge from the building and return water to the original water source.	At every building stage
LEVERS FOR CHANGE	**Implement new business models** Innovative new business models (eg. product as a service) can increase the utilisation of underused products, components and buildings.	Investors, National Government, Local Authorities, Clients and Developers	**Have circular business model approaches, that recover, reuse or recycle materials and products, been adopted within local supply chains?**	**Yes / No**	Investors report on the benefits of circular economy approaches including the potential for competitive returns while reducing waste, preserving natural resources, and addressing climate change. Investors explore, with legal teams, contract arrangements to address risk related to circular business models (e.g. challenges with using alternative or regenerative materials). National government and local authorities strengthen policy frameworks to mobilise private finance and investment in support of circularity. Clients and developers adopt new circular business model approaches (such as PAAS and take-back schemes) and evaluate circular economy criteria at each building stage.	Planning and at every building stage
	Improve data availability and reporting Participation in circular value chains should be incentivised and taken into account through Environmental, Social and Governance (ESG) reporting and assessment of Scope 3 emissions.	Clients, Design Team and Contractors	**Are circularity-related metrics included within ESG reporting? (e.g. reduction in raw material use, waste, water use and alternative material use**	**Yes / No**	Clients, design team and contractors report on circularity-related metrics within ESG reporting. This data assists investors to align with new sustainable finance regulations (e.g TCFD, SFDR) and all stakeholders involved work towards a consistent ESG reporting format to allow for comparable data and reporting.	At every building stage
	Evolve certification and labelling schemes Certification and labelling schemes should provide the appropriate guidance and indicators to align with circularity principles.	All Stakeholders	**Are updated material datasets available for use in certification and labelling schemes?**	**Yes / No**	National government and local authorities enable material data (including whole life carbon data) to be collected and included within a centralised database, supporting the industry in measuring and reporting on circularity. Certification and labelling schemes are continually updated to assess circularity-related metrics and indicators. All stakeholders increase data transparency and improve certifications schemes when centralised databases are utilised. However, data ownership will vary across each stakeholder and collaboration across the value chain will be required.	At every building stage
	Upskill, educate, collaborate and build partnerships Globally, addressing existing gaps in education and skills development will be crucial as the circular economy is a concept that requires all stakeholders to think and act differently.	Owner, Design Team and Contractors	**Have net zero skills and training plans been implemented?**	**Yes / No**	Owner, design team and contractors adopt net zero (waste, water, carbon and ecology) skills and training plans supported by professional institutions. This should also include circular economy design principles and retrofit competency requirements, and applies to all built environment stakeholders, not just sustainability professionals.	Planning and at every building stage
		All stakeholders	**Have best practice examples and challenges been shared so the industry can learn how different circular economy processes (e.g. procurement of reused materials) can happen?**	**Yes / No**	All stakeholders, including developers, owners, design team and contractors, explore models for collaboration, where partnerships facilitate a knowledge sharing process that allows for transparency so that the industry can learn how different circular economy processes (e.g. procurement of reused materials) can happen.	At every building stage

7.2
Next Steps

WorldGBC's network and partners are committed to driving the adaptation of a circular economy throughout all stages of the built environment.

Image Credit: Lance Anderson

Next steps for the Circularity Accelerator global programme include:

- **Developing a closed-loop vision:** the circular economy movement is urgently in need of a rallying cry - a recognisable symbol of highest-level ambition and best practice that all interim targets can work towards. 'Net zero carbon emissions' is the guiding goal for the decarbonisation agenda, and this sub-sector needs an accessible, communicable high-level goal to set targets against.
- **Consistency in measurement methodologies and indicators:** estimates suggest that over 400 indicators are currently being used to measure circular economy factors across the built environment. Consistency and guidance for the industry around key indicators to use for tracking progress and performance benchmarks is a priority for WorldGBC to explore alongside our network and industry partners.
- **Training and upskilling for circular economy:** WorldGBC is committed to the dissemination of quality training and communication materials for our global network, in collaboration with 75+ Green Building Councils (GBCs) and industry partners from all around the world.GBCs bring people together and provide industry guidance. Through the leadership of their members and businesses across the value chain, they are paving the way in demonstrating that action can, and must, be taken in the transition to circular practices.
- **Advocacy:** national and sub-national policy change remains a key lever in the transition to a circular economy, and the WorldGBC network will support the development and implementation of clear and impactful policy recommendations.

For more information on the WorldGBC's Circularity Accelerator global programme please visit worldgbc.org/circularity-accelerator

08

GLOSSARY OF COMMON TERMS

ALTERNATIVE MATERIALS:	Consist of secondary, bio-based and regenerative (renewable) materials. Alternative materials include natural materials like rock or adobe that are not as commonly in use as materials such as steel or aluminium.
BIO-BASED MATERIALS:	Products that mainly consist of a substance (or substances) derived from living matter (biomass) and either occur naturally or are synthesised.
BIODIVERSITY:	Includes all the different kinds of life found in a geographic area, this includes the variety of animals, plants, fungi, and microorganisms like bacteria that make up our natural world. Each of these species and organisms work together in an interconnected ecosystem to maintain balance and support life.
CLIMATE CHANGE:	Refers to the long-term shifts in temperatures and weather patterns. These shifts may be natural, such as through variations in the solar cycle. But since the 1800s, human activities have been the main driver of climate change, primarily due to burning fossil fuels like coal, oil and gas.
CARBON EMISSIONS:	Refers to all greenhouse gas emissions (GHG). Where the global warming potential (GWP) of emissions is quantified in units of carbon dioxide equivalence - one kilogram of carbon dioxide therefore has a GWP of 1 kg CO_2e.
CARBON FOOTPRINT:	Refers to the amount of carbon dioxide released into the atmosphere as a result of the activities of a particular individual, organisation, or community.
ECOSYSTEM:	An ecosystem is a geographic area where plants, animals, and other organisms, as well as weather and landscape, work together to form life.
ECOSYSTEM SERVICES:	Includes the direct and indirect contributions of ecosystems to human wellbeing. Examples include provisioning services (providing food, wood, water, medicine); regulating services (regulating climate and air quality, storing carbon, protecting against extreme weather events, preventing soil erosion, treating wastewater, pollinating); cultural services (recreation and tourism); and habitat services (providing species with habitat).
EMBODIED CARBON:	Includes material extraction and production, transportation, manufacturing, construction and maintenance (including repair, replacement and renovation) and deconstruction and end-of-life processing for reuse, recovery or recycling and disposal of waste.
END OF LIFE CARBON:	The carbon emissions associated with deconstruction (or demolition), transport from site, waste processing and disposal phases of a building or infrastructure's lifecycle which occur after its use.
NATURAL CAPITAL:	Includes natural assets in their role of providing natural resource inputs and environmental services for economic production. Natural capital is the world's stock of natural resources, including geology, soils, air, water and all living organisms.
NATURE-BASED SOLUTIONS:	Actions inspired by, supported by, or copied from nature that aim to help societies address a variety of environmental, social and economic challenges in sustainable ways.
NET ZERO EMBODIED CARBON:	A net zero embodied carbon asset is a (new or retrofitted) building or infrastructure asset that is highly resource efficient with upfront carbon minimised to the greatest extent possible, as a last resort, offset to achieve net zero.
NET ZERO OPERATIONAL CARBON:	A net zero operational carbon asset is a (new or retrofitted) building or infrastructure asset that is highly energy efficient and powered using on-site and/or off-site renewable sources.
NET ZERO WHOLE LIFE CARBON:	A net zero whole life carbon asset (new or retrofitted) is highly energy efficient, with upfront carbon reduced to the greatest extent possible and all remaining carbon reduced or, as a last resort, offset to achieve net zero across the whole lifecycle. This lifecycle encompasses both embodied and operational carbon.
OPERATIONAL CARBON:	Emissions associated with energy used to operate the building or infrastructure.
RECYCLED MATERIAL:	Has been reprocessed from recovered material by means of a manufacturing process.
SECONDARY MATERIALS:	Materials or products with recycled content (ISO 14021). Recycled content by proportion or mass including: • Pre-consumer: material diverted from the waste stream during the manufacturing process. • Post-consumer: material generated which can no longer be used for its intended purpose.
UPFRONT CARBON:	Emissions from materials' production and construction phases of the lifecycle before the building or infrastructure begins operation.
WHOLE LIFE CARBON:	Emissions throughout the lifecycle of a built asset. This lifecycle encompasses both embodied and operational carbon.

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For more information on circular economy in the built environment, see WorldGBC's **'Circularity Accelerator'** global programme, and reach out to your national **Green Building Council** for local activities.

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2.3

Measuring Circularity in the Built Environment

Measuring the progress of a circular economy is essential to the actual implementation of a functioning circular economic system.

DIGITAL MATERIAL PASSPORTS:

Digital materials passports are a key strategy for tracking the circulation of building and construction materials in a closed-loop system, by hosting open-source data defining the characteristics of materials in products used, and enabling the identification of value for recovery, reuse and recycling.

Material passports can be connected to wider digital tools – such as Building Information Modelling (BIM) software, digital inventories and logs, which could be further connected to supply chains[16], logging all modifications and maintenance an asset has undergone. For useful product-level data to become available it is critical that all tiers of the supply chain work together with a commitment to transparency and data-sharing in order to facilitate the implementation of circular business models and strategies across the wider built environment.

For more information refer to report Section 3.2

until the end of its life, the following indicators have been proposed to establish quantifiable goals and indicators at different stages.

2.3
Measuring Circularity in the Built Environment

Measuring the progress of a circular economy is essential to the actual implementation of a functioning circular economic system.

Circular Economy: In 2021, Circle Economy and BCG introduced the CIRCelligence Indicators Framework. CIRCelligence[17] is a proprietary metric and tool that analyses the entire value chain from input to end of life, and anchors circular thinking into the business and its ecosystems. It evaluates material flows but also qualitative components, such as material values and engagements with the broader business ecosystem.[18]

World Business Council for Sustainable Development (WBCSD): WBCSD developed the 'Circular Transition Indicators (CTI) – Metrics for Business, by Business'. The CTI process helps companies' scope and prepare the assessment and interpret its results, understand its risks and opportunities, prioritise actions and establish SMART targets to monitor progress.

European Commission: The European Commission's Level(s) Framework is a voluntary reporting mechanism that uses existing standards and provides a common EU approach to the assessment of environmental performance in the built environment. This framework can be used for unified procurement frameworks.

CASE STUDY:

Pasaporte de materiales y activos sostenibles (P+MAS) - a pioneering material passport platform in Latin America

The "Sustainable Materials and Assets Passport: P+MAS" is a project developed and managed by Chile Green Building Council (Chile GBC) and the Technological Center for Innovation in Construction (CTeC), both being non-profit organisations and specialists, promoting sustainability and innovation in the construction sector in Chile. This initiative is part of the circular economy challenges for the construction sector of CORFO (agency of the Ministry of Economy) and is co-financed with contributions from renowned material manufacturing and real estate companies.

P+MAS is an innovative and pioneering technological platform at the national and Latin American level and its objective is the disclosure of material passports of real estate assets, based on verified information that supports attributes of circularity, environmental impacts and toxicity of all the materials, products and components of a building, becoming a large inventory for the actors of the ecosystem and providing detailed information that will support the sustainable management of real estate assets.

For buildings, the platform considers the entry of information by categories and subcategories in a standardised format to facilitate the entry of portfolios and favor the comparison among assets. The purpose of the passport is to collect and verify supporting evidence that communicates sustainability attributes in materials and buildings, promoting and encouraging regeneration, non-renewable resources preservation, emissions reduction, transparency of chemical components and avoidance of hazardous chemicals, hence reducing the environmental and social footprint of the built environment, in addition to collecting relevant information for use in public policies and frameworks.

P+MAS is an initiative that contributes to the development and implementation of whole life-cycle circularity models.

For more information:
Plataforma Pasaporte de Materiales para la Construcción

Source: ChileGBC

CASE STUDY:

The Recycled Houses; Denmark.

'Are recycled materials as durable as new materials?' Between 1990-1994, three apartment buildings, known as 'The Recycled Houses', were built from 80-90% recycled materials in Horsens, Odense and Copenhagen. The aim was to employ full-scale, traditional construction methods making the greatest possible use of recycled materials.

Whilst circular economy and recycling of materials in the construction sector are a high priority, there is still uncertainty and a lack of documentation for recycled materials' quality and durability. Currently this is one of the biggest challenges for the implementation of recycled materials in construction on a larger scale. The evaluation of the recycled apartments, which have been in operation for 30 years, supports the development of circular economy and recycling in the construction sector, demonstrating that:

- As long as recycled materials are carefully selected and, in many cases, tested prior to construction, their quality and condition will be equal to that of new materials after 30 years of living in and using the recycled property. It makes no difference whether materials are old or new, what matters is their quality.
- After 30 years, the recycled materials are seen to have the same quality in terms of durability and quality as corresponding new materials. Upon examination of the recycled properties and comparing them with reference buildings, no significant differences in durability and strength were observed.
- Most materials appear in good condition 30 years later and have not required more maintenance than usual.
- Interviews were conducted with operators (housing companies) and residents to hear their experiences of the condition of the apartments. The majority of residents are happy living in these buildings and do not have any negative perceptions of the recycled materials used – instead they are proud of it.

For more information:
The Recycled Homes

Source: WSP

CASE STUDY:

Delivering steel´s full reuse potential

Steel reuse is now a viable low-carbon option for all parties to implement. This is demonstrated, from the perspectives of contractor, steel producer, fabricator, engineer and the client, on the Elephant and Castle Town Centre project in London, UK.

The project is a mixed-use development with four buildings and a shared basement. It is currently on site and being constructed by Multiplex. The project originally had a total of 372 tonnes of designed steel, and by substituting 26% of this with reclaimed steel, the team will be able to achieve a saving of 160 tonnes of CO_2e (A1-A3). This is a significant achievement and highlights the opportunities for carbon savings, whilst remaining cost neutral.

To unlock the full potential of the reuse of steel, WSP developed a digital section matching tool to enable the project to achieve the optimum configuration for the replacement of new by reclaimed steel, and therefore the greatest carbon saving.

The automated tool uses an optimisation algorithm to maximise the tonnage of designed steel sections to be replaced with reclaimed sections. It allows the user to change the allowable depth and width increase of the steel sections, which increases the possibility of a reused section match being found. Parameters have been carefully considered to create a holistic approach such as maximum allowable weight increase of the section to optimise the carbon saving on this project while also ensuring that greater carbon benefits from use of the section on a different project or process are not prevented. The tool allows the Revit Models to be updated within a matter of minutes, ensuring that design iterations can be quickly produced and sent to the project team. This ensures that we can rapidly respond to changing stocklists of existing steel and keep the wider team updated.

