Interreg
North Sea

Co-funded by
the European Union

CircleBIM

Good Practices

for circular planning and construction

CIRCLEBIM

CircleBIM is co-funded by the European Union (ERDF)
under the Interreg North Sea Programme 2021-2027.

Good Practices

exchange and analysis

Authors:

Buro De HAAN

Jaap Snijder

Arjan de Haan

Herbert Born

University College North Denmark (UCN)

Dorthe Holmberg Lauritzen

Mette Bisgaard Madsen

Meinhardt Thorlund Haahr

Raphael Peter Harrow-Hodgkinson

01-10-2025

Status: Final

Interreg North Sea

Co-funded by the European Union

CircleBIM

Summary

This report was created as a part of the Interreg North Sea, CircleBIM project ([CircleBIM CircleBIM | Interreg North Sea]). The report was created with the involvement of all 13 partners:

The "CircleBIM Good Practices Exchange and Analysis" (A1.2) report supports the development of the CircleBIM framework (A1.1). The aim is to identify and analyse transferable circular construction strategies enabled by digital tools like BIM. Through real-world case studies and lessons from EU projects, it provides a structured foundation for designing pilot projects, informing stakeholder engagement, and shaping local circular construction partnerships. The report's insights feed into key project activities (A1.3, A1.4, A1.5, A1.6, A2.1), helping align innovation efforts with practical, scalable solutions for circular public planning and construction.

Contents

1. Introduction

This report presents the outcomes of the Good Practice Exchange and Analysis activity (A.1.1) within the broader effort to support innovation in circular public planning and construction (PPC). Led by University College of Northern Denmark (UCN) and Buro De Haan (BDH), the activity aims to gather, evaluate, and share examples of how circular economy and digital processes, particularly those supported by Building Information Modeling/Management (BIM), are being applied in real-world contexts. These Good Practices (GPs) are drawn from three sources; (1) real-world construction projects (Chapter 4. Cases), (2) European initiatives, such as CIRCuIT, CTB, BBoBB, KARMA, and the Flemish Living Labs on Circular Construction (Chapter 5. Lessons learned from other development projects) and Research (6. BIM supported Tools). The GPs are assessed for their effectiveness, transferability, and relevance to public authorities seeking to strengthen their capacity for innovation.

At its core, the report serves two main purposes: to inspire public sector actors through examples of circular construction, and to offer strategic guidance on how to adopt and scale such practices. It does so by systematically identifying transferable solutions – whether tools, methods, technologies, or planning approaches – that align with circular economy principles and demonstrate measurable impacts.

Ultimately, the report contributes to the project's overarching goal of enhancing public sector innovation capacity. By showcasing how BIM-enabled circular strategies have been applied successfully, and by analysing what makes them effective and transferable, this report supports stakeholders, particularly municipalities and planners, in navigating the transition toward more sustainable, resilient, and resource-efficient construction systems. Through knowledge exchange and critical analysis, it seeks to accelerate the adoption of circular practices and digital tools that can transform the built environment.

2. Definitions

In the pursuit of sustainable development, circularity and BIM have emerged as complementary frameworks that are central to the CircleBIM project. Circularity defines the overall sustainability ambition, while BIM provides the digital infrastructure needed to realise and document these ambitions throughout the construction process.

Rooted in the principles of the circular economy, circularity aims to eliminate waste, keep materials in continuous use, and regenerate natural systems (Ellen MacArthur Foundation & ANSYS Granta, 2019). This approach contrasts with the traditional linear “take-make-dispose” model and, in the context of construction, translates into strategies such as material reuse, modular and flexible design, lifecycle thinking, and design for disassembly.

BIM (Building Information Management) is a methodology that works with a digital representation of the physical and functional characteristics of construction projects to facilitate collaboration and information sharing throughout the project lifecycle. It supports informed decision-making throughout all project phases, from early design to deconstruction. BIM enables the integration and tracking of sustainability data, including material passports, lifecycle assessments (LCA), and dismantling plans.

Within **CircleBIM**, circularity and BIM are closely interlinked. BIM supports the implementation and documentation of circular strategies by enabling data-driven decisions that align with value preservation principles as outlined in the Butterfly Model. This synergy forms the analytical foundation for identifying and evaluating good practices in circular construction

Circularity

Circularity in construction is rooted in the broader concept of the circular economy, which provides the overarching framework for rethinking how resources are managed across sectors and scales. The circular economy is understood as a systemic approach that seeks to eliminate waste and pollution, keep products and materials in use, and regenerate natural systems. Based on a literature study and a questionnaire with 44 experts, Nobre & Tavares (2021) propose the following definition on circular economy:

> *“Circular Economy is an economic system that targets zero waste and pollution throughout materials lifecycles, from environment extraction to industrial transformation, and to final consumers, applying to all involved ecosystems. Upon its lifetime end, materials return to either an industrial process or, in case of a treated organic residual, safely back to the environment as in a natural regenerating cycle. It operates creating value at the macro, meso and micro levels and exploits to the fullest the sustain- ability nested concept. Used energy sources are clean and renewable. Resources use and consumption are efficient. Government agencies and responsible consumers play an active role ensuring correct system long- term operation.”(Nobre & Tavares, 2021)*

Based on a systematic literature review of 316 publications, Ossio et al. (2023) propose a clearer definition of Circular Construction in the built environment:

> *“Circular Construction is a multidimensional and dynamic economic system for construction based on the application of Circular Economy principles. It aims to achieve buildings and infrastructure designs considering different systemic levels (micro, meso, and macro) to achieve a built environment that targets zero waste and pollution. It allows construction materials and products to remain in use, retaining their maximum value by following biological or technical looping strategies through and within the whole life cycle of construction projects. This*

approach operates in a sus- tainable, clean, and renewable way, allowing for the regeneration of natural systems. It is enabled by a context defined by technology, management sys- tems, government policies and regulations, business models, and social and stakeholder behavior that enable construction needs to be met sustainably." (Ossio et al., 2023)

Circularity in construction represents a paradigm shift from a resource-intensive, linear model to a regenerative system that prioritizes resource retention, material reuse, and waste prevention. Unlike traditional models characterised by short material lifespans and a "take-make-dispose" logic – circular construction seeks to maintain materials and resources at their highest possible value and utility for as long as possible (Ellen MacArthur Foundation, 2015). The ambition is to minimise the use of virgin materials, reduce environmental impacts, and build resilience by extending the service life of building components (Pomponi & Moncaster, 2017). The waste hierarchy provides a guiding logic: prevention is prioritised, followed by reuse, recycling, energy recovery, and, as a last resort, disposal (European Commission, 2018).

Circularity in construction must be addressed across all project phases to ensure that materials and resources remain in circulation at their highest value. In the initiation phase, circular goals and ambitions are defined, shaping the project's overall direction. Planning and design phases are crucial for embedding circular thinking into building concepts and technical solutions. During permitting and procurement, circularity needs to be integrated into regulations, tendering, and supply chain decisions. The construction phase affects how well circular plans are implemented and documented. At delivery, accurate information must be transferred to support long-term management. In the operation and maintenance phase, ongoing decisions influence the durability, adaptability, and future reuse of building elements. Finally, pre-demolition audits and deconstruction processes determine how effectively materials can be recovered and fed back into new cycles. Each phase offers critical opportunities to preserve value, prevent waste, and close material loops.

Circularity in construction also necessitates systemic change, including new forms of cross-sector collaboration, value chain integration, and the development of business models that incentivise reuse, long-term value creation, and lifecycle thinking. This shift moves beyond technical measures, placing circularity as a shared responsibility across the entire construction ecosystem.

In this context, data plays a vital role, as Thomas Rau from Madaster quotes "Waste is a material without an identity". Effective circular initiatives increasingly rely on the availability and accessibility of accurate information such as material characteristics, origin, lifecycle impacts, and disassembly potential. BIM supports this need by enabling digital documentation, traceability, and the creation of material passports, which enhance transparency and facilitate decision-making across project phases. Beyond its role in data management, BIM can also act as a collaborative platform that connects stakeholders across disciplines and project phases. By enabling shared access to information, BIM facilitates cross-sector collaboration, supports integrated value chains, and lays the groundwork for business models that prioritize reuse, long-term performance, and lifecycle value creation.

The Butterfly Diagram

The Butterfly Diagram, developed by the Ellen MacArthur (Ellen MacArthur Foundation, 2019b), provides a clear and comprehensive framework for understanding and operationalizing circular strategies, see Figure 1. It illustrates how materials and components can circulate through two interconnected loops: the biological cycle (left), where organic materials are safely returned to nature, and the technical cycle (right), where non-biodegradable materials are preserved and reused at their highest possible value.

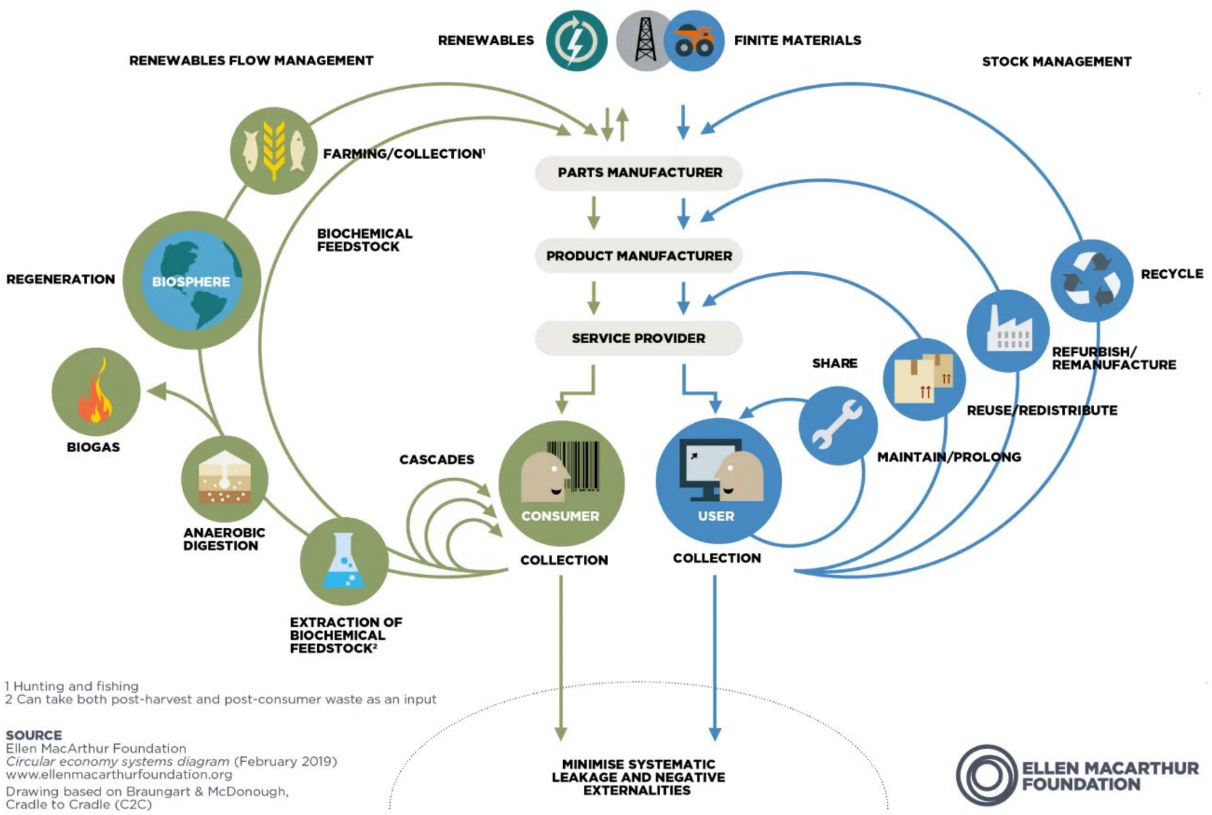


Figure 1: The Butterfly Diagram (also referred to as the Material Circularity Indicator (MCI) illustrating the two key cycles of a circular economy: the biological cycle and the technical cycle. The diagram highlights loops to minimize waste and preserve value within the economy (Ellen MacArthur Foundation, 2019b)

The Biological Cycle (Renewables Flow Management): The left side of the Butterfly Diagram represents the biological cycle, which deals with materials that are of biological origin and can safely return to the environment. These are typically renewable, biodegradable materials such as food waste, natural fibres, wood, or bio-based packaging.

The left side is essentially a process map – it shows how materials move from production to end-of-life and back into the system. In this cycle, materials are circulated through processes like farming and biological harvesting, followed by cascading uses (e.g., reusing cotton textiles as insulation), and ultimately through anaerobic digestion or composting, where they are broken down and returned to the biosphere as nutrients.

The aim is to regenerate natural systems by ensuring that materials are cycled safely and effectively back into the environment without causing harm, thus restoring soil health, biodiversity, and ecosystem function.

There are three main types of loops, each with its own function and depth, shown as concentric circles from small (inner) to large (outer)

<u>Cascades (Three inner loops):</u> These represent the multiple uses of biological materials before they are biologically processed. These three unlabelled cascading loops indicate progressive reuse of materials across lower-value applications. They are visually smaller to emphasize that each inner loop retains more value, for example:

- Reusing cotton clothing as insulation material in wall assemblies.
- Using sawdust from timber processing as animal bedding before composting.
- Reusing natural-fibre carpets as acoustic insulation in non-visible construction layers.

<u>Biochemical Feedstock:</u> In the Butterfly Diagram, “Biochemical Feedstock” refers to the diversion of biological materials for use in industrial processes. Although the diagram does not specify the mechanisms involved, this stage typically entails processing renewable biological resources to obtain valuable compounds — such as oils, resins, and sugars — which can be used as substitutes for fossil-based materials in various manufacturing contexts. In the context of construction, these bio-based feedstocks are increasingly integrated into building products, adhesives, coatings, and composites, contributing to reduced reliance on non-renewable resources and enabling more circular material flows, for example:

- Use of tall oil (a by-product of wood pulping) as a base for bio-based wood preservatives and coatings in timber construction. (*Tall oil can replace synthetic or fossil-derived binders in exterior treatments*)
- Extraction of lignin from wood processing for use in bio-based adhesives and insulating foams.
- Production of biopolymers from starch or cellulose for bio-based wall coverings, paints, or flooring materials. (*These materials replace petroleum-derived binders in interior construction products*)
- Bio-based resins made from plant oils (e.g., linseed or castor oil) used in flooring finishes, sealants, and composites. (*Such materials are already available commercially in sustainable building product lines.*)

<u>Regeneration (outer loop):</u> The outermost loop on the biological side of the Butterfly Diagram represents the complete regenerative cycle of biological materials. It illustrates how biological materials flow from farming and collection, through biological processing, and back into natural systems, enabling the restoration of soil health and ecosystems. This loop shows a pathway where both energy and nutrients are recovered from organic materials, closing the cycle through regeneration.

Farming / Collection: The cultivation or harvesting of renewable biological resources that serve as input materials for products, for example:

- Cultivation of fast-growing crops like hemp, flax, or straw used in insulation materials (*e.g., hempcrete or straw bale construction*).
- Forestry for certified timber used in structural framing or cladding.

Extraction of Biochemical Feedstock: Before end-of-life treatment, some biological materials may undergo processing to extract valuable biochemical compounds (e.g., oils, resins, or starches) for use in industrial products, for example:

- Extracting lignin from wood by-products for use in bio-based adhesives or insulation foams.
- Using plant oils (e.g., linseed oil) to create natural sealants or low-emission coatings for wood surfaces.

Anaerobic Digestion: After use, remaining biodegradable materials are broken down in oxygen-free environments to produce biogas and a nutrient-rich byproduct called digestate, for example:

- Organic site waste (e.g., straw offcuts, biodegradable packaging) sent to anaerobic digestion facilities instead of landfill.
- Green waste from landscape preparation processed to recover energy and nutrients.

Biogas: The anaerobic digestion process produces biogas, which can be used as a renewable energy source for heating, electricity, or fuel, for example:

- Biogas generated from organic construction waste can supply district heating systems or power temporary site infrastructure, reducing reliance on fossil fuels.

Regeneration: The anaerobic digestion produced during digestion is applied to land as a natural fertilizer, enriching the soil and closing the loop by supporting new biological production, for example:

- Use of digestate or compost in landscaping, green roofs, or urban planting schemes integrated into the built environment.

The Technical Cycle (Stock Management): The right side illustrates the technical cycle, which applies to finite materials — such as metals, plastics, and synthetic composites — that do not biodegrade and cannot regenerate naturally. The goal in this cycle is to preserve the quality and value of these materials for as long as possible, thereby minimizing waste and reducing the need for virgin resource extraction Strategies include:

Maintain/Prolong**:** Extending the service life of materials and components through proper maintenance.

- Regular inspection and resealing of building façades to prevent water infiltration and material degradation.
- Scheduled maintenance of HVAC systems to maximize their operational lifespan instead of early replacement.
- Maintaining timber structural elements through careful treatment against rot and insects, rather than replacing them.

