wbcsd

The business case for circular buildings:

Exploring the economic, environmental and social value

Foreword

The building sector is responsible for almost half of global resource use, including 12% of all freshwater use, and it produces up to 40% of global CO_2 emissions and solid waste. The sector also employs, on average, more than 10% of the workforce globally.[1] With urbanization increasing rapidly in the world's most populous countries, building sustainably is essential to achieving sustainable development.

A circular economy addresses these challenges and has the potential to cut down CO_2 emissions from materials and reduce impacts on nature. At the same time, it presents a business opportunity in terms of innovation and business models that the sector shouldn't miss.

In 2018, the World Business Council for Sustainable Development (WBCSD) and Circle Economy published Scaling the Circular Built Environment: pathways for business and government, highlighting how the entire value chain can move towards a more circular value chain. The report identifies several challenges that inhibit the sector from moving towards circularity, including:

- **Culture and beliefs –** consumer perception, hesitancy to collaborate, status quo bias
- **Regulations –** limited leverage of green public procurement, counterproductive regulations, rigidity
- **Market –** artificially low virgin material prices, circularity not included in valuation assessments, limited understanding of risks associated with the linear model
- **Technology –** limited data and information sharing, circularity not integrated into existing systems
- **Education –** limited understanding or awareness in the value chain

This report aims to address the market barrier by providing qualitative and quantitative explanations of how real estate, development and finance can articulate the financial return of circular projects. It addresses the education barrier by sharing this information to inform those at the beginning of the value chain of the economic opportunity inherent in integrating circularity into decision-making processes. We have also complemented the financial value of a circular economy with examples of how to derive environmental and social value.

The circular economy is an economic model that is regenerative by design.[2] The goal is to retain the value of the circulating resources, products, parts and materials by creating a system with innovative business models that allow for long life, optimal (re)use, refurbishment, remanufacturing and recycling. By applying these principles, organizations can collaborate to design out waste, increase resource productivity and maintain resource use within planetary boundaries.

From our survey and interviews, we found a limited understanding of what a circular economy means for the built environment. Hence, we have developed an operational definition of a circular building with several stakeholders to provide a common language.

Today, there is a greater need than ever to understand how circular solutions can enable the transition to a low-carbon, nature-positive and just economy. This report builds on, and complements, the World Green Building Council's (WorldGBC) Beyond the Business Case report for a sustainable built environment to help deliver this transition.

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Executive summary

THE CIRCULAR ECONOMY

The circular economy is a practice that seeks to reduce resource consumption and keep materials and products in use through ongoing adaption. Reuse is a crucial tool in achieving a net-zero carbon economy and the wider Sustainable Development Goals.[4] This approach seeks to keep a building's materials and resources in use as long as possible in a closed circle of extended use, reuse and recycling. The principle is that if a building adopts a circular approach in its design, operation and deconstruction, then over time it is possible to maximize its value, both financially and socially, while minimizing the negative environmental impacts from the extraction, transformation and landfilling of raw materials.

THE REPORT

This work builds on WBCSD's report Scaling the circular built environment: Pathways for business and government, which sets out what the business and broader value case is in adopting a circular economy approach across the building life cycle.

Recent publications[5] promote the economic, environmental and social benefits of adopting circular economy solutions. Yet, quantitative data to support a shift from niche to mainstreaming a circular economy in the built environment is still largely missing.

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.

Firstly, we have carried out a review of available literature to highlight the state of knowledge within the circular economy field and the evidence supporting the business case.

Secondly, we have engaged stakeholders actively involved in delivering circular economy practices worldwide in surveys and in-depth interviews to better understand how they derive value from circular economy approaches and what their viewpoint is on the state of the market.

And lastly, three case studies illustrate the report findings, outlining four examples of value creation and providing quantitative numbers on the potential of the different business cases. The circular projects are:

- Upcycle Studios and Resource Rows (Copenhagen, Denmark)
- Park 20|20 (Hoofddorp, Netherlands)
- Exchange House (London, UK)

Credits: Rasmus Hjortshøj - Coast - Upcycle Studios

THE ECONOMIC VALUE CASE

Encouragingly, over 60% of respondents of a global survey[6] said that they are actively involved in a circular economy, with many others actively learning and aiming to implement a circular economy. This points to a general awareness and understanding across the value chain that circular economy practices reduce negative environmental impacts, for example from pollution or CO_2 emissions, and can lead to improved public image, credibility and sustainability performance. However, there was little data in the survey to quantify this.

The three circular projects studied in this report provide some quantitative evidence for the business case:

- Avoided costs from new land acquisition and landfilling costs by prioritizing existing building land use (e.g., Upcycle Studios Case Study);
- Rapid sales through enhanced branding and local community buy-in (e.g., Resource Rows), supported by a close collaboration with the municipality and dispensation of traditional approval routes to incentivize material reuse (e.g., 830m^3 of concrete and seven metric tons of wood reused from Copenhagen Metro for Upcycle Studios);[7]
- A demonstrable lease price advantage achieved through reductions in energy costs and service charges through circular building design and the use of novel business models such as servitization (where customers pay for a service rather than buying equipment, such as air conditioning) (EUR €25/m_2/yr – Park 20|20).

THE BROADER VALUE CASE

Survey respondents described the environmental benefits of a circular economy as the best understood "value impact" from adopting circular economy practices. The survey and case studies highlighted significant reductions in CO_2 emissions for developments that prioritize circular economy approaches.

That approximately 75% of stakeholders surveyed agreed that circular economy principles had a tangible impact on carbon emissions and waste reduction further reinforces this viewpoint, as do the findings from the case studies analyzed, for example:

- Upcycle Studios and Resource Rows (Copenhagen, Denmark) – exemplifying building level material reuse delivering up to 45% reductions in CO_2 emissions by reusing materials and installing recycled products;
- Park 20|20 (Hoofddorp, Netherlands) – cradle to cradle strategies at a masterplan scale using 30% fewer materials than normal;
- Exchange House (London, UK) – commercial office refurbishment upcycling through collection of over 137 tons of materials for reuse by local enterprises and charities.

While these case studies highlight a broader value case, there is clearly a lack of consistent quantitative data supporting circular practices. To catalyze the transition, we recommend that the use of established industry tools such as whole-life carbon assessment and life-cycle costing also measure and account for the benefits of circular solutions, such as e.g., accounting for residual value of solutions, components and materials, and reductions in operational expenditures, demolition or (future) carbon costs.[8] We propose a set of KPIs for this purpose in the sections on the value cases below.

DRIVERS OF CHANGE

The existing market still provides challenges for widespread uptake. As the cost of virgin materials is lower than that of recycled materials and the costs associated with the upskilling and logistics required for circular practices are substantial, this balance needs to shift if the business case is to be more competitively widespread. In addition, a lack of consistent industry regulation and certification for material reuse points to a challenging market environment for widespread investment. However, the landscape is changing rapidly, both from a policy and climate perspective. Investors are increasingly looking at the environmental, social and governance (ESG) reporting credentials of businesses to help determine future business viability. Also, the recent ongoing development of new economic taxonomies will help to signpost sustainable finance activities for the delivery of sustainable goals.

These future scenarios will undoubtably accelerate circular uptake and include the following:

- **Future resource scarcity:** Supply chain impacts from geopolitical, climate and health impacts creating a lack of availability of raw and processed materials.
- **Legislative change:** Increasing legislation and costs associated with CO_2 emissions, landfilling and virgin resource extraction.

Increasing demand of sustainable buildings and the incentivization of investments into sustainable project activities to address global net-zero carbon legislation; for example, ESG strategies are already a competitive differentiator and are set to become a regulatory imperative in Europe.

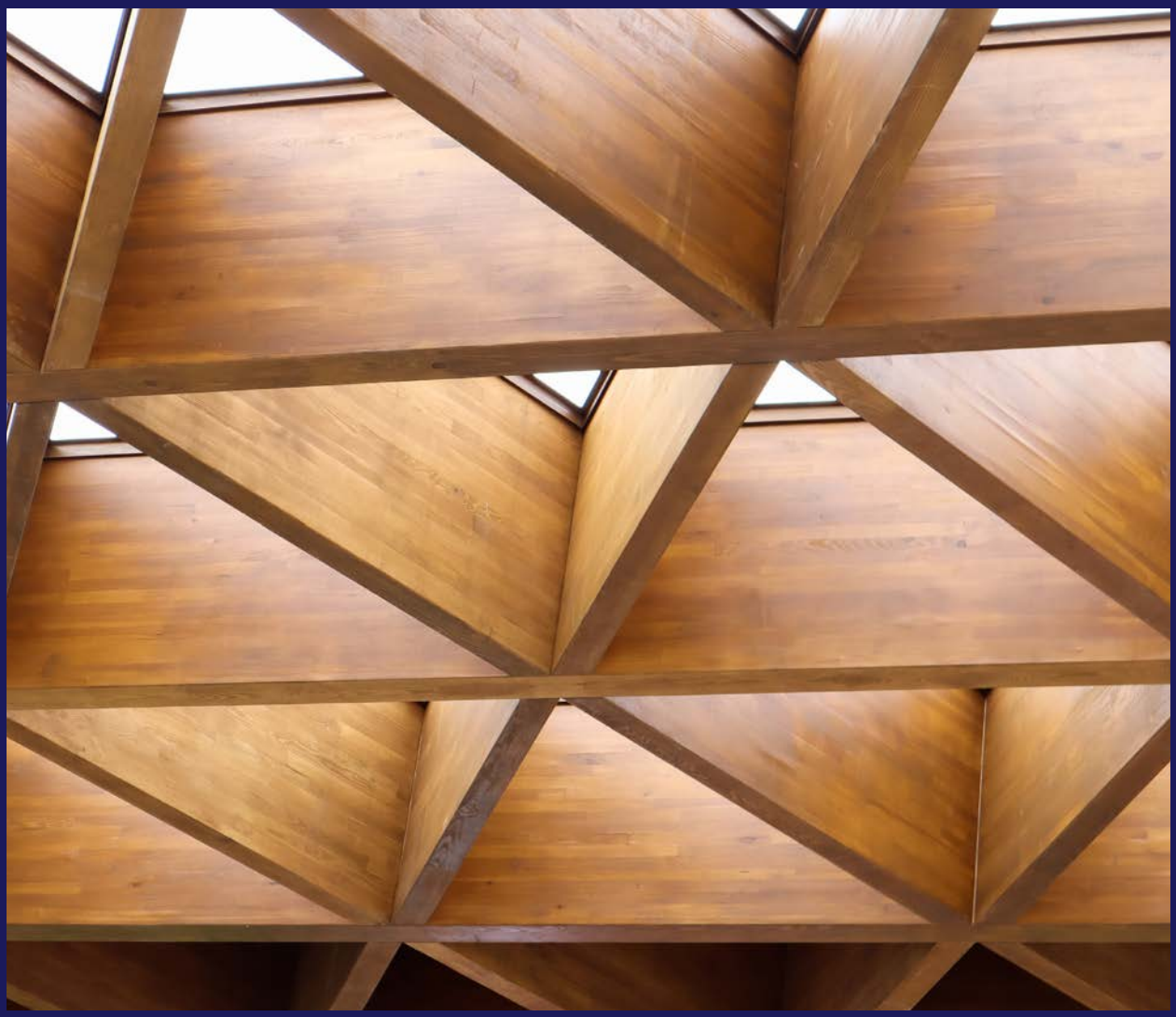
- **Market volume:** Increasing the logistics and skills capacity to meet ongoing changes in stakeholder demands as awareness of social and environmental impact climb the agenda.

These change drivers will likely catalyze demand and provide further data supporting widespread business case viability.

A CALL FOR ACTION

The circular projects we analyze in this report evidence benefits for the adoption of circular economy practices.[9] However, there is clearly a need to collect more quantitative data, especially economic data, to support business cases to shift from niche to mainstream for circular economies in buildings. There is a need to improve the understanding and data required to support a robust business case.

The tools that traditional management practices use widely are not fully suited to support the design of value retention models and other circular solutions. Hence, we call on business to measure circularity by adopting established industry approaches such as whole-life carbon assessment and life-cycle costing early in a project's decision-making process, including the accounting for residual value of solutions, components and materials, and reductions in operational expenditures, demolition or (future) carbon costs.



1 Introduction

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A NEED FOR CHANGE

The construction industry is responsible for the consumption of roughly half of virgin resources globally and close to 40% of global CO_2 emissions.[10] Therefore, it is no longer a question of whether the building industry should change, but how.