Such digital tools help overcome one of the main challenges for circularity in construction materials, the uncertainty, and a lack of documentation on their quality and durability.

For more information:
Elephant and Castle Town Centre

Source: WSP

Locally Sourced Materials

Localising the supply chain represents a tremendous opportunity to help the environment and the local economy. The amount of energy it takes to produce and transport materials should be considered crucial in the selection process of materials, as these factors are reflected in the embodied carbon emissions of an asset. Materials and products vary in the amount of energy they require for production, as do various transportation modes.

When transportation and energy consumption are reduced, emissions that cause climate change and impact human health are also lowered. **Procuring materials locally can enable entrepreneurial activity, with the potential to provide employment to traditionally underserved branches of society, such as women and young people entering labour markets and facing unemployment.**

Responsible and Healthy Materials

Key global organisations are encouraging the use of environmentally responsible, healthy, low carbon products ready for a circular economy by delivering a common language and multi-attribute criteria that can be used to select better products.

Existing frameworks, such as 'Mindful Materials' and GBCA's 'Responsible Products Framework', have significant commonalities, including setting out criteria relevant for building products and materials based on their impact on people, place, and planet. These are based on established industry protocols such as EPDs and HPDs. While there may be some differences between tools and systems, there is a growing consensus on the core attributes of a responsible product.

Urban Mining and Material Cascading

CASE STUDY:

Xiao Jing Wan University, China - a history of locally sourced brick masonry buildings

The complex of university buildings was designed and constructed to respect the area's vernacular heritage whilst minimising the environmental impact of construction by sourcing and manufacturing materials locally.

The local area, east of Shenzhen, has a long tradition of constructing masonry brick buildings using locally sourced soil, therefore the entire manufacturing process was carried out at a neighbouring factory, reducing the embodied carbon produced during the material extraction and production, transportation, manufacturing and construction processes. The main materials used are purpose-made bricks and concrete. Xiao Jing Wan is a coastal university-style campus designed by Foster and Partners for China Resources Group, and achieved the Certificate of Green Building Design Label - 2 Star. The 55,000 square-metre university campus is part of a larger mixed-use development, consisting of a hotel, clubhouse, retail and residential components.

For more information:
Xiao Jing Wan University | Projects | Foster + Partners

Source: Foster + Partners

CASE STUDY:

Cross-laminated secondary timber (CLST)

Solid timber waste is typically chipped and downcycled into products such as particle board and animal bedding with limited reclamation of solid timber through salvage yards. In a circular economy, biological materials should be cascaded through reuse and high-value recycling, which increase the built environment's capacity to store biogenic carbon, before downcycling to lower-grade products and eventually returning to the biosphere. An example of high-value recycling is using recovered wood in mass timber products like CLT and glulam, which can displace the need for carbon-intensive virgin materials. Upcycle waste timber to retain its sequestered carbon over the long term, and allow local production of mass timber products[31].

On this basis, a team at University College London has been researching the potential to use salvaged wood to make 'cross-laminated secondary timber' (CLST), with support from the Ramboll Foundation, the UK National Interdisciplinary Circular Economy Research CE-Hub, and UK Research and Innovation.

As Dr Colin Rose, lead researcher and inventor of CLST says, "Transforming secondary timber into CLST presents a business case for reusing or upcycling materials on an industrial scale. The process turns low-value materials into a standardised component. It's the kind of product we urgently need to meet the demands of the construction industry, while vastly reducing environmental impacts."

Find out more about the research here:
https://ukclt.com/

CASE STUDY:

Product take-back models in use in the commercial real estate sector

The built environment has a significant potential to reduce carbon emissions through circular practices in fit-outs. A building fit-out is a process whereby interior building materials and components are installed, including flooring, wall and window coverings, partitions, doors, furniture and equipment. On average, fit-outs happen every eight years and are responsible for a third of emissions over the life of a building.

Holistic procurement strategies can break the silos between the stakeholders involved in fit-outs and strip-outs by designing spaces with a waste reduction mindset and working with material suppliers to close the loop on end-of-life materials so fewer materials would be required. During strip-outs, end-of-life materials can return to the supply chain as second-hand components, salvaged materials or recycled as feedstock for new products.

Several companies are leading the exploration of circular business models to support more sustainable building fit-outs. For example, Saint Gobain is taking back glass for closed-loop recycling, and CBRE saved nearly 315,000 pounds of emissions by using recycled content to furnish their offices in 2021.

Other organisations such as **Globechain** or **Rheaply** are enabling material marketplaces, and ByFusion is compressing single-use plastics from buildings to use as building blocks.

Other initiatives from CBRE include:

- **Closed-loop recycling:**
  Recycling carpet tiles as feedstock for new carpet. Through the Interface ReEntry Programme, CBRE helped a technology client prevent about 1,700 square metres (11.24 tonnes) of carpet from going into a landfill using closed-loop recycling. About 35% of the old carpet was turned into "fluffy yarn" and incorporated into engineering plastics and materials. In comparison, 65% of it was made into crumbs which were converted into Glasbac RE sheets, a material to create a brand-new carpet tile.
- **Reuse programme:**
  Repairing furniture to be sold back into workspaces or donated. CBRE partnered with Crown Workspace to assist a life science client in diverting unwanted furniture from a landfill. This reuse programme generated £40,000 in resale fees and £12,000 worth of donations, providing a second life and reducing carbon emissions to approximately 10,800 square metres of cleared fixtures and fittings.

Source: CBRE

CASE STUDY:

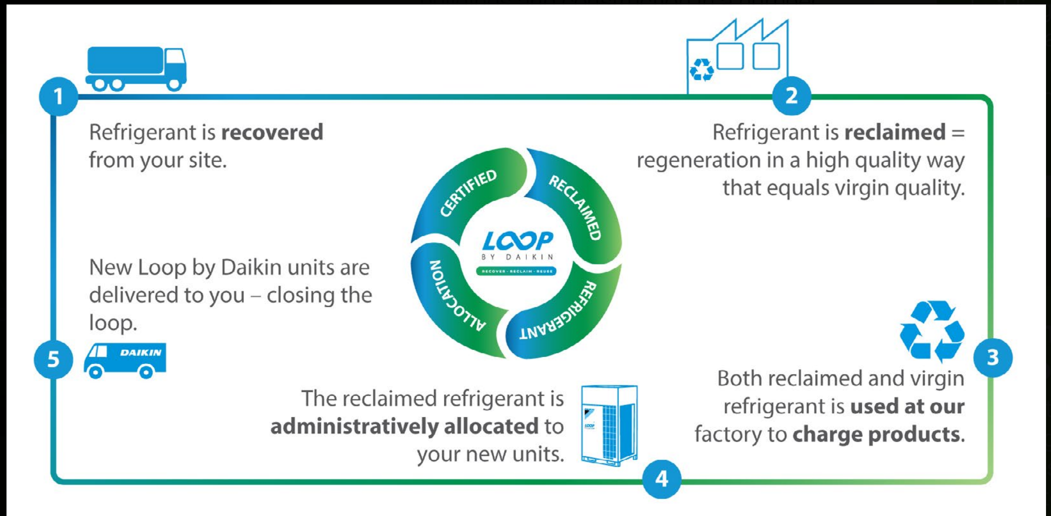
Hungary leading innovation of the circular economy by enabling the trade of reclaimed refrigerants

Through amendments to the current legislation, the Hungarian Government is encouraging unit owners and service companies to choose reclamation as an alternative to disposal for recovered fluorinated greenhouse gases (F-GHG), so that they only become waste when absolutely necessary.

To help this happen, businesses and individuals can store, sell, or provide the refrigerant recovered from their own units for reclamation or disposal. Embracing the new opportunities, Daikin, a member of Hungary Green Building Council (HuGBC), created the programme "LooP by Daikin – Recover-Reclaim-Reuse[34] " to lower the environmental impact of cooling and heating, especially in retail and other industries.

The principles of LooP are simple, but the environmental impact is significant: the initiative has allowed them to avoid the yearly production of 250.000 kg of virgin refrigerant gases for cooling and heating systems. The LooP by Daikin – Recover-Reclaim-Reuse for key accounts and investors is closing the loop by providing them a reliable supply of reclaimed refrigerants for certified Daikin units at their sites.

How does "LooP by Daikin – Recover-Reclaim-Reuse" work?



LooP by Daikin –
Recover-Reclaim-Reuse circular economy for refrigerants.
Copyrights Daikin

The role of the Extended Producer Responsibility (EPR)

Extended Producer Responsibility (EPR) is an environmental policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products. Assigning such responsibility in principle provides incentives to prevent waste at the source, promote product design for the environment and support the achievement of public recycling and materials management goals[35].

In France, for instance, the EPR has been part of the legislation since 1975. The law states that producers, importers and distributors may be required to contribute to the disposal of waste from their products. Since 1992, the law applies to household waste, and the number of EPR channels has increased since then in France and in Europe.

Thanks to the law on the circular economy passed in 2020, this system is developing even further and has modified and strengthened the EPR system. In addition, there is a stronger incentive for eco-modulation, funds dedicated to repair, reuse, and many other proposals favourable to the evolution of consumption patterns[36].

The French EPR scheme will cover the construction sector from May 2023, which is considered a major development to drive the collection, sorting and build-up of the necessary business model to recognise the value to secondary material streams.

Material Take-Back

Material take-back in today's markets is often organised by a manufacturer or retailer to collect used products or materials from consumers and reintroduce them to the original processing and manufacturing cycle. A company may implement this programme in collaboration with end-of-life logistics and material processing firms[45]. The process of material take-back reduces the requirement for new materials in product creation and incentivises better design for disassembly and reuse by the manufacturer.

There are multiple benefits for implementing a take-back programme, including: stronger customer relationships, lower cost of goods sold due to secondary material supply, alternative supply of critical raw minerals, mitigated risks associated with hazardous materials handling and reduced environmental impacts. These benefits can result in lower cost or discounts to consumers when they participate. However these programmes can be complex to implement as it may be a major challenge to convert end products back to raw material, and the cost of recycling may be high. **The support of governments is required to assist in creating the necessary infrastructure, incentives and waste regulations to accelerate the implementation of take-back programmes at scale.**

CASE STUDY:

84 Harrington Street in Cape Town, South Africa, named world's tallest hemp built building

84 Harrington Street in Cape Town, South Africa is a 12-storey building featuring a total of 50 apartments built using hempcrete blocks and hemp construction materials. Hempcrete is a carbon negative material, meaning that it sequesters CO_2 from the atmosphere. About 108kg of CO_2 can be locked away as biomass per cubic meter of hempcrete for the lifespan of the building.

Developed by Hemporium and Afrimat Hemp, the project has set new standards for constructing multi-storey buildings using alternative regenerative building materials, inspired by hemp blocks created in Europe. With its suitable climate South Africa could allow for the large-scale cultivation of industrial hemp, considering that hemp is a versatile material that could be used in textiles, cosmetics and even processed to create an alternative to plastic.

Hemp grows quickly and contributes to the purification of contaminated soils, requires little water, no pesticides or herbicides and is inherently pest resistant. Therefore its cultivation can be completely toxin-free. The material also has the capacity to maintain healthy indoor air quality.

The benefits of building with hemp in a multi-story building:

- Hemp is 100% natural, CO_2 absorbing, energy saving, very lightweight and durable. Using hemp blocks reduces the CO_2 footprint of a building in construction as well as its operational CO_2 footprint. It has the potential to be a zero-waste material, as previously used hempcrete can be reused and added to new mixes.
- It has excellent thermal insulation values and good thermal mass well above regulation standards in South Africa, leading to substantial energy savings compared with conventional building technologies. The superior acoustic performance ensures privacy between units. It is simultaneously breathable and inherently airtight. As a vapour-permeable building envelope, it regulates internal relative humidity, eliminating condensation on internal faces.
- Hemp construction can be very simple and low-tech. It has the potential to create a whole new industry particularly relevant in a South African context.

For more information on the project: *Materiality – WOLF + WOLF*

Source: Hemporium and Afrimat

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CASE STUDY:

Cutting-edge technologies towards carbon-neutral concrete

Concrete is an essential element for the built environment as it is a strong, durable, and versatile material that can withstand great stresses without yielding. Apart from providing structural strength, concrete contributes to energy efficiency of buildings when providing thermal mass for the appropriate applications. Technologies to decarbonise concrete include the carbon capture in minerals to be used as low emission raw material in green cement and the Carbon Capture Utilisation and Storage projects (CCUS). Holcim, a global leader in innovative and sustainable building solutions, is partnering with research organisations to find globally scalable technologies to accelerate industrial decarbonisation.

Holcim currently has over 50 Carbon Capture Use and Storage (CCUS) projects in various stages of development, including the Carbon to Business (C2B) project at the Höver cement plant in Germany being implemented with technology partners Cool Planet Technology and Hereon.

The C2B project uses gas separation membranes that allow some components of a gas mixture to pass more readily than others, and hence capturing CO_2 in a gaseous state. In 2022, the project successfully completed testing proving that the methodology is feasible for use in cement manufacturing facilities. The next phase, starting in 2023, will use the same technology at a larger scale, as a one-year test duration aiming to capture 6,000 tonnes of CO_2.

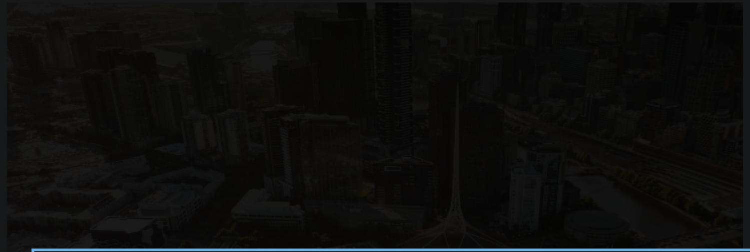
Holcim has also partnered with Eni to store CO_2 into olivine, a widely available mineral. Researchers at Holcim's Innovation Center are exploring the use of this carbonated olivine as a new low emission raw material for the formulation of its green cement. Holcim and Eni's global operations, combined with olivine's broad availability worldwide, would make the CCUS solution highly scalable. It would enable the permanent sequestration of CO_2 into building materials for greener construction.