Reuse/Redistribute: Reusing elements in the same or different contexts without significant transformation.

- Refurbish/Remanufacture: Upgrading components for continued use.
- Recycle/Cascade: Breaking down materials for reprocessing, ideally at high value.

Refurbish/Remanufacture: Upgrading components for continued use.

- Refurbishing old wooden windows by repairing frames, replacing glazing with energy-efficient glass, and resealing them.

- Refitting and upgrading modular office partitions for use in a new office design.
- Remanufacturing lighting fixtures by updating wiring and fittings to meet new standards while retaining the original housing.

Recycle: Breaking down materials for reprocessing, ideally at high value.

- Crushing demolished concrete into aggregates for use in new concrete or roadbeds.
- Melting down aluminium window frames to produce new aluminium profiles.
- Recycling old gypsum drywall to produce new plasterboard materials.

Circular Design in principals

Circular design principles are a foundation for rethinking how we design, build, and plan. They support the shift from a linear "take-make-dispose" model, toward a circular model emphasizes longevity, material recovery, and regeneration (Kirchherr et al., 2017; Ossio et al., 2023; Zhang et al., 2022), see also Figure 2 and Figure 3. This notion has been articulated through theoretical frameworks such as those in Marchesi & Tavares (2025), who examines “circular building design” by mapping design strategies across building lifecycle phases and emphasizing systemic innovation integrating technical, social, organizational, and institutional dimensions. These principles underpin the transition to a circular economy as outlined in the (Ellen MacArthur Foundation, 2020) Butterfly Diagram, as described in the preceding section, which visualizes two key loops: the biological cycle – focused on composting and regeneration of natural materials – and the technical cycle – focused on maintenance, reuse, refurbishment, and recycling of durable materials

In the context of the built environment, circular design principles provide practical pathways to close material loops, reduce embodied carbon, and support long-term value retention of materials and buildings. A systematic literature review by Ossio et al. (2023) collated 316 publications on circular economy principles applied across sectors, highlighting the importance of defining the concept, and explicitly including the built environment as a key domain of application. Building on this review, Ossio et al. (2023) identify five main clusters of research that shape how circular economy principles are applied in the built environment - “R” frameworks or strategies, construction and demolition waste (CDW) management, building design approaches (BDAs), business models and networks, life cycle assessment (LCA).

“R” Framework or strategies

The first cluster identified by Ossio et al. (2023) concerns the application of “R” frameworks or strategies—from the familiar 3Rs (**reduce**, **reuse**, **recycle**) to extended frameworks with up to 10Rs—which guide interventions across product lifecycles to extend material utility and close loops, Figure 2. (Kirchherr et al., 2017). Ossio et al. (2023) further explain; **Reduce** emphasizes efficiency in production and minimizing the use of virgin resources; **Reuse** extends the life of products or components by enabling them to serve their original purpose again; and **Recycle** focuses on recovering materials to create new products. Over time, the framework has expanded to include up to 10 or even 11 Rs, adding concepts such as **Refuse**, **Rethink**, **Repair**, **Refurbish**, **Remanufacture**, **Repurpose**, and **Replace**. These strategies collectively promote higher levels of circularity by slowing, closing, and tightening material loops, as shown Figure 1 and described by Ellen MacArthur Foundation (2019b). In construction, recycling remains one of the most common practices, but it often sits at the bottom of the hierarchy due to issues such as downcycling, high energy use, and limited value retention. Greater emphasis is therefore placed on strategies that preserve higher value, such as reuse, repair, and refurbishment, while also considering biological cycles where materials are biodegradable or compostable. The R framework thus provides a comprehensive lens for embedding circularity throughout design, production, use, and end-of-life phases.

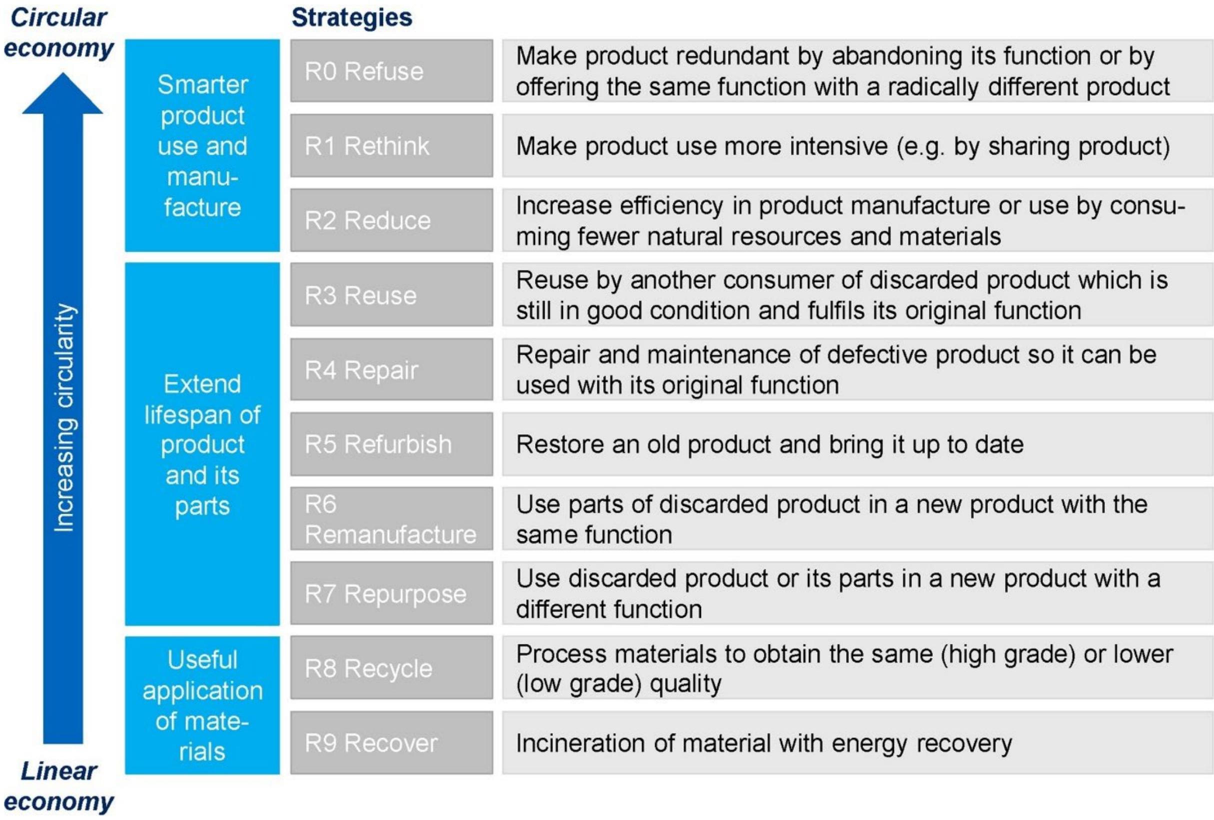


Figure 2: The 10R framework. From (Kirchherr et al., 2017)

Construction and demolition waste management

The second cluster identified by Ossio et al. (2023) focuses on CDW management, see Figure 3 (b), where strategies such as prevention, reuse, recycling, and recovery are prioritized to minimize waste flows and reduce reliance on disposal (landfilling). CDW management frameworks are often structured as hierarchies that rank strategies from the most desirable to the least. The original “Lansink scale” prioritized prevention and reuse over recycling, energy recovery, and disposal, and has since evolved into more detailed sector-specific models, such as the Delft Ladder, which expands options to improve waste handling and reduce environmental impacts. In Figure 3 (a), Zhang et al. (2022) have compare the 10R framework and circular economy with (b) CDW management framework. In practice, according to Ossio et al. (2023), effective CDW management depends on several factors, including economic incentives, regulatory frameworks, technological options, and the awareness and capacity of practitioners. Approaches such as lean construction and modern methods of construction have shown potential to significantly reduce CDW through efficiency gains and better resource use. However, challenges remain in monitoring progress. While macro-level indicators exist, such as the Material Circularity Indicator (MCI) and the Circular Transition Indicators (CTI), there is still a lack of standardized and holistic metrics at product, company, and regional levels. This gap complicates performance tracking and hinders consistent adoption of circular practices, underscoring the importance of integrating CDW management as a cornerstone of circular construction

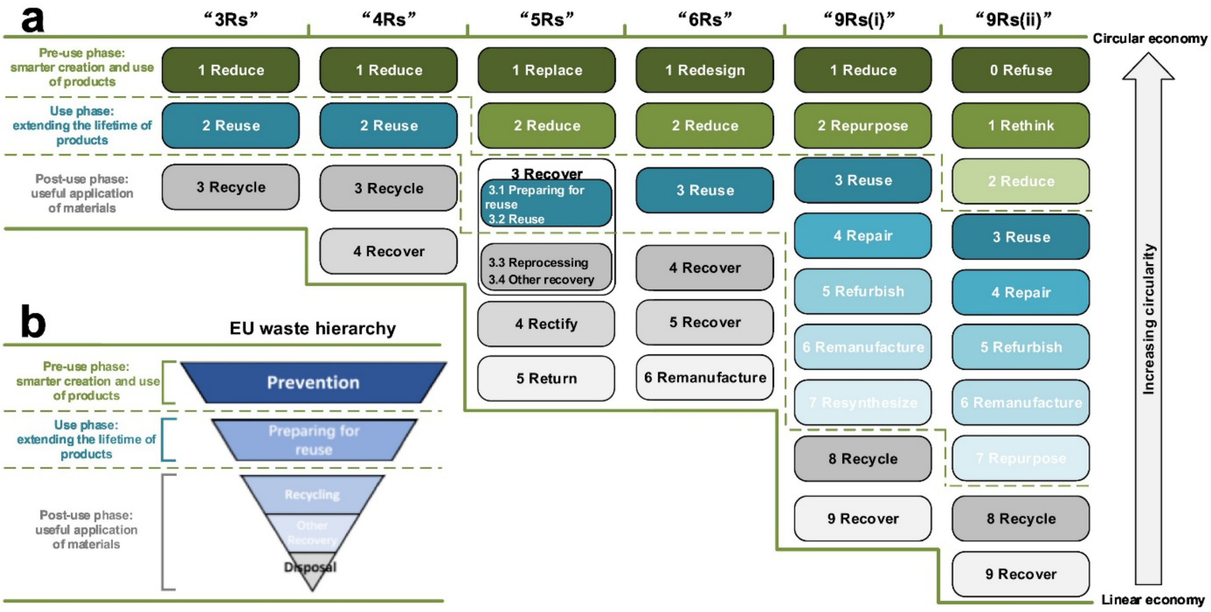


Figure 3: Comparison of (a) circular economy and (b) waste hierarchy framework. From (Zhang et al., 2022)

Building Design Approaches

A third cluster identified by Ossio et al. (2023) addresses BDAs, particularly design for disassembly, adaptability, and longevity, which enable buildings to serve as material banks and facilitate future reuse of components. In the cases described in section 4 Cases, the following BDAs have been used:

Design for Disassembly (DfD), also called Reversable building designs (RBD)**:** ensures that materials, components, and systems can be taken apart at the end of a buildings, infrastructure, and urban components life or during renovations without damage. This facilitates high-value reuse and reduces material downcycling. Components designed for disassembly avoid irreversible bonds, rely on mechanical fasteners, and often incorporate documentation (e.g., material passports) to track origin and reuse potential. By enabling materials to remain in the technical loop at their highest value, DfD aligns directly with the "reuse", "remanufacture", and "recycle" flows of the butterfly model's technical side.

Design for Adaptability (DfA): promotes the flexibility of buildings, public infrastructure, and urban spaces to accommodate new functions and needs over time. This principle supports lifespan extension, which slows the resource loop and reduces the need for new materials. Strategies include open floor plans, modular partitions, or standardized systems that allow flexible use. DfA reduces obsolescence and supports maintenance and refurbishment loops – also reinforcing the "slowing" strategy central to circularity.

Design with Reuse (DwR): prioritizes the integration of reclaimed materials or components from existing into new construction. It is a proactive strategy that avoids virgin material extraction and keeps materials in circulation at their highest utility. This principle requires early planning, availability mapping (e.g., through urban mining inventories), and often reverse logistics. DwR directly feeds into the reuse loop in the technical cycle and enhances the embodied value of construction projects by leveraging existing material capital.

Design with Bio-based Materials (DwB): supports the biological cycle of the butterfly model by prioritizing materials that are renewable, biodegradable, and can safely return to the biosphere.

Examples include timber, hempcrete, mycelium-based insulation, and bio-composites. These materials, when untreated with harmful chemicals, can be composted or digested to regenerate natural systems. DwB enables regenerative flows, reduces dependency on fossil-based materials, and encourages carbon sequestration during the material growth phase.

Some authors relate designs for circularity as "**Design for X**'' approaches (**DfX),** such as **Design for Circularity (DfC), Design for Disas- sembly (DfD), Design for Maintenance (DfM), Design for Adaptability (DfA), Design for Recovery (DfR), Design for Change (DfCh**), **Design for Deconstruction (DfD).**

Business models and Networks

The fourth cluster identified by Ossio et al. (2023) links circular construction to the development of business models and networks that embed circularity into the construction value chain. Unlike conventional models, circular business models integrate principles of sustainability directly into their value propositions, delivery mechanisms, and ways of capturing value. This creates what is often called a "circular advantage," where companies benefit from closing resource loops, extending product lifetimes, and reducing waste, while also gaining competitiveness in the market. Approaches such as life cycle costing strengthen this by showing how material durability, reuse, and reduced maintenance translate into economic value. Service-oriented models, including product–service systems and leasing arrangements, are particularly relevant, as they encourage building adaptability and promote long-term usability. However, significant barriers remain, such as fragmented supply chains and a lack of indicators to assess the benefits of circularity. To overcome these, collaboration across networks and the use of digital tools like BIM and ICT are critical enablers, allowing better integration of stakeholders and data transparency. Ultimately, this cluster emphasizes that business models are not only financial structures but also mechanisms to align incentives, foster collaboration, and embed circular thinking throughout the construction process.

Life Cycle Assessment

Finally, the fifth cluster identified by Ossio et al. (2023) is the application of Life Cycle Assessment (LCA) in the built environment. LCA provides a structured way of evaluating resource use and environmental impacts across all stages of a building or component's life cycle, from raw material extraction to end-of-life. It highlights inefficiencies and embodied impacts, offering valuable insights for improving resource efficiency. However, conventional LCA methods are limited when applied to circular construction, as they typically capture only a single life cycle and struggle to account for processes such as reuse, remanufacturing, or refurbishment. To address this, researchers have proposed adaptations that integrate a multi-cycling perspective, extending assessments to reflect the repeated use of materials and components. Recent developments also combine LCA with life cycle costing to evaluate both environmental and economic outcomes, or link LCA to Building Information Modelling (BIM) to estimate salvage potential from the design stage. These approaches strengthen the role of LCA as a decision-support tool in guiding circular strategies and in demonstrating the benefits and trade-offs of different design and waste management options

Circularity Key Performance Indicators

To translate the principles of the circular economy into measurable outcomes, Circularity Key Performance Indicators (CIs) provide a quantitative framework to assess how effectively materials, components, and building systems retain value and remain in circulation across the built environment's lifecycle. As such, CIs bridge conceptual circular strategies – like those in the Ellen MacArthur Foundation (2019b) diagram, se Figure 1 – with actionable design and operational metrics.

One CIs is Material Circularity Indicator (MCI) and express circular performance as a percentage (0–100%), calculated based on parameters such as the origin and end-of-life fate of materials, recycling efficiency, and service life duration (Ellen MacArthur Foundation & ANSYS Granta, 2019; Heisel & McGranahan, 2024). For instance, in a case study, Ellen MacArthur Foundation (2019a) compared two consumer products and found that a standard widget scored only 6% circularity, while a more durable and recyclable premium version reached 61%, and a redesigned widget with closed-loop recovery achieved 98%. These indicators complement life cycle assessments (LCA) by focusing not solely on environmental impacts, but on material retention, reuse potential, and design adaptability – core tenets of a circular construction model.

According Ossio et al. (2023), however, circularity in construction still lacks holistic and standardized indicators. Existing metrics are more developed at the macro level (e.g., national or EU policy frameworks), while micro-level tools for companies and projects remain underdeveloped. Among the most recognized indicators adapted to the construction sector are the MCI (Ellen MacArthur Foundation & ANSYS Granta, 2019) and the Circular Transition Indicators (CTI) (WBCSD, 2022).Both are designed to evaluate how materials cycle through technical or biological loops, see Figure 1. Other established sustainability assessment methods – such as LCA, Life Cycle Costing (LCC), Social-LCA, and certification schemes like LEED, BREEAM, and DGNB – can also serve as proxies to measure aspects of circularity. At the building level, Material Passports (MP) – acting as an information-based indicator - represents a promising approach, providing detailed data on material composition, quality, and reuse potential throughout a building's lifecycle. In addition, merging approaches such as the Building Circularity Indicator (BCI), its disassembly-focused variant (BCIDR), and BIM-based tools like the Whole-life Performance Estimator (BWPE) extend assessment capabilities to design and salvage planning.