A circular economy is a crucial tool in achieving a net-zero carbon economy and the wider Sustainable Development Goals.[11] Circularity and the more efficient use of materials present opportunities to reduce greenhouse gas (GHG) emissions[12] and tackle biodiversity loss.[13] Also, there will be opportunities to improve the social value of the built environment, for example better local community uses for assets or promoting local sharing economies.

Several factors are currently slowing down the transition to a circular built environment,[14] including the lack of market data and measurements.

ADDRESSING BARRIERS

Worldwide, stakeholders in the built environment are seeing the potential in circular construction. However, many find the field hard to navigate due to market barriers that include:

- Low virgin material prices;
- Circularity not considered in asset valuation and perceived to be without a measurable economic return on investment;
- Lack of experience in a complex value chain leading to higher perceived risks and reluctance to provide financial support;
- High upfront investment costs, such as in product innovation or in mobilizing an integrated design process;
- Limited subsidies or market incentives for secondary materials and products;
- Lack of market volume or economies of scale for new and innovative circular products;
- Low landfilling costs;
- Lack of customer demand in many market segments and geographies.

The following enablers highlight key ways to address barriers and mainstream viability for the circular economy business case:

- **Waste legislation and standards:** These must evolve to further apply strict landfilling regulations and facilitate the reuse of secondary materials.
- **Demand for circular products:** We expect market demand to increase for circular products as they help to support the delivery of net-zero carbon ambitions and reduce waste streams. However, supply chain, logistics and storage capacity will need to increase to service this.
- **Material transport and logistics:** Time and geographical matching are key. Materials handled come in large quantities and both transport and storage are expensive. Densely populated areas are the optimal setting for this.
- **Quality:** This is another key prerequisite and selective demolition and sorting are key to ensuring quality. Standards and norms must catch up with recycling technologies and processes.
- **Price:** Circular solutions must be cost-effective.
- **Standardized industry tools:** These help set a building's market value in the context of the circular economy. This requires professional skills to develop tools that can measure CO_2 value and residual value from creating, capturing and distributing reused materials to assess this.
- **Risk:** A business case should consider how the business can use the circular economy to mitigate the need to address future risks stemming from legislation changes, resource scarcity and environmental impact, while balancing expected increases in demand to meet corporate image and stakeholder satisfaction.

BUSINESS CASE ACROSS BUILDING STAGES AND VALUE CHAINS

The circular potential is different at each stage of a building's lifetime. The specific business opportunities that arise for the relevant stakeholders within each stage will also change.

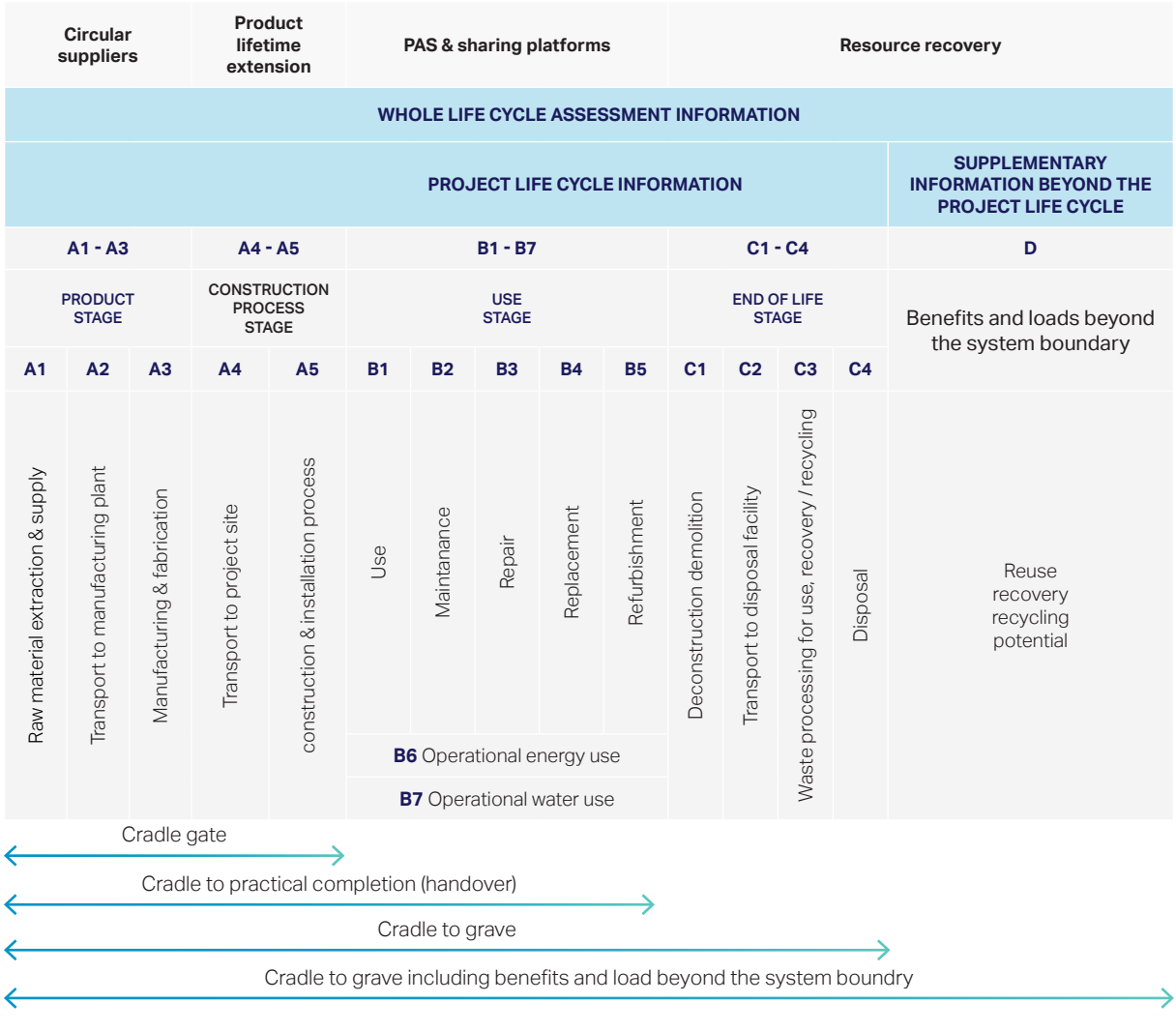
To help understand the business case potential, we engaged with stakeholders across the value chain who have experience in the field of circular construction. These stakeholders are actively supporting the transition to the circular economy and are adopting emerging circular business models, for example:

- **Circular supplies** – using non-toxic reusable or recyclable materials or procuring renewable materials;
- **Product lifetime extension** – maintaining and extending product lifetimes;
- **Product as a service** – leasing or servitization instead of product ownership;
- **Sharing platforms** – sharing products or assets and optimizing their use;
- **Resource recovery** – using waste from used products and resources and by-products from other industries to make new products.[15]

Often circular economy discussions end up just being about how to avoid waste in the future. But the potential is so much greater. Even though these later stages are crucial to solving waste issues, they fail to capture the business potential across all building stages, including upcycling of products, designing for disassembly, and the potential of the sharing economy.

It is this potential for innovation and the development of new business models that the industry shouldn't miss.

Figure 1: Life-cycle stages as defined by EN 15978 stages and circular business models



2 Methodology

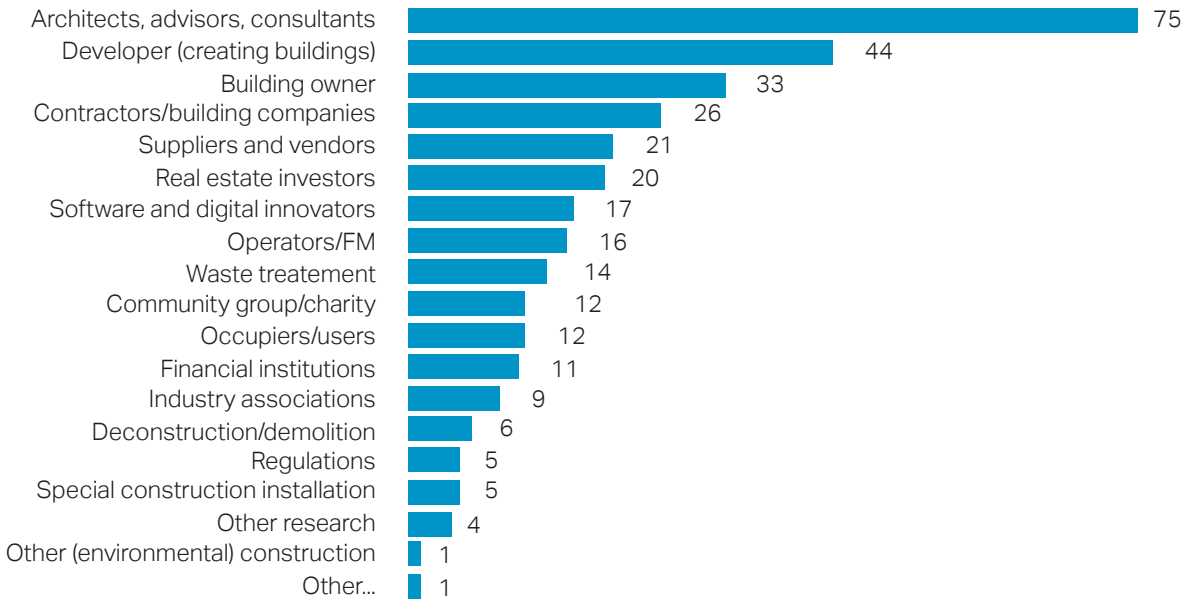
② Methodology

We have brought together the following key phases of work to provide the current state of play of the market:

- **Literature review** – We reviewed 25 reports to better understand how the adoption of circular economy practices creates emerging value and if there are emerging key performance indicators that support value creation and will support the wider business case for adoption. A summary of the literature is outlined in the section below.
- **Engaging with stakeholders** – We ran a global online survey involving 203 stakeholders across the value chain and with 25 follow-on interviews to gain insights into stakeholder viewpoints, their benefits, and details on market viability in adopting circular approaches. The main findings from the survey and the interviews are embedded in the analysis.
- **Case studies** – Three in-depth case studies that outline value creation experiences in realized circular building projects support the literature review and interview findings.

Collaboration with leading practitioners across the value chain has also provided opportunities to gain further insights and test project findings with industry experts. Companies and Organizations that have collaborated to this report are listed in the acknowledgment section.

Figure 2: Global survey responses: Primary markets and then add on the same line: (Europe, Asia, North America, Middle East, South America) and roles within the value chain



3 Literature review

3 Literature review

We carried out a literature review to understand how the adoption of circular economy thinking and practices is creating emerging value. The review considered if there are emerging quantitative key performance indicators that support value creation and business case development.

In reviewing the reports, it was clear the complexity and magnitude of the circular economy does not allow for any one single performance value or index. We suggest to instead present the circular economy as a set of interconnected social, environmental and economic benefits with nuanced importance relative to geography, culture and demographics.

The literature suggests that a circular economy approach helps reduce environmental impacts by helping to decarbonize the construction industry and its value chain while providing a platform to improve social value impacts.

Businesses need to adapt to new business models such as pay-per-use, lease and take-back schemes that both offer financial flexibility to their clients and help them extract value from an asset before the end of its life and recycling. Being visibly environmentally responsible will create additional value for businesses and promoting sustainability will help strengthen the brand image.

While the literature review supports a need for the importance of a top-down policy and bottom-up demand, there is a lack of consistent data across the reviewed literature that quantifies the scale of value creation in adopting circular economy approaches. However, there are emerging values structured on the themes of social, environmental and economic value creation. Table 1 provides a summary.

Cross-cutting themes

We found the following themes referenced across the literature and related to social, environmental and economic value creation.

Policy impact and engagement: Ensuring there are clear, consistent and long-term policies for circular economy directives that will drive development and will make investing more attractive is essential.[16]

Innovation, research and development: The literature places innovation at the heart of catalyzing value creation; and development can help introduce new business models.[17]

Economic value

The literature pointed to the following economic themes.