Source: Holcim

4.1 Circular Building Design and Construction Strategies

Designers of buildings and infrastructure are well-placed to challenge business-as-usual approaches and unleash forward-looking designs that consider the entire lifecycle of an asset.

Circular design and construction offers extensive environmental opportunities and socio-economic benefits if the appropriate design and construction strategies are implemented. In practical terms, it requires all stakeholders including investors, clients, developers and design teams to take a longer-term view, considering the past, present and future use of a building's products and components – including how to procure, maintain and retain their value and usefulness over multiple lifetimes.



Linking net zero and circularity

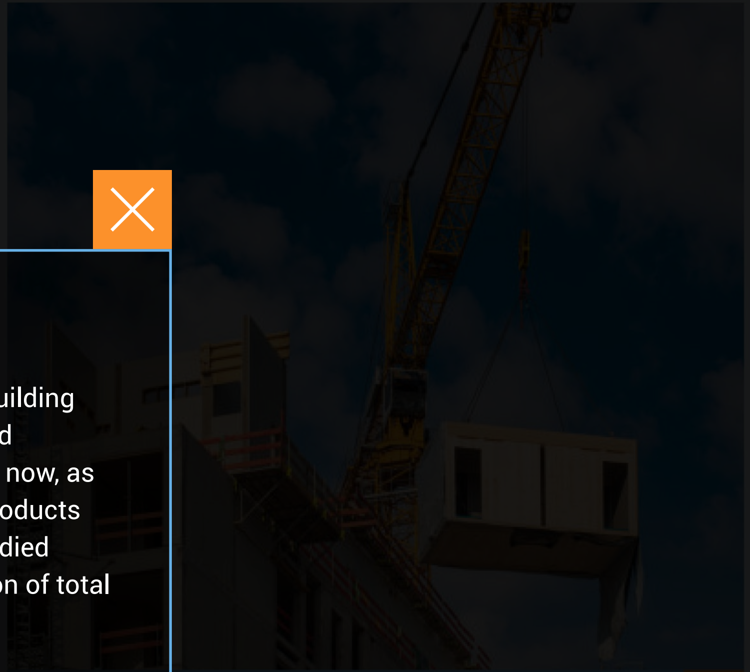
The implementation of circular design principles is an essential part of the solution for a net zero carbon future. While industry has traditionally focused on addressing operational carbon, increased efforts to tackle embodied carbon emissions at a global scale must now be equally prioritised.

WorldGBC's Whole Life Carbon Vision calls for all new buildings to be net zero carbon in operation and all new buildings, infrastructure and renovations to have at least 40% less embodied carbon with significant upfront carbon reduction by 2030. By 2050, all new buildings, infrastructure and renovations must have net zero embodied carbon.

By 2050, all buildings, including existing buildings must be net zero operational carbon[42]. Net zero embodied carbon should be pursued as part of a strategy to decarbonise the whole building lifecycle, recognising the urgency of addressing embodied emissions, which are being released into the atmosphere now, as we continue to extract and manufacture materials and products for construction. As operational carbon is reduced, embodied carbon will continue to grow in importance as a proportion of total emissions.

For more information: Whole Life Carbon Vision - World Green Building Council

For more information:
Whole Life Carbon Vision - World Green Building Council



CASE STUDY:

Quay Quarter Tower, Sydney Australia - setting a global benchmark for adaptive reuse

Designed and constructed to have a net-positive or at least a net-zero impact on the environment, rather than being demolished, the existing commercial skyscraper was upcycled, retaining more than 60% of its existing structure and extending the asset's design life by 50 years with minimal intervention. In 2022, the project won the World Building of the Year award at the World Architecture Festival in Lisbon.

The project has been certified by WELL, 6 Star Green Star Office Design v3, and 5.5 Star NABERS Office Energy Rating Base Building. It was developed in a collaboration between Architects 3XN (Danish), BVN (Australian), Structural Engineers BG&E and ADG, MEP/Façade Engineers, Arup, and Multiplex Construction, *"To achieve net zero targets we needed to work collaboratively with all stakeholder parties including architects, engineers and government. We needed to think out of the box, use the latest technologies and speed up our digital skills. Structural engineers are falling behind on digital technology, so we need to catch up, build momentum, and start using digital tools effectively in our structural design. I get excited every time I see a new development and a new way of design, because I see we are closer to achieving that great outcome"*- Reza Hassini, BG&E.

Key challenges:

- To integrate the old structure with the new structure;
- To understand the original structure and to retain it;
- To integrating the new structure with the old structure and;
- To verify the complex design of the new model, the first of its kind in the world.

Circularity outcomes

- 66% of the building's existing columns, beams and slabs and 95% of its internal walls were retained
- 50% of the building's resources were reused from the existing building
- The reuse of materials resulted in a total carbon saving of over 7,500 tonnes, an estimated economic savings of $130 million and an estimated construction time saving of 12 months
- A 4D structural model (digital twin in ETABS) was developed and calibrated during the construction to study the current and future structural behaviour
- A comprehensive structural testing program was implemented to determine the strength of the existing structure
- The health of the structure was monitored during the construction by the installation of various instruments and sensors to demonstrate the structural sufficiency of existing structure
- The life of the asset was extended by at least 50 years

For more insight on the design journey and the collaboration between all the stakeholders, **listen here** to Reza Hassini share the journey to transform the old AMP Centre to the world class Quay Quarter Tower.

Find more information about the project **here**.

Source: VinZero

CASE STUDY:

Burwood Brickworks Shopping Centre, Australia - an industry leading sustainable retail design and construction

Developed by Frasers Property Australia the Burwood Brickworks Shopping Centre project team conducted 'healthy' materials research to create a freely available resource known as the Greensheet for the Australian market.

The Greensheet provides a comprehensive list of building materials used in the building's construction, this living document lists some 1,400+ building materials which go significantly beyond being 'sustainable' – they have been thoroughly vetted based on criteria contributing to the regenerative buildings' movement. Each product has been examined based on factors such as its place of origin, materials used in its manufacture, whether it is responsibly sourced, its embodied carbon, its waste impacts, and its impacts on air quality when used internally. Throughout the design, construction and operation phases of the project, the waste hierarchy has been adopted and through this process, 99% of construction waste was diverted from landfill.

In 2021, the Burwood Brickworks formally achieved the Living Building Challenge Petal Certification. The certification required the development to have a net-positive impact, operating in a clean and efficient manner. This sustainable retail design and construction was a first in Australia, and currently, no other retail centre development globally has accomplished this rating.

For more information:
Burwood Brickworks Shopping Centre, Australia

Source: GBCA (Green Building Council of Australia)

CASE STUDY:

Canada's largest heritage rehabilitation project

Canada's 100-year-old parliament building, Centre Block in Ottawa, is undergoing an extraordinary retrofit that blends heritage conservation with sensitive contemporary interventions including seismic upgrades, modernised building systems, and new spaces to support parliamentary operations.

The project teams at WSP and HOK are going to great lengths to preserve and repurpose as much of the building's existing fabric as possible. For example, as part of the seismic upgrades and the design interventions, approximately 500 metric tonnes of steel will be removed from the building and repurposed.

Reusing steel has a significant environmental benefit over recycling, as the re-melting and shaping of steel into usable members accounts for approximately 95% of steel's embodied carbon. Extensive testing, as part of the seismic upgrades process, demonstrated that the existing steel was structurally suitable for reuse. Approximately 200 tonnes will be reused within Centre Block, 200 tonnes will be made available for use by other projects within the Parliamentary Precinct, and any remaining steel will be repurposed on other projects or recycled.

There was an initial assumption that deconstructing and reusing steel would be expensive. But following an in-depth review of the process and costs, it was determined to be cost-neutral and potentially cost-saving due to the rising price of steel.

This reuse of steel is salvaging the equivalent of 1250 tonnes of carbon emissions from the existing steel, in addition to reducing embodied carbon from new steel by approximately 120 tonnes.

Conserving and reusing historic buildings is integral to a circular economy. This project demonstrates the importance of assessing the opportunity to reuse materials, not just recycle them, and the wider benefits this could bring.

For more information:
Canada's Largest and Most Complex Heritage Rehabilitation Project

Source: WSP

According to the ISO 20887: Sustainability in buildings and civil engineering works — Design for disassembly and adaptability, the following principles should be considered when designing for:

- **Disassembly:** 1. Ease of access, 2. Independence, 3. Avoidance of unnecessary treatments and finishes, 4. Supporting reuse business models, 5. Simplicity, 6. Standardisation, 7. Safety of disassembly
- **Adaptability:** 1. Versatility, 2. Convertibility and 3. Expandability .

Adaptability principles

- **Versatility:** is the ability to accommodate different functions with minor system changes, like community rooms or sport halls; versatile structures and spaces facilitate alternative uses even over the course of a day. This can reduce the overall building footprint, required floor area, costs, and resources.
- **Convertibility:** is the ability to accommodate substantial changes in user needs by making non-structural modifications, either on a regular or irregular basis. This can improve the profitability of a space, as well as reduce the need for other facilities, thereby reducing resource and energy use.
- **Expandability:** is the ability to accommodate a substantial change that supports or facilitates the addition of new space, for instance, allowing vertical or horizontal additions in floor space.

Disassembly principles

- **Ease of access:** allows for components, especially those with the shortest anticipated life cycle, to be easily approached, with minimal damage to and impact on it and adjacent assemblies.
- **Independence:** allows parts, components, modules and systems to be removed or upgraded without affecting the performance of connected or adjacent systems.
- **Avoidance of unnecessary treatments and finishes:** finishes that can prevent the substrate from being reused or recycled should be avoided. Finishes should serve a specific purpose, e.g. for fire and/or corrosion protection.
- **Supporting reuse business models:** this principle is concerned with supporting the market for re-used, refurbished, remanufactured and recycled materials and products now and in the future, in support of circular economy business models. Design approaches to provide resources for future construction works should facilitate the use of secondary materials and resources in buildings and infrastructure.
- **Simplicity:** is the quality of an assembly or system that is designed to be straightforward, easy to understand and meet performance requirements with the least amount of customisation. It reduces the number of elements, components (subcomponents), or materials to the minimum required to execute the intended function.
- **Standardisation:** use of common components, products, or processes to satisfy a multitude of requirements. They make it easier for contractors to disassemble structures while using efficient and repetitive techniques.
- **Safety of disassembly:** any component, module or system to be disassembled requires a disassembly plan that is considered at the onset of design to ensure its effectiveness.

For more information:
ISO 20887:2020

CASE STUDY:

Pyörre House, Finland - the first Finnish building designed and constructed to test the EU's design criteria for adaptability, disassembly and recyclability

Pyörre House is a steel-framed single-storey detached house built for the Lohja Housing Fair in 2021. The building has 227 m² of floor space and the primary construction is made of steel. The house has been designed and constructed to embrace low-carbon circular principles and strategies. Of all the materials used on the project, it is made up of 22.1% recycled, 15.3% renewable and 62.6% non-renewable materials. The design team carefully mapped the use of materials and building components for the project, exploring ways in which the building could retain its value and usefulness over the long term.

An evaluation of the building was carried out during the design and construction phases, before taking the building into use. At the time of the evaluation, there were no official methods for assessing the circular economy of buildings and there were few methods in Europe that were suitable for a quantitative assessment of circularity. Therefore, the assessment of circularity was based on a combination of three complementary assessment methods: EU´s Level(s)1, German DGNB and the Building Circularity Tool of OneClickLCA software, with this combined method, it was possible to quantify both climate burdens (carbon footprint) and potential climate benefits (carbon handprint). Assessment for the ease of disassembly and for the utilisation of disassembled products and materials has been made based on design documents. Although the utilisation would take place in the future, its potential has conservatively been estimated according to today's practices. For example the load bearing frames made up of steel, glulam and timber parts are attached to each other with screws and attachment plates and within the assessment the utilisation potential of these building parts, opportunities were identified for the reuse of components, the recycling of steel and energy recovery of wood.

The project has been included within the Ministry of the Environment's low-carbon construction pilot programme, specifically created to develop a set of suitable criteria through which buildings of all types (including residential) could assess their carbon footprint and carbon handprint, where carbon handprint is the positive actions taken to have a positive impact on the climate - the opposite of footprint. The carbon handprint of the building is almost as high as its carbon footprint. This is due to the good recyclability potential of the chosen building materials, especially regarding steel components.

For more information:
House Pyörre, National Housing Fair at Lohja 2021, Material and climate declaration

Source: FinlandGBC

CASE STUDY:

Minimising waste at deconstruction, Kāinga Ora – Homes and Communities

Construction and demolition waste may represent up to 50% (6 million tonnes per year) of all waste to landfills in New Zealand. Consequently, the municipality of Kāinga Ora established an ambitious deconstruction and demolition programme, which aims to reuse or recycle up to 80%, or more, of uncontaminated materials by weight in Auckland and Northland development areas, and 60% of uncontaminated materials in all other regions.

The programme prioritises house relocation and deconstruction over demolition, wherever possible. Relocation enables a whole house to be repurposed, while deconstruction allows for greater reuse of materials. In 2021, Kāinga Ora expanded the relocation programme to cover at least 7% of all public houses removed from development areas nationally. These targets complement the Kāinga Ora Environment Strategy which includes a range of initiatives aimed at reducing the impact of construction and demolition on the environment.

The Kāinga Ora municipality completed its first public housing deconstruction project, where 8 houses were removed using deconstruction at a Mount Albert development in Auckland. The project achieved 85% diversion from landfill, diverting 203 tonnes of building construction and demolition waste. What's more, the cost and duration of the deconstruction were found to be similar to conventional demolition.

For more information:
Kāinga Ora – Homes and Communities

Source: NZGBC (New Zealand Green Building Council)

The Waste Hierarchy:

In order to minimise negative impacts of waste, the Waste Hierarchy was proposed as a model to establish preferred programme priorities and evaluate processes that protect resources.

The European Commission for instance, developed a five-step "waste hierarchy" for the EU Waste Framework Directive, in which preventing waste is the preferred option, and sending waste to landfill should be the last resort[50].

The Directive highlights waste management principles, such as:

- avoid endangering human health and harming the environment,
- avoid risking water, air, soil, plants or animals,
- avoid causing a nuisance through noise or odours, and
- avoid 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".

Organisations such as the United States Environmental Protection Agency follow a similar hierarchy and highlight the potential of energy recovery. Converting non-recyclable waste materials into electricity and heat generates a renewable energy source and reduces carbon emissions by offsetting the need for energy from fossil sources, and reduces methane generation from landfills. After energy is recovered, approximately ten percent of the volume remains as ash, which is generally sent to a landfill [64].