A consolidated overview of the main KPIs identified across the academic literature included in this report is presented below in Table 1.

Table 1: Circularity Key Performance Indicators and assessment tools identified in the literature reviewed for this report.

KPI / Indicator	Tool / Framework	Description	Source
Circularity performance (0–100%)	Circularity Indicator (CI)	Quantifies reuse, recyclability, renewable content, and lifespan. Expressed as a % score.	(Heisel & McGranahan, 2024)
Material recovery and reuse potential	Material Passports (MPs)	Digital records of material properties and reuse/recycling potential.	(Heisel & McGranahan, 2024; Honic et al., 2024)
Material Circularity	Material Circularity Indicator (MCI)	EMF-developed metric adapted to construction.	(Ellen MacArthur Foundation & ANSYS Granta, 2019; Ossio et al., 2023)
Circular Transition readiness	Circular Transition Indicators (CTI)	WBCSD framework for transition measurement.	(Cambier et al., 2020; Ossio et al., 2023; WBCSD, 2022)

KPI / Indicator	Tool / Framework	Description	Source
Environmental impacts	Life Cycle Assessment (LCA)	Evaluates resource use, energy, emissions, and waste across lifecycle.	(Cambier et al., 2020; Ossio et al., 2023)
Economic performance	Life Cycle Costing (LCC)	Cradle-to-grave financial assessment including reuse/residual value.	(Cambier et al., 2020; Ossio et al., 2023)
Sustainability & circularity in buildings	Certification schemes (LEED, BREEAM, DGNB)	Multi-criteria frameworks including circularity-related measures.	*(Giarma et al., 2025)*
Social dimension of circularity	Social-LCA (S-LCA)	Identified as underdeveloped; social KPIs scarce.	(Ossio et al., 2023)
Building Circularity index (BCI)	Building Circularity index (BCI)	Combines material circularity with building-level factors.	*(Güngör et al., 2025)*
Disassembly & reuse potential	Building Circularity Indicator – Disassembly Reconsidered (BCIDR)	Focuses on ease of disassembly and recovery.	*(Güngör et al., 2025)*
Whole-life performance & salvage	BIM-based Whole-life Performance Estimator (BWPE)	Estimates salvage performance of components at design stage.	(Ossio et al., 2023)
Longevity of resources	Longevity Indicator (LI)	Measures lifetime extension of resources.	(Pineda-Martos et al., 2025)
Design adaptability	Design for Adaptability (DfA)	Indicator for flexibility and adaptive reuse.	(Giarma et al., 2025)
Design for deconstruction	DfD Indicator	Evaluates how easily components can be dismantled and reused.	(Giarma et al., 2025)

In addition to the indicators identified in this report, Güngör et al. (2025) provide a comprehensive review of circularity metrics in the academic literature. To make these indicators easier to navigate, we present them in four categories according to their primary level of application: micro (product-level), micro (building-level), meso (organizational/business-level), and macro (regional/national-level). This categorization is intended to aid clarity in this report and does not appear in Güngör et al.'s original classification. Table 2 summarizes the indicators.

Table 2: Circularity Indicators Identified in Güngör et al. (2025) Grouped by Product, Building, Meso, and Macro Levels.

Level	Indicators
Micro (Product-level)	Material Circularity Indicator (MCI); Material Reutilization Part (C2C); Circle Assessment (CA); Circularity Assessment Tool (CAT); Circular Benefits Tool (CBT); Product-Level Circularity Metric (PCM); Resource Duration Indicator (RDI); End-of-Life Recycling Rates (EoL-RRs); Recycling Indices (RIs); Reuse Potential Indicator (RPI); Recycling Rates (RRs); Sustainable Circular Index (SCI); Value-based Resource Efficiency (VRE).
Micro (Building-level)	Building Circularity Indicator (BCI); Building Circularity Indicator (Disassembly Reconsidered) (BCIDR); BIM-Based Building Circularity Assessment (BBCA); Modified Alba Concept (MAC); Alba Concept BCI (ACBCI); Modified Building Circularity Indicator (MBCI); Predictive Building Circularity Indicator (PBCI); Circularity Indicator for Pedestrian Bridges (CIPB); ARCH Circular Environmental Indicator Framework (ARCHCEIF); MADASTER Circularity Indicator (MAD-CI); FLEX 4.0; BIM-based Whole-life Performance Estimator (BBWPE); Bridge Circularity Assessment Framework (BCAF); Gypsum End of Life Measurement Indicator (GEOLMI); RIPAT 1.0; Framework for Circular Buildings (FCB); Platform CB'23 (PCB); Circularity Calculator (CC); Circular Building Assessment Prototype (CBAP); C-CALC; Circular Assessment Criteria for Envelope (CACE); Circular Construction Evaluation Framework (CCEF); Whole Building Circularity Indicator (WBCI); Product Circularity Index (PCI); Element Circularity Index (ECI); Whole-Life Performance Estimator (WLPE); Deconstruction and Resilience (3DR); Disassembly and Deconstruction Analytics System (D-DAS).
Meso (Organizational / Business-level)	Circular Economy Measurement Scale (CEMS); Circular Economy Scale (CES); Circular Business Model Based Circularity Indicator (CBMCI); Integrated Energy Performance and Circularity (IEPC); Circular Economy Company Assessment Criteria (CECAC); Circular Economy Index (CEI); Circular Economy Performance Indicator (CEPI); Circular Economy Toolkit (CET); Circular Economy Toolbox US (CETUS); Circular Economic Value (CEV); Circularity Potential Indicator (CPI); Super-efficiency Data Envelopment Analysis Model (DEA); Synthetic Economic Environmental Indicator (SEEI); Critical Success Factors (CSFs).
Macro (Regional / National-level)	Circular Economy Indicators for India (CEII); Circular Economy Indicator Prototype (CEIP); Circular Economy Monitoring Framework (CEMF); Circular Impacts Project EU (CIPEU); Circularity Material Cycles (CIRC); Closed Loop Calculator (CLC); Circularity Pathfinder (CP); Evaluation of CE Development in Cities (ECEDC); Evaluation Indicator System of Circular Economy (EISCE); Indicators for Material Input for CE in Europe (IMCEE); Environmental Protection Indicators (EPICE); Evaluation of Regional Circular Economy (ERCE); Eco-efficient Value Ratio (EVR); Economy-Wide Material Flow Analysis (EWMFA); Five Category Index Method (FCIM); Hybrid LCA Model (HLCAM); Indicators for Consumption for CE in Europe (ICCEE); Circularity Indicator Project (ICT); Indicators for Eco-design for CE in Europe (IECEE); Indicators of Economic Circularity in France (IECF); Integrative Evaluation on the Development of CE (IEDCE); Input–Output Balance Sheet (IOBS); Indicators for Production for CE in Europe (IPCEE); Industrial Park Circular Economy Indicator System (IPCEIS); Measuring Regional CE–Eco-Innovation (MRCEEI); National Circular Economy Indicator System (NCEIS); Regional Circular Economy Development Index (RCEDI); EU Resource Efficiency Scoreboard (RES); Global Resource Indicator (GRI).

BIM: From Building Information Modelling to Building Information Management

Building Information Modeling is widely recognized as a transformative digital process in the construction sector. It enables more efficient, sustainable, and collaborative project delivery by combining a digital 3D model with structured, functional information such as materials, costs, and schedules (Volk et al., 2014). However, in the context of circular construction and lifecycle thinking, BIM is increasingly understood not just as a modelling tool, but as a comprehensive information management process - Building Information Management (EU BIM Task Group, 2017; International Organization for Standardization, 2018) .

This management-oriented interpretation emphasizes the creation, use, and continuous updating of building information throughout the entire lifecycle of a built asset - from design and construction to operation, renovation, and ultimately reuse or deconstruction. Managing this information effectively is essential for enabling circular practices such as material passports, reuse planning, and long-term asset management (Akbarnezhad & Xiao, 2017; Ellen MacArthur Foundation, 2019a, 2021).

Technical aspects and standards

The PAS 1192 series – withdrawn in December 2018 and replaced by the ISO 19650 (Shillcock, 2019)- introduced the concept of BIM levels, which describe an organization's or project's maturity in digital collaboration:

- Level 0: Minimal digital use - 2D drawings and document
- Level 1: Use of 3D models and standardized protocols, but limited collaboration.
- Level 2: Coordinated use of 3D models and shared data, often using open formats like IFC.
- Level 3: Full integration of data-rich environments, enabling technologies such as digital twins and real-time data management.

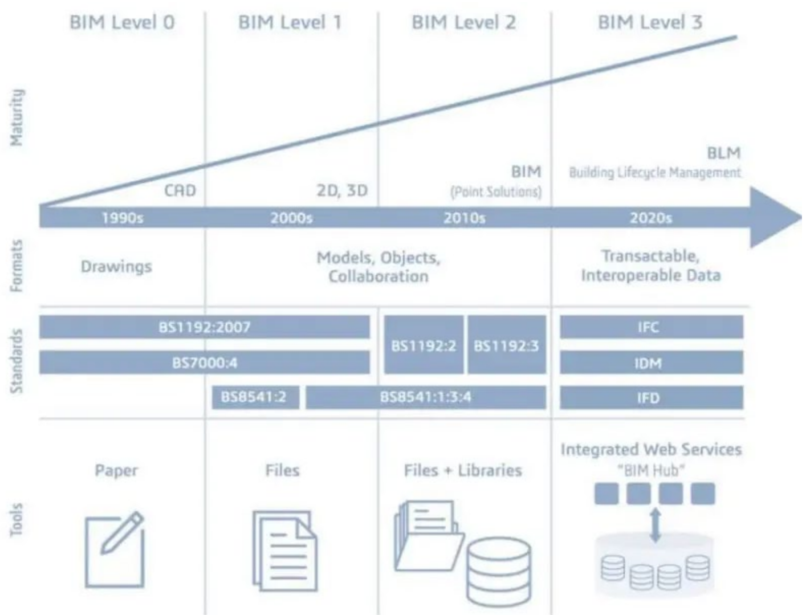


Figure 4: BIM Maturity levels (Biblus Editorial Team, 2025)

The PAS 1192 have been replaced by the international standard ISO 19650 (BSI Group - Netherlands & Say Building, 2019). It provides a robust framework for managing building information. They shift the focus from geometry to information structures, responsibilities, and collaboration processes and emphasizes:

- The use of a Common Data Environment (CDE): A centralized platform for storing, sharing, and updating project information across stakeholders (International Organization for Standardization, 2018).
- Defined roles and responsibilities: Clarifies who is responsible for producing, checking, and approving information at each project stage.
- Structured information workflows: Ensures data consistency, reduces errors, and enhances interoperability.

OpenBIM and Interoperability

OpenBIM, promoted by BuildingSMART - a global non-profit organization composed of corporate and institutional organizations – is a key enabler of Building Information Management. By supporting open standards such as IFC (Industry Foundation Classes), IDS (Information Delivery Specification) and BCF (BIM Collaboration Format), OpenBIM ensures that information is not locked into proprietary systems. This guarantees data accessibility and continuity across tools, platforms, and lifecycle stages (buildingSMART International, 2025).

For circular construction, this openness is vital: it ensures that data about materials, components, and systems remain accessible and reusable in future building phases, supporting more sustainable and resource-efficient decisions (Platform CB’23, 2022).

Conclusion: Toward lifecycle-centric BIM

BIM is no longer just about producing digital models - it's about managing building information strategically and sustainably. Within the CircleBIM project, this lifecycle-oriented approach supports circular construction by ensuring that data flows are transparent, reliable, and interoperable across all stages of a building’s life.

By embracing Building Information Management, grounded in standards like ISO 19650 and practices like OpenBIM, stakeholders can unlock BIM's full potential: not only as a design tool, but as an essential infrastructure for circularity, collaboration, and long-term value creation. Accordint to Ossio et al. (2023)BIM is critical in applying CE strategies and business model innovations

3. Methodology overview

The methodological approach of this report is based on a collaborative and transnational process designed to identify and analyse good practices in circular construction, with a specific focus on BIM-supported processes.

The CircleBIM project aims to promote circular construction practices through digital integration, particularly Building Information Management (BIM). This report seeks to identify and illustrate good practices of circularity in construction. The methodology, see Figure 5, follows a structured, two-pronged approach: (1) a review of real-life practical demonstrations, and (2) an analysis of relevant EU development projects. The approach balances conceptual rigor, grounded in the Ellen MacArthur Foundation's Butterfly Diagram (Figure 1, page 8), with contextual relevance drawn from a diverse range of European experiences.

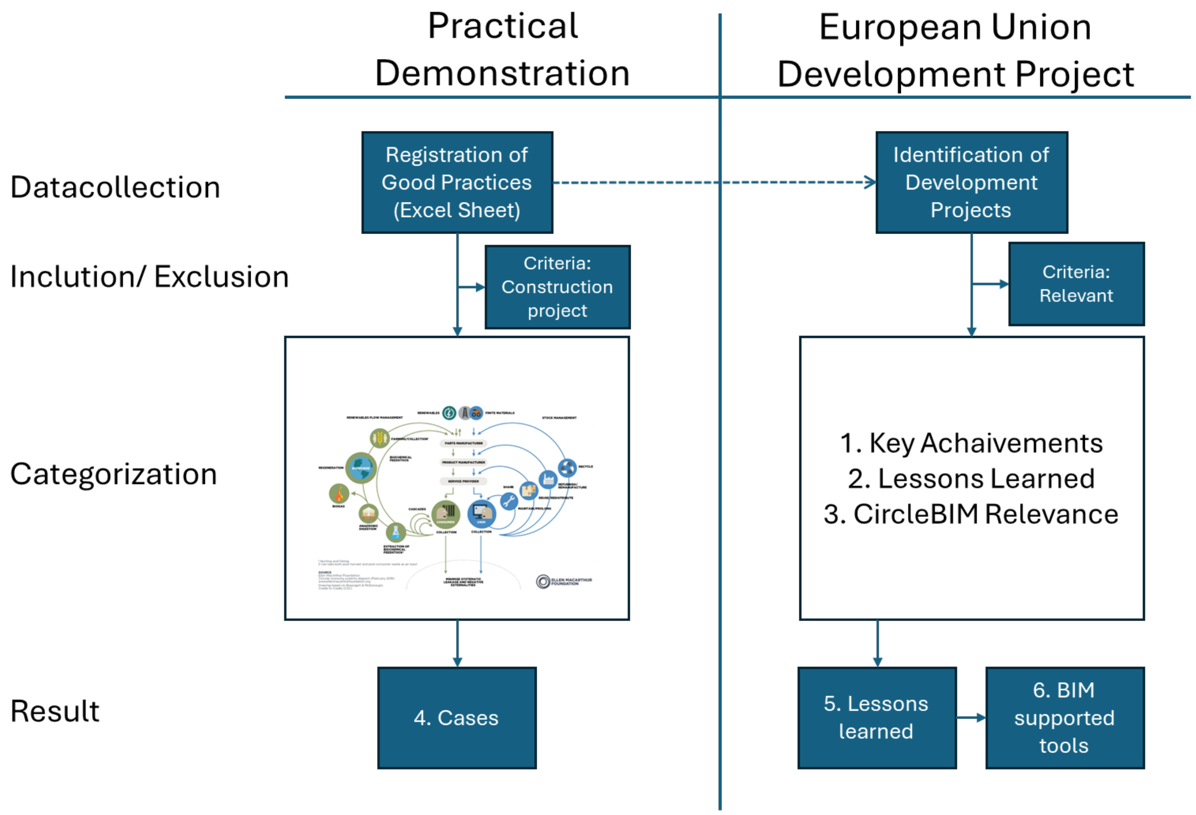


Figure 5: Overview of the methodology used in this report.

Data Collection: A total of 44 examples were collected through a collaborative data gathering process in which all project partners were asked to submit relevant materials. These included links to documentation and descriptions of initiatives and projects they considered meaningful examples of circularity in construction. The material ranged from case descriptions to policy papers, but only those aligned with defined criteria were included in the final analysis.

Selection Criteria:

- For real-life **Practical Demonstrations**, the inclusion criterion was strict: only completed or active construction projects were accepted. This excluded tools, knowledge centres, and academic literature. From the collected dataset, 8 such projects met the criteria. These examples represent applied circular strategies in construction and serve to anchor theoretical principles in practice.
- For **EU development projects**, the focus was on initiatives where circularity and BIM integration were central. Projects were included if they demonstrated efforts to operationalize circular principles through digital means, particularly BIM. Seven projects met these criteria,

each offering different insights into enabling frameworks, technological integration, and stakeholder collaboration across national contexts.