- **Cost savings:** Clarion's circular economy strategy resulted in £5 million in cost savings for waste disposal and materials purchases.[18]
- **Increased prices of products and services:** Actors want to minimize their risks and therefore deny their responsibility. By paying more, the client can give the risk to others.[19]
- **New business opportunities:** The idea of selling a service rather than a product can spur innovation for increased service longevity and intelligent waste management, and create incentives to close production and consumption loops.[20]
- **Financial flexibility:** A lease program can offer better financial flexibility and give the investor better control over their monthly costs without requiring high investment costs, thereby motivating them to select the best performing solution.[21]
- **Value retention:** A circular economy can ensure the extraction of the greatest possible value from resources before they become waste.[22]
- **Legal compliance:** Early adoption of circular economy principles can put companies at the forefront of future regulations and requirements to operate in the built environment, not least by invoking influence on said future policy-making and legal frameworks.[23]

Table 1: Summary of emerging themes from the literature review

ECONOMIC VALUE CASE	BROADER VALUE CASE	
	SOCIAL VALUE	ENVIRONMENTAL VALUE
• Cost savings • Increased prices of products and services • New business opportunities • Financial flexibility • Value retention	• Local job creation • Strengthened brand • Stakeholder satisfaction • Cultural identity • Knowledge sharing	• Lowered CO_2 emissions • Minimized waste • Lower use of virgin materials • Improved material transparency

POLICY

INNOVATION AND R&D

Environmental value

The literature pointed to the following environmental themes.

- **Transparency:** Strategic investments in environmental product declarations, data disclosure and research and development will help to foster new carbon-free production processes and carbon capture techniques.[24]
- **Minimized waste production:** Offsite production and designing out waste can reduce material and onsite waste management.[25]
- **Reduced CO_2 emissions:** The London Plan encourages the use of the circular approach as a tool for carbon reduction and gives guidance on circular economy statements.[26]
- **Lowered use of virgin materials:** Reducing the use of virgin material reduces exposure to price volatility and supply shocks due to natural disasters or political events.[27]
- **Strategic goals:** Recycling materials in building projects can help reach overall strategic sustainability goals on a state or municipal level.[28]

Social value

The literature pointed to the following social themes.

- **Local job creation:** Several studies discuss the positive impact on local job creation and stimulation of small- to medium-sized businesses, showing the positive effect of job creation. New business opportunities such as selective demolition, reuse and recycling create jobs.[29]
- **Branding (public image):** A circular economy can add branding value (enhanced public image) and a way to promote and communicate the sustainability credentials of a business to local communities and stakeholders.[30]
- **Stakeholder satisfaction:** Social value is a critical element for client and local stakeholder-led initiatives that intend to reduce waste, strengthen community networks, create a sense of ownership for residents and promote a sharing economy.[31]
- **Staff and employee satisfaction:** Motivation to innovate, participation in R&D activities and knowledge sharing is powerful tool for attracting and retaining talented people.[32]
- **Preservation of cultural heritage:** Repurposing and redesigning existing spaces rather than tearing them down allows for the preservation of historical architecture and cultural identity.[33]
- **Knowledge sharing:** Collaboration across the whole value chain and sharing best practices will convert barriers into business opportunities. Pilot projects will motivate learning and contribute to knowledge creation.[34]

4 What is a circular building?

4 What is a circular building?

A circular business case requires a definition to galvanize action and provide stakeholders with a common understanding and approach for delivery.

The work of this project is not to redefine what the circular economy is, but to ensure the definition and language relate to that of developing and maintaining buildings.

Circular built environment vision

In alignment with the WorldGBC, our overarching vision for a circular built environment is:

North Star: A built environment that facilitates the regeneration of resources and natural systems, while providing socio-economic benefits through a circular economy.

2030: 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.

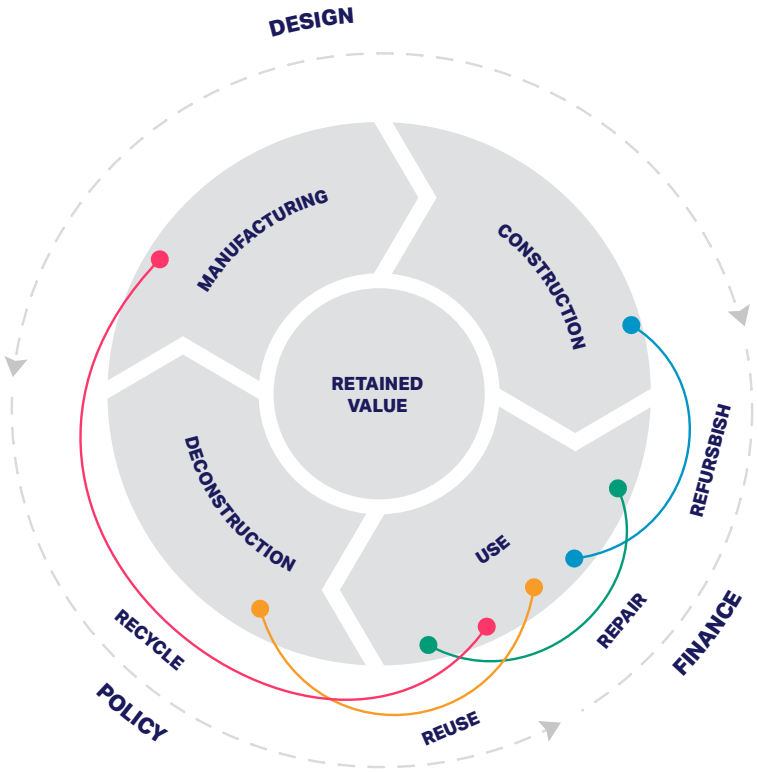
Circular building definition

A circular building optimizes the use of resources while minimizing waste throughout its whole life cycle. The building's design, operation and deconstruction maximize 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;
- Life-cycle assessment (LCA), life-cycle costing (LCC) and readily available digital information (such as building material passports).

The report defines the building whole life cycle as follows:

Figure 3: A circular building – life-cycle stages



5 The business case for circular buildings

PARK 2020_Masterplan Completed Buildings ©WM+P

5 The business case for circular buildings

We developed this report with the objective of articulating a quantitative business case for a circular economy in the built environment. However, the research, the case studies and the interviews with experts show that stakeholders still perceive circular buildings as innovative projects whose economic value resides mostly in market differentiation, with a difficulty to measure economic return on investment.

Instead of a single economic benefit, it is more appropriate to describe circular solutions as a set of interconnected environmental, social and economic benefits with nuanced importance relative to geography, culture and demographics.

The table below strives to quantify, based on the available data from the four projects analyzed, this overall interconnection of benefits.

The following chapters provide a breakdown of the overall business case, showing the economic, environmental and social benefits of circular solutions drawn from the case studies and survey findings. To improve the data collection, measurement and reporting of the circular economy in buildings, we also propose a set of enabling activities and key performance indicators.

Table 2: Business benefit impact[35]

CASE	DESIGN & CONSTRUCTION COST	ASSET VALUE	OPERATIONAL COSTS	RISK MITIGATION	ENVIRONMENTAL VALUE	SOCIAL VALUE
Resource Rows/ Upcycle Studios	Land and acquisition costs avoided from asset reuse	Fastest sales in the neighborhood 6% overall decrease in acquisition and maintenance costs	-	Collaboration between partners in design and construction led to lower risk in material acquisition	Upcycle Studios: 65 tons CO_2-eq ~ 45% savings 914 tons of waste avoided	Use of existing materials creates uniqueness and catalyzes a sense of ownership in the building 18 jobs created
	High-quality building pricing: circular building being 8-10% more expensive, due to innovative approaches	Branding and market differentiation		Project partnerships reduced delays in the building process when working with innovative approaches		
	Lower costs of materials but higher costs of manufacturing – re-processing secondary materials can be costly				Resource Rows 20 tons CO_2-eq ~ 29% savings 463 tons of waste avoided	

CASE	DESIGN & CONSTRUCTION COST	ASSET VALUE	OPERATIONAL COSTS	RISK MITIGATION	ENVIRONMENTAL VALUE	SOCIAL VALUE
Park 20|20	Higher design and Construction cost (+ 21%)	Servitization mitigates against obsolete equipment risk	Reduction of appr. 40% energy compared with existing building offices; savings of EUR €80.000/year	The risk of product failure or the responsibility for maintenance (product as a service) Increased flexibility and development	Buildings designed to perform 54% more efficiently than a conventional code complaint building	+3% productivity based on non-toxic materials, the shape of the building and layout of the plan
		The higher rental price used to offset higher initial construction costs.		margin (+5%) lead to lower operating costs and reduce the real estate investment risk		Shared spaces improve spatial use costs,
		(EUR €25/m2 per year) Design for disassembly & material bank value: adding EUR €125 – 135/m² net lettable area gained				providing capital expenditure savings of 4%
Exchange House British Land and Globechain	Exchange House BritishLand and Globechain[36]	-	-	-	Supported British Land's commitment to achieve a net-zero carbon portfolio and create greater social impact Material reused: 137 tons	Charities have collected and benefited of 5,889 items, improving spaces and facilities they use

Park2020_©Var der Torren
Fotografie courtesy William McDonough + Partners

The Economic value case

The need to make the economic value case is critical if the circular economy is going to move from a niche to a mainstream concern. For this to happen, circular strategies must translate into positive economic and profit value indicators.

The case studies analyzed and the survey show emerging evidence of economic benefits, such as:

- Avoided costs from new land acquisition and landfilling costs by prioritizing existing building land use (Upcycle Studios);
- Increased value by residual material valuation and component value after deconstruction of material passports (Park 20|20);
- Lease price advantage delivered through reductions in energy costs and service charges through circular building design and use of novel business models such as servitization (Park 20|20);
- Market differential and rapid sales through enhanced branding and local community buy-in (Upcycle Studios & Resource Rows).

Business cases considering medium- to long-term timeframes will certainly need to address likely impending future net-zero carbon legislation, increasingly volatile material supply chain markets triggered by either resource scarcity or geopolitical impacts, and ever-increasing demands for improved sustainability reporting. When considering these likely future scenarios, the economic case will strengthen.

The survey underlines this viewpoint as stakeholders indicated that likely future resource scarcity along with policy and legislative changes will further strengthen the business case for a circular economy.

Life-cycle costing is currently the most widely used tool used by the industry to inform financial decision-making. However, when working with circular economy practices, almost a third of stakeholders when asked did not know how to create a monetary business case for circular performance. **There is clearly a need to adapt conventional economic tools to be able to measure the retained value of a building in adopting a circular approach.**

Figure 4: Global survey results for "What economic value has been created, captured and distributed using circular economy principles in your work?"

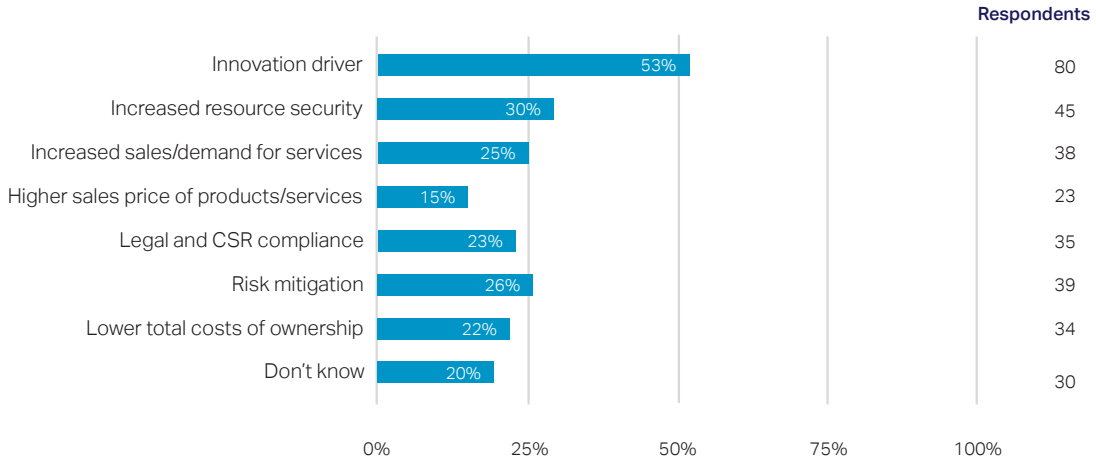
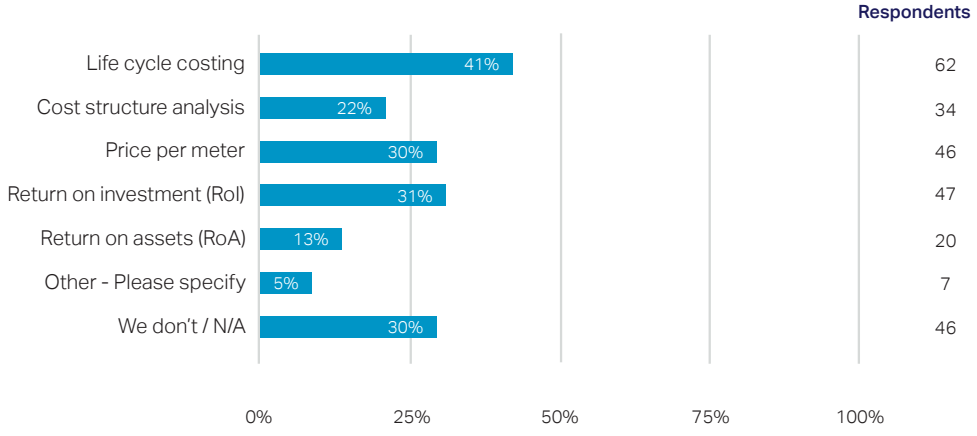


Figure 5: Global survey results for "How do you measure financial outputs when working with a circular economy?"