CASE STUDY:

You can't improve what you don't measure - responsible operational waste management

The Curitiba headquarters of Brazilian engineering and green building consulting firm, Petinelli, a member company with USGBC, was the first building to certify using LEED Zero, a programme which tracks net zero performance in the categories of waste, water, energy and carbon. In addition to achieving LEED Zero Waste, the building has also achieved ambitious net zero targets set for energy and water.

The zero waste initiative led to practices that continued to reduce waste whilst training building occupants and during a one year period, 850 kg of waste was composted instead of sent to landfill. At the same time, waste reduction strategies were implemented to avoid the use of single use items such as paper and plastic and thus prevented the use of 70 kg of these materials during the assessment period. The 440-square-meter office building is housed in a converted warehouse where all energy is produced on-site, with an energy-use intensity for the site of only 25 kilowatt hours per square meter, per year. A 15 kilowatt photovoltaic array provides around 125% of the energy needed to run the 25-person office. While Brazil offers plenty of sun for Petinelli's solar array, it also rains 200 days out of the year in Curitiba, consequently a system for harvesting and treating rainwater has been installed at the company's headquarters. Having achieved LEED Zero Energy and LEED Zero Waste certifications previously, the headquarters functions as a "living laboratory and showroom" of performance objectives that the firm encourages for its clients.

'You can't improve what you don't measure' is an essential principle when it comes to implementing responsible operational waste management practices, where waste streams need to be measured, monitored and improved upon over the building's entire operational phase.

For more information:
Petinelli Curitiba

Source: USGBC

CASE STUDY:

JP Morgan Chase HQ - New York City's first all-electric, circular and net-zero skyscraper

Located at the heart of Manhattan, Foster + Partners conceptualised this building as the city's first all-electric tower, with a programme that prioritises employee wellness and sustainability.

The project recycled, reused or upcycled 97% of the building materials from the demolition – far exceeding the 75% requirement of the leading green building standard. It's 100% powered by renewable energy sourced from a hydroelectric plant. In addition to operating on net zero carbon emissions, the building will use state-of-the-art building technology and systems to ensure it operates as efficiently as possible, including intelligent building technology that uses sensors, AI and machine learning systems to predict, respond and adapt to energy needs; advanced water storage and reuse systems to reduce water usage by more than 40%.

The project is part of New York City's Midtown East rezoning plan. The tower will rise to a height of 423 metres over 60 storeys on its projected completion in 2025. Hosting a varied programme that will build on the legacy of its predecessor, the new tower will integrate green spaces, a street level public plaza, and 2.5 million square feet of flexible and collaborative workspace.

Norman Foster, Founder and Executive Chairman of Foster + Partners, states in an official release, "270 Park Avenue is set to be a new landmark that responds to its historic location, as well as the legacy of JPMorgan Chase in New York. The unique design rises to the challenge of respecting the rhythm and distinctive streetscape of Park Avenue, while accommodating the vital transport infrastructure of the city below."

Find more information about the project **here.**

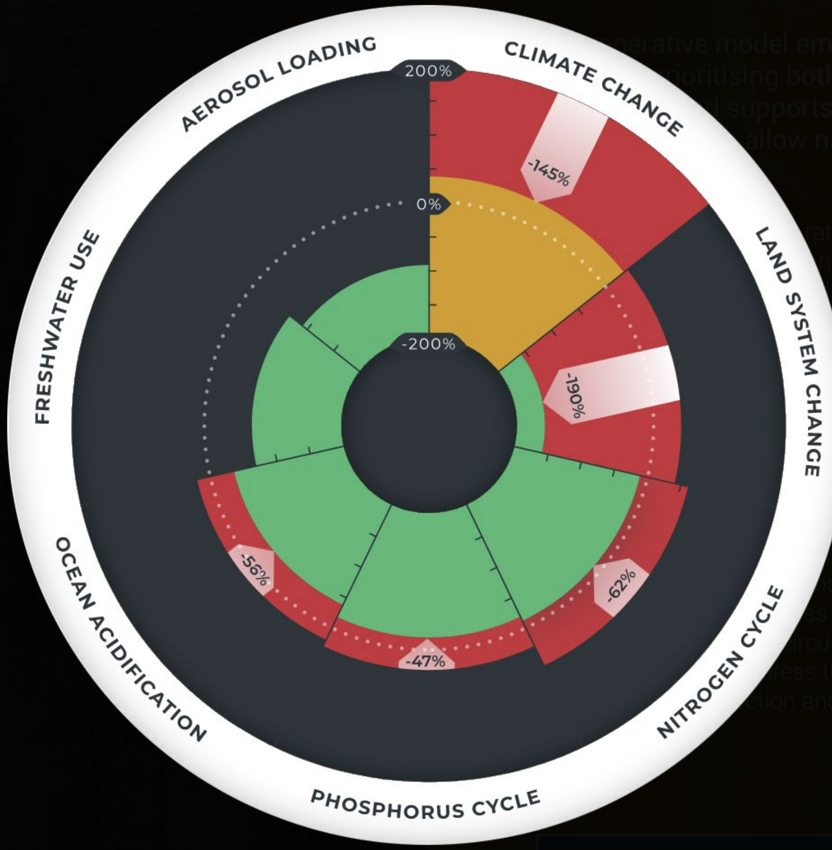
Source: Foster + Partners

The Planetary Boundaries:

The planetary boundaries concept presents a set of nine planetary boundaries within which humanity can continue to develop and thrive for generations to come.

Crossing these boundaries increases the risk of generating large-scale abrupt or irreversible environmental changes. Since then the planetary boundaries framework has generated enormous interest within science, policy, and practice [55].

Analysis of planetary boundaries overshoot by Circular Economy:



For more information:
CGR 2023

CASE STUDY:

Creating Circular Materials, Compatible with Life: A compilation of leading industry resources to guide healthy, non-toxic material use in buildings

For years, Circularity practitioners have needed to develop an advanced knowledge of toxicology to be able to ask the right questions of their supply chain to exclude anything suspected to be harmful to life. To increase the accessibility of circular, sustainable and healthy materials, experts at Brightworks Sustainability have partnered with visionary leaders through years of stakeholder engagement and material vetting to offer the following free and comprehensive resources (see listed below).

These leading organisations have committed to prioritising the use of responsibly manufactured materials, which are healthy and low-carbon, and exclude any substances suspected to be harmful to humans or the environment, which has a positive impact for building occupants, as well as people and communities throughout the supply chain. They have worked extensively with their suppliers to ensure that the products they use will bring the Circular Economy ever closer.

Salesforce – Healthy and Sustainable Materials Guide

The Durst Organization – Building Case Studies

Harvard University – Harvard Healthier Building Materials Academy

In creating these resources, the material health experts at Brightworks and our partners have been supported by the foundational work completed by our peers around the world:

The Green Science Policy Institute - The Six Classes

The Living Future Institute - The Red List

The Healthy Building Network – Home Free

The European Commission – REACH

Health Product Declaration Collaborative - Open Standard

Building Green – Product Guidance

Mindful Materials - The Common Materials Framework

It is widely understood that circularity is the practice by which resources are managed in ways that provide benefit to all life, **a systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution**. Our resources begin as part of the earth, and will continue to be circular, provided they are appropriately extracted and managed. Both the most essential and complex task in practicing circularity is achieving this by engaging with stakeholders in the extraction and manufacturing community at all levels, to ensure that products are not harmful to humans or the natural world at all stages of their life.

Source: Brightworks Sustainability, Salesforce, Harvard University, and The Durst Organization

Biomimicry - Bringing Nature's Best Practices to the Built Environment

CASE STUDY:

MODULATIO' designs biomimicry solutions for industry

Within a structure, stress is not distributed evenly: some areas must withstand considerable constraint, while others have moderate or little force exerted upon them. So, the question is: Why use the same density of material everywhere? Inspired by this question, MODULATIO' created a solution inspired by nature and replicable with different materials: *The Alveolar and Lattice Structures with Variation of Effort and Density (SALVED).*

This technology (MODULATIO's patented) makes possible to adapt the quantity of a material to specific needs. The mechanical performance is equivalent to a solid structure, with 2 or 3 times less material, weight, and CO_2 emissions, and since these structures are obtained by molding, they can be mass-produced and adapted to different materials. **SALVED** has other key features such as heat dissipation, sound attenuation and vibration absorption.

MODULATIO' is a young start-up whose mission is to help industry reduce the consumption of raw materials. Therefore, MODULATIO' is working on several projects with multinational companies, including MINrAll: a construction system co-developed with HOLCIM and SIKA. It combines two technologies: Carbon Prestressed Concrete (CPC) Slabs and MODULATIO' structures. CPC slabs are one of Holcim's low-carbon materials; they use high-strength concrete reinforced with prestressed carbon fibers to make them up to 5 times thinner and lighter than a traditional reinforced concrete slab. CPC panels have a high tensile resistance, whereas MODULATIO' structures have a high resistance to compression. MINrALL makes a sandwich with both components in order to achieve resilience and rigidity.

MINrAll enables the construction sector to:

- Save natural resources. At this stage of the study, MINrALL provides up to 49% reduction in material consumption and mass. The next development steps will focus on significantly reducing the CO_2 footprint of the solution from optimised material design.The lower weight results in less transportation and the optimisation of other structural parts, such as foundations.
- Participate in the circular economy. The modular approach allows the disassembling and reusing of components. The system is mostly mineral (no steel bars). This means it is easy to recycle at the product's end of life.
- Industrialise production. CPC slabs and MODULATIO's structures are manufactured by Holcim in off-site facilities and connected by Sika. The prefabricated solutions are fast and easy to install on-site.

The first application of MINrALL will be on a heavy vehicle bridge. The pilot of this low-carbon, light and circular-constructed bridge is scheduled for 2024.

Source: MODULATIO'

Biomimicry -
Bringing Nature's Best Practices to the Built Environment

Five centuries ago, Leonardo da Vinci urged his students to "seek their lessons in nature". Today, this approach is a structured methodology: biomimicry. It is both a school of thought and a scientific and technological discipline: it is based on the principle of using nature as a model to meet sustainable development challenges, and a combination of biology and technology to solve human problems by transferring models from living organisms. Indeed, these models have been tested and validated by 3.8 billion years of evolution and selection.

Biomimicry is not only about learning from the results of evolution (such as form, function, or relationship), but also about learning from the process of evolution (such as collective intelligence), and the evolution success parameters (such as permanent reuse). It is a systemic approach that places us within our ecosystem.

The biomimetic approach applies the principles of living things' effectiveness to the design of products, buildings, services, or even organisations. For example:

- **Nature uses only the quantity of matter necessary.** For instance, the alveolar structures of bones allow them to be both solid and light, while drawing locally from renewable

CASE STUDY:

Apple Park - A campus to promote creativity, innovation and wellbeing

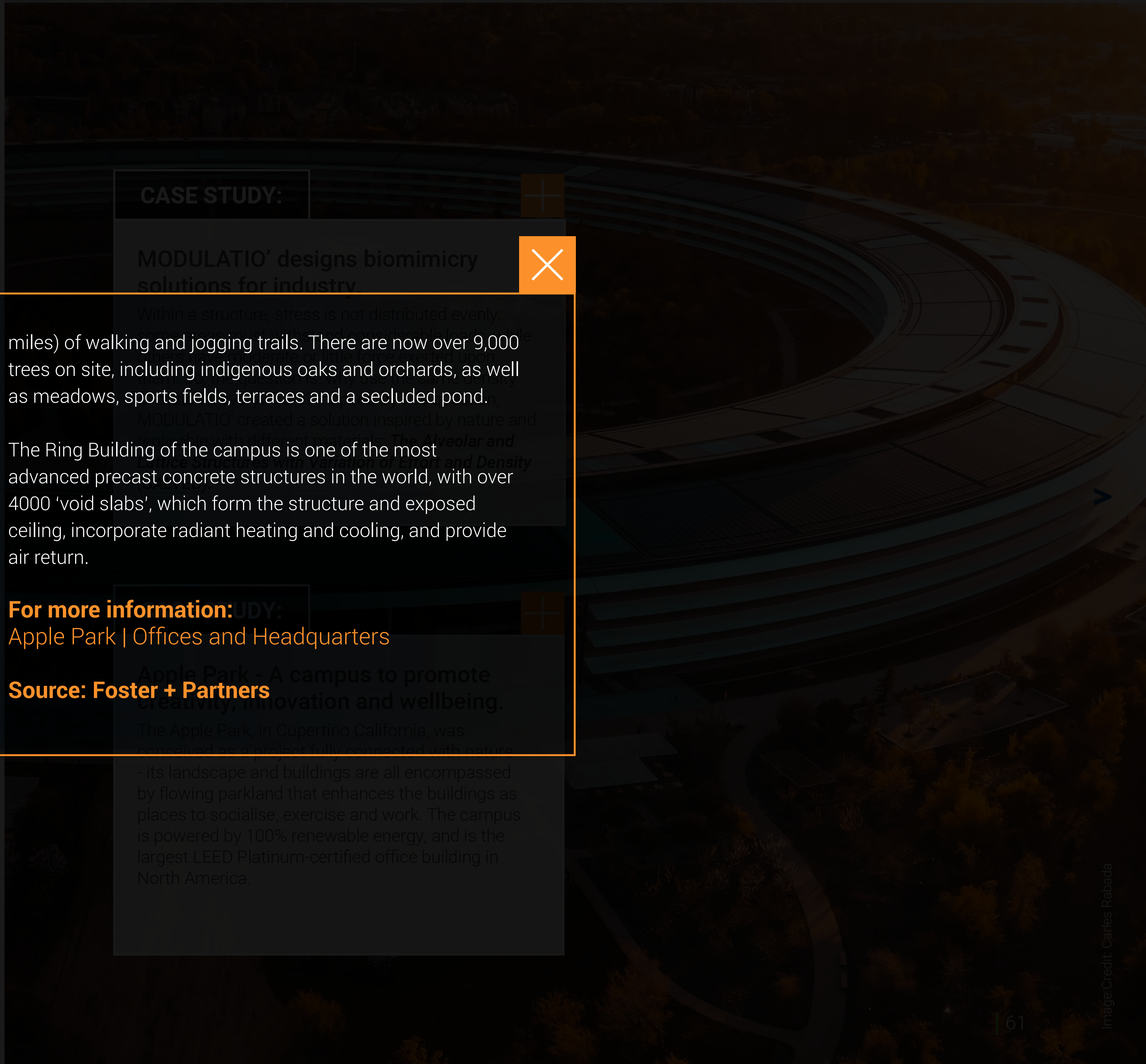
The Apple Park, in Cupertino California, was conceived as a project fully connected with nature - its landscape and buildings are all encompassed by flowing parkland that enhances the buildings as places to socialise, exercise and work. The campus is powered by 100% renewable energy, and is the largest LEED Platinum-certified office building in North America.