Analytical Framework:

- For real-life **Practical Demonstrations**, the Ellen MacArthur Foundation's Butterfly Diagram (Figure 1, see also page 8) was adopted as the central analytical and communication framework. It categorizes circular strategies into technical and biological loops and provides a structured lens for evaluating interventions such as reuse, maintenance, refurbishment, and recycling.
  Each of the eight real-life construction cases was examined to identify which loops in the Butterfly Diagram the project engaged with. A narrative was developed for each, describing how circular strategies were implemented and supported through design and execution. Additionally, the projects were evaluated for how they applied design principles such as modularity, adaptability, and disassembly.
  The results of this analysis are presented in Chapter 4 (Cases), where the Butterfly Diagram serves as a visual map linking each example to specific material loops, thereby illustrating the diversity and potential of circular construction strategies.
- For the **EU development projects,** seven examples were included and subjected to a three-tiered analytical lens:
  1. Key Achievements – Identifying outcomes, outputs, and implemented innovations.
  2. Lessons Learned – Assessing challenges, barriers, and enablers encountered.
  3. CircleBIM Relevance – Evaluating the potential transferability and inspiration for CircleBIM's objectives.

This approach enabled a structured cross-case synthesis that focuses not just on successes but on the pathways and contexts that shaped them. Chapter 5 (Lessons Learned) consolidates these insights to guide future policy and practice.

In addition to the two-tiered analysis presented in Chapters 4 and 5, a third analytical step was undertaken to address the digital tools identified across the reviewed EU development projects. This additional layer of analysis focused on the BIM-supported tools found in the EU development projects (Chapter 5), providing a more detailed understanding of how digital technologies enable circular strategies in practice.

The aim of this analysis, presented in Chapter 6 (BIM Supported Tools), was threefold:

1. To describe the tools themselves and group them into meaningful tool categories
2. To classify each tool based on its relevance to different phases of the building process
3. To assess the BIM maturity level associated with each tool, drawing on established BIM maturity frameworks to indicate the degree of integration, interoperability, and lifecycle support.

This third step builds directly on the insights gathered in Chapter 5 and offers a structured typology of digital tool use in circular construction, thereby contributing to the CircleBIM project's broader objective of linking circularity and digitalization in a practically applicable way.

4. Cases

To further explore how circular strategies and BIM-supported processes are used in practice, this section presents real-world cases that exemplify successful implementations across different European contexts. The cases reflect a variety of project types, scales, and geographic settings, offering insights into how digital tools and circular approaches interact in practical construction environments.

Each case is analysed using the Butterfly Model (Figure 1, see also page 8) as the central framework. By categorising circular strategies, such as reuse, refurbishment, and recycling, within the model's technical and biological loops, the analysis provides a structured and comparative approach to understanding circular value creation. This helps identify the specific contributions of each project to material value preservation and resource efficiency.

Beyond documenting results, the selected cases offer transferable insights for policymakers, practitioners, and public stakeholders. They reveal the enabling conditions and digital tools that have made success possible, while also addressing common barriers and lessons learned. In doing so, the cases help bridge the gap between strategic ambition and practical implementation and support broader efforts to promote circular and resource-conscious construction systems.

Table 3: Overview of the analysed cases.

	Maintain/ prolong	*Reuse/ redistribute*	*Refurbish/ remanufacture*	*Recycle*	*Biobased*	*Design strategy*
Van der Sluis transport, Staphorst	X	X	X	X		DfD/ DfA
Temporary courthouse, Amsterdam		X	X	X		DfD/ DfA/ DwR
Green Hub House, Aalborg		X	X			DwR
Buildwise, Zaventem			X	X		DwR
Recygénie, Gennevilliers				X		
Økern Portal, Oslo				X		
Heuvelstraat, Sivolde			X	X	X	DwR/ DwB
SAWA, Rotterdam	X	X	X	X	X	DwB

Reference projects

Maintain/prolong

Newbuild Van der Sluis te Staphorst

Client:	Van der Sluis Transport, Staphorst
Architect:	Buro de Haan, Staphorst
Installations:	Bisschop Installatie, Punthorst
Location:	Staphorst (The Netherlands)
Function:	Office/ industry
Area:	2.680 m^2
Structural materials:	Steel, hollow-core slab floor, aluminium windows
Completion year:	2024
Reference:	(Buro De Haan Architectuur | Ontwerp Van der Sluis Transport, 2024)

Other circular strategies used:
- Reuse/redistribute;
- Refurbish/remanufacture;
- recycle.

During the construction of the new premises for Van der Sluis Transport in Staphorst, there was a deliberate choice for sustainable and low-maintenance materials. Two notable decisions were the implementation of a green roof and the use of aluminium window frames.

Figure 6: Green roof Van der Sluis transport Buro de Haan. Archive photo. (Buro De Haan Architectuur | Ontwerp Van der Sluis Transport, 2024)

The green roof shown in Figure 6, acts as a protective layer on top of the roofing. The vegetation shields the underlying roof covering from UV radiation, temperature fluctuations, and precipitation. As a result, the roofing wears out much more slowly and its lifespan is extended by many years. Additionally, the green roof provides extra insulation and helps retain rainwater, making the building more resistant to extreme weather conditions and water flooding.

For the window frames shown in Figure 7, aluminium was chosen. A material renowned for its exceptional durability and low maintenance. Aluminium frames do not require sanding or painting and are resistant to all weather conditions. This means they last a very long time, even with minimal maintenance, without losing their functionality or appearance. Moreover, aluminium frames are fully recyclable, which supports the project's circular ambitions.

Thanks to these material choices, maintenance is kept to a minimum while actively contributing to the extended lifespan of the building. This ensures that the premises remain functional, representative, and sustainable, with minimal impact on the environment.

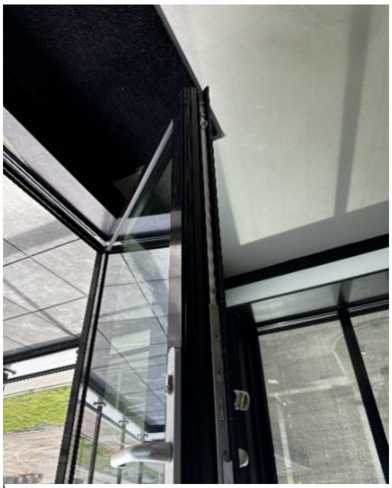


Figure 7: Aluminium windowframes Buro de Haan. Archive photo. (Buro De Haan Architectuur | Ontwerp Van der Sluis Transport, 2024)

Reuse/redistribute

Temporary Courthouse in Amsterdam/Enschede (The Netherlands)

Primary client:	Rijksvastgoedbedrijf (Government Real Estate Agency)
Architect:	Cepezed
Structural engineering:	IMd Raadgevende Ingenieurs
Installations:	Ingenieursbureau Linssen

Location first design:	Amsterdam (The Netherlands)
Location second design:	Enschede (The Netherlands)
Function first design:	Courthouse
Function second design:	Office, Knowledge lab
Area:	5.400 m^2
Structural materials:	Steel, hollow-core slab floor, prefabricated timber modules, aluminium windows
Completion year:	2016
Rebuild in:	2022

Reference: (remountable construction: showcase temporary court in Amsterdam | cepezed, 2016)

Other circular strategies used:
- refurbish/remanufacture
- recycle.

Figure 8: Temporary courthouse Amsterdam. (remountable construction: showcase temporary court in Amsterdam | cepezed, 2016)

The temporary courthouse in Amsterdam (Figure 8) designd by cepezed, is an inspiring example of circular construction and the smart reuse of building components. When it became clear that a temporary building would be needed during the construction of the new courthouse in Amsterdam, the decision was made to design a building that is fully demountable after its period of use, so that its components could be directly reused or repurposed.

After four years of service in Amsterdam, the building was carefully dismantled at the beginning of 2022, ensuring that nearly all building components remained intact (Figure 9). This included, among others, the steel structure, façade panels, floor elements, and technical installations. The elements shown in Figure 9 are now being repurposed for the construction of a new office and knowledge lab in Enschede. Thanks to the smart design, the modules could be disassembled like a kit, transported, and reconstructed-giving the building a second life.

Figure 9: Disassembling temporary courthouse. (remountable construction: showcase temporary court in Amsterdam | cepezed, 2016)

This project illustrates the many advantages of reusing and reallocating building components: it minimizes waste, reduces environmental impact, and enables the efficient use of resources. Additionally, it creates flexibility for future developments. The temporary courthouse (Figure 10) thus serves as a blueprint for future-proof construction, with circularity, sustainability, and adaptability at its core. This approach perfectly aligns with the ambitions of the circular construction economy and demonstrates that high-quality architecture and sustainability can go hand in hand.

Figure 10: Elements temporary courthouse. (remountable construction: showcase temporary court in Amsterdam | cepezed, 2016)

Van der Sluis Transport: Demountable Construction for Future Reuse

Client: Van der Sluis Transport, Staphorst
Architect: Buro de Haan, Staphorst
Installations: Bisschop Installatie, Punthorst

Location: Staphorst (The Netherlands)
Function: Office/ industry
Area: 2.680 m^2
Structural materials: Steel, hollow-core slab floor, aluminium windows
Completion year: 2024

Reference: (Buro De Haan Architectuur | Ontwerp Van der Sluis Transport, 2024)

Other circular strategies used:

- Maintain/ prolong;
- Refurbish/ remanufacture;
- recycle.

Figure 11: New build project of Van der Sluis transport. (Buro De Haan Architectuur | Ontwerp Van der Sluis Transport, 2024)

The new build project of Van der Sluis Transport in Staphorst, shown in Figure 11, stands as a leading example of circular construction, in which the principles of Reuse and Redistribute are applied in innovative ways. Unlike many circular projects, no reclaimed materials from other buildings were used here. What makes this project unique is the way the design and execution are fully tailored to the future reuse of materials.

For the building, detailed disassembly manuals were prepared, specifying exactly how all components from the steel structure, suspended ceilings, and metal stud walls (Figure 12) to installations can be removed in the future without damage. Thanks to this documentation, all materials and components can be easily dismantled and reused elsewhere. This greatly facilitates the process of reuse and prevents unnecessary material loss.

Designing and building for disassembly not only ensures the preservation of material value but also stimulates the regional flow of materials (redistribute). By considering future disassembly right from the design phase, the lifespan of materials is significantly extended and waste is minimized.

Thanks to the involvement of Buro De Haan, supported by a GPR calculation, it has been ensured that the building meets strict sustainability standards. The reference project of Van der Sluis Transport demonstrates that, with smart design choices and clear disassembly instructions, circularity and practical applicability can go hand in hand.

Figure 12: Demountable elements for future reuse at the Van der Sluis transport premises. (Buro De Haan Architectuur | Ontwerp Van der Sluis Transport, 2024)

Refurbish/remanufacture

Green Hub House:
Pioneer in Refurbishment and Remanufacturing of Building Components

Client:	Himmerland Housing Association
Architect:	C.F. Møller
Engineer:	NIRAS
Other partners:	Aalborg University, BUILD
Location:	Aalborg (Denmark)
Function:	Residential building
Area:	4.000m^2
Structural materials:	Prefabricated timber modules, reused terracotta cladding, hollow-core slab floor
Completion year:	2027
Reference:	(Green HUB house | Himmerland Boligforening, 2025)

Other circular strategies used:
- Reuse/redistribute

Green Hub House, located in Aalborg and designed by C.F. Møller Architects (Figure 13 and Figure 14), is a flagship project setting new benchmarks for sustainable housing in Denmark. As a demonstration project within the "From 4 to 1 Planet" initiative, it serves as a living laboratory for applying circular principles such as refurbishment and remanufacturing of building components.

At the core of the design is the reuse of materials. The buildings are constructed from prefabricated timber modules on screw foundations, drastically reducing both climate impact and groundwork. The façades feature reused terracotta cladding and recycled hollow-core floor slabs, while ventilation components are also reclaimed and repurposed. This approach minimizes material waste and significantly lowers raw material consumption.

Four sustainability principles form the foundation of Green Hub House: sufficiency, efficiency, circularity, and sharing. Together, these principles guide the creation of compact, flexible homes with high living quality and a low environmental footprint. Thanks to adaptable layouts, the dwellings can meet changing residential needs and social dynamics.

The project also places great emphasis on landscaping and community facilities, including green meeting spaces, rainwater management, and biodiversity. Energy-efficient systems, such as heat recovery and optimized hot water supply, ensure a comfortable indoor environment.

Green Hub House demonstrates that refurbishment and remanufacturing of building components are not only technically and ecologically feasible, but also contribute to attractive, future-proof living environments. The project stands as an example for circular construction across Europe.

Figure 13: Visualisations of the Green Hub House. C.F. Møller Architects. Green Hub House. (Green HUB house | Himmerland Boligforening, 2025)

Figure 14: Visualisations of the Green Hub House. C.F. Møller Architects. Green Hub House. (Green HUB house | Himmerland Boligforening, 2025)

Buildwise in Zaventem

Client: Buildwise (former WTCB)
Architect: BOVA-Architects
Engineer: Bureau d'Etudes Greisch

Location: Zaventem (Belgium)
Function: Office
Area: 6.500 m^2
Originaly build: 1999
Completion year: 2022

Reference: (Buildwise by BOVA-Architects| architectenweb.nl, 2022)

Other circular strategies used:
- recycle.

Figure 15: Buildwise building Zaventem before renovation. (Buildwise by BOVA-Architects| architectenweb.nl, 2022)

Figure 16: Visualisation of the building after renovation. (Buildwise by BOVA-Architects| architectenweb.nl, 2022)

The Buildwise office in the Zaventem building, shown in Figure 15 and Figure 16, is a leading reference project in the field of circular construction and the application of refurbishment and remanufacturing principles. During the renovation of this building, the focus was deliberately placed on reusing and renewing existing materials and building components, instead of complete replacement.
A key part of the project was the systematic inventory and assessment of the existing building elements. Thanks to the use of BIM (Figure 17), all relevant data could be accurately recorded and shared with the entire construction team. This enabled components still in good condition, such as climate ceilings, partition walls, and lighting, to be refurbished. Where necessary, components were remanufactured or adapted to meet current standards.

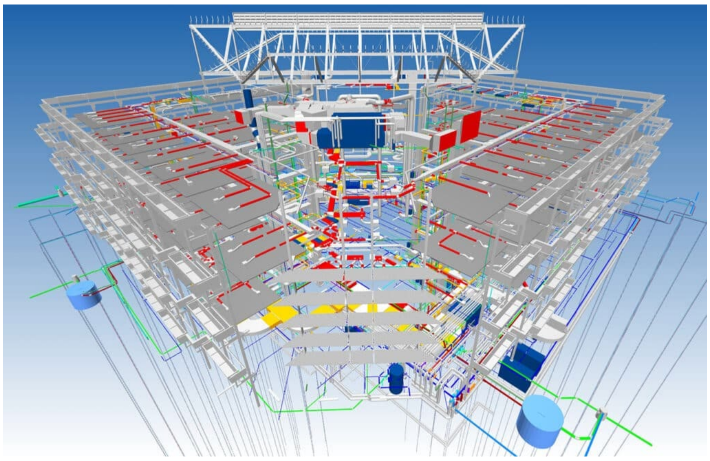


Figure 17: Overview BIM model. (Construire la Wallonie, 2023)

The BIM model functioned not only as a digital database but also as a tool for ensuring circularity and data quality. Project partners could easily check whether materials were technically and economically suitable for reuse. This minimized waste and significantly reduced the project's environmental footprint.

The WTCB office building demonstrates that refurbishment and remanufacturing are highly applicable within office renovations, provided they are supported by digital tools and integral collaboration between all stakeholders. The project therefore serves as an inspiring example for the sector: forward-looking, sustainable, and efficient.

Recycle

Recygénie : Pioneer in Recycling Construction Materials

Client:	Seqens, France (social housing company)
Architect:	A26 Architects
Engineer:	Ingea
Location:	Gennevilliers (France)
Function:	Residential housing
Area:	-
Structural material:	Concrete
Completion year:	2024
Reference:	(Pioneer in Recycling | A26 architects | Holcim.com, 2024)

Other circular strategies used:

- Recycle

The Recygénie project, shown in Figure 18, is a leading reference project shaping the future of circular construction. Located in Gennevilliers, just outside Paris, this project, realized by Holcim in collaboration with innovative partners, focuses on the reuse of construction materials sourced from demolished buildings. While traditional waste is often treated as a residual product, Recygénie demonstrates that complete recycling of building components is both possible and rewarding.

The remarkable building is the first in the world to be constructed entirely from 100% recycled concrete. Concrete in which all components – cement, aggregates and water – are made of recycled materials (Holcim, 2023). By employing advanced techniques such as separating, cleaning, and recombining concrete aggregates, a high-quality new construction material is produced. This not only conserves primary raw materials but also significantly reduces CO_2 emissions.