CASE STUDY: Masterplan scale: Product as a service & lifetime extension models

PARK 2020_Masterplan Completed Buildings ©WM+P

PARK 20|20

Location: Taurus 60, 2132 LS Hoofddorp, the Netherlands
Construction: 2010 -
Size: 114,000 square meters
Project partners:

- Delta Development Group
- Architect and master planner: William McDonough + Partners

Cost: €1,400 per m²

KEY BENEFITS

Park 20|20 is an office building park in the Netherlands that is based on the circular building concept. The architects designed the buildings as material banks and they included several energy and CO_2 savings features. It is on land reclaimed from the sea.

THE CIRCULAR APPROACH

- **Design for disassembly**

  The creators designed the buildings with a cradle-to-cradle[37] concept in mind. To support this concept, the creators developed the buildings for disassembly and for next use as housing. Designing for disassembly, modularity and product as a service strategies for both core and shell and the tenant fittings, led to increased flexibility and lower total cost of tenancy, which opened the potential for increased rental prices and lowers operational costs at tenant turnover.

  Design for disassembly also gave the flexibility to optimize for the development of the surrounding area, making best and highest use attainable beyond the first use, thus lowering investment risk and optimizing potential return.

- **Creating a material passport and using residual material valuation.**

  The buildings show €70-80 per m² net lettable area (NLA) residual material and component value – after deconstruction costs. Compared to a €55 per m² NLA cost of demolition. This creates a positive value difference of around EUR €125 to €135 per m² NLA.

- **Reducing use of materials**

  Furthermore, the park focusses on reducing both the use of materials and waste of space, as the designers swapped out the usual concrete floors for thin, hollow, steel-beamed level separators. It uses 30% fewer materials than normal and allows seven floors to fit in the normal height of six. Together with the initial design of the buildings, they serve as material banks in the future and are also easily adaptable for other functions.

- **Reduced use of resources**

  The buildings are intended to perform 54% more efficiently than a conventional code-complaint building and integrate renewable solar power. Park 20|20 has closed systems for energy and water. It uses renewable energy such as solar, provided by the PV cells integrated in the individual buildings as well as in Delta's solar park nearby. Heating comes from a geothermal well providing warm water for the park, stored in the summer, and cold water provides cooling in the winter. Wastewater treatment takes place onsite, where grey water from all the buildings goes to a central plant clarification basin with a helophyte filter.

CIRCULAR OUTCOMES

The first building was sold with a 23% return, showing the profitability of this innovative circular building. Overall, there is a focus on employee satisfaction and the consequent higher productivity level. This, together with lower energy costs, is supposed to offset the somewhat higher rental price of €210 per square meter, versus the average of €135 in the area. The building's quality measures include factors such as carbon dioxide levels, toxicity, sound and light. In one of the buildings, rented by Plantronics, a survey showed that 91% of employees say the design creates an enjoyable work environment and 87% say the office allows them to work productively.

Qualitative business benefits & indicators

Core enabling themes & indicators

These are examples of themes and indicators that are directly related to the benefits delivered by circular solutions. The benefits described are a result of the insights gathered from stakeholder interviews and analysis of the case studies.

CORE ENABLING THEME	REQUIREMENT/KPI	BENEFIT DESCRIPTION
Design and construction costs *Costs resulting from designing and constructing circular buildings*	Life cycle costing	Acquisition costs avoided from reuse
	Operational expenditures (€)	Reduced whole-life operating costs resulting from maintainable and adaptable buildings
	Demolition costs (€)	Costs avoided from landfilling and demolition
	Carbon costs (€)	Reduced exposure to carbon costs through reuse
Asset value *Increasing market value resulting from circular approaches*	Occupancy and vacancy rate (%)	Market differentiation and branding Increase in market transaction value resulting from higher residual value
	€/net lettable area (NLA)	
	Return on investment/return on asset (%)	
Operating costs *Costs associated with resource use, long-term operations and maintenance costs*	€/m2 year	May reduce ongoing maintenance costs as assets become more adaptable and maintainable through adoption of circular practices; whole-life costing used to quantify benefits; new business models focused on performance outcomes (e.g., servitization)

Supportive themes for economic value & business benefits

Supportive themes & indicators

Examples of themes and indicators that relate to broader sustainability agendas that the adoption of circular economy strategies support indirectly.

SUPPORTIVE THEME	REQUIREMENT/KPI	BENEFIT DESCRIPTION
Workplace productivity and health *Circular strategies that improve indoor environments resulting in bottom-line business benefits*	€/net lettable area (NLA)	Reuse of safe low-toxicity materials for high-quality indoor environments; improved workplace productivity
Risk mitigation *Circular strategies to mitigate against increasing sustainability and regulatory risk factors such as local building codes, mandatory disclosure, and offsetting*	Policies	Addressing a changing regulatory landscape relating to energy & resource consumption, carbon emissions & mandatory disclosure.
	ESG	Investor risk screening may define assets not able to address regulatory change as stranded assets (assets that have suffered from unanticipated or premature write-downs, devaluations or conversion to liabilities)

Environmental value

Survey respondents described the environmental benefits of a circular economy as the best understood "value impact" from adopting circular economy practices. As stakeholders are increasingly using whole-life carbon[38] assessments to quantify CO_2 emission reductions, the report highlighted significant reductions in CO_2 emissions for developments that prioritize circular economy approaches.

Case study examples include Upcycle Studios and Resource Rows, which delivered up to 45% reductions in CO_2 emissions by reusing materials and installing recycled products. Approximately 75% of those surveyed agreed that circular economy principles had a tangible impact on carbon emissions and waste reduction, further reinforcing this viewpoint. Also, 60% of respondents agreed that circular economy principles reduce material consumption.

We found that the typical measures of environmental impacts from carbon emissions use life-cycle assessments, just as measures to improve a building's resource efficiency and waste management use indicators such as the percentage of weight diverted from landfill and the amount of recycled materials used. Local planning policy and the continued uptake of environmental third-party certification often drive requirements to measure and report.

Stakeholders identified the use of material passports as a useful way to embed digital information on the materials used within a building into a digital log book to enable information on identifying material value for its recovery and reuse alongside other material characteristics. They cited the creation of a material passport to improve material transparency within a building, which would help with the financial assessment of retained material value, and to inform decision-making during maintenance and end-of-life phases.

Figure 6: Global survey results for "What economic value has been created, captured and distributed using circular economy principles in your work?"

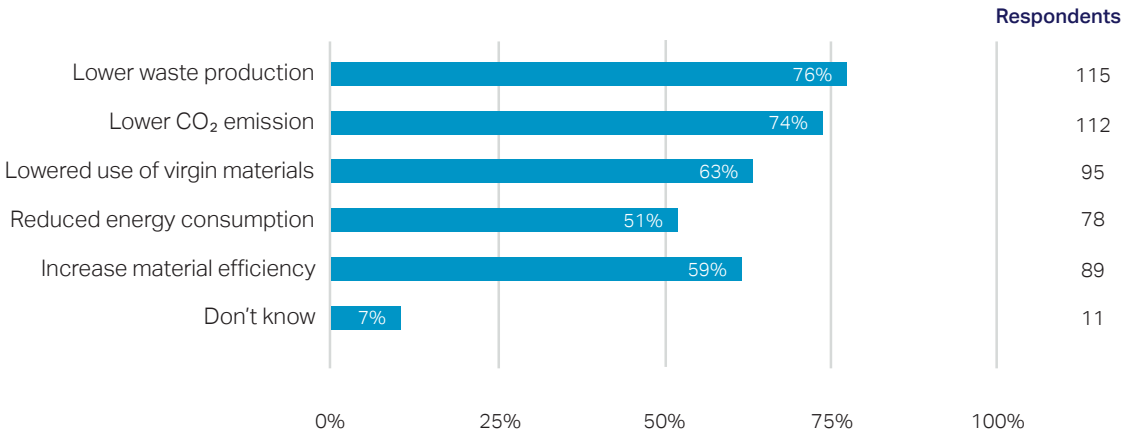
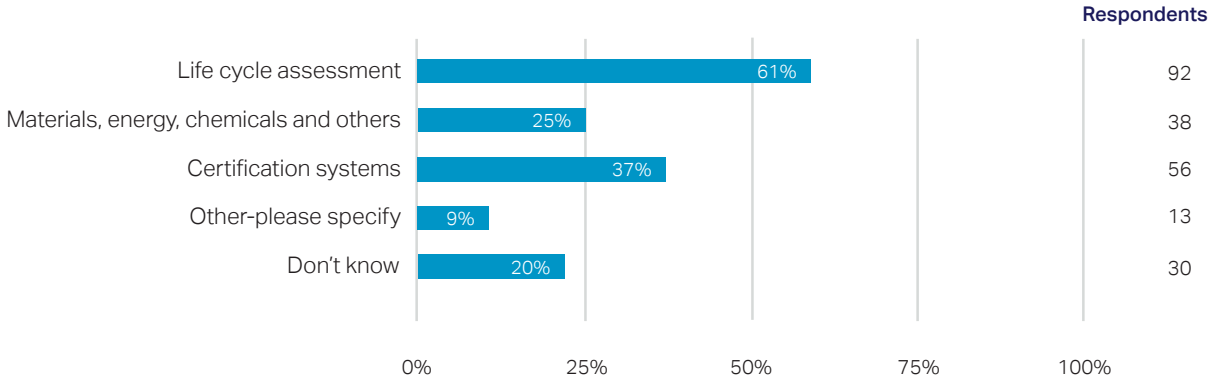


Figure 7: Global survey results for "How do you measure the financial, environmental or social outputs when working with the circular economy?"



THE RESOURCE ROWS

Location: Ørestaden, Denmark
Construction: 2017-2019
Size: 9148 m2
Project partners:
- Architect: Lendager
- Developer: NREP A/S
- Consulting engineer: MOE
Total cost: EUR €38.3 million

UPCYCLE STUDIO

Location: Ørestaden, Denmark
Construction: 2015-2018
Size: 3340 m²
Project partners:
- Architect: Lendager
- Developer: NREP A/S
- Consulting engineer: MOE

Total cost: €13.9 million

THE CIRCULAR APPROACH

The project's partners had a vision to make innovative projects that would demonstrate the possibilities of recycling, reusing and upcycling materials. At the same time, it would serve as a learning experience for these innovations and processes on commercial terms. Resource Rows and Upcycle Studio address challenges related to waste, resource scarcity and climate by lowering the consumption of materials and CO_2 emissions.

Through local processing, innovation and local expertise, used materials generally deemed worthless become high-quality resources. Circular approaches:

- The façade characterizes Resource Rows. It uses upcycled brick units created through the selective demolition of two provincial school buildings and from the historic Carlsberg brewery. Seven tons of otherwise worthless wood from the Copenhagen Metro Construction, which would have been downcycled as fuel, has been upcycled to constitute façades, terraces and flooring materials.
- UP windows characterize Upcycle Studios. The UP windows are recycled windows primarily from public housing renovation: a waste stream that is usually crushed and incinerated without regard for the often functional, residual life of the components.

ENABLERS THAT HAVE ALLOWED THESE INNOVATIVE CIRCULAR PROJECTS

The pioneering in Resource Rows and Upcycled Studio required the acceptance of greater risk and were more time consuming to build than traditional buildings.

Close collaboration between partners was therefore necessary. Usually, the authorities need to approve facades; due to resource recovery, Resource Rows couldn't provide façade drawings. The partners applied for dispensation to overcome this barrier; as Copenhagen municipality had a desire for increased recycling in the area, it approved the project. Furthermore, the storytelling in the projects showing strong material connections with the local Carlsberg factory, schools and metro created great interest and a lot of public promotion. For instance, the Minister of Climate (DK) and other relevant stakeholders attended the opening ceremony. This shows the strong brand equity for both the partners and the projects.