The 71-hectare (175-acre) site was previously dominated by impervious surfaces. Today, the green space has been increased from 20% to 80% with over six kilometres (four miles) of walking and jogging trails. There are now over 9,000 trees on site, including indigenous oaks and orchards, as well as meadows, sports fields, terraces and a secluded pond.

The Ring Building of the campus is one of the most advanced precast concrete structures in the world, with over 4000 'void slabs', which form the structure and exposed ceiling, incorporate radiant heating and cooling, and provide air return.

For more information:
Apple Park | Offices and Headquarters

Source: Foster + Partners



CASE STUDY:

The Pledge for Transparency and Performance in Materials

The call for Environmental Product Declarations (EPDs) has exponentially increased in the last couple of decades as a result of the call for more transparency from users, developers and authorities. In fact, the EPD credit is the most popular Materials & Resources credit in the LEED rating system and Several manufacturing companies, such as Saint-Gobain have embraced this movement and are raising the bar in the circularity goals.

Saint-Gobain included the following strategies in its decarbonisation roadmap and the 2030 commitments of their environmental strategy:

- Product portfolio: third-party verified Environmental Product Declarations (EPD), based on Life Cycle Analysis (LCA) for 100% of the products;
- Natural resources and circular economy: 80% reduction in non-recovered production waste; 30% increase in virgin raw materials avoided;
- Water: 50% reduction in industrial water withdrawal, zero discharge in drought areas;
- Packaging: 100% recyclable packaging, containing more than 30% recycled or bio sourced materials.

For more information:
Climate change | Saint-Gobain

5.2 Regenerative Cities

CASE STUDY:

The Green Factor Method

Many cities in countries like the UK, Germany, Sweden, Finland and the US are using the Green Factor Method to ensure that urban regeneration projects maximise the multiple benefits of green and blue infrastructure in delivering resilient, healthy and environmentally friendly cities. The Green Factor Method is an ecological tool used to mitigate the effects of construction by ensuring sufficient quantity and quality of green infrastructure.

Cities like Berlin use the Biotope Area Factor (BAF) as the ratio of the ecologically effective surface area to the total land area, and in the calculation, the individual parts of a plot of land are weighted according to their "ecological value", where sealed surfaces, for instance, would have a weighting factor of 0.0 and surfaces with vegetation, connected to the soil below would have a weighting factor of 1.0[63].

For more information: Helsinki_GreenFactor

5.2 Regenerative Cities

Urbanisation is growing at an unprecedented rate, which contributes significantly to the climate crisis and biodiversity loss. Cities hold many potential solutions to reverse these trends.

Cities account for an estimated 80% of global GDP and consume almost half the resources extracted globally[40]. Sustainable cities must be regenerative, with the ability to regenerate the natural resources consumed. For example, food supplies could be supplemented through urban agriculture, energy through solar rooftops, geothermal and bio-waste, and water through storm water collection at the neighbourhood scale. This enhanced ecosystem service infrastructure within the urban area improves the city's self-sufficiency as

CASE STUDY:

Making the case for Clean Construction: Mexico City

Implementing **Clean Construction** principles is part of the solution to a resilient, resource-efficient, decarbonized and just construction ecosystem that ensures all people enjoy thriving and healthy urban lives. Since signing the **C40 Clean Construction Accelerator** in 2020, Mexico City has integrated ambitious strategies to tackle the negative impacts of our current construction systems, such as the use of recycled materials, guidelines for underused assets and urban greening projects are being promoted through economic incentive, building codes and environmental standards, scaling up the transition.

San Francisco co-led the development of the **C40 Advancing Towards Zero Waste Accelerator** in 2018, which aims to reduce disposal to landfill or incineration by 50% by 2030, using a 2015 baseline and reduce the generation of waste by 15%. By signing the **C40 Clean Construction Accelerator** in 2021, San Francisco reinforced its commitment to adopt circular and decarbonised measures on their built environment. The city's leadership stems from their firm circular approach on prevention and reduction first, followed by material reuse and markets. Therefore, the goal is to ensure that infrastructure is in place to support any policy requirements. The approach is to bolster three distinct areas:

1. The network of suppliers and receivers,
2. A virtual inventory and asset management platform,
3. Physical laydown space.

For more information:
Making a case for Clean Construction in cities

Source: C40

CASE STUDY:

La Borda social housing complex in Barcelona

Co-operative involvement was crucial for defining the project's environmental strategies; the participation of the building occupants in all phases, from the design to the construction and further operational management, was essential. La Borda social housing complex in Barcelona was driven by its focus on community, proposing a new paradigm in social housing focussing on the basics of social, communal spaces. The building is the highest constructed building from cross-laminated timber (CLT) in Spain. CLT is well-known for its carbon sequestration benefits and typically shorter construction period required.

Passive bioclimatic strategies were developed, with solutions that involve the users' active role in climate management. All the residential units are organised around a central courtyard and beneath a polycarbonate roof that acts as a greenhouse, capturing solar heat energy during the winter and drawing in additional ventilation through the summer. La Borda has a centralised system to generate hot water and heating using a biomass boiler, and solar panels were installed on the upper terrace.

The co-operative decided to not build underground parking for cars and estimated a saving, after 75 years, (construction and use) of 500-800 tonnes of carbon dioxide. This strategy also gives a direct benefit in sustainable mobility and reducing the inhabitants' ecological footprint. However, to achieve this changes in the regulations were needed; this was made at city level in Barcelona, and now applies to all new buildings.

Communal decisions have been incorporated into the building's management, where communal facilities, such as the shared laundry room with five washing machines that require less energy to run than one machine per household. Monitoring energy data revealed that, despite its communal usage, a disproportionate amount of energy was being expended by the laundry facilities; as a result only one of the machines runs with hot water and energy consumption has gone down.

At the heart of this project is an understanding of the link between social and environmental justice.

For more information:
Sustainable building, sustainable living: La Borda, Barcelona by Lacol

Source: C40

CASE STUDY:

Light as a Service (LaaS)

Lighting as a Service (LaaS) is a business model in which lighting is treated as a service and a contract is set based on a subscription. The model enables customers to reduce installation and maintenance cost while significantly reducing CO_2 emissions.

To support these goals, Signify, a world leader in lighting, created "*ALight*" - a project designed specifically to help reduce the building carbon footprint of the company Air Liquid, while achieving economical savings, and improving the workspace environment with high quality lighting.

Air Liquide is aiming to reduce its CO_2 emissions by 33% by 2035 versus 2020, and targeting full carbon neutrality by 2050. That's why an upgrade of the lighting network from traditional to LED lighting was identified as an efficient and cost-effective project.

So far, Air Liquide has launched the ALight project across 31 sites in Europe, Asia and the Middle East, leading to the installation of more than 8,600 new LED fixtures, reducing energy consumption by an estimated 2,840 Megawatt-hours per year and CO_2 emissions by around 770 tonnes per year. This compares to the yearly emissions of around 270 cars, or 300 round-trip flights from Paris to New York — and Air Liquide is showing no signs of stopping there!

Find more information **here.**

Source: C40

CASE STUDY:

Arden Precinct – Circular Economy Embedded into Masterplanning and Building Design

Through the adoption of circular economy principles, a pioneering precinct-wide waste management plan has been developed for the Arden Precinct in the north of Melbourne, Australia. This 44.6-hectare development will accommodate 34,000 jobs and 15,000 residents. It aspires to set the standard for best practice in sustainable urban renewal, aiming to become Melbourne's first circular and toward zero waste precinct, in line with net-zero carbon emissions targets by 2040.

The Arden Circular Economy Strategy provides practical guidance on how circular economy principles can be embedded into masterplanning and building design, in a holistic approach that spans the whole lifecycle of the project. It includes:

- Identifying targets in line with circular economy principles
- Preserving heritage value
- Ensuring adequate spatial allocation

To effectively transition to a circular economy, a mindset shift is required, from viewing 'waste' as a problem that needs to be disposed of, to 'materials' with value for reuse, repair, repurposing and recycling.
The benefits of this include:

- Significant contribution to net-zero carbon emissions targets
- Extensive financial savings
- Enhanced social capital

The process of embedding circular economy throughout the Arden Precinct varies according to the status of different zones of the project:

- Brownfield zones requiring no demolition represent the ideal opportunity to apply circular design strategies from design through to construction. It may include new structures designed for disassembly at the end of their lifecycles, thereby eliminating future demolition waste.
- Developed zones with existing infrastructure focus on reusing existing buildings and materials as far as possible.

The strategy explores opportunities for stakeholders at every stage of the precinct's lifecycle to contribute to its circular economy outcomes:

- Design stakeholders: integrate circular design principles from the outset
- Construction stakeholders: minimise the impact of construction practices
- Operational stakeholders: utilise the design effectively and keep materials in use as long as possible through reuse and repair
- End of service stakeholders: disassemble and/or handle materials at end of their current use so they may be kept in use or returned to the system
- Community and building users: community initiatives, such as hubs for upcycling, reuse, repairing and sharing; on-site community garden composting; plastic free zones; spaces allocated to materials storage

The strategy will set the initial direction and will be reviewed and adapted over time to meet the evolving needs of the local community and environment.

For more information:
Arden Precinct – towards a resilient, zero waste and circular precinct

Source: WSP

CASE STUDY:

A City´s Leadership to Unlock Full Circularity Potential – San Francisco

With the goal to be a net zero carbon city by 2040 without the purchase of offsets, the City of San Francisco has seen in circularity an opportunity to optimise resources and tackle climate change. The vision was key: while the private sector is a key innovator and developer, the public sector needs to be a facilitator to overcome obstacles.

San Francisco co-led the development of the advancing toward zero waste declaration in 2018, which aims to reduce disposal to landfill or incineration by 50% by 2030, using a 2015 baseline and reduce the generation of materials by 15%. After prevention, the City believes that material reuse and markets are critical for circularity. Therefore, the goal is to ensure that there is infrastructure in place to support any requirements.

The approach is to bolster three distinct areas:

1. **The network of suppliers and receivers,**
2. **A virtual inventory and asset management platform,**
3. **Physical laydown space.**

As an example to enhance networking, the Bay Area All For Reuse Alliance was created in partnership with a neighbouring municipality, the Business Council on Climate Change, and the All For Reuse Initiative. While there are educational and networking elements, the primary purposes of the Alliance are to sign on to a common pledge and create individual action plans to increase reuse within each organisation, with a focus on tenant improvement projects.

The *Building Resources Innovation Center* (BRIC) is under development. The goal is to create a replicable secondary market for commercial building materials interwoven with novel circularity programmes, as well as community services. Some ideas include piloting an "escrow" process for the temporary storage of salvage products to aggregate the larger product quantities required for commercial construction, and a last mile extended producer responsibility programme to gather targeted products en masse for donation first, and then eventual pickup by the manufacturer. The BRIC components themselves will be adaptable and designed for disassembly and reassembly so that it can be relocated if necessary to respond to the city's evolving urban fabric.

For more information: https://sfenvironment.org/building-materials-management.

Sustainable finance catalysing ESG disclosure

The investment landscape is changing – sustainable finance is no longer a trend but a groundswell. The flow of capital towards ESG oriented funds has experienced a steep exponential increase; in the third quarter of 2021 global sustainable funds hit a record high of $3.9 trillion, more than doubling in less than 12 months[90]. This trend reflects growing interest from private firms in sustainable and energy transition projects. One of the main reasons is that companies that can demonstrate sustainable supply chains and good human rights records are less vulnerable to environmental shocks or reputational damage[91]. Additionally, climate change and other societal challenges also pose significant investment risks that are increasingly recognised by the financial sector, and transformative action can be taken to future-proof assets and reduce portfolio risk from both regulatory and physical climate damage drivers.

ESG reporting is a tool that communicates actions and performance towards sustainability. Therefore, it has been globally used by the private sector on a voluntary basis, but in view of the capabilities of the tool and the need to accelerate the transition to sustainable societies, several initiatives worldwide are gradually introducing mandatory reporting:

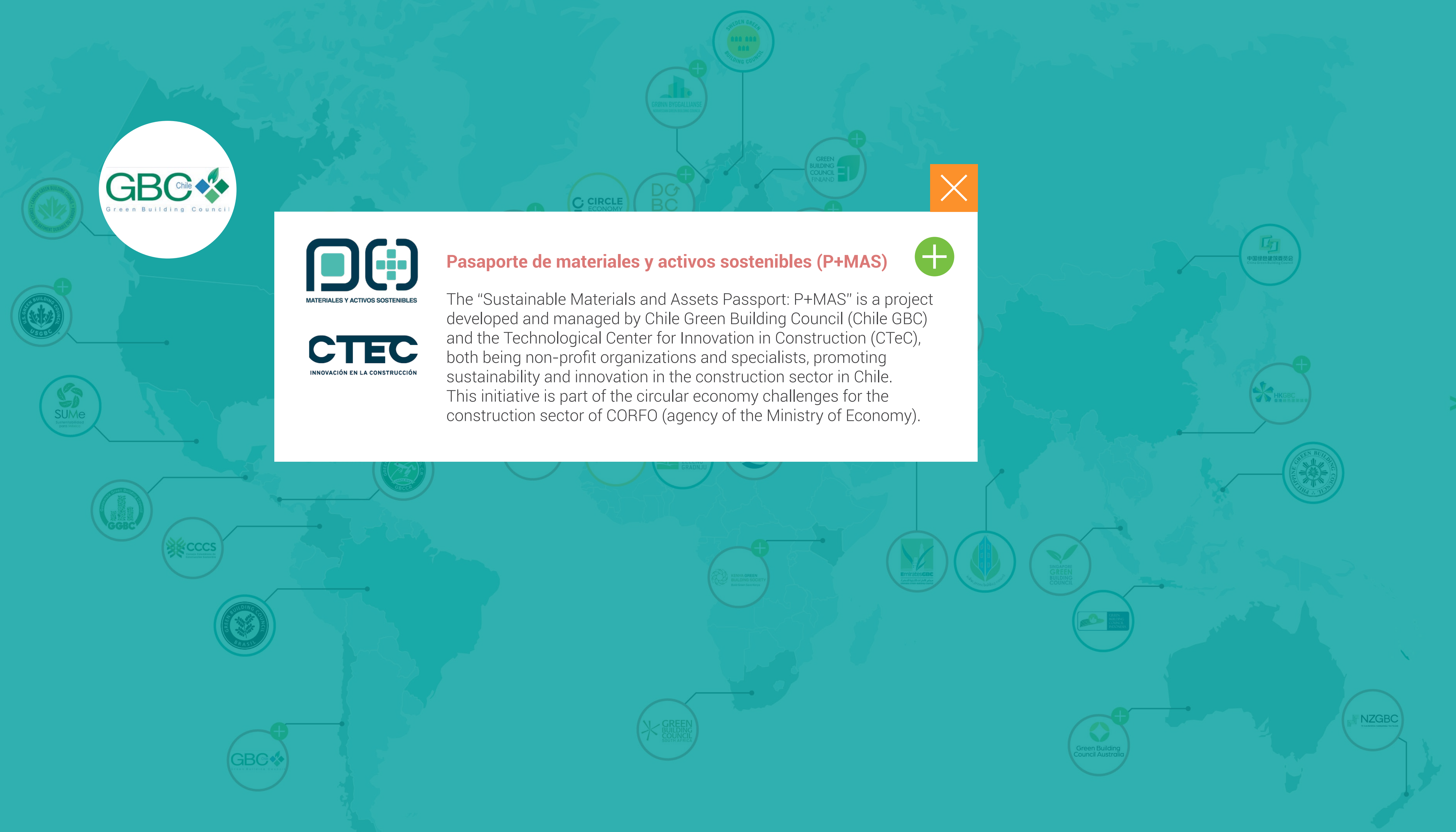
- In June 2021, the G7 Finance Ministers announced their support for mandatory ESG disclosures, stating that such disclosures "provide consistent and decision-useful information for market participants that will help mobilise the trillions of dollars of private sector finance needed, and reinforce government policy to meet our net zero commitments"[92].
- In Europe, since 2017, large companies (listed with over 500 employees) must comply with the EU Non-Financial Reporting Directive (NFRD), which requires disclosure of social and environmental issues in annual reports, and by 2023, the NFRD will be expanded with the Corporate Social Responsibility Directive (CSRD), which will introduce stricter reporting requirements under the new EU sustainability reporting standards and in line with the EU Taxonomy.
- In the US, ESG reporting is largely not mandatory, but that might be changing; the Executive Order on Climate-Related Financial Risk in 2021 included a call for public disclosure of such risks[93].

The most prominent reporting frameworks for the built environment sector include (at time of publication include, but are not limited to):

- **World Green Building Council Net Zero Carbon Buildings Commitment:** The Commitment provides a framework to recognise and promote advanced climate leadership action from businesses, organisations, cities and subnational governments in decarbonising the built environment, to inspire others to take similar action and remove barriers to implementation.
- **The Task Force on Climate-related Financial Disclosures (TCFD):** Provides recommendations to companies on the types of information that companies should disclose to support investors. The recommendations are structured around four thematic areas including: governance, strategy, risk management, and metrics and targets. This information helps investors in assessing and pricing risks related to climate change[94].
- **UN Principles for Responsible Investment:** The six Principles were developed to assist investors, they offer a menu of possible actions for incorporating ESG issues into investment practice, such as advocating for ESG training for investment professionals[95].
- **GRESB:** Provides validated ESG performance data and peer benchmarks for investors to improve business intelligence, industry engagement and decision-making by investment professionals[96].
- **Science Based Targets initiative (SBTi):** Enables the private sector to set science-based emissions reduction targets. These targets provide a pathway for companies to reduce emissions, prevent the worst impacts of climate change and future-proof business growth[97].
- **CRREM (Carbon Risk Real Estate Monitor):** CRREM is a tool that allows investors and property owners to assess their assets to risks based on energy and emission data and the analysis of regulatory requirements[98].
- **Climate Bonds Initiative:** Developed the Climate Bonds Standard and Certification Scheme to help drive down the cost of capital for climate projects in developed and emerging markets[99].
- **The EU Taxonomy:** The EU Platform on Sustainable Finance, proposed in March 2022, that buildings comprise at least 50% from a combination of re-used components, recycled content, or responsibly-sourced renewable materials, and that at least 90 % of the non-hazardous construction and demolition waste generated on the construction site is prepared for re-use or recycling[100]. *[These recommendations are subjected to modifications from the European Commission.]*

Circular Built Environment: Resources for the Global Industry

The WorldGBC global network aspires to increase awareness and accessibility of circular economy solutions for the built environment. This interactive map features market leadership from Green Building Councils who participate in the Circularity Accelerator global programme, in addition to industry partners.



Pasaporte de materiales y activos sostenibles (P+MAS)

The "Sustainable Materials and Assets Passport: P+MAS" is a project developed and managed by Chile Green Building Council (Chile GBC) and the Technological Center for Innovation in Construction (CTeC), both being non-profit organizations and specialists, promoting sustainability and innovation in the construction sector in Chile. This initiative is part of the circular economy challenges for the construction sector of CORFO (agency of the Ministry of Economy).

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Circulariteit

What is our goal? The environmental impact of the construction sector in the Netherlands will be 50% lower in 2030 compared to 2020, with raw materials being reused as much as possible.

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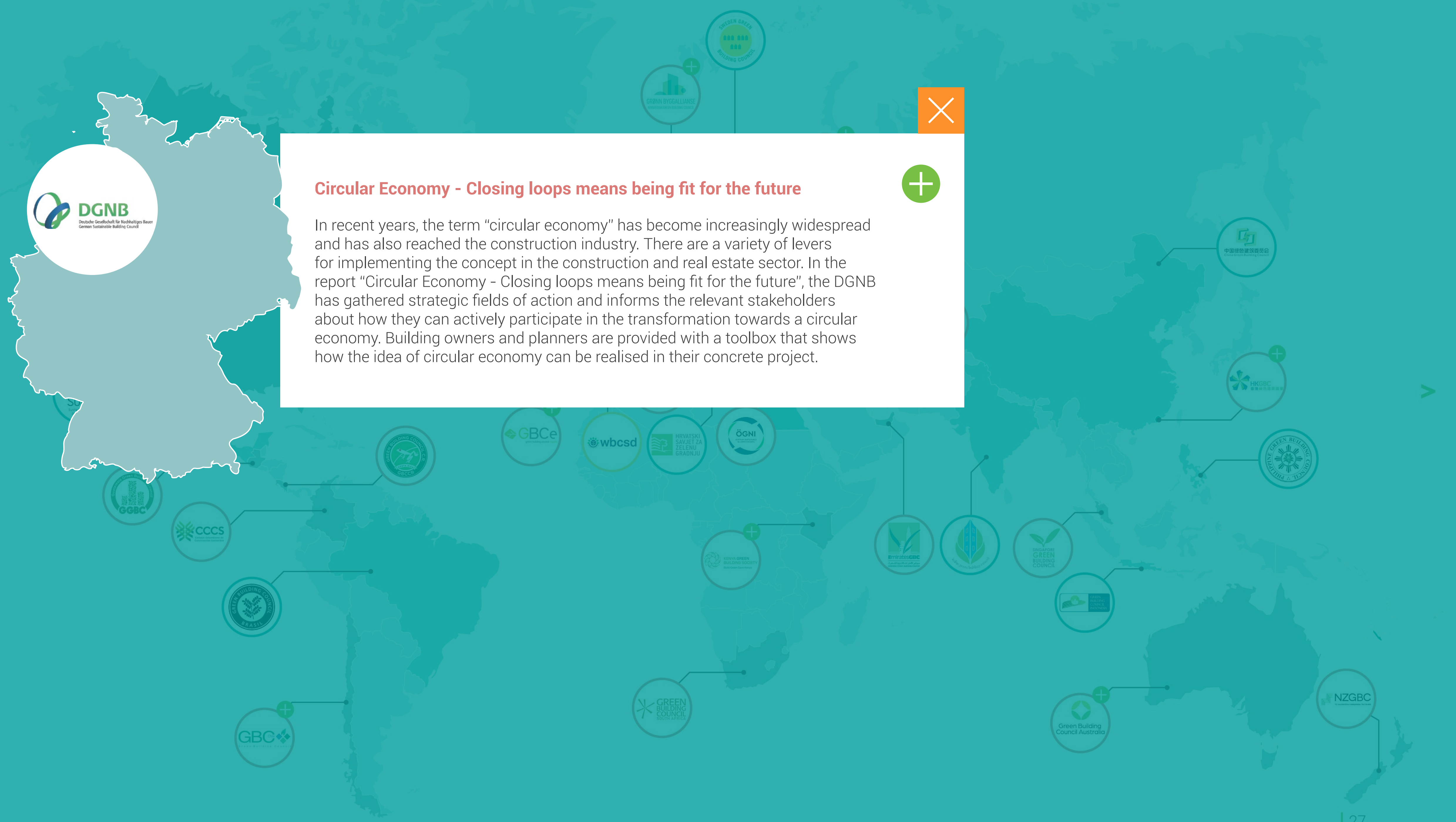

Circular Economy - Closing loops means being fit for the future

In recent years, the term "circular economy" has become increasingly widespread and has also reached the construction industry. There are a variety of levers for implementing the concept in the construction and real estate sector. In the report "Circular Economy - Closing loops means being fit for the future", the DGNB has gathered strategic fields of action and informs the relevant stakeholders about how they can actively participate in the transformation towards a circular economy. Building owners and planners are provided with a toolbox that shows how the idea of circular economy can be realised in their concrete project.

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Circular Built Environment: Re... for the Global...

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Responsible Products Framework

The vision of the Framework is to drive the supply chain to deliver transparent, healthy, low-impact, and net zero carbon products that are part of a circular economy. The Framework outlines criteria for scoring how 'responsible' a product is, and to support the built environment industry in adapting to and driving this change.

Mindful Materials (a framework based on established industry protocols such as EPDs) and GBCA's Responsible Products Framework both set out similar criteria relevant for building products and materials, showcasing core attributes for a responsible product. The GBCA's framework defines these attributes across four categories: Responsible, Healthy, Positive, and Circular. Additionally GBCA is developing its Green Star Fitouts tool to focus primarily on circularity. This will reward the implementation of circular principles, such as, material and product reuse and design for disassembly.

A Circular Economy Discussion Paper

The circular economy has been highlighted as one of the megatrends shaping the next phase of the built environment. Momentum is gathering across the world; however, Australia is lagging behind countries in Europe and Asia.

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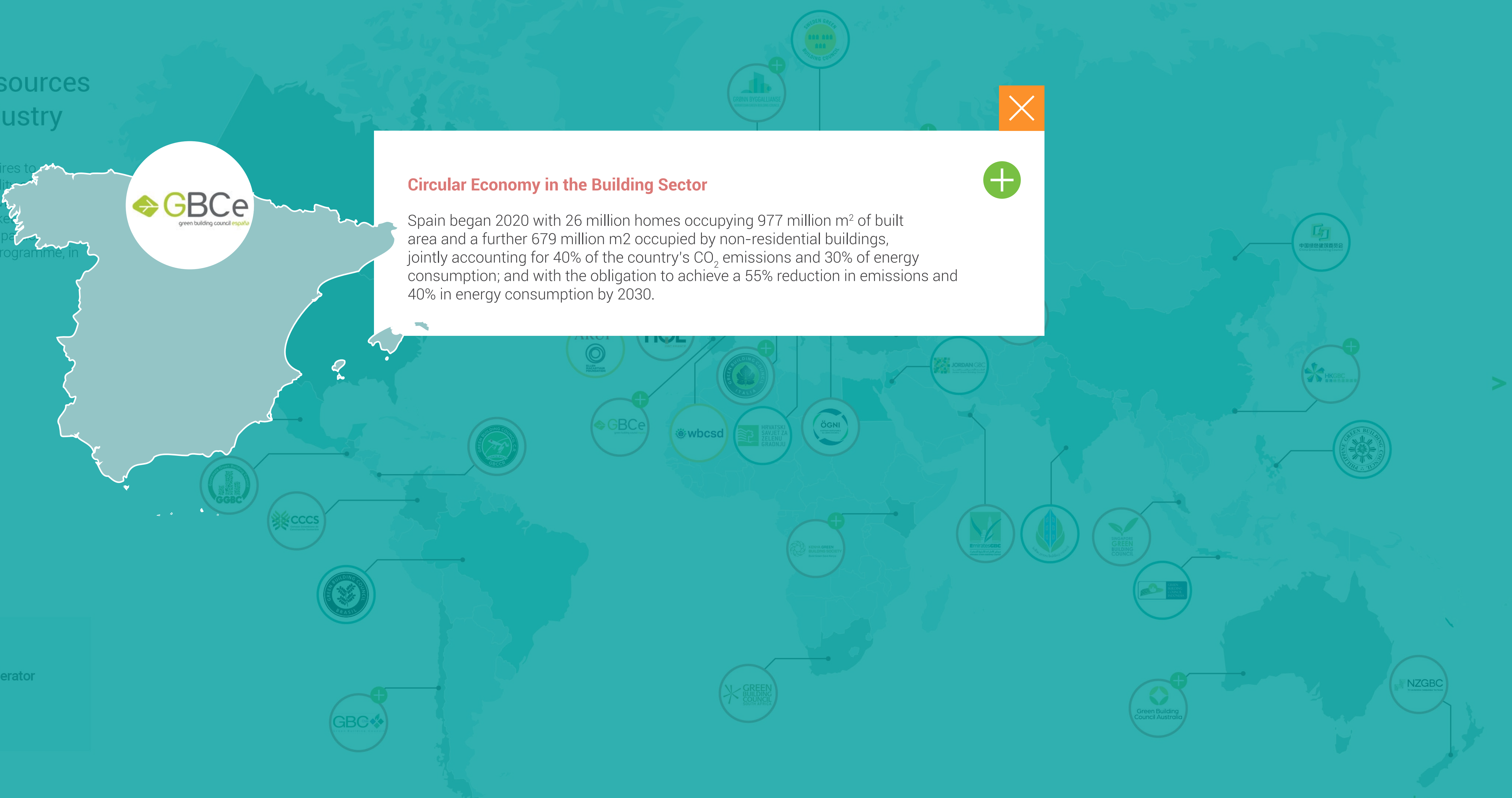

Circular Economy in the Building Sector

Spain began 2020 with 26 million homes occupying 977 million m^2 of built area and a further 679 million m2 occupied by non-residential buildings, jointly accounting for 40% of the country's CO_2 emissions and 30% of energy consumption; and with the obligation to achieve a 55% reduction in emissions and 40% in energy consumption by 2030.