With Recygénie, Holcim has proven that the circle can indeed be closed: transforming an old building into a new one, without any loss of quality or aesthetics. The project serves as a “living lab” and a source of inspiration for architects, engineers, and policymakers worldwide. In 2024, the project received a prestigious World Changing Ideas Award from Fast Company, recognizing its innovative power and impact on sustainable construction.

Recygénie demonstrates that large-scale reuse and recycling of complete building components is achievable. The project thus sets a new standard for the construction sector. The ambition is clear: from demolition to circular building, helping shape a green and sustainable future for the built environment.

Figure 18: Visualisation project Recygénie. *(Pioneer in Recycling | A26 architects | Holcim.com, 2024)*

Økern Portal

Reference Project Økern Portal: Innovative Use of Recycled Aluminium

Client: Oslo Pensjonsforsikring (OPF)
Architect: DARK Arkitekter
Developer: HENT AS
Engineer: Norconsult

Location: Oslo (Norway)
Function: Office, Catering, Fitness center, rooftop park
Area: 80.000 m^2
Structural material: Steel, prefabricated elements
Completion year: 2021

Reference: (DARK Arkitekter | Økern Portal, 2021)

Other circular strategies used:
- Recycle

The Økern Portal in Oslo, Norway, (Figure 19) is a leading example of sustainable construction, with circular principles at its core. This large-scale development project combines modern design with environmentally friendly building methods, placing particular emphasis on the use of recycled building materials-especially aluminium.

At Økern Portal, a Wicona curtain wall solution was selected, featuring aluminium profiles composed largely of recycled material. Aluminium is particularly well suited for reuse, as it retains its quality and strength after recycling. The use of recycled aluminium significantly reduces the project's CO_2 emissions and environmental impact, without compromising the aesthetics or functionality of the façades.

Designed by DARK Arkitekter, the project is centered on sustainable and future-proof urban development, with energy efficiency and material selection as key pillars. The recycled aluminium in the façade systems (Figure 20) contributes to a lightweight and robust structure with excellent thermal performance and a long lifespan. Additionally, the use of secondary aluminium aligns perfectly with Økern Portal's ambition to minimize its ecological footprint and promote circular economy principles.

In summary, Økern Portal is an inspiring example of how innovative construction techniques and the use of recycled materials, such as aluminium, can contribute to sustainable urban development. The project demonstrates that sustainability and high-quality architecture can go hand in hand, setting a valuable standard for future building projects in Norway and beyond.

Figure 19: Overview of the project Økern Portal. (DARK Arkitekter | Økern Portal, 2021)

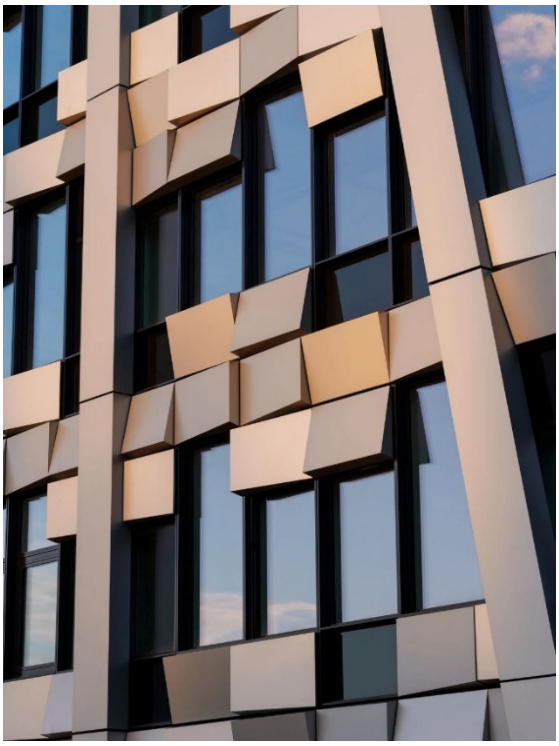


Figure 20: Close up aluminium facade Økern Portal. (DARK Arkitekter | Økern Portal, 2021)

Biobased

Project Heuvelstraat Silvolde: Sustainable and Biobased Construction

Client: Wonion, Ulft
Architect: Architectengroep Gelderland
Contractor: Bouwbedrijf Klanderman Varsseveld
Installer: Wassink Installatie

Location: Silvolde (The Netherlands)
Function: Housing
Area: -
Structural material: Concrete floor, sand-lime blocks (first phase), straw building (second phase)
Completion year: 2024

Reference: (Heuvelstraat, 2024)

Other circular strategies used:
- refurbish/remanufacture
- recycle.

On Heuvelstraat in Silvolde (Figure 21 and Figure 22), housing corporation Wonion is delivering a remarkable reference project in sustainable and future-proof construction: 28 net-zero rental homes, realized in two phases. This project stands out for its holistic use of circular and biobased construction materials, serving as an inspiring example for both the building sector and the region.

Reuse of Materials and Circular Construction
The old houses on Heuvelstraat were dismantled using circular demolition practices. Materials such as roof tiles and bricks were carefully removed, processed, and partially reused in the new development. Additionally, circular window frames and façade panels made from recycled ceramics are being employed. This not only reduces waste but also visibly preserves the history of the site.

Biobased Insulation and Cladding
For insulation, biobased materials such as straw and hemp were chosen. These natural fibers provide excellent insulation properties and contribute to a healthy indoor climate. The façade cladding partially consists of pressed, recycled materials and biobased panels, which further reduces the project's ecological footprint.

Green and Collectively Sustainable
The sustainability approach extends beyond just building materials: street layout and resident involvement play a significant role as well. Green spaces are maintained together, residents are engaged in climate-adaptive measures such as rain barrels and water infiltration, and the homes are fully electric with no gas connection, equipped with solar panels.

Heuvelstraat Silvolde is an inspiring example of how biobased and circular construction can go hand in hand with social sustainability and high living quality.

Figure 21: Heuvelstraat, Sivolde. (Heuvelstraat, 2024)

Figure 22: Heuvelstraat, Sivolde. (Heuvelstraat, 2024)

Sawa, Rotterdam (The Netherlands)

Client:	Nice Developers, ERA Contour
Architect:	Mei Architects
Structural Engineer:	Pieters Bouwtechniek
Building Physics Consultant:	DGMR
Location:	Rotterdam (The Netherlands)
Function:	Residential housing, Catering, social functions
Area:	12.000 m^2
Structural material:	CLT, Glulam, Steel (for additional stability)
Completion year:	2025
Reference:	(SAWA - Mei architects and planners, 2025)

Other circular strategies used:
- Maintain/ Prolong;
- reuse/redistribute;
- Refurbish/remanufacture;
- Recycle.

SAWA: Pioneer in Biobased Construction and Biodiversity

SAWA, shown in Figure 23 is a flagship residential project in Rotterdam that excels in the use of biobased building materials. The building is constructed largely from wood, specifically Cross Laminated Timber (CLT) (Figure 24). An innovative construction method in which wooden planks are glued together in alternating directions. Both the load-bearing structure (columns, beams), floors, and ceilings are made from these biobased materials. This results in a light yet strong structure that also sequesters atmospheric CO_2 over the long term. The timber used is sourced from sustainably managed European forests; for every tree harvested, four are replanted.

Beyond the wooden frame, SAWA features additional biobased applications, including timber façades, finishings, and insulation materials derived from plant-based raw materials. Prefabrication of the CLT elements minimizes construction waste and significantly shortens building time.

What makes SAWA unique is its comprehensive commitment to biodiversity and circularity. Green terraces, façades, and rooftop gardens are incorporated throughout the building and its surroundings, providing space for native plants, flowers, and nesting areas for birds and insects. This creates a biodiverse ecosystem that enhances urban liveability.

Circularity is central to the project: recycled materials are used wherever possible, and waste from production is kept to a minimum. The wooden building components can be reused or recycled at the end of their life. In this way, SAWA minimizes its ecological footprint and sets a new benchmark for sustainable, future-proof construction.

Figure 23: Visualisation of the SAWA project Rotterdam. (SAWA - Mei architects and planners, 2025)

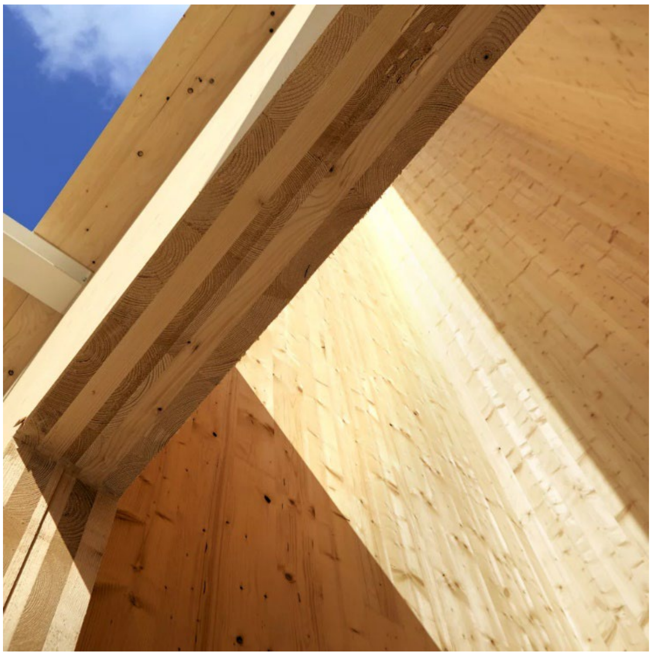


Figure 24: Close up on the CLT of SAWA. (SAWA - Mei architects and planners, 2025)

Key learnings from the cases

The reviewed cases across Europe demonstrate how circular construction strategies, enabled by digital tools like BIM, can be successfully implemented in diverse contexts. Key lessons include:

Design for Disassembly (DfD) is crucial for enabling future reuse and redistribution of building components.

Material choices (e.g., aluminium, timber, recycled concrete) significantly impact the building's lifespan, maintenance needs, and recyclability.

BIM tools play a central role in documenting, assessing, and coordinating circular strategies, especially in refurbishment and remanufacturing.

Prefabrication and modularity support circularity by simplifying construction, reducing waste, and enabling adaptability.

Biobased materials (e.g., straw, hemp, CLT) offer ecological benefits and contribute to healthier indoor environments.

Community involvement and landscaping enhance social sustainability and long-term value.

Circular demolition practices allow for the recovery and reuse of valuable materials, preserving historical and environmental value.

Policy and planning alignment are essential to scale circular practices beyond pilot projects.

Key Learning prompts

Circularity · Reuse · Redistribute · Refurbish · Remanufacture · Recycle · Biobased · Sufficiency · Efficiency · Sharing · Design for Disassembly (DfD) · Design for Adaptability (DfA) · Design with Reuse (DwR) · Design with Biobased (DwB) · Prefabrication · Modularity · BIM (Building Information Modeling) · Material Passport · Low-maintenance materials · Green roof · Aluminium · CLT (Cross Laminated Timber) · Screw foundations · Circular demolition · Digital documentation · Lifecycle extension · Resource efficiency · Stakeholder collaboration · Urban biodiversity · Community engagement · Climate adaptation · Zero-emission housing

5. Lessons learned from other development projects

Lessons learned from other development projects provide insight into a curated selection of European development projects focused on circular construction, digital integration, and sustainable transformation. The selected projects each contribute practical approaches, methods, and forms of collaboration that are relevant and potentially applicable in the context of CircleBIM and similar initiatives.

Through descriptions of practice-oriented approaches and concrete outcomes, the section allows for reflection on how circular strategies and digital tools, including BIM, material passports, and digital twins, have been applied in different settings. It also highlights the organisational and policy frameworks that have supported these efforts and identifies common success factors.

The aim of this section is to enhance understanding of effective solutions and their potential for adaptation and application across different contexts. This knowledge can support the ongoing work with strategy development, project planning, and informed decision-making with circular and digital transitions in the construction sector. The projects presented in Table 4:

Table 4: Overview of the analysed development projects.

	BIM	*Material passports*	*Digital twin / platform*	*DfD / Reuse planning*	*Stakeholder involvement*	*Biobased*	*Policy / Governance*	*Life cycle analysis*
Digital Deconstruction	X	X	X	X	X		X	X
City Loops	X		X	X	X		X	X
FutureBuilt	*			X	X		X	X
Circular Trust Building – CTB	X	X	X	X	X		X	*
Building Based on Biobased (BBoBB)	*				X	X	X	*
CIRCuIT – Circular Construction in Regenerative Cities	X	X	X	X	X		X	X
Circular Economy in the Construction Sector (KARMA)	*				X		X	*
DEvelopers of CIrcular SOlutions (DECISO)	*			*	X		X	
CircBoost – Boost the Future Of Construction	*			*	X		X	
BAMB – Buildings as Material Banks	X	X	X	X	X		X	X
GrowingCircle	*	X	X	X	X	X	*	*
FutureBEEing	X	X	*	*	X	X	X	X
Digital4CircularContstruction	X	X	X	X	X		X	X
Cirpass 2	X	X		X	X		X	
CCBuild		X	X	X	X			X

**Not implied*

Digital Deconstruction

Project title:	Digital Deconstruction - Advanced Digital Solutions Supporting Reuse and High-Quality Recycling of Building Materials
Project program:	Interreg North-West Europe
Timeline:	2019-2023 (completed)
Project partners:	13 partners from the Netherlands, France, Belgium, Luxembourg, and Ireland, including Provincie Limburg (lead partner), Build360, and Atlantic Technological University (ATU).

The Digital Deconstruction project aimed to accelerate circular construction by developing an innovative digital decision support system. By integrating 3D scanning, BIM, material and building databases, and blockchain technology, the project helped define the most sustainable and economical strategies for building deconstruction and reuse.

Key achievements:

- Development of a Digital Platform: A comprehensive platform was created, enabling efficient management, reuse, and traceability of building materials, significantly reducing waste and CO_2 emissions.
- Pilot Projects: Practical pilots across multiple countries demonstrated the application of digital deconstruction tools and provided valuable real-world feedback.
- International Collaboration: Cross-border cooperation strengthened networks, knowledge exchange, and commitment to circular construction principles.

Lessons learned:

- Data Quality and Accessibility: Accurate, accessible building data is crucial for creating effective digital twins and optimizing deconstruction strategies.
- Need for Standardization: Developing common protocols for data collection, modeling, and reuse enhances collaboration and project efficiency.

CircleBIM relevance

Digital Deconstruction demonstrates the powerful synergy between BIM, lifecycle thinking, and circularity. Integrating advanced digital tools shows how digital twins, material banks, and blockchain can transform deconstruction planning, design-for-disassembly, and sustainable construction practices at scale.

More information

https://vb.nweurope.eu/projects/project-search/digital-deconstruction/

https://build360.ie/digital-deconstruction/

State of The Art Report – digital tools for urban mining: ddc_wpt1_d11_state-of-the-art_digital-tools-for-urban-mining.pdf

City Loops – Urban Circularity Assessment in Bodø

Project title:	CityLoops – Urban Circularity Assessment in Bodø
Project program:	EU Horizon 2020-funded research project
Timeline:	2019-2023 (completed)
Project partners:	28 partners including municipalities, research institutions, and industry actors across Europe. Bodø Municipality collaborated with Metabolism of Cities in this assessment.

The CityLoops project in Bodø, Norway, focused on embedding circular economy principles into urban development, particularly in managing construction and demolition waste (CDW) and soil. Through the BIM integration with Urban Circularity Assessment (UCA), the project mapped material flows and building stock, showing that Bodø's economy is highly linear (90%) and carbon-intensive, with a building stock of over 4.2 million tonnes.

Two key initiatives stood out:

- Digital Tools and Marketplaces: With the use of BIM methodologies, Bodø developed digital platforms to track, manage, and facilitate the reuse of construction materials, helping reduce waste and optimize resource use.
- Environmental Program: An overarching environmental framework was created, incorporating policies for nature conservation, mass handling, circular treatment of materials, and energy efficiency.

Citizen and stakeholder engagement played a major role in promoting reuse practices and building local circular capacity.

CircleBIM relevance

CityLoops demonstrated that combining BIM with urban circularity assessments can significantly enhance circular construction efforts. BIM enabled detailed material tracking, supported design for reuse, and facilitated the creation of digital marketplaces for secondary materials. By integrating BIM with tools like the UCA, the project provided a shared digital environment that improved both strategic planning (e.g., policy development and environmental programming) and operational management (e.g., logistics and mass handling). BIM also helped visualize and simulate reuse scenarios, making it easier to communicate complex data to stakeholders and foster broader engagement. This integration exemplifies the potential of CircleBIM – the fusion of BIM and circular economy strategies – to drive sustainable urban development.