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CASE STUDY: Building scale: Resource recovery & circular supply models

Circular outcome

Upcycle studio

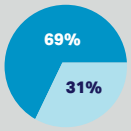
Embodied carbon
32% CO_2 saving

Full lifetime
45% CO_2 saving

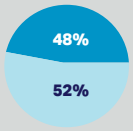
Saved 914 tonnes of waste
In total

Building opeation per year
72% saving
1.2kg CO_2 -eq per year

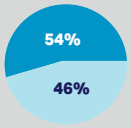
Material distribution (weight)



CO_2 distribution



Cost distribution



Upcycled New

Resource rows

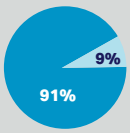
Embodied carbon
12% CO_2 saving

Full lifetime
29% CO_2 saving

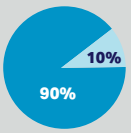
Saved 463 tonnes of waste
In total

Building opeation per year
48% saving
2.1kg CO_2 -eq/m2 per year

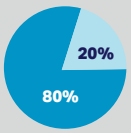
Material distribution (weight)



CO_2 distribution



Cost distribution



Upcycled New

More information on the case studies is provided in the appendices.

Environmental core themes

Core enabling themes & indicators

These are examples of themes and indicators that directly support measuring and delivering a circular economy, with a strong focus on environmental value creation.

CORE ENABLING THEME	REQUIREMENT/KPI	BENEFIT DESCRIPTION
CO_2 emissions *Reduction in whole-life carbon emissions throughout the building's life cycle through circular practices*	Whole Life carbon report $kgCO_2eq/m^2$	Quantify whole life carbon impacts Support decarbonization strategies
Circular inflow* *Measuring circular resourcing of materials, products and parts upon construction*	% virgin materials	Reduce virgin material extraction
	% recycled content	Increase circular supplies/reduce virgin material extraction
	reuse (weight/volume)	Increase circular supplies/promote material reuse
	% sustainably managed biomass	Increase circular supplies
Circular outflow* *Measuring how resources, materials, products and parts can be recovered at end of life and what is actually recovered*	% recyclable, reusable, refurbishable, remanufacturable content	Reduce virgin material extraction
	% actually recycled, reused, refurbished, remanufactured	Promote material reuse
	% diversion	Minimize landfilling

*Apply these indicators from the materials up through the aggregated totals that make up a whole building

Environmental core themes

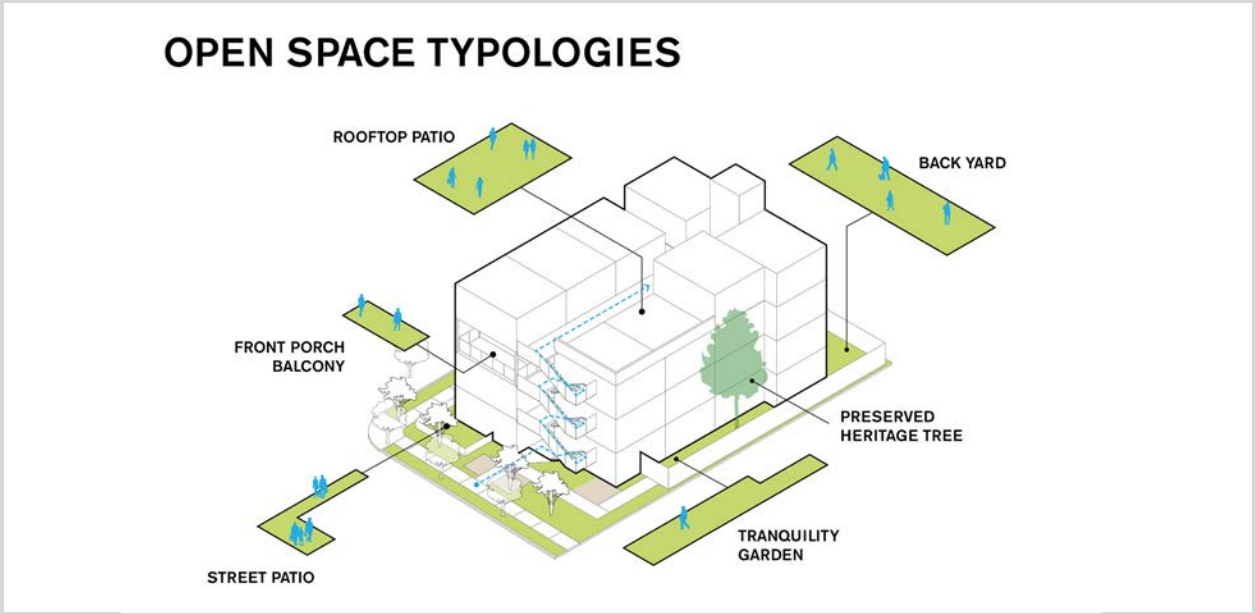
Themes & indicators

These are examples of themes and indicators that relate to broader environmental sustainability agendas that the adoption of circular economy strategies indirectly support.

% WATER RECYCLED ONSITE	REQUIREMENT/KPI	BENEFIT DESCRIPTION
Energy *Promoting onsite circular resource use***	% from onsite renewables	Onsite circular resource use
Water *Promoting onsite circular resource use***	% water recycled onsite	
Biodiversity *Impact on biodiversity*	Significant impact of products on biodiversity	

**Onsite renewable closed loop systems, e.g., site rainwater or grey water reuse systems

CASE STUDY: Watts Works



Watts Works
Developer: Daylight Community Development

Architect: Studio One Eleven

Program: 25-units of permanent supportive housing, community space for social services such as counseling, community-based health care, treatment, and employment training

The project—named Watts Works—is a joint venture with LA-based firm Studio One Eleven, Decro Corporation, Daylight Community Development, and The People Concern. The four-story complex is slated to hold 24 studio apartments for homeless individuals, 58 shipping containers were utilized on Watts Works which equals about 4,500 lbs. per container which equates to about 108 tons of materials recycled. One container is about 1520 cubic feet x 58 containers which equates to 88,160 cubic feet of volume recycled. Using shipping containers is cost effective and works well in small developments.

The containers are 100% recycled. The metal removed for the containers for doors or windows is recycled for other components, so there is no waste that is disposed into a landfill. When compared to conventional wood or steel stud construction on site, the waste is typically 10-15% of the total product ordered.

The social value of circular buildings

Social value, by definition, will be project-specific and outcome-based, and requires qualifying material benefits to local communities and stakeholders based on their needs. More details and measuring tools on social value are available at WorldGBC.

However, the findings of the report point to an emerging value case link between social value and the circular economy. When questioned, stakeholders said that they perceived internal public and private policy, alongside improving corporate image with local community stakeholders, as the greatest driver for social value improvements through a circular economy. While corporate image is difficult to measure and hard to quantify, if companies take positive action, they can strengthen brand reputation.

88% of responses in the global survey identified social value benefits from circular principles.

The opportunity for local job creation and the new skills required for circular approaches such as selective demolition, material sourcing, remanufacturing and installation was another consistent positive value creation theme. This transition is positive but we note that job creation should aim to be equitable, so that existing workers are not left behind.

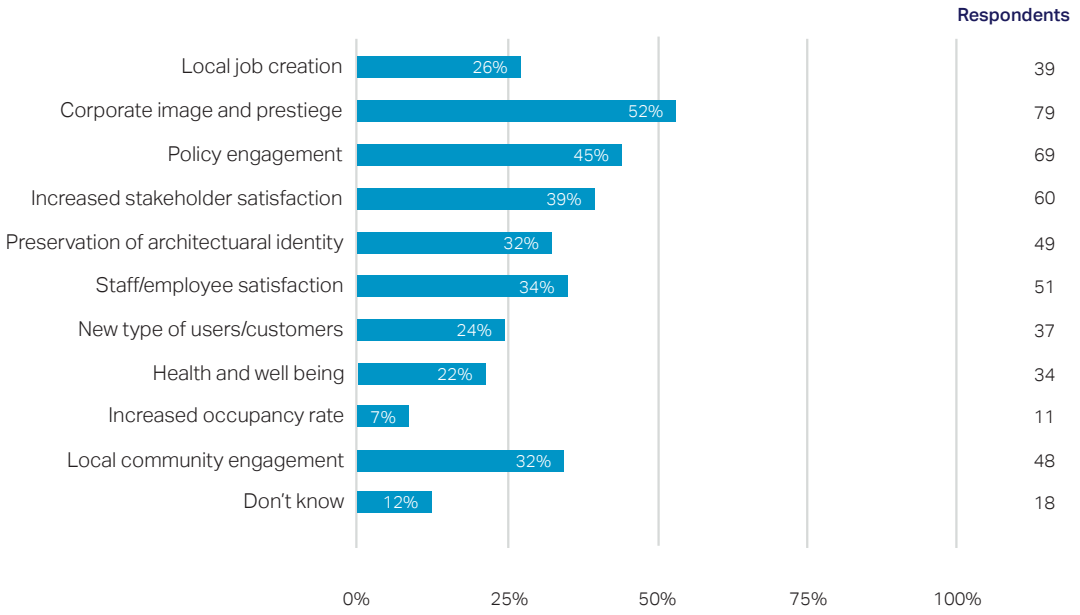
The Resource Rows and Upcycle Studios case studies echo this, showing the creation of 18 jobs resulting from specialized site material sourcing, manufacturing and installation.

Other social examples include:

- At Park 20|20 designing for disassembly and flexibility has enabled the buildings to better adapt to the needs of future tenants. This included the possibility to change potential future connections between floors and to reposition stairs for better use in addressing local needs.
- Maintaining the cultural heritage of a building/district. The Resource Rows project innovatively reused the brick walls of Carlsberg's historical breweries in Copenhagen, providing history to a modern neighborhood. This linking to the factory created great local interest, with the Minister of Climate and other key stakeholders attending the opening ceremony. This strong brand helped to create one of the fastest selling developments in the neighborhood.

"A circular building requires more planning and careful design. Taking an element from one building and bringing it into another means identifying and working with a new value chain. When new elements are made through upcycling, this also creates new jobs where you need a different set of skills compared to producing new products."
Anne Solgaard, Head of learning and leadership, Norwegian Green Building Council

Figure 8: Global survey results for "What social values have been created, captured and distributed using circular economy principles in your work?



CASE STUDY: Exemplary reuse of materials: British Land and Globechain

Exchange House

Address: Exchange House, 12 Primrose St, London EC2A 2HS, UK
Refurbishment year: 2021
Size: 65,000 square feet

Project partners:

- Developer: British Land
- Contractor: KpH Deconstruction
- Reuse marketplace: Globechain

Reuse data:

- Items collected: 5,889
- Materials reused: 137 tons
- People benefited: 3,154
- Sectors benefited: children & youth, education & training and arts
- BREEAM/LEED recognized for credits

ABOUT EXCHANGE HOUSE

Exchange House is a 10-storey building at Broadgate, a 32-acre office-led campus adjacent to Liverpool Street Station. Joint owners British Land and GIC are investing £1.5 billion in Broadgate's evolution into a world-class, mixed-use destination for London.

The refurbishment of levels 9 and 10 at Exchange House took place with live offices in operation in the rest of the building. Sustainability was a priority from the outset, supporting British Land's commitment to achieving a net-zero carbon portfolio by 2030 and creating greater social impact.

At the tender stage, British Land engaged Globechain, the largest environmental, social and governance (ESG) reuse marketplace worldwide. Globechain connects enterprises from the construction, retail, hospitality and office sectors with non-profits, small businesses and people to redistribute unneeded items.

During the tender process, KpH Deconstruction engaged with the project team to explore how the reuse of materials could enhance environmental benefits and add social value while delivering commercial returns. Following discussions with Globechain to further understand the process, KpH devised a strategy to overcome potential logistical and program barriers, including loading area limitations and insurance requirements in the building.

At the pre-demolition audit stage, KpH identified all potential items for reuse, including carpets, floor tiles, ceiling lights, blinds, doors and telecommunications equipment. They then stripped these out and listed them for reuse on Globechain. Through Globechain's network of members, charities and local community groups collected 5,889 items, benefiting up to 3,154 people by improving the spaces and facilities they use.

Beneficiaries included an East London charity focused on supporting survivors of abuse and preventing abuse in children and women, which used materials to renovate its local community office. A South-East London charity upgraded spaces in a community school and library used by over 2,000 students. Altogether, charities collected over 137 tons of materials for reuse, 14% of all stripped out material by weight, delivering more significant environmental and social benefits than recycling, at no extra cost.

KpH also shared lessons learned with the wider team to take forward to future projects, such as immediately transferring listed items to an appropriate storage location while awaiting collection, to prevent potential impacts on program timings. KpH is already engaging with Globechain on behalf of another client, further expanding best practice.