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Sustainable Built Environment Publications

Green Building Council Finland produce studies and operating models that enable those working in the field to accelerate their own responsible operations. All our publications are free to download.

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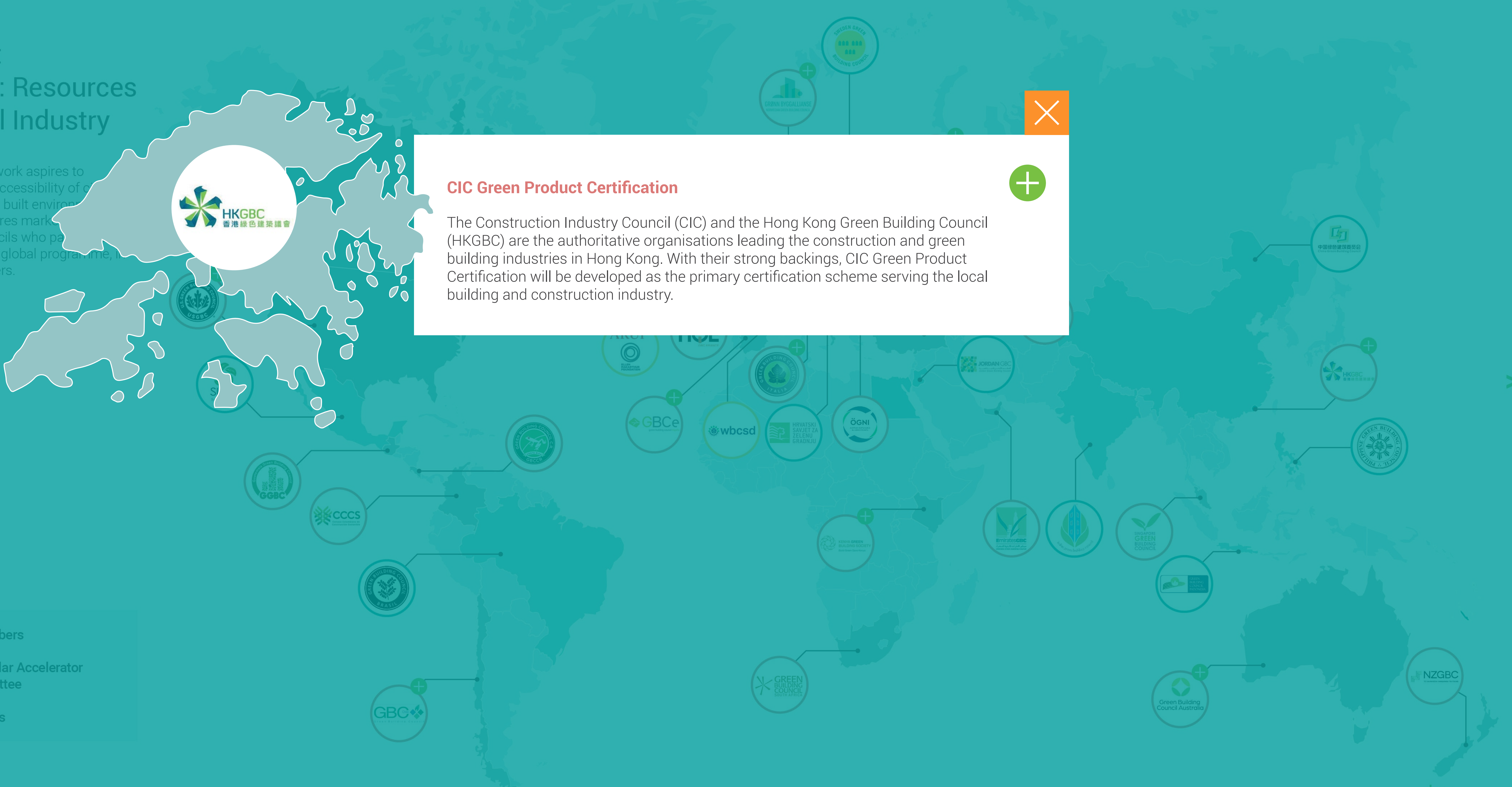

CIC Green Product Certification

The Construction Industry Council (CIC) and the Hong Kong Green Building Council (HKGBC) are the authoritative organisations leading the construction and green building industries in Hong Kong. With their strong backings, CIC Green Product Certification will be developed as the primary certification scheme serving the local building and construction industry.

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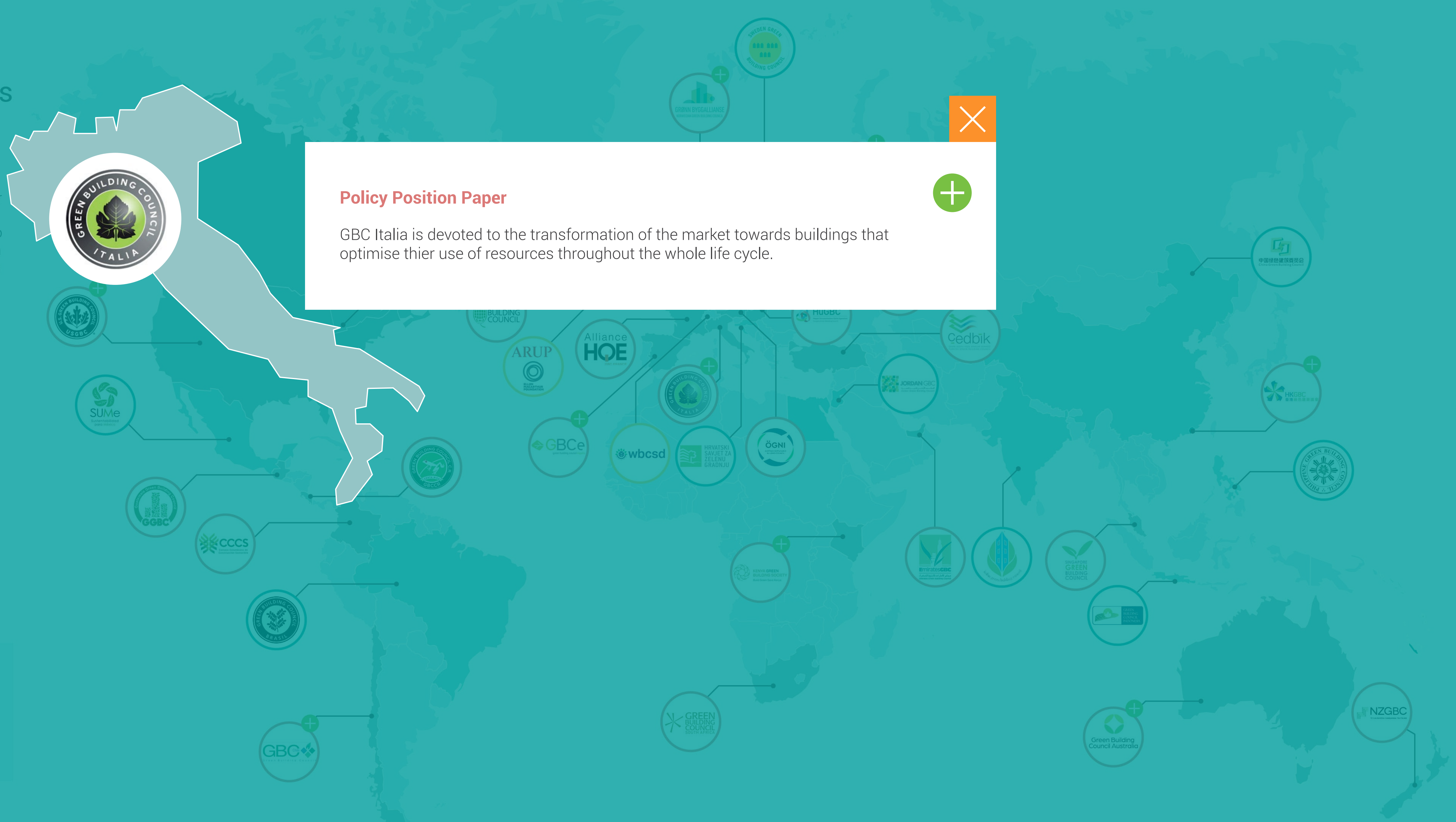

Policy Position Paper

GBC Italia is devoted to the transformation of the market towards buildings that optimise thier use of resources throughout the whole life cycle.

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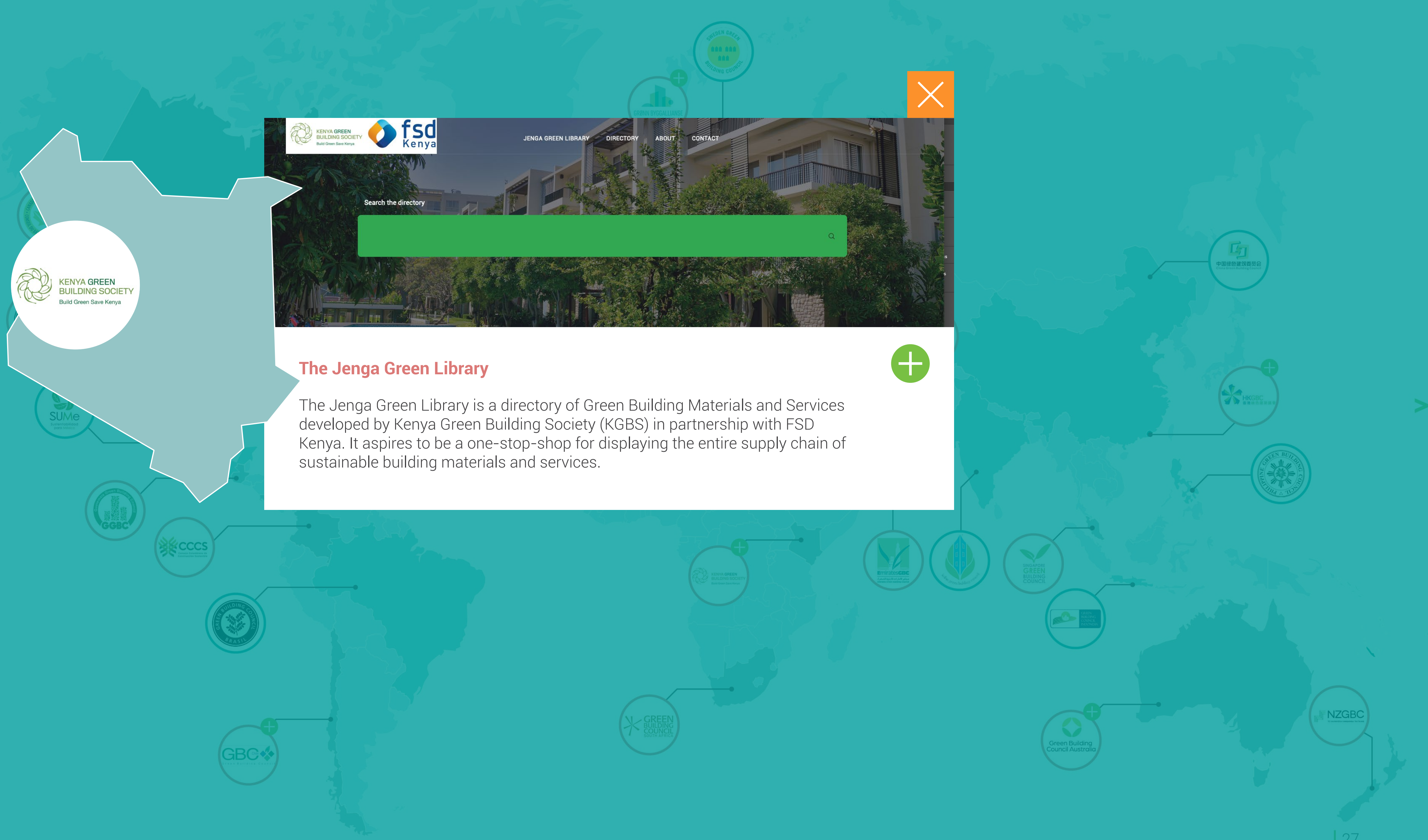

The Jenga Green Library

The Jenga Green Library is a directory of Green Building Materials and Services developed by Kenya Green Building Society (KGBS) in partnership with FSD Kenya. It aspires to be a one-stop-shop for displaying the entire supply chain of sustainable building materials and services.

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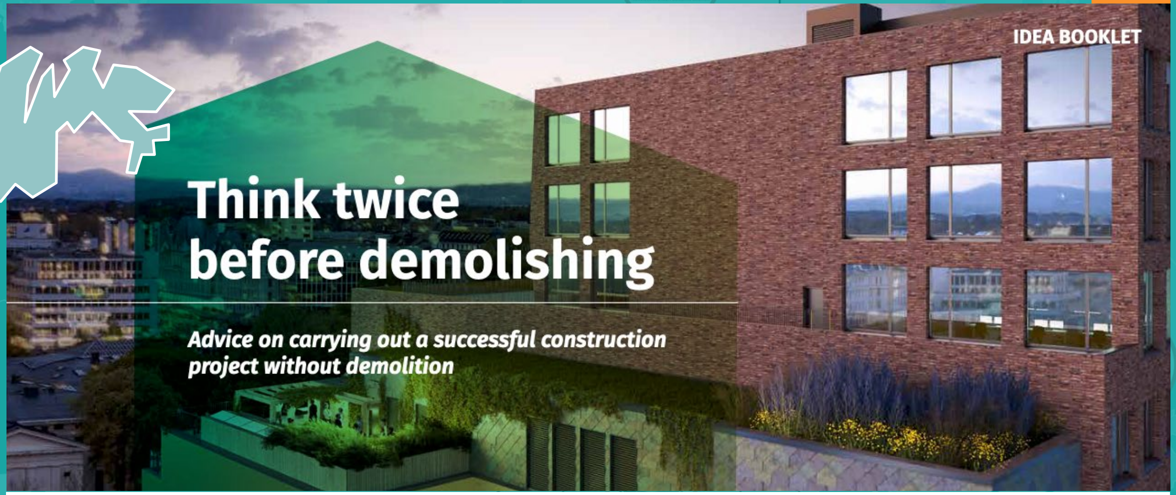

Think Twice Before Demolishing

Think twice before demolishing is an idea booklet with advice for carrying out a successful construction project without demolition.