More information

https://cityloops.metabolismofcities.org/city/bodo/uca-report/

https://cityloops.eu/cities/bodoe

Material flow mapping · Urban metabolism · Digital marketplaces · Stakeholder engagement · Circular planning

FutureBuilt

Project title:	FutureBuilt
Project program:	Norwegian innovation and demonstration programme
Timeline:	2010-ongoing
Project partners:	Oslo, Bergen, Trondheim, Stavanger and Kristiansand; Norwegian authorities (e.g. Enova, Husbanken, DiBK), Non-Governmental Organizations, architects, developers and private actors.

FutureBuilt is an innovation program in Norway that promotes climate-friendly urban development. Launched in collaboration with municipalities such as Oslo, Bergen, Trondheim, Stavanger, and Kristiansand, its vision is to demonstrate that climate-neutral urban areas with high-quality architecture are achievable. FutureBuilt focuses on pilot projects that reduce greenhouse gas emissions by at least 50% compared to current standards. These projects showcase sustainable urban design and construction, aiming to inspire broader adoption. By emphasizing innovative solutions in architecture, planning, and mobility, FutureBuilt contributes to creating vibrant, low-carbon communities while highlighting Norway's leadership in sustainable urban development.

CircleBIM relevance

FutureBuilt's focus on climate-neutral urban development aligns closely with the goals of the CircleBIM project, which promotes circular economy principles in the construction sector through digital technologies. FutureBuilt's pilot projects demonstrate innovative approaches to reducing carbon emissions by at least 50%, highlighting practical strategies and scalable solutions. These projects embody the circular economy's principles by integrating resource-efficient design, reuse, and lifecycle thinking—core components of CircleBIM. The program's emphasis on collaborative partnerships across municipalities and disciplines reflects the collaborative nature of CircleBIM. FutureBuilt's focus on digital innovation, sustainable construction practices, and climate-conscious design makes it an ideal reference for CircleBIM, offering concrete examples of how digital tools like BIM can advance circular and sustainable construction in Northern Europe.

More information

https://www.futurebuilt.no

Public-private collaboration · Lifecycle assessment (LCA) · Reuse at scale · Zero-emission construction

Circular Trust Building – CTB

Project title: Circular Trust Building (CTB)

Project program: EU-funded research project – North Sea Region

Timeline: 2023–2026 (ongoing)

Project partners: Partners from the Netherlands, Belgium, Denmark, Germany, Sweden, and France, including municipalities (e.g. Groningen, Vejle, Roeselare), universities (e.g. Hanze UAS, Linnaeus University), housing organizations and sustainability hubs.

The CTB project aims to accelerate circular construction practices across the North Sea Region by focusing on reuse, collaboration, and digital trust. The project promotes the reuse of materials in buildings, the development of frameworks for sharing data, and new regional agreements between public and private stakeholders. CTB operates through pilot projects, policy development, and stakeholder workshops. Eight regional demonstration cases are being implemented to showcase how circular design, disassembly planning, and low-carbon construction methods can reduce material footprints by at least 25%. Key tools include material passports and shared digital platforms that connect supply and demand for reclaimed materials. These platforms serve as collaborative environments that:

- Act as digital marketplaces for listing and sourcing reclaimed construction materials.
- Support standardized data sharing and interoperability with BIM and material passports.
- Enable visualization and simulation of reuse scenarios through BIM integration.
- Foster trust and transparency via governance features like audit trails and access controls.
- Serve as knowledge hubs for training, case studies, and cross-sectoral learning.

The project also fosters cross-sectoral capacity building and learning through open networks.

CircleBIM relevance

CTB demonstrates how BIM, combined with material passports and shared digital platforms, can support circular construction. BIM enables traceability, design-for-disassembly, and reuse planning, while digital frameworks ensure secure data sharing and collaboration. Tools like Regional Circular Deals further show how governance, trust, and digital integration can unlock practical reuse strategies across the sector.

More information

[Circular Trust Building - CTB CTB | Interreg North Sea]

Digital trust frameworks · Material passports · Regional circular deals · Design-for-disassembly · Cross-sector governance

Building Based on Biobased (BBoBB)

Project title:	Building Based on Biobased (BBoBB)
Project program:	Interreg North Sea Region Programme, co-funded by the European Union
Timeline:	2023 –2026 (ongoing)
Project partners:	16 partners from Belgium, Denmark, France, Germany, and the Netherlands, including regional governments, universities, design networks, agricultural advisors, and educational institutions.

The BBoBB project aims to accelerate the adoption of biobased materials in construction by developing and strengthening value chains from raw material cultivation to end-use in buildings. By integrating stakeholders across the entire chain – from farmers to designers and builders – the project seeks to overcome barriers such as fragmented knowledge, regulatory challenges, and limited market awareness.

Key activities are organized into three work packages:

- Governance and Policy: Enhancing policies and regulations to support biobased construction.
- Demonstration of Costs and Benefits: Implementing regional pilot projects to showcase the economic and environmental advantages of biobased materials.
- Design and Awareness: Engaging designers and architects to innovate with biobased materials and raise public awareness.

Regional pilots include projects like Denmark's "Hampens Hus", a hemp-based demonstration house, and design initiatives in Belgium focusing on interior applications using flax, hemp, and miscanthus. These pilots serve as practical examples to inspire broader adoption of biobased construction methods.

The project not only modernizes construction practices but also ensures that biobased solutions are viable, traceable, and ready for broader market adoption with the integration of BIM in the BBoBB framework.

CircleBIM relevance

While BBoBB primarily focuses on material value chains and stakeholder collaboration, the integration of digital tools such as BIM can enhance the project's objectives. BIM can facilitate the documentation and analysis of biobased materials, support lifecycle assessments, and improve coordination among stakeholders. Incorporating BIM into BBoBB's framework could further strengthen the scalability and replicability of biobased construction practices.

More information

https://www.interregnorthsea.eu/bbobb

CIRCuIT – Circular Construction in Regenerative Cities

Project title:	Circular Construction in Regenerative Cities (CIRCuIT)
Project program:	EU-funded research project – Horizon 2020
Timeline:	2019–2023 (completed)
Project partners:	31 partners across Denmark, Finland, Germany, and the UK, including municipalities (e.g. Copenhagen, Hamburg, London, Vantaa/Helsinki Region), universities, research institutes, architectural firms, and sustainability organizations.

The CIRCuIT project aimed to mainstream circular construction practices in major European cities by focusing on transformation of existing buildings, reuse of building materials, and design for adaptability and disassembly. It promoted a shift from demolition and linear resource use towards extending building lifecycles and closing material loops.

CIRCuIT worked through 36 pilot demonstrators, city roadmaps, digital tool development, and policy recommendations. Demonstrators showed how material reuse, building transformation, and circular design principles can reduce embodied carbon and resource use by significant margins.

Key tools include pre-demolition audits, circularity indicators, and digital platforms like the Material Reuse Portal. CIRCuIT also fostered cross-sectoral collaboration to support scaling of circular solutions.

CircleBIM relevance
CIRCuIT integrated digital methods such as BIM and material mapping to support circularity. It developed digital tools to document material inventories, track reuse potential, and assess lifecycle impacts, facilitating better planning, design, and decision-making in construction projects.

The project emphasized governance through city-level circularity policies, public procurement criteria, and early stakeholder engagement to embed circularity from the planning phase onward. All approaches were tested and demonstrated across real-world urban projects, providing scalable models for future circular construction initiatives.

More information
Circular Economy Built Environment | Circuit

https://report.circuit-project.eu/

Transformation of existing buildings · Material reuse · Circular design · Digital mapping · City-level policy alignment

Circular Economy in the Construction Sector (KARMA)

Project title:	KARMA
Project program:	Interreg Europe – EU-funded cooperation project
Timeline:	2023-2027 (ongoing)
Project partners:	7 partners from Germany, Belgium, Italy, Hungary, and Romania, including Free and Hanseatic City of Hamburg (lead partner), Circular Flanders, Regione Calabria, and Suceava Municipality.

The KARMA project aims to drive circular construction practices by improving local and regional climate policies through interregional cooperation. Focused on the construction sector's resource intensity and environmental impact, KARMA promotes greater resource efficiency, optimized waste management, and new circular business models for public and private construction projects.

KARMA organizes policy learning activities, staff exchanges, and stakeholder engagement to identify and transfer good practices. The project targets improvements to policy instruments such as Regional Operational Programmes and Sustainable Energy and Climate Action Plans. Key areas include housing restoration, demolition waste management, procurement innovations, and governance for circular construction.

CircleBIM relevance

While KARMA focuses on policy improvements rather than direct technology development, its work underscores the importance of aligning digital methodologies such as BIM with circular economy policies. Strengthening governance frameworks ensures that future approaches to digital deconstruction, material tracking, and circular design are grounded in robust policy foundations across Europe.

More information

https://www.interregeurope.eu/karma

Policy improvement · Regional cooperation · Demolition waste management · Circular procurement · Governance alignment

DEvelopers of CIrcular SOlutions (DECISO)

Project title:	DEvelopers of CIrcular SOlutions (DECISO)
Project program:	EU Horizon Europe – Circular cities and regions initiative
Timeline:	2022–2025 (ongoing)
Project partners:	Partners from Italy, Germany, Portugal, and Greece, including research institutions, regional authorities, and sustainability organizations.

The DECISO project aims to support European cities and regions in advancing the circular economy by developing innovative financing schemes and strengthening local ecosystems. Through collaboration between municipalities, citizens, and businesses, DECISO mobilizes stakeholders to implement systemic solutions that promote material reuse, waste reduction, and low-carbon development.

The project focuses on enabling investment in circular economy initiatives by assisting promoters in the creation of financial models and programmes, considering not only economic aspects but also technical, legal, and social dimensions. By providing tailored support services, DECISO helps local and regional actors overcome practical barriers to circular innovation.

CircleBIM relevance

DECISO offers valuable lessons on how to build local capacity for circular construction through coordinated financing and stakeholder mobilisation. Particular emphasis is placed on designing funding mechanisms that incentivise material reuse in the construction sector, alongside promoting collaborative initiatives that connect municipalities, industry actors, and community groups.

In addition, the project demonstrates how systemic approaches such as backcasting methods, cross-sector alliances, and the scaling of successful pilot projects can accelerate the mainstreaming of circular principles across urban development. DECISO shows that strong local governance structures and integrated financing tools are key enablers for the transition to a circular built environment.

More information

Official project website (news, activities, results):
https://www.decisoproject.eu/

Official EU project registration on CORDIS (formal project description):
https://cordis.europa.eu/project/id/101082232

The project website provides up-to-date information about DECISO's activities, outputs and partners, while the CORDIS page offers the official EU project record with formal details such as funding, objectives, and consortium members.

Circular financing models · Local ecosystems · Stakeholder mobilisation · Material reuse incentives · Systemic approaches

CircBoost – Boost the Future Of Construction

Project title: CircBoost

Project program: Horizon Europe – EU-funded research and innovation project

Timeline: 2023–2027 (ongoing)

Project partners: 28 partners from across Europe, including research institutions, municipalities, construction companies, and digital technology providers.

CircBoost focuses on scaling up circular construction practices by demonstrating high levels of material reuse and digital innovation through five major pilot projects across Europe. The project aims to reach material reuse rates of 40–90%, as seen in the Barcelona and Sortland pilots. Solutions include BIM-based Digital Twin technology for selective demolition, material traceability systems, and new circular business models.

CircBoost also develops training materials, policy recommendations, and digital platforms to support widespread adoption of circular construction across Europe.

CircleBIM relevance

CircBoost deeply integrates BIM methodologies and Digital Twin technologies throughout the building lifecycle. BIM models are used to plan selective deconstruction, identify reusable materials, and connect these to digital material banks. Blockchain technology ensures secure traceability of materials, from original construction through reuse cycles. The project also pioneers dynamic BIM updates during the use phase, enhancing building adaptability and reuse potential. CircBoost showcases how combining BIM, IoT, and data-driven deconstruction methods can unlock large-scale, systemic circularity in construction.

More information

https://circboostproject.eu/

Digital twins · Selective demolition · Dynamic BIM · Material traceability · Circular business models

BAMB – Buildings as Material Banks

Project title:	BAMB – Buildings as Material Banks
Project program:	EU Horizon 2020 research and innovation programme
Timeline:	2015–2019 (completed)
Project partners:	15 partners from 7 European countries, including research institutions, universities, construction companies, technology providers and public authorities.

The BAMB project focused on transforming the building sector towards a circular economy by enabling buildings to function as material banks. The aim was to create reversible, flexible buildings where materials can easily be retrieved and reused at the end of a building's life.

A key innovation was the integration of BIM to support circular construction practices. BIM was used as a digital backbone to manage and visualize material data throughout the building lifecycle. By embedding material passports – digital datasets describing the characteristics of building materials and components – into BIM systems, the project enabled more informed decision-making for design, maintenance, and deconstruction. This integration allowed stakeholders to track materials in real time, plan for reuse, and optimize resource efficiency.

Other innovations included the promotion of reversible building design principles and the validation of these concepts through demonstration projects and pilots. These efforts showed how buildings can be designed, maintained, and dismantled to maximize material reuse and support a circular economy.

CircleBIM relevance

BAMB delivers insights for digital circular construction, especially regarding the role of structured data in enabling reuse. The material passport concept illustrates how comprehensive, standardised material data supports lifecycle management, deconstruction planning, and secondary material markets.

The emphasis on reversible design shows how early planning can significantly increase the recoverability of materials. BAMB also demonstrated the importance of creating data infrastructures and digital tools that integrate material information into BIM systems, helping architects, engineers, and owners make circular choices throughout a building's lifecycle.

More information

https://www.bamb2020.eu

Material passports · Reversible design · Structured data · Lifecycle planning · Digital infrastructure

GrowingCircle

Project title:	GrowingCircle
Project program:	National initiative focused on circular renovation practices
Timeline:	2021–2024
Project partners:	Iceland, Liechtenstein, and Norway Grants; involving construction sector stakeholders, data specialists, and sustainability experts.

GrowingCircle is a national initiative aiming to improve circularity and sustainability in the renovation of residential buildings. It includes 58 completed renovation projects, of which six detailed case studies examine key aspects of circular construction and resource management.

The case studies focus on evaluating relevant data templates according to ISO 23387 standards, assessing the role of data in asset management, and analysing the efficiency of pre-demolition audits. Additional focus areas include promoting design for disassembly and identifying key data to enhance sustainability in renovation processes.

CircleBIM relevance

GrowingCircle provides practical insights into how structured data management supports circular practices in building renovations. By applying ISO-compliant data templates and focusing on asset management, the project demonstrates how digital documentation can extend building lifespans and promote reuse strategies.

In particular, it highlights data templates as central enablers for circular construction, connecting multiple innovation strategies while addressing technical, economic, and sustainability challenges. The emphasis on pre-demolition audits and design for disassembly further shows how early data collection and planning reinforce circular outcomes.

More information

[Growing Circle](https://growingcircle.netlify.app/cases)

https://growingcircle.netlify.app/cases

Note:

ISO 23387 defines a standardised structure for construction product data to improve digital interoperability and support circular economy practices.

Reference:

ISO 23387:2020 – Data templates for construction works – Concepts and principles (International Organization for Standardization, 2020)

Renovation strategies · Data templates (ISO 23387) · Pre-demolition audits · Asset management · Design-for-disassembly

FutureBEEing

Project title: FutureBEEing
Project program: Interreg VI A – Deutschland-Nederland Programme
Timeline: 2023–ongoing

Project partners: Cross-border collaboration between Dutch and German partners, including universities, design institutions, biomaterial innovators, and sustainability organizations.

The FutureBEEing project accelerates the transition to climate-resilient and circular neighborhoods through innovative approaches for neighborhood sustainability. It focuses mainly on existing neighborhoods, with special attention to integrating circular and sustainable construction methods. A key innovation in the project is the integration of digital tools and methodologies such as BIM, which supports the use of circular materials and enhances data-driven decision-making in neighborhood development. By leveraging BIM, the project enables better planning, visualization, and lifecycle management of sustainable construction practices, making circular strategies more transparent and actionable.

The project aims to implement circular strategies through a holistic approach to neighborhood development. It is dedicated to developing solutions for the sustainability of existing neighborhoods, particularly in the cross-border areas of the Netherlands and Germany. The integration of biobased materials and sustainable construction methods is facilitated through the FB tooling. Additionally, FutureBEEing works to enhance collaboration between public and private parties, accelerating sustainable neighborhood development.

CircleBIM relevance
FutureBEEing lays the foundation for utilizing digital tools, such as BIM (Building Information Modeling), to support the use of circular materials. CircleBIM plays a crucial role in developing digital tools for biobased materials, creating material passports, and promoting circular approaches within the built environment. The project contributes to material traceability and supports the circular economy by digitally managing lifecycle data and carbon assessments of materials.

Through the FB tooling, circular strategies become more accessible and applicable by linking data to realistic neighbourhood transition scenarios, making sustainable decisions in neighbourhood development easier to implement.