"Building on our earlier successful circular fitout at Regent's Place, we were keen to see what could be achieved on a smaller project, the partial refurbishment of Exchange House, Broadgate. We could see real benefit in bringing Globechain to the project given their alignment with our own sustainability aspirations in upcycle rather than recycle. Fantastic collaborative work between Globechain and enabling works contractor KpH not only reduced environmental impacts at Exchange House but also added social value by sharing materials with local community groups, with no impact on program or costs. A huge thank you to all involved. We are already taking lessons learned through to other projects, as we work to transform our portfolio to net-zero carbon by 2030."

Anthony Chudleigh, Project Director at British Land

Figure 9: Sectors impacted

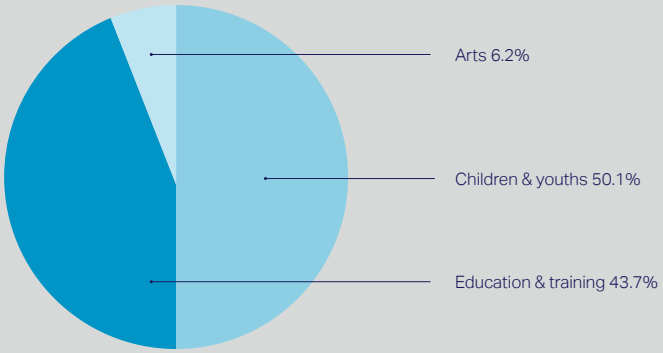
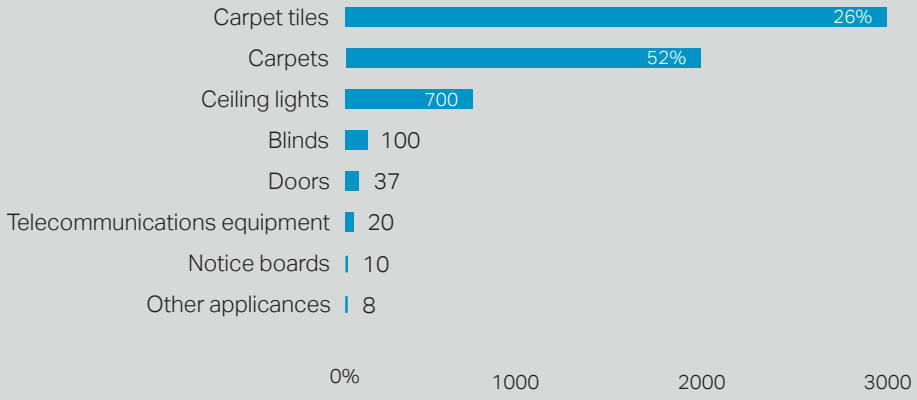


Figure 10: Top items listed



"At the very least, circularity creates opportunities for new skilled jobs. They require people to repair, refurbish with specific skill sets."

Prof. Seeram Ramakrishna, University of Singapore

CORE ENABLING THEME	REQUIREMENT/KPI	BENEFIT DESCRIPTION
Job creation *Local job creation and new skills opportunities from circular practices*	# new jobs created for circular practices	Improve local skills relating to circular practices
Local material networks *Scaling of distribution and logistics networks*	Within # km	Catalyze local storage and transport networks
Cultural heritage *Preserving cultural heritage and esthetic*	Increased local community/stakeholder satisfaction (from survey results)	Local engagement, interest and belonging
Adaptability *Buildings designed for future flexibility*	% gross internal area (GIA) that can be adapted	Buildings that can adapt to changing local needs

Social value core themes

These are examples of themes and indicators that directly support measuring and delivering circular economy, with a strong focus on social value creation.

With this set of performance indicators, drawn from the circular benefits identified throughout the report, we would like to address one of the key barriers encountered when developing it: the lack of financial data supported by consistent broader value evidence.

This is a large set of KPIs aiming to help stakeholders consistently measure and track the performance of circular value within buildings and to help communicate performance and support transactions along the value chain. The most significant ones should be included in the tools that traditionally management practices use widely that are currently not fully suited to supporting the design of value retention models and other circular solutions.

Credits: Share Building©Dirk_Verwoerd

6 Who gets the value?

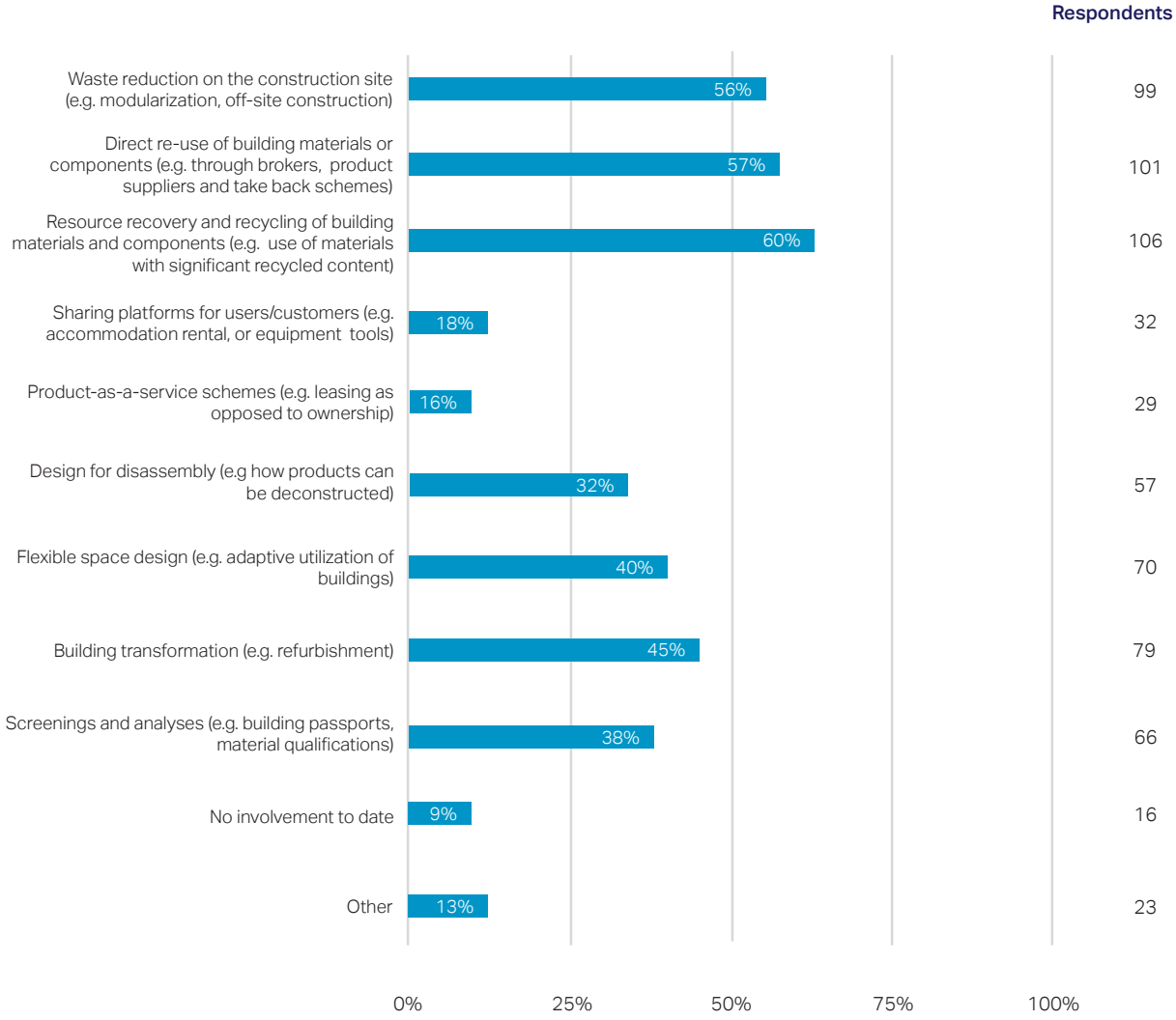
6 Who gets the value?

There is increasing awareness of the circular economy in the built environment. Most global survey respondents are actively involved in circular projects or are learning to be able to implement them.

Those that are active are broadly involved in circular activities that deliver environmental benefits through waste reductions and material reuse, as well as the transformation and repurposing of existing buildings.

While many activities were common across the value chain, stakeholder perspectives do change depending on their role across the life cycle, which in turn can influence the type of benefit adopting circular practices can create. By example, survey responses show that stakeholders do not perceive, capture or quantify value from a circular economy in the same way.

Figure 11: Global survey results for the type of circular activities in the built environment stakeholders have been involved with



This section and the following table illustrates examples of the benefits of the implementation of circular solutions for the different built environment stakeholders, as evidenced from the case studies and survey findings.

Table 3: Stakeholder business benefits from circular economy

STAKEHOLDER GROUP	EXAMPLE STAKEHOLDERS	EXAMPLE BUSINESS AND VALUE BENEFIT
Regulation and policy stakeholders	Municipalities, including national, regional and sub-regional policy makers, certification bodies	Realization of local policy outcomes, driven by national legislation – branding value for the municipalities Local job creation (Exchange House, Upcycle Studio and Resource Rows)
Financial institutions, investors	Institutional investors, real estate investors interested in total cost of ownership	Whole-life asset valuation models where circular buildings that can better adapt to future needs Development into new financial markets Enhanced disclosure in support of increasing ESG requirements (All case studies)
Developers and building owners	Construction and property companies involved in the construction, refurbishment and ongoing ownership of buildings	Branding and market differentiation Increased asset value Reduced operational and maintenance costs Asset with enhanced corporate image leading to faster leasing and sales performance Improved corporate image (valid for most stakeholders) (Parc 20|20, Upcycle Studio and Resource Rows)
Designers, engineers and consultants	Architects, engineers and property consultants working across the development life cycle	New opportunity for project design and circular construction approaches Addressing emerging policy requirements Circular expertise leads to additional consultancy revenue Implementation of innovation (Parc 20|20)
Material producers and suppliers	Material manufactures, logistics and supply companies providing primary building materials	Reduced costs aligned with reduced virgin material extraction and waste reduction Increased product and material opportunities/revenue for innovative material reuse Additional revenues from construction and demolition waste management services Reduced CO_2 emissions Better compliance with ESG requirements (Upcycle Studio and Resource Rows)
Building contractor	Building contractors and construction companies	Expertise provides market differential (Upcycle Studio and Resource Rows)
Building users	Building occupiers, operational staff, estate and facilities management	Reduced landlord service charges to tenants resulting from adaptable and maintainable buildings Alignment of sustainability ambitions (Parc 20|20)
Deconstruction, demolition, resource recovery suppliers	Deconstruction, demolition and strip-out contractors, market stakeholders involved with enabling resource recovery	Creating new resource from circular supplies Minimized waste/landfilling charges (All case studies)

7 Drivers for change

Credits: Park 2020_Greenhouses ©Sande[illegible]der Torren
Fotografie courtesy William McDonough + Partners

7 Drivers for change

The existing market still provides challenges for widespread uptake of circular economy in the built environment. With the cost of virgin materials lower than that for reused materials – and costs associated with the upskilling and logistics required for circular practices – this balance needs to shift to ensure the business case is more competitively widespread.

However, with net-zero carbon (NZC) targets expected to form an increasingly frequent core theme in local, national and international legislation over the next decade, the implementation of circular economy principles is set to become more prevalent as a major tool to tackle this.

Recent studies show that material supply chains are increasingly sensitive to disruption from both geopolitical[39] and health impacts, and climate change[40,41] impacts.

Businesses should therefore consider the likely impact of these future scenarios on the viability of any business case for a circular economy.

Table 4: Future resource scenarios

FUTURE SCENARIO EXAMPLE	MARKET IMPACTS	ECONOMIC IMPACTS
Resource scarcity	Supply chain impacts from geopolitical, climate and health impacts create a lack of available raw and processed materials. Tools developed to assess retained material value.	Significant cost increase for virgin and raw material. Costs of landfilling continue to increase.
Legislative change	Increasing legislation and costs associated with CO_2 emissions, landfilling and virgin resource extraction. Incentivizing investment into sustainable project activities to address global net-zero carbon legislation. For example, with ESG strategies already a competitive differentiator, they are set to become a regulatory imperative in Europe. Increasing demand of sustainable buildings. Certification bodies bring forward quality approvals for reused and adapted materials.	Increased cost of CO_2 emissions and ban on landfilling. Increased demand of sustainable solutions.
Market volume	Supply demands increase as investor and occupier awareness of social and environmental impacts continue to rise. Circular supply chains and their logistic networks are catalyzed.	Market demand triggers new valuation tools to assess retained value. Introduction of green bonds. Companies that trade at a premium from improved ESG performance are more attractive to investors.