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TRUE

TRUE is a zero waste certification programme dedicated to measuring, improving and recognising zero waste performance.

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System Enablers for a Circular Economy

UKGBC's new programme of work focuses on system enablers for a circular economy. While circular economy principles increasingly find their way into construction projects, a widespread adoption at scale is still not happening. Matching supply and demand of reused materials, questions around risk and warranty and legal frameworks are just some of the areas that currently stop a circular economy from becoming mainstream.

Circular economy guidance for construction clients

UKGBC has produced a circular economy guidance for construction clients, which provides comprehensive practical guidance to support construction clients who want to ask for circular principles in their project briefs for non-domestic built assets.

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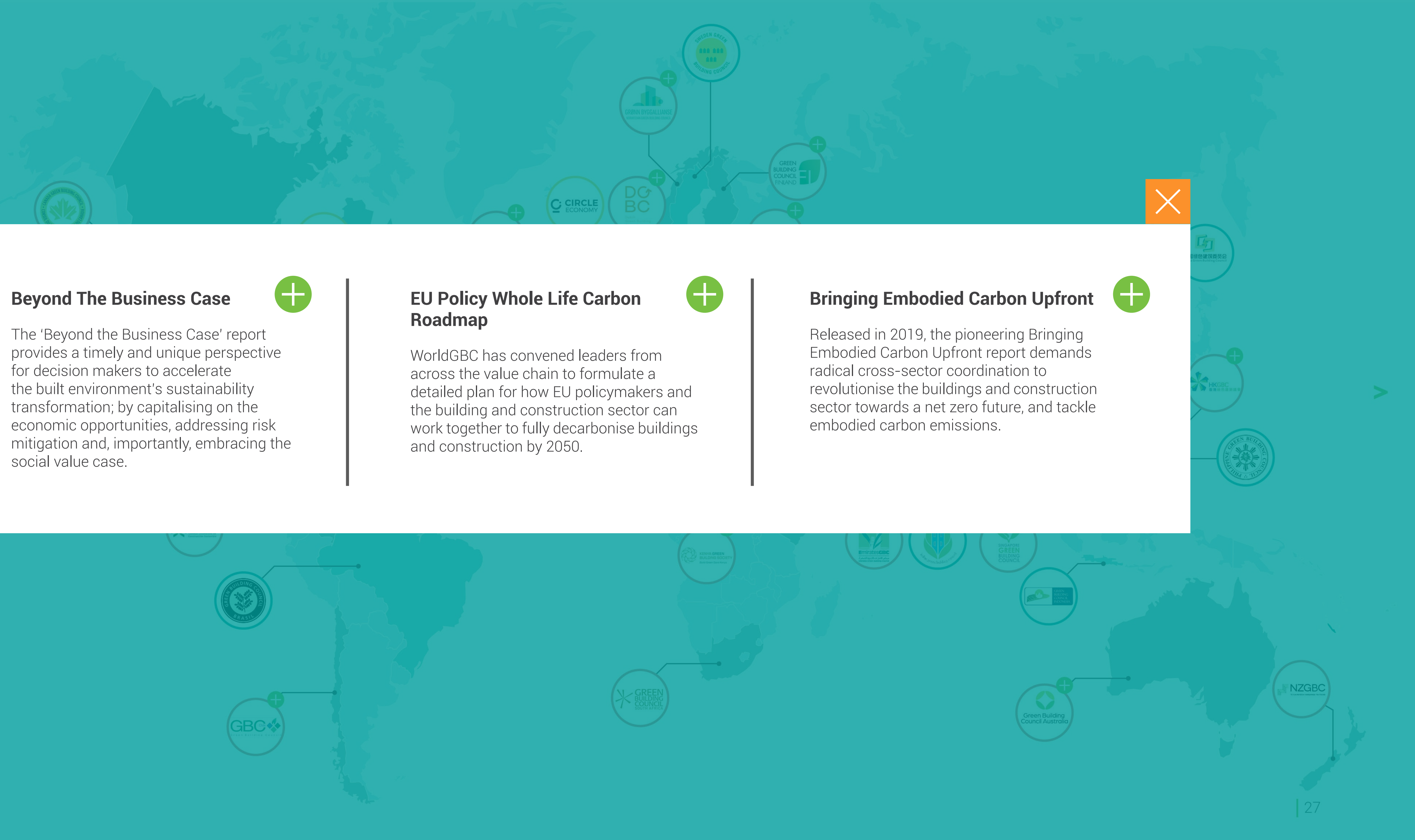

Beyond The Business Case

The 'Beyond the Business Case' report provides a timely and unique perspective for decision makers to accelerate the built environment's sustainability transformation; by capitalising on the economic opportunities, addressing risk mitigation and, importantly, embracing the social value case.

EU Policy Whole Life Carbon Roadmap

WorldGBC has convened leaders from across the value chain to formulate a detailed plan for how EU policymakers and the building and construction sector can work together to fully decarbonise buildings and construction by 2050.

Bringing Embodied Carbon Upfront

Released in 2019, the pioneering Bringing Embodied Carbon Upfront report demands radical cross-sector coordination to revolutionise the buildings and construction sector towards a net zero future, and tackle embodied carbon emissions.

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Measuring Circular Buildings – Key Considerations

Building on WBCSD's Circular Transition Indicators methodology, this draft white paper is a first step toward creating a unified framework for the built environment, setting out key considerations for measuring circular buildings. It defines what companies need to measure, how to measure it and how to interpret the results to assess how circular a building is.

The Business Case for Circular Buildings: Exploring the economic, environmental and social value

This report articulates the business case of pursuing circularity in the built environment consisting of the economic value alongside a broader value case, including environmental and social factors. It brings together qualitative and quantitative research identifying how to derive value and who could capture that value.This report complements the World Green Building Council's (WorldGBC) Beyond the Business Case report.

Circular Economy - Practitioner Guide

The Practitioner Guide is designed to help accelerate your transition towards the circular economy.

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Circular Built Environment: Resources for the Global Industry

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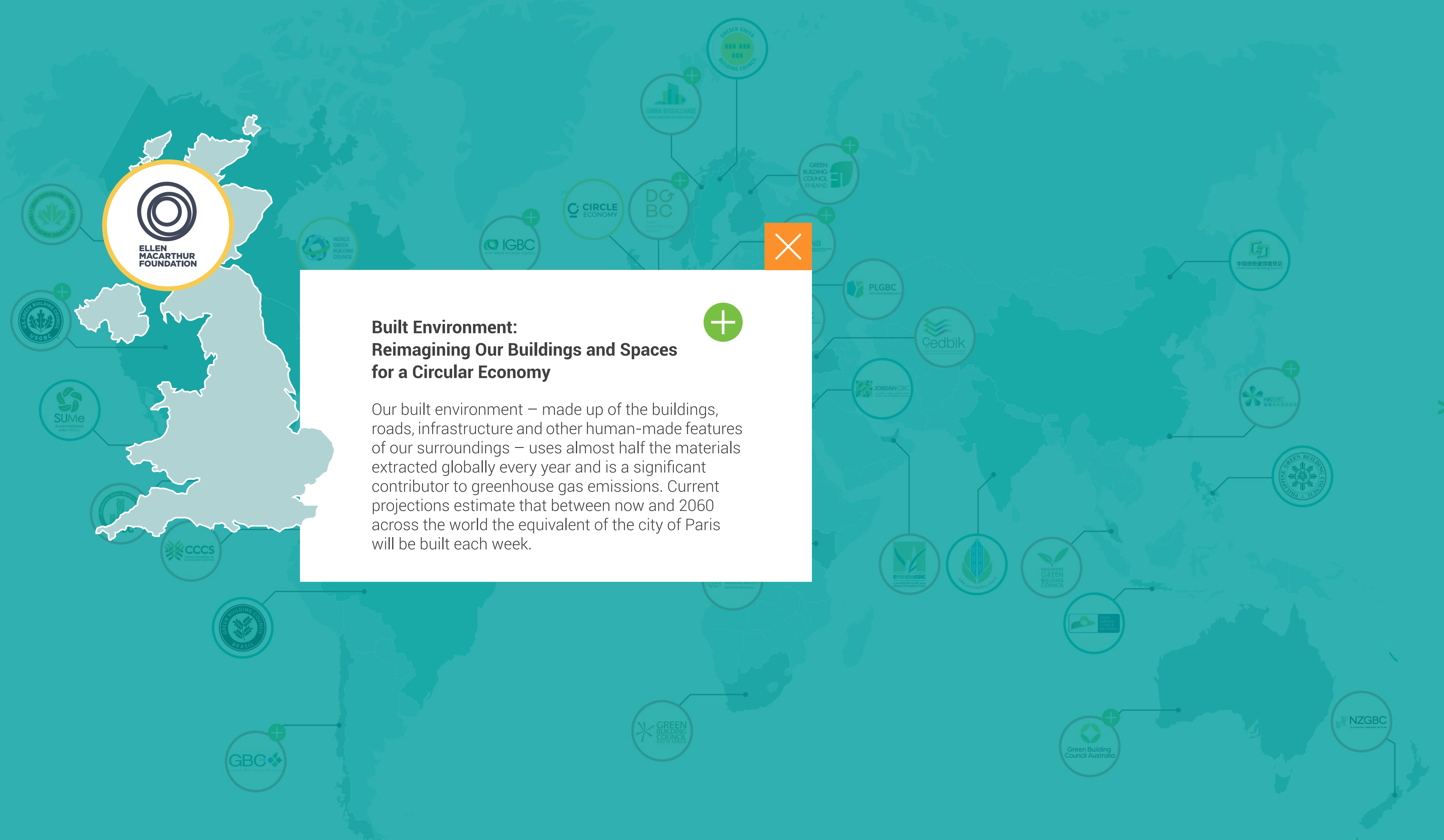

Built Environment: Reimagining Our Buildings and Spaces for a Circular Economy

Our built environment – made up of the buildings, roads, infrastructure and other human-made features of our surroundings – uses almost half the materials extracted globally every year and is a significant contributor to greenhouse gas emissions. Current projections estimate that between now and 2060 across the world the equivalent of the city of Paris will be built each week.

WorldGBC Members
WorldGBC Circular Accelerator Steering Committee
Industry Partners

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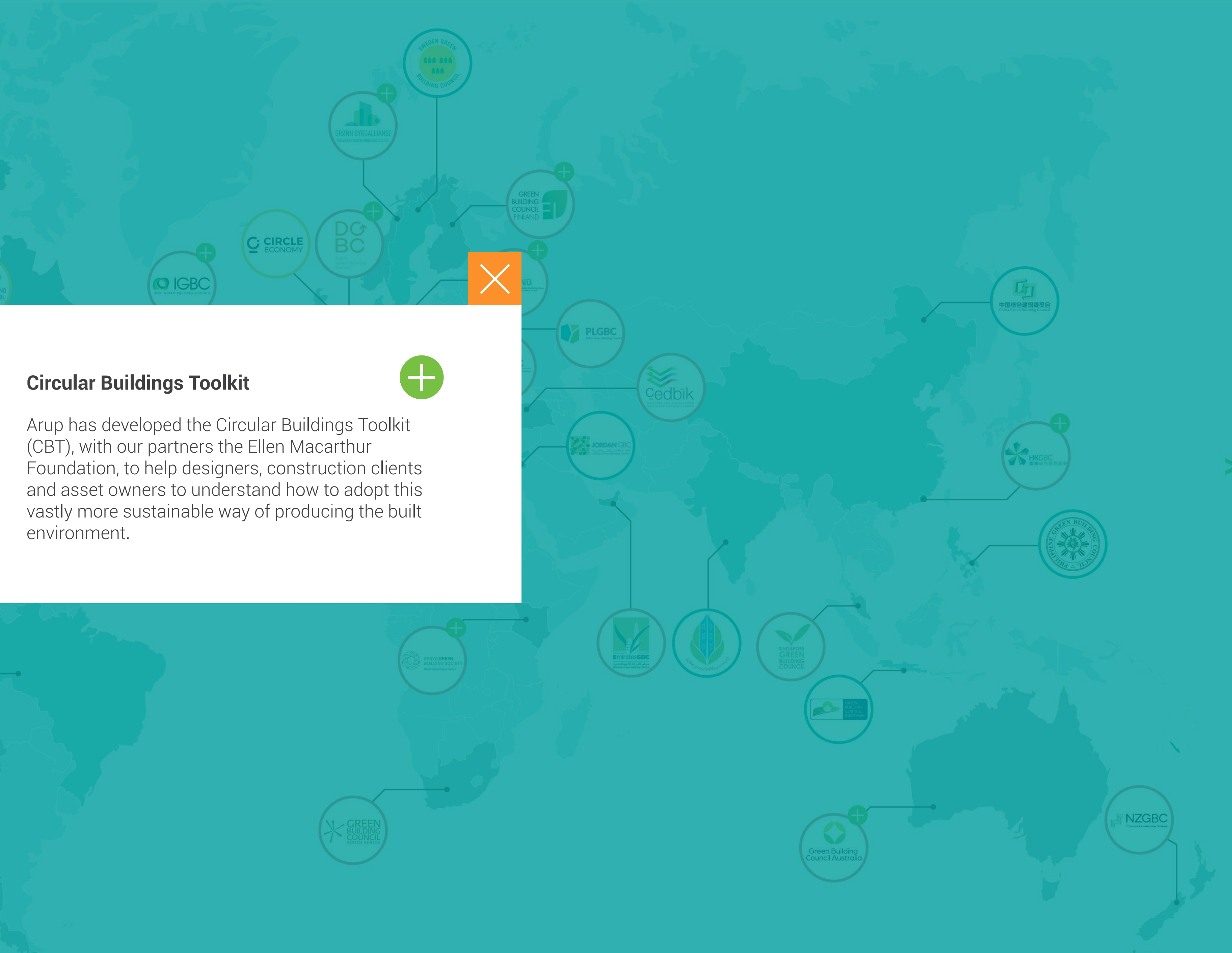

Circular Buildings Toolkit

Arup has developed the Circular Buildings Toolkit (CBT), with our partners the Ellen Macarthur Foundation, to help designers, construction clients and asset owners to understand how to adopt this vastly more sustainable way of producing the built environment.

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CIRCULARITY ACCELERATOR

worldgbc.org

WORLD GREEN BUILDING COUNCIL