More information
https://deutschland-nederland.eu/en/projects/futurebeeing/

Biobased materials · Digital workflows · Embodied carbon tracking · Educational outreach · Cross-border collaboration

Digital4CircularContstruction

Project title: Digital4CircularContstruction
Project program: Living Lab research initiative (Belgium-based)
Timeline: Ongoing
Project partners: Belgian research institutes, digital innovation partners, and industry stakeholders focused on digitalisation and circular construction.

Digital4CircularConstruction (D4CC) is an ongoing Living Lab research initiative in Belgium, uniting Belgian research institutes, digital innovation partners, and industry stakeholders to accelerate circular construction through digitalisation. The project addresses one of the most pressing barriers to circular practices in the built environment: fragmented, unreliable data exchange across the construction value chain. By developing an open-source shared protocol and agreement system, D4CC fosters interoperability and trustworthy, scalable data flows, enabling all stakeholders – from designers and contractors to material suppliers and asset owners – to exchange and access reliable circular data.

Central to D4CC is its focus on BIM as the backbone for data structuring and exchange. By integrating LCA, material passports, and building passports into BIM-enabled workflows, the project automates decision-making and streamlines circular construction practices. D4CC enhances traceability of materials and components, facilitates design for disassembly, and supports adaptive reuse, aligning closely with circular economy principles.

Moreover, the project bridges not just technical but also governance gaps by ensuring that data agreements are clear, open, and accessible. This ensures seamless communication across organisations and throughout the building lifecycle, laying the groundwork for a future in which data-driven circular construction becomes the norm rather than the exception.

CircleBIM relevance

Digital4CircularConstruction (D4CC) is directly aligned with the CircleBIM aim to advance circular construction through digital innovation. By positioning BIM as the backbone for data exchange, D4CC addresses interoperability, data trust, and integration of circularity-focused information like LCA, material passports, and building passports. Its development of an open-source protocol not only ensures broad accessibility but also enhances transparency and consistency across the construction value chain. By bridging technical and governance gaps, D4CC demonstrates how BIM can facilitate real-world circular outcomes, ensuring that materials, products, and components are traceable, reusable, and integrated seamlessly into lifecycle assessments.

More information

www.digital4circularconstruction.be

Interoperability · BIM integration · Circular data flows · Material and building passports · Lifecycle Assessment (LCA)

Cirpass 2

Project title:	Cirpass 2 – Digital product Passport
Project program:	Innovation Action funded by the European Commission under the Digital Europe Programme
Timeline:	2024-2027 (ongoing, continuing Cirpass 1 (2022-2024))
Project partners:	The CIRPASS-2 consortium comprises 49 partners from across Europe and beyond, including industry leaders, research institutions, digital technology companies, and standardisation organisations.

CIRPASS-2 aim at enabling the large-scale deployment of Digital Product Passports (DPPs). By creating standardized digital identities for products, CIRPASS-2 addresses a key challenge in the transition to a circular economy – the need for transparency and traceability of materials and components across their lifecycle. The project spans four critical value chains: textiles, electrical and electronic equipment, tyres, and construction materials, directly supporting more sustainable and circular practices in these industries.

In the construction sector, CIRPASS-2's development of DPPs is highly relevant for BIM. By linking detailed material and product information through DPPs into BIM environments, stakeholders can access real-time, trustworthy data on a product's origin, composition, lifecycle performance, and end-of-life options. This connection enables circular construction strategies, such as design for disassembly, material reuse, and improved lifecycle management. The integration of DPPs into BIM workflows facilitates data-driven decision-making for architects, engineers, contractors, and facility managers, enhancing collaboration and promoting a circular built environment.

CIRPASS-2 also supports standardisation efforts to ensure interoperability and broad adoption of DPPs across Europe, aligning with the construction industry's increasing reliance on digital twins and BIM models to manage the complexity of modern, sustainable buildings. By demonstrating real-world pilots, including in construction, CIRPASS-2 showcases how digital technologies and circular economy principles can drive a more resilient, resource-efficient, and low-carbon future for Europe's built environment.

CircleBIM relevance

D4CC directly targets core CircleBIM challenges: interoperability, data structuring, and digital trust. By framing BIM as a backbone for circular data flows, the project reinforces the potential for BIM to support LCA, traceability, and reuse planning. It bridges technical and governance gaps, ensuring that tools and platforms can communicate across organisations and life cycle stages. This lays the foundation for scalable, data-driven circular construction practices.

More information

https://cirpass2.eu/

Digital Product Passports · Circular economy · Traceability · Construction materials · standardisation

CCBuild – Centre for Circular Building

Project title: CCBuild – Centre for Circular Building

Project program: CCBuild is part of Vinnova's "Challenge-driven Innovation" (Utmaningsdriven Innovation, UDI), Step 3.
Led by the IVL Swedish Environmental Research Institute in collaboration with broad stakeholders in the Swedish building and real estate sector.

CCBuild is a Swedish national arena designed to accelerate and enable the transition to circular construction through digitalization, collaboration, and reuse. It provides digital services, tools, and knowledge to stakeholders in construction, real estate, interior, and furniture sectors to facilitate both internal reuse (within projects or organizations) and external reuse via a digital marketplace.

Key components include:

- Marketplace: A platform where reusable building materials, interiors, furniture and circular services can be listed and procured.
- Product bank: A digital inventory and registry for materials, products and components, which supports internal reuse (within organizations or projects), as well as quality assessment, including environmental/climate impacts.
- Inventory app: A mobile app synchronized with the product bank to tag, label, record and manage inventory of reusable items. Helps in documenting what exists, its condition, usability etc.
- Digital services & value analysis: Tools and services to analyze and evaluate re-use, both for material quality and environmental/climate effects.
- Collaboration & knowledge sharing: CCBuild acts as a meeting point ("arena") for industry players to share good practices, develop circular working methods, and jointly overcome technical, logistical and regulatory barriers to reuse in the construction sector.

The idea is to make reuse easier, more transparent, and more standardised, thereby contributing to reduced waste, lower carbon footprints, and more efficient material flows in built environment lifecycle phases: construction, demolition, interior refurbishment etc.

CircleBIM relevance

CCBuild is directly relevant to CircleBIM as it provides the digital infrastructure – product bank, inventory app, and marketplace – that makes building materials traceable and reusable. These tools complement CircleBIM's goal of embedding circular data and reuse workflows into BIM for public construction projects. By serving as a national arena for collaboration in Sweden, CCBuild offers practical experience, tools, and industry engagement that CircleBIM can build upon and scale across the North Sea Region.

More information
https://ccbuild.se/en/

Circular construction · Digital marketplace · Material traceability · Reuse and upcycling

Key learnings from other development projects

Across the projects presented, a clear pattern emerges that circular solutions in construction are significantly strengthened when digital tools, processes, and methodologies, such as BIM, material passports, and digital twins, are integrated early in planning and decision-making processes. The most successful initiatives combine technological innovation with strong collaboration across stakeholders and governance levels, often supported by targeted political or organisational frameworks.

Several projects highlight the importance of

Early stakeholder involvement

Standardized data models and transparency

A clear strategy for reuse and disassembly, already in the design phase

These experiences demonstrate that meaningful progress toward a more circular construction sector is not driven by a single solution but by the interplay between tools, practice, and governance. Some of the interesting common clusters for the development projects are:

- **Digital Tools & BIM**: Most projects used BIM to support lifecycle planning, material tracking, and collaboration. Some advanced projects applied digital twins and blockchain for enhanced traceability.
- **Material Traceability**: Material passports and digital inventories were common tools to support reuse and design-for-disassembly.
- **Design for Circularity**: Several projects integrated design-for-disassembly (DfD) and lifecycle thinking early in the planning phase to retain material value.
- **Governance & Collaboration**: Cross-sector partnerships and supportive policy frameworks were key to enabling circular practices.
- **Biobased Materials**: A few projects explored biobased construction as a low-carbon alternative, though this remains a growing area.

Key Learning prompts

Digital twins · BIM integration · Material passports · Lifecycle analysis · Traceability
Cross-sector collaboration · Regional governance · Policy innovation · Trust frameworks
Biobased materials · Value chains · Design-for-disassembly · Circular procurement
Urban transformation · Data transparency · Stakeholder engagement · Digital marketplaces

6. BIM supported Tools

This section constitutes an evaluation and mapping of the previously enumerated projects which can improve circularity in projects, and that can inspire users of the CircleBIM Framework to their own innovative applications of BIM tools and technology. Tools were evaluated according to the relevant phase within the CircleBIM Framework, their purpose as it relates to circularity, and the minimum BIM maturity level required to successfully implement the tool. The results of this evaluation are collated in Table 5 – note that this collation is indicative and not prescriptive, thus the use of a given tool for a given project is still dependent on an individual assessment of the needs and peculiarities of that project.

Table 5: Overview of the analysed BIM supported Tools.

Tool Category	*Phase*	*Description*	*BIM Maturity Level*
Circularity Measurement	All Phases	Methodologies and tools for quantifying and monitoring Circularity Performance.	0+
LCA	Planning & Procurement of Design, Design, Permitting & Procurement of Construction, Operation, Management, Maintenance, Pre-demolition Audit	Methodologies and tools for Life Cycle Assessments, including modelling and comparison of circular alternatives.	0+
LCC	Planning & Procurement of Design, Design, Permitting & Procurement of Construction	Methodologies and tools for Life Cycle Costing, including modelling and comparison of circular alternatives.	0+
Stakeholder Engagement Platforms	All Phases	Tools, technologies, and platforms that enable stakeholder engagement, knowledge sharing, and dissemination of project/municipality circularity performance.	1+
Digitalisation Tools	Construction, Pre-demolition Audit, Demolition/Deconstruction	Tools for generating data from existing, non-digital building, material, and product documentation.	1+
Materials Passports/Data-repositories	Planning & Procurement of Design, Design, Permitting & Procurement of Construction, Construction, Delivery, Operation, Management, Mainenance, Pre-demolition Audit, Demolition/Deconstruction	Documentation of materials, products, and components, that provide the necessary information for reuse.	1+
Digital Marketplaces	Planning & Procurement of Design, Design, Permitting & Procurement of Construction, Construction,	Platforms that facilitate the sale, donation, purchase, and lending of materials, products, components, and equipment, as well as tools and	1+

	Operation, Management, Maintenance, Pre-Demolition Audit, Demolition/Deconstruction	platforms that enable collation of these.	
Data-Sharing Solutions	All Phases	Tools, technologies, reference architecture, and the services built on these that facilitate sharing and traceability/reliability of data.	2+
Digital Twin	All Phases	Tools, technologies, and interfaces that enable the integration of multiple data-sources to create digital models of buildings and municipalities based on real-time data and with the possibility to simulate potential project impacts.	3

Tool Descriptions

The following constitutes a concise presentation of the identified tools, including a short description, assessment of the required BIM maturity level, and examples where appropriate.

Circularity Measurement

Circularity measurement tools and methodologies serve to quantify the degree of circularity in a project, municipality, or region, with the goal of developing indicators that motivate improvement. The exact definition of what constitutes circularity can vary, as methodologies must be developed with an intended end-use. Thus, methodologies that are applicable for monitoring municipal circular economy readiness are not appropriate for monitoring renovation project circularity, and project teams must assess these tools in light of their specific use-case.

Most circularity measurement methodologies are not BIM-dependant, thus require only the lowest BIM maturity level. However, BIM solutions can serve to collate and store the data required to apply these methodologies, and highly integrated BIM systems can integrate these measurement methodologies through services and plugins, thereby expediting their use.

Application Examples

- The Platform CB'23 circularity measurement method defines indicators, data-requirements, and determination methods for circularity in construction (*Measuring Circularity Guide A Measurement Method for Circular Construction*, 2022).
- The Digital DeConstruction project's Reversible BIM tool implements a methodology for generating a Digital Reversibility Assessment (DRA), which evaluates a building's potential for reuse based on a method described by E. Durmisevic (Circular Building Knowledge Platform, 2022).
- The Buildings As Material Banks (BAMB) project developed a Circular Building Assessment Prototype based on the Circular Building Assessment (CBA) methodology developed as a part of the same project. The prototype integrated BIM-model data with Materials Passports and geomEngine data to generate assessments (BAMB, 2018).

Life Cycle Analysis (LCA)

LCA are a key methodology for determining construction projects' environmental impacts, with the aim of quantifying said impacts to motivate improvement. These assessments are becoming standard practice with a number of member states mandating LCAs for certain building types. A methodology for these assessments in Europe is standardised in the ISO 14040 and ISO 14044 standards, and a developing ecosystem of practitioners can provide independent assessments of projects.

In principle, LCA is not BIM-dependent, and thus, requires the lowest level of BIM maturity. However, web services and tools that integrate BIM data with external databases to generate LCA reports are available, which facilitate comparison of circular alternatives and expedite the design phase.

Application Examples

- Tally is a Revit plug-in that enables LCA generation based on a BIM-model from within the BIM-model software (Tally, 2021).
- The EC3 tool integrates BIM-model quantity data with a third-party Environmental Product Declaration (EPD) database. EPD-data is supply-chain specific, and the tool enables EPD-declaration for manufacturers, as well as audit and verification of these (Building Transparency, 2024).

Life Cycle Costing (LCC)

LCC is the process of calculating the total cost of a building over its entire lifespan. Such analyses are an integral part of the building process, thus circular projects must also pass muster with respect to these analyses. ISO 15686 standardises the methodology for these assessments.

Similarly to the previously discussed tools, LCC is not BIM-dependent, but integration with BIM-tools can expedite workflows and enable analyses that would otherwise be prohibitive timewise.

Application Examples

- Research by Galle, W., et al. demonstrated a method for BIM-based LCC analysis comparing conventional and circular scenarios (Waldo Galle, 2016).

Stakeholder Engagement Platforms

Stakeholder engagement is an essential aspect of any project, and this is particularly pertinent for municipal projects, as municipalities have an essential facilitatory role in fostering local circular economies. Engagement can include spreading awareness of circular principles and methodologies all the way to dissemination of concrete performance indicators and reports.

Stakeholder engagement requires at least file-based BIM considering the modern digital landscape, while greater integration with data storage systems and Augmented and Virtual Reality (AR & VR) technologies enables the use of innovative platforms and solutions.

Application Examples

- Bodø municipality engaged a broad range of stakeholders with a range of events, workshops, and conferences, including gamification and networking initiatives (Bodø, 2024b).
- Helsinki, Copenhagen, London, and Hamburg used Tableau to create a circularity dashboard that visualises each municipality's circular economy capacity (CIRCUIT, 2023).

Digitalisation Tools

Digitalisation tools enable the creation of BIM data and models from documentation that is not yet digitalised. This can range from BIM-model software plug-ins that can convert 2D plans into 3D models to automated workflows utilising drone-based 3D scanning and GIS-integrated model generation. While the focus of the assessed tools has largely been on model generating tools, this is not mandatory, and digitalisation tools can deal with all forms of BIM, where conversion from physical or less digitised documentation to higher levels of digital integration is desired.

Application Examples

- WiseBIM is a Revit plug-in that enables the generation of 3D models from 2D plans (WiseBIM, 2024).
- BIM-Y, 4D Architects, and Block Materials created a method for generating 3D point-clouds from a portable 3D scanning solution. These point-clouds could then be converted into 3D models (Circular Building Knowledge Platform, 2024).

Materials Passports/Data-repositories

Materials passports document key information about materials, products, and components, particularly their composition, properties, and use history. This facilitates data-sharing for the materials in question, which facilitates circular construction and reuse.

At a foundational level, materials passports and data-repositories require file-based BIM, as material data must be centralised for the concept to create value. Greater levels of BIM integration can have synergetic effects with other tools by creating a data-rich environment for analysis methods and other activities.

Application Examples

- The CityLoops project developed a databank which integrated with a digital marketplace, enabling storage of uniform data, including 3D-models and reports, regarding reuseable materials, components, and products, that could be validated and later uploaded to the marketplace (Mikkeli, 2024).
- The BAMB project specifies templates for products that manufacturers can use, which in turn facilitates integration of product data in CBA assessments (BAMB, 2018).

Digital Marketplaces

Digital marketplaces include a variety of platforms and aggregation tools/platforms that facilitate the sale, donation, sharing, and purchase of used and surplus materials, products, components, and equipment. These platforms serve to formalise the circular economy in a market-space that not only creates networks between construction stakeholders, but that also can generate market data for further analysis.

These platforms require at least a file-based BIM, to facilitate sharing of material specifications in order to ascertain value and reusability. Further integration could enable integrated procurement, such as implemented in some Electrical CAD solutions – though this has yet to be demonstrated.