8 Conclusion

8 Conclusion

The value cases set out within this report highlight the potential for building a circular economy. The literature review, the survey, the interviews and the case studies illustrate how circular practices can provide competitiveness in the marketplace.

Some examples:

- A lease price advantage from increased flexibility and lower costs resulting from changing interiors or workplaces, which opens the potential for increased rental prices and lowers operational costs at tenant turnover
- Market differential and rapid sales through enhanced branding and local community buy-in (Upcycle Studios & Resource Rows)
- Increased asset value through accounting for residual material value and reduced deconstruction and landfilling costs: adding €125-135/m^2 net lettable area gained
- 20 tons CO_2-eq ~ 29% emissions reductions and 18 job created using old building materials and keeping the buildings ahead of impending future legislation (Upcycle Studios & Resource Rows)
- Avoided costs from new land acquisition and landfilling costs by prioritizing existing building land use (Upcycle Studios).
- 6% overall decrease in acquisition and maintenance costs, compared to a standard building.

Despite the illustrated advantages of implementing circular economy solutions, these remain difficult to measure quantitatively.

Stakeholders across the supply chain increasingly need to measure and better quantify the benefit or consequence of their activities on the wider industry or community, reducing negative environmental impacts such as pollution, CO_2 emissions, and on biodiversity, and understanding performance and progress. Yet, established industry approaches need to evolve in order to better measure quantitatively the value and benefits of circular solutions.

We call on business **to measure circularity** by adopting established industry approaches such as **whole-life carbon** assessment and **life-cycle costing** early in a project's decision-making process, including the accounting for residual value of solutions, components and materials, and reductions in operational expenditures, demolition or (future) carbon costs.

This will help to:

- Identify a consistent **set of whole-life carbon and cost benefits related to a circular** economy;
- Articulate and understand the **business case** following the steps described;
- Develop **a supportive ecosystem across the value chain** for circular solutions.

Governments and public authorities are also key stakeholders in embedding requirements for development projects to prioritize asset and material reuse. This will in turn help to strengthen the business case, catalyze the market and create supply demand for projects and their supply chains through clear, consistent and long-term regional policies on circular economy directives. Such directives would enshrine requirements for developments that address circular economy thinking and make investing more attractive,[42] as well as incentives for innovation and new collaborations[43] to catalyze uptake.

Appendices

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Appendices

Resource Rows and Upcycle Studios case study – Additional data

The business case for upcycling building materials

Resource Rows	Upcycle Studios
Address: Else Alfelts Vej, 2300 København S	**Address:** Robert Jacobsens Vej, 2300 København S
Construction year: 2017-2019 Size: 9,148 m^2	**Construction year:** 2015-2018 Size: 3,340 m2
Housing: • 63 apartments, 29 row houses	**Housing:** • 20 row houses
Project partners: • Developer: NREP A/S • Contractor: Arkitektgruppen • Architect: Lendager ARC • Upcycle material supplier: Lendager UP • Consulting engineer: MOE	**Project partners:** • Developer: NREP A/S • Contractor: Arkitektgruppen • Architect: Lendager ARC • Upcycle material supplier: Lendager UP • Consulting engineer: MOE
Total cost: EUR €38.3 million	**Total cost:** EUR €13.9 million

The same project team developed Resource Rows and Upcycle Studio, roughly over the same time span. While different in building typology, they are both residential building projects that sit 500 meters from each other in the Ørestad area of Copenhagen. The key learning in terms of environmental, economic and social outcomes are consistent across the two projects. Therefore, we propose bundling them as a single case, with a focus on the upcycling of building materials for reuse.

On Resource Rows

Resource Rows is a residential project comprising 29 row houses and 63 apartments in Ørestaden. Resource efficiency and optimization formed the underlying concept of the project. With the Resource Rows project, NREP strived to challenge and investigate what a thorough understanding of resources can bring in terms of value and quality for new constructions. The project was underwritten based on a conventional row house and apartment project, meaning that all sustainability efforts had to fit in a conventional budget frame for implementation in the final project. There was very little room for experimenting with the building's form, as it had to fit into a strongly defined framework and building typology determined by the masterplan for the neighborhood. This means that much of the environmental savings derive from upcycled material use.

Material circulation in Resource Rows

Among other upcycled material products, the Resource Rows façade, composed of upcycled brick units, characterizes the building. The selective demolition of two provincial school buildings and from the historic Carlsberg brewery provided the materials for the creation of the brick units. Lendager UP brick unit innovation made it possible to upcycle brick walls with cement mortar that would otherwise have been downcycled into landscape fill materials.

Seven tons of otherwise worthless wood from the Copenhagen Metro Construction, which would have been downcycled as fuel, has been upcycled to constitute façades, terraces and flooring materials. The company refined the wood using the Japanese Yakisugi technique, charring the surface with fire to impregnate it – making it fireproof and completely resistant to fungus and insects – extending its life and minimizing toxic polymers.

The building's courtyard hosts a biodiverse array of plant life; on the roof, greenhouses made of recycled wood house vegetable gardens.

On Upcycle Studios

At the end of construction, Upcycle Studios was the commercial construction with the largest share of upcycled building materials in the world. Upcycle Studios consist of 20 three-story row houses designed with the future of urban living in mind. Upcycle Studios is experimental in form and building typology. The split-level homes include private residential space, as well as a more public/commercial building front where residents can have a home office, set up a coffee shop or run a daycare. The goal with Upcycle Studio was to create a frame for living in which residents can repurpose parts of their home as their work/life changes.

Material circulation in Upcycle Studios

UP Windows characterize Upcycle Studios. UP Windows are double layer thermal windows in the 6.5-meter tall south-facing facade, where staggered frames between the two layers provide a dynamic pattern. The recycled windows primarily come from public housing renovation: a waste stream that is usually crushed and incinerated without regard to the often functional, residual life of the components. In addition to a notable CO2 reduction, the assembled-UP Windows exceed thermal and acoustic demands for new three-layer windows.

The primary building blocks of the housing – concrete and wood – are also made from materials that were supposed to be incinerated, downcycled or discarded. A conscious decision not to coat the housing contributes to the overall expression. For example, to avoid sealants, plaster, fillers and felting, the buildings are to a large extent raw concrete on the inside. The building consists of 837 m^3 of upcycled concrete made with 904 tons of crushed concrete waste from the construction of the Copenhagen Metro.

Thus, the houses look different from each other and the indoor climate improves without degassing fillers and the like. Except for the window frames, all wood consists of processed discarded wood from Dinesen. Exterior wooden façades, often made of pressure-impregnated low-quality wood, are strong planks of Douglas fir. The wood is finished with organic linseed oil. In addition, there has been a focus on heat supply. Upcycle Studios is equipped with air-to-water heat pumps powered by solar cells on the individual terraced houses, which ensures low heating costs.

ENVIRONMENTAL VALUE CREATION

Resource Rows LCA statistics:

- Embodied carbon: 12% CO_2 savings
- Full lifetime: 29% CO_2 savings
- Saved 463 tons waste in total
- Building operation per year: 48% savings – 2.1 kg CO_2eq/m^2 per year
- Material distribution (weight)
  - Upcycled: 9%
  - New: 91%
- CO_2 distribution
  - Upcycled: 10%
  - New: 90%
- Cost distribution
  - Upcycled: 20%
  - New: 80%
- Looking at materials, we have a 12% reduction.
- Looking at both embodied CO_2 and CO_2 from operations across a 50-year lifetime, we reach a 29% CO_2 reduction.

Upcycle Studios LCA Statistics:

- Embodied carbon: 32% CO_2 savings
- Full lifetime: 45% CO_2 savings
- Saved 914 tons waste in total
- Building operation per year: 72% saving 1.3 kg CO_2eq/m^2 per year
- Material distribution (weight)
  - Upcycled: 69%
  - New: 31%
- CO_2 distribution
  - Upcycled: 48%
  - New: 52%
- Cost distribution
  - Upcycled: 54%
  - New: 46%
- Looking at materials, we have a 32% reduction.
- Looking at both embodied CO_2 and CO_2 from operations across a 50-year lifetime, we reach a 45% CO_2 reduction.

The economic and social factors of Resource Rows and Upcycle Studios are mostly common in that the learnings and benefits are the same across projects.

ECONOMIC VALUE CREATION

- Short time on the market – fastest sales/renting in the whole Ørestad area
- High-quality, unique and extremely attractive housing for the same price point as conventional buildings – blue ocean strategy (diversify your product)
- Overall figures for Upcycle Studios show that the construction is competitive on price on an overall level
- Overall decrease in acquisition costs compared to benchmark
- Overall decrease in maintenance costs compared to benchmark

- Primary material costs higher compared to benchmark
- Decreased costs on supplementary building components and surface building parts – leveling the increase in primary material costs
- When buying "upcycled building materials", we spent less on raw materials and much more on manufacturing – since waste is cheap but reprocessing can be more costly than raw materials
- On an overall LCC level, we don't see any increase in the acquisition costs of building materials; however, if we zoom in on the cost-structure of the building products, we see another picture

SOCIAL VALUE CREATION

1. Added value for users of the building:

- Residents of Resource Rows and Upcycle Studios revealed in an anthropological study that the materials and the stories behind the building projects are catalysts for the sense of ownership and, perhaps, the main reason that they identify with the building. The stories provide ample ground for identification on a subjective level as they allow for individual interpretations depending on what is most important to the residents. The materials are the foundation of the residents' individual interpretation. Despite differences in family types, income and age, the residents feel that their home is made for people like them. The materials serve as daily reminders of the uniqueness of their home.
- The residents feel that the concept, the aesthetic, and the sustainable story represent them personally. For example, residents Birgitte and Kim moved from another town in Denmark specifically to live in Resource Rows. "Why live like everybody else when you can live in something special that fits perfectly? I think one takes ownership over the construction. We tell everybody about it. We're proud of the history of the project. You take ownership over it. The style and the material selection. The bricks are from Carlsberg." Through the upcycling of the brick facades the buildings also contribute to historical preservation through material storytelling, capturing important Danish cultural identity.

2. Local job creation and changes in cost structures

- In addition to the residential projects proving to increase livability for the residents, the material innovations have also contributed to job creation. In a post doc research project done in collaboration with Aarhus University, Julia L. K. Nußholz (PhD) found this to be true.
- Results from Upcycle Studios show that upcycling-based windows, concrete and wood created a total of 18 jobs (equivalent to 6 months of full-time employment), including material development, sourcing, manufacturing and installation. Other companies than Lendager saw more than two-thirds of the jobs created. Across the different material innovations, different value chain phases proved to be more labor intensive. In addition, upcycling leads to several new value-adding activities: first, the disassembly of post-consumer windows; second, the collection of wood and processing that was previously only stored; and third, glass that would otherwise be downcycled.
- An overall finding is that, at the value chain level, the project succeeded in implementing a sustainability strategy that enhances value in the value chain network and warrants job creation, while offering solutions to manage materials more efficiently, reducing environmental impacts, satisfying customer demand, and helping the building sector transition to more sustainable practices.

UNDERSTAND YOUR BUSINESS CASE

The report highlights the differing stakeholder viewpoints in adopting circular economy practices, whether an investor is looking to attract premium market rates or a demolition contractor is seeking to create new resources and value. A business case will need to adapt to this and set out the value case captured from circular practices, while acknowledging these differences in perceptions, drivers and risks.

We therefore suggest the following steps (or questions) to help the different stakeholders navigate the development of a business case.

1. Identify your minimum business case requirements

Focus in on what business value benefits from circularity you should include as an absolute minimum within your business cases – based on your role, market and region in which you operate. Make sure the business benefit is quantifiable.

2. Include the most impactful circular business model

Once you have identified what the business benefits are, include and quantify which business model is the most appropriate in delivering benefits.

3. Consider the impact from future scenarios

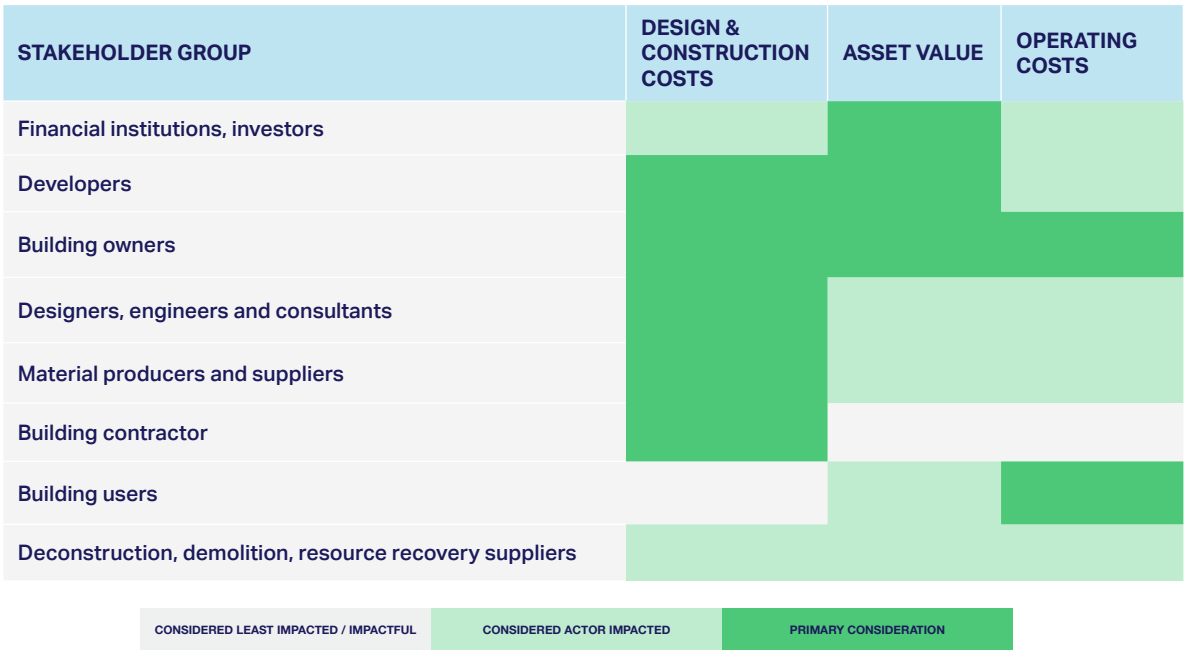
Depending on the timescale for your business case, consider impacts on business case viability in the medium and long term from changing future.

Figure 12: Steps to develop a business case graphic

STEP 1: IDENTIFY THE MINIMUM BUSINESS BENEFITS THE BUSINESS CASE MUST SUPPORT

Reader signpost: Table 3 illustrates example stakeholder benefits

Figure 13: Stakeholder perspectives, role and impact in realizing circular economy benefit



Reader action: Stakeholder should structure the business case for a circular economy to focus on the primary consideration business benefits shown in Figure 11 as a minimum, combined where possible with lesser impactful benefits highlighted.

STEP 2: CONSIDER, AS A MINIMUM, THE MOST IMPACTFUL BUSINESS MODEL TO COVER THE ASSET LIFE CYCLE

Once you have identified the primary and secondary business benefits, you should consider which appropriate circular business model to adopt to deliver the benefit.

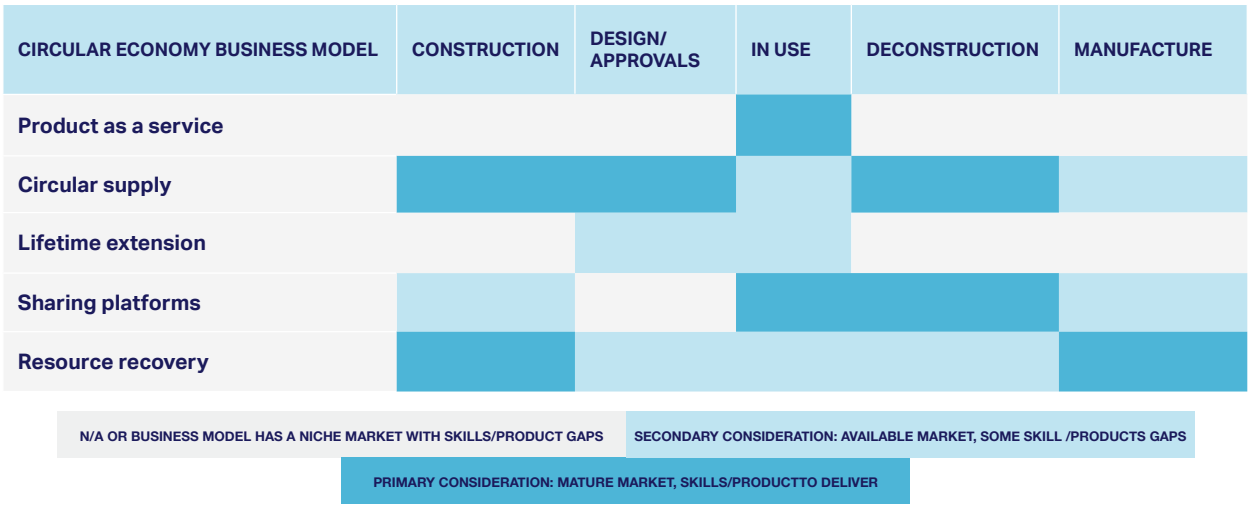
Table 5: The five circular business models[44]

BUSINESS MODEL	DESCRIPTION	EXAMPLES
Products as a service	Servitization and leasing instead of product ownership	Light as a service[45]
Circular supply	Reduce raw material use, use reusable or recyclable materials	Reused facade materials in Upcycle Studios and Resource Rows case study
Lifetime extension	Maintain lifetimes through maintenance, repairs, upgrades	Buildings as material banks (BAMB) as seen in Park 20|20 case study
Sharing platforms	Sharing of products/assets	Local reuse and take back schemes, e.g., Globechain as seen in Exchange House case study
Resource recovery	Waste from products processed to make new materials and products	Potentially waste-bound timber from local construction projects upcycled to constitute façades, terraces and flooring materials in Upcycle Studios and Resource Rows case study

The value and impact of the business models identified above will differ between stakeholders in the supply chain. Therefore, you should use the heat map on the following page.

The heat map highlights where in the asset life cycle it is best to deploy potential circular business models to realize business benefits.

Figure 14: The five circular business models[44]



Reader action: Based upon where in the supply chain life cycle they are most active, stakeholders should populate their business case for a circular economy with the primary considerations business models shown in Figure 12 as a minimum, combined where possible with lesser impactful models highlighted.

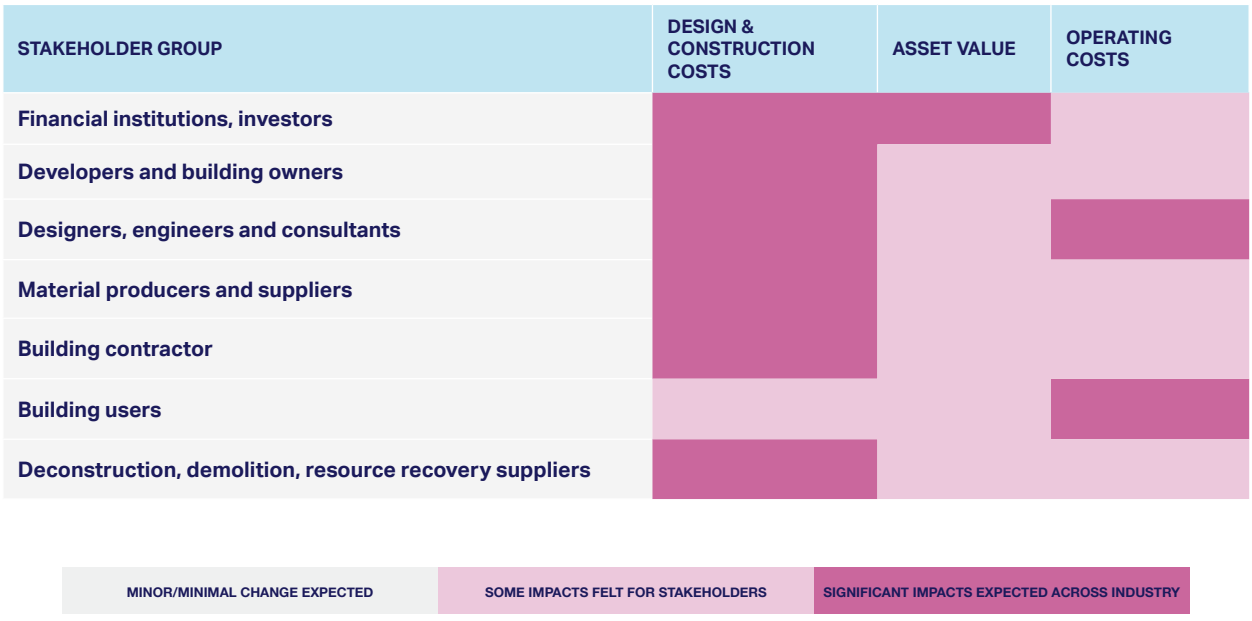
STEP 3: CONSIDER THE SENSITIVITY OF THE BUSINESS CASE TO FUTURE SCENARIO CHANGES

The testing of medium- and long-term impacts is an important step to stress test the business case against the impacts on supply chains from future resource scarcity, legislative change and market demand.

Reader action: Table 4 describes these impacts in more detail.

The following heat map highlights the potential changes that will further catalyze the business benefits in adopting circular practices.

Figure 15: Circular business models across the asset life cycle



Reader action: Based upon the business benefits chosen in step 1 and business models adopted in step 2, stakeholders should then overlay the significant future scenario changes shown in Figure 13 as a minimum, combined where possible with lesser impactful models highlighted.

Endnotes

[1] UN Environment Sustainable Buildings and Climate Initiative. Retrieved from file: https://europa.eu/capacity4dev/file/13845/download?token=F5gO9LHM

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[3] See acknowledgement section.

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[5] See, for instance:

- European Environment Agency (2020). Cutting greenhouse gas emissions through circular economy actions in the buildings sector. Retrieved from https://www.eea.europa.eu/publications/cutting-greenhouse-gas-emissions-through
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[6] See details of the survey and interviews in the Methodology chapter.

[7] UK Green Building Council (UKGBC) (2019). Circular economy guidance for construction clients: How to practically apply circular economy principles at the project brief stage.

[8] Building certification schemes can support the measuring of several of the stated circular economy aspects as they provide the respective methodologies and tools. (Life-cycle analysis, life-cycle costing and ease of recovery and recycling are, for example, integrated in the German Sustainable Building Council's (DGNB) certification system since the very first version launched in 2008.) Furthermore, they allow an external assessment and verification and can also provide benchmarks for specific aspects.

[9] Environmental (e.g., reduced CO_2 emission) and social (e.g., local take back schemes, charity, social enterprises) are evident in the case studies. However, there is a lack of financial data.

[10] "Building and construction activities together account for 36% of global final energy use and 39% of energy-related carbon dioxide (CO_2) emissions when upstream power generation is included". Source: World Green Building Council (2019). "New report: the building and construction sector can reach net zero carbon emissions by 2050". Retrieved from https://worldgbc.org/news-media/WorldGBC-embodied-carbon-report-published

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[15] For examples of what these circular business models mean for the sector, see Circle Economy and WBCSD (2018). Scaling the Circular Built Environment, Pathways for business and government. Retrieved from https://www.wbcsd.org/Programs/Circular-Economy/Factor-10/Resources/pathways-for-business-and-government

[16] Arup, Ellen MacArthur Foundation, 3XN/GXN (2018). From principles to practices: First steps towards a circular built environment.

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[33] Ellen MacArthur Foundation (2016). Circularity in the built environment: Case studies.

[34] van den Berg (2019). Managing Circular Building Projects.

[35] Back in 2013 the World Green Building Case issued The Business Case for Green Building report, which quantifies the economic benefits from sustainable building practices across the themes of design and construction, asset value, operating costs, workplace productivity and health and risk mitigation. We used these themes to set out indicators and requirements to support the circular business case in Table 2.

[36] Exchange House – British Land and Globechain case study.

[37] Cradle to Cradle Certified® is a globally recognized measure of safer, more sustainable products made for the circular economy. See https://www.c2ccertified.org/about/about

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ABOUT WBCSD

WBCSD is the premier global, CEO-led community of over 200 of the world's leading sustainable businesses working collectively to accelerate the system transformations needed for a net zero, nature positive, and more equitable future.

We do this by engaging executives and sustainability leaders from business and elsewhere to share practical insights on the obstacles and opportunities we currently face in tackling the integrated climate, nature and inequality sustainability challenge; by co-developing "how-to" CEO-guides from these insights; by providing science-based target guidance including standards and protocols; and by developing tools and platforms to help leading businesses in sustainability drive integrated actions to tackle climate, nature and inequality challenges across sectors and geographical regions.

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