Application Examples

- Genbyg.dk is a Danish company that buys and sells used materials and components, as well as facilitating B2B through their network of building sector actors (Genbyg.dk, 2025).
- Werflink is a Belgian platform where users can buy, sell, donate, and share used and surplus materials, products, components, and equipment (Werflink, 2025).
- Salza is a Swiss platform that enables building owners to register materials, components, and products in their buildings before demolition in order to facilitate reuse and circularity when these buildings reach their end of life (Salza, 2025).
- Materials Reuse Portal is a result of the EU Horizons Circuit project that collates listings from multiple marketplaces, as well as facilitating creation of materials passports through user uploaded data (CIRCUIT, 2022).
  Integration Guide: (CIRCUIT; ReLondon, 2022)

Data-Sharing Solutions

Data-sharing is a key enabler of circular construction, but there are many challenges for this including regulatory frameworks, data interoperability, and trust between stakeholders. Data-sharing solutions are a catch-all for technologies, platforms, and frameworks that enable data-sharing through solving one or more of these challenges.

Data aggregation and management from multiple sources to multiple end-users is a key goal of high-level BIM, thus it is important that foundational processes and technologies are already well-entrenched for successful data-sharing to take place. Ultimately, data-sharing with external stakeholders has web integration as a focal target, although internal sharing can function as a stepping stone to this.

Application Examples

- The Circuit project developed a number of recommendations for gathering, using, and improving the quality of data for measuring circular indicators (CIRCUIT, 2025).
- The Growing Circle project investigated Digital Data Templates (DDTs) as enablers for circular construction supported by BIM-based digital twin (Growing Circle, 2022).
- BIMchain exploits blockchain technology to verify and track data, identities, and transactions for the purpose of enabling sharing of BIM-data. Key facets include identity management, traceability, and encrypted storage of historical event data (BIMchain, 2018).

Digital Twin

Digital twin is a data-based modelling concept that ranges from digital shadows built solely on historical data to digital twins with integrated model- and simulation-based feedback. It is particularly these advanced implementations that support circular construction with the possibility to model and analyse environmental changes and construction process impacts based on multiple real-time data-streams.

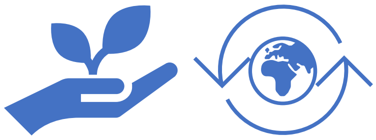
Digital twin can be seen as the logical development of BIM level 3, where the “BIM Hub” becomes a data-source in its own right. Interoperability is key, as multiple analysis and visualisation solutions should ideally integrate with the twin in order to extract maximal value. Digital twin projects are likely to be complex, involve many stakeholders, and require specialist knowledge to ensure successful implementation.

Application Examples

- The CityLoops project developed a digital twin of Bodø, Norway, by integrating data from many data-sources, including statistical, municipal, and emissions data. The twin could then be accessed for visualisation and analysis through platforms such as ArchGIS, Archicad, and Power BI (Bodø, 2024a).

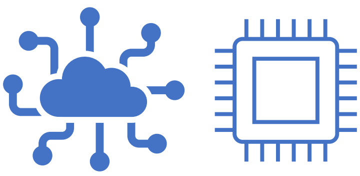
7. Future work

As the CircleBIM project moves forward, it becomes essential to define measurable targets that can guide the continued integration of circular principles and digital tools in the construction sector. Future work should focus on scaling tested practices, strengthening cross-sector collaboration, and ensuring consistent data-driven implementation across projects. To monitor and evaluate progress, a structured set of Key Performance Indicators (KPIs) is proposed. These KPIs cover three critical areas: circularity of materials, digital integration through BIM, and organisational development across stakeholders and regions.



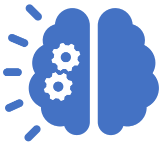
Circularity KPIs

- % of reused or recycled materials per project
- % reduction in virgin material use
- Design for Disassembly (DfD) rating score
- Lifecycle carbon savings (kg CO_2-eq/m^2)
- % of component designed for reuse in future projects
- % of bio-based or renewable materials



Digital Integration KPIs

- % of projects using BIM beyond LOD 200 (information-rich models)
- % of components with linked material passports
- Number of interoperable data exchanges between platforms (e.g., BIM ↔ material banks)
- % of building components traceable via digital IDs



Organisational KPIs

- Number of stakeholders trained in circular-BIM workflows
- Number of regional/national policies aligned with digital circularity practices
- Number of partnerships established for pilot implementation

Establishing relevant KPIs enables CircleBIM and its partners to translate strategic goals into actionable metrics. By tracking circular material flows, digital maturity, and stakeholder engagement, these indicators will support continuous learning, policy alignment, and transparent reporting. The KPIs also provide a shared foundation for benchmarking progress across regions and scaling successful approaches. Moving forward, these measures will be crucial in embedding digital circularity as a standard practice in construction projects across Europe.

Visibility and documentation of BIM use

While this report highlights several promising practices in circular construction, one notable gap across the case studies is the limited visibility and documentation of BIM processes. Although BIM was often implied or assumed to be part of the workflow, few projects explicitly described how it was applied to support circular strategies such as material tracking, lifecycle assessment, or design for disassembly.

This lack of clarity presents a challenge for knowledge transfer and replication. For the CircleBIM project to scale its impact, it is essential that future work focuses on making BIM use more transparent, structured, and measurable. This includes:

- Clearly documenting how BIM tools were used in each phase of the project.
- Sharing practical workflows and data structures that support circular outcomes.
- Ensuring that BIM-related practices are captured in project reporting and linked to specific KPIs.
- Encouraging project teams to reflect on lessons learned from BIM implementation, including challenges and workarounds.

By improving the visibility of BIM processes, CircleBIM can foster stronger knowledge sharing, enable replication of successful methods, and support the development of standardized digital circularity practices across the sector.

References

Akbarnezhad, A., & Xiao, J. Z. (2017). Reusing building materials and components: An overview of current practices. *Resources, Conservation and Recycling*, *123*, 131–135. https://doi.org/10.1016/j.resconrec.2017.02.007

BAMB. (2018). *Circular Building Assessment Prototype - BAMB*. https://www.bamb2020.eu/post/cba-prototype/

Biblus Editorial Team. (2025). *BIM maturity Levels: from stage 0 to stage 3*. Biblus. https://biblus.accasoftware.com/en/bim-maturity-levels-from-stage-0-to-stage-3/

BIMchain. (2018). *Bimchain*. https://bimchain.io/

Bodø. (2024a). *3D GIS-based visualisation tools for monitoring and planning Blueprint for replication*.

Bodø. (2024b). *Stakeholder engagement in Bodø Extract from the Demonstration Report*.

Building Transparency. (2024). *EC3 - Building Transparency*. https://www.buildingtransparency.org/tools/ec3/

Buildings Forum. (2022). *Buildings Forum*. https://buildings-forum.com/fr/projects/detail/3045

buildingSMART International. (2025). *openBIM*. BuildingSMART. https://www.buildingsmart.org/about/openbim/

Buildwise by BOVA-Architects| architectenweb.nl. (2022). *Circulariteit is leidraad bij renovatie WTCB-kantoorgebouw in Zaventem - architectenweb.nl*. https://architectenweb.nl/nieuws/artikel.aspx?id=49155

Buro De Haan Architectuur | Ontwerp Van der Sluis Transport. (2024). *Buro De Haan Architectuur | Ontwerp Van der Sluis Transport*. https://www.bdh.nl/architectuur/portfolio/van-der-sluis-transport#

Cambier, C., Galle, W., & De Temmerman, N. (2020). Support Tools for Circular Building. *Buildings*, 1–20.

CIRCUIT. (2022). *Home - Material Reuse Portal*. https://materialreuseportal.com/

CIRCUIT. (2023). *Circularity Dashboard | Circuit*. https://www.circuit-project.eu/circularity-dashboard

CIRCUIT. (2025). *Data and indicators for a circular built environment | CIRCULAR CONSTRUCTION IN REGENERATIVE CITIES*. https://report.circuit-project.eu/chapter/data-and-indicators-for-a-circular-built-environment

CIRCUIT; ReLondon. (2022). *Project Progress Update Project Aims and Objectives*.

Circular Building Knowledge Platform. (2022). *Reversible BIM - Circular Building Knowledge Platform*. https://knowledgeplatform.gtb-lab.com/project/reversible-bim-2/

Circular Building Knowledge Platform. (2024). *3D Scanning - Circular Building Knowledge Platform*. https://knowledgeplatform.gtb-lab.com/project/3d-scanning/

Construire la Wallonie. (2023). *Le BIM facilite la validation des données et la circularité d'un projet pilote prestigieux*. https://construirelawallonie.be/construction/le-bim-facilite-la-validation-des-donnees-et-la-circularite-dun-projet-pilote-prestigieux/

DARK Arkitekter | Økern Portal. (2021). *DARK Arkitekter | Økern Portal*. https://darkarkitekter.no/prosjekt/okern-portal

Ellen MacArthur Foundation. (2019a). *NON-TECHNICAL CASE STUDIES An approach to measuring circularity*.

Ellen MacArthur Foundation. (2019b). *The butterfly diagram: visualising the circular economy*. https://www.ellenmacarthurfoundation.org/circular-economy-diagram

Ellen MacArthur Foundation. (2020). *The circular economy: Definition & model explained [Video interview with Dame Ellen MacArthur by Joe Iles]*. https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview?

Ellen MacArthur Foundation. (2021). *Circular economy in the built environment*.

Ellen MacArthur Foundation, & ANSYS Granta. (2019). *METHODOLOGY: An approach to measuring circularity Published 2015 , adapted in 2019 Project Team*.

EU BIM Task Group. (2017). Handbook for the introduction of Building Information Modelling by the European Public Sector. In *EU BIM Task Group / European Commission*. http://www.eubim.eu/handbook/

European Commission. (2018). *Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste*.

Genbyg.dk. (2025). *Brugte byggematerialer - Danmarks største udvalg - Genbyg.dk*. https://genbyg.dk/

Giarma, C., Lombardi, P., Askar, R., Trubina, N., Tovar, D. S., Salles, A., Oral, H. V., Pineda-Martos, R., Karanafti, A., Feizollahbeigi, B., Mateus, R., Moghadam, S. T., Turk, J., Borg, R. P., & Bragança, L. (2025). Implementation and Consideration of Circularity Within International Sustainability Assessment Methods. In L. Bragança, P. Griffiths, R. ASkar, A. Salles, V. Ungureanu, K. Tsikaloudaki, D. Bajare, G. Zsembinszki, & M. Cvetkovska (Eds.), *Circular Economy Design and Management in the Built Environment: A Critical Review of the State of the Art* (pp. 545–624). Springer.

Green HUB house | Himmerland Boligforening. (2025). *GREEN HUB HOUSE — Boligbyggeri fra 4 til 1 planet*. https://www.4til1planet.dk/blog_eksempelbyggerier/green-hub-house

Growing Circle. (2022). *Growing Circle*. https://growingcircle.netlify.app/knowledge/data-templates-circular-construction-enablers

Güngör, B., Agibayeva, A., Karaca, F., Askar, R., Giarma, C., Rosado, L., Pineda-Martos, R., Griffiths, P., & Bragança, L. (2025). Circularity Tools and Frameworks for New Buildings. In L. Bragança, P. Griffiths, R. ASkar, A. Salles, V. Ungureanu, K. Tsikaloudaki, D. Bajare, G. Zsembinszki, & M. Cvetkovska (Eds.), *Circular Economy Design and Management in the Built Environment A Critical Review of the State of the Art* (pp. 431–458). Springer.

Heisel, F., & McGranahan, J. (2024). Enabling Design for Circularity with Computational Tools. In C. De Wolf, S. Çetin, & N. Bocken (Eds.), *Circular Economy and Sustainability A Circular Built Environment in the Digital Age* (1st ed., pp. 97–110). Springer.

Heuvelstraat, S. | W. (2024). *Heuvelstraat, Silvolde | Wonion*. https://www.wonion.nl/projecten/heuvelstraat-silvolde/

Honic, M., Magalhães, P. M., & Bosch, P. Van den. (2024). From Data Templates to Material Passports and Digital Product Passports. In C. De Wolf, S. Çetin, & N. Bocken (Eds.), *A Circular Built Environment in the Digital Age* (1st ed.). Springer. https://doi.org/https://doi.org/10.1007/978-3-031-39675-5_5

Hout. (2025). *Hout*. https://woneninsawa.nl/hout

International Organization for Standardization. (2018). *ISO 19650-1:2018 —Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — Part 1: Concepts and principles*. https://www.iso.org/standard/68078.html

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221–232. https://doi.org/10.1016/J.RESCONREC.2017.09.005

Marchesi, M., & Tavares, V. (2025). Design Frameworks for Circular Buildings: Circular Principles, Building Lifecycle Phases and Design Strategies. In L. Bragança, P. Griffiths, R. Askar, A. Salles, V. Ungureanu, K. Tsikaloudaki, D. Bajare, G. Zsembinszki, & M. Cvetkovska (Eds.), *Circular Economy Design and Management in the Built Environment* (pp. 127–173). Springer. https://doi.org/https://doi.org/10.1007/978-3-031-73490-8_6

Measuring Circularity Guide A measurement method for circular construction. (2022).

Mikkeli. (2024). *Databank and digital marketplace for recovered materials Blueprint for replication*.

Nobre, G. C., & Tavares, E. (2021). The quest for a circular economy final definition: A scientific perspective. *Journal of Cleaner Production*, *314*, 127973. https://doi.org/10.1016/J.JCLEPRO.2021.127973

Ossio, F., Salinas, C., & Hernández, H. (2023). Circular economy in the built environment: A systematic literature review and definition of the circular construction concept. *Journal of Cleaner Production*, *414*, 137738. https://doi.org/10.1016/J.JCLEPRO.2023.137738

Pineda-Martos, R., Askar, R., Karaca, F., Simone, M. De, Borg, R. P., Malešev, M., Radonjanin, V., Bas, B., Çavdar, A. D., Puma, G. C. C., Rosado, L., & Bragança, L. (2025). Circularity Criteria and Indicators at the Construction Material Level. In L. Bragança, P. Griffiths, R. ASkar, A. Salles, V. Ungureanu, K. Tsikaloudaki, D. Bajare, G. Zsembinszki, & M. Cvetkovska (Eds.), *Circular Economy Design and Management in the Built Environment - A Critical Review of the State of the Art* (pp. 299–333). Springer.

Pioneer in Recycling | A26 architects | Holcim.com. (2024). *World's first fully recycled concrete building | Holcim*. https://www.holcim.com/who-we-are/our-stories/fully-recycled-concrete-building

Platform CB'23. (2022). *Measuring Circularity Guide: Core method for measuring circularity in the construction sector*.

Pomponi, F., & Moncaster, A. (2017). Circular economy for the built environment: A research framework. *Journal of Cleaner Production*, *143*, 710–718. https://doi.org/10.1016/J.JCLEPRO.2016.12.055

remountable construction: showcase temporary court in Amsterdam | cepezed. (2016). *remountable construction: showcase temporary court in Amsterdam | cepezed*. https://www.cepezed.nl/en/tijdelijke-rechtbank-amsterdam-op-weg-naar-enschede/

Salza. (2025). *Salza*. https://salza.ch/

SAWA - Mei architects and planners. (2025). *SAWA - Mei architects and planners*. https://mei-arch.eu/projecten/sawa/

Shillcock, P. (2019). *From BS 1192 to ISO 19650 and everything in between*. NBS. https://www.thenbs.com/knowledge/from-bs-1192-to-iso-19650-and-everything-in-between?utm_source=chatgpt.com

Tally. (2021). *Tally*. https://choosetally.com/

Volk, R., Stengel, J., & Schultmann, F. (2014). Building Information Modeling (BIM) for existing buildings — Literature review and future needs. *Automation in Construction*, *38*, 109–127. https://doi.org/10.1016/J.AUTCON.2013.10.023

Waldo Galle. (2016). *GalleW.2016ScenarioBasedLifeCycleCostingDoctoralthesis.VrijeUniversiteitBrusselBrussels (1)*. https://www.researchgate.net/publication/321170412_Scenario_Based_Life_Cycle_Costing_an_enhanced_method_for_evaluating_the_financial_feasibility_of_transformable_building

WBCSD. (2022). *Circular Transition Indicators v3.0*. World Business Council for Sustainable Development. https://www.wbcsd.org/resources/circular-transition-indicators-v3-0/

Werflink. (2025). *Parksharing Werflink is hét online deelplatform voor ieder bedrijf actief in de bouwsector | Parksharing Werflink*. https://www.floow2.community/werflink.html

WiseBIM. (2024). *WiseBIM AI for Autodesk® Revit®*. https://wisebim.app/

Zhang, C., Hu, M., Di Maio, F., Sprecher, B., Yang, X., & Tukker, A. (2022). An overview of the waste hierarchy framework for analyzing the circularity in construction and demolition waste management in Europe. *Science of The Total Environment*, *803*, 149892. https://doi.org/10.1016/J.SCITOTENV.2021.149892

References Figures

Figure 1: The Butterfly Diagram (also referred to as the Material Circularity Indicator (MCI) illustrating the two key cycles of a circular economy: the biological cycle and the technical cycle. The diagram highlights loops to minimize waste and preserve value within the economy (Ellen MacArthur Foundation, 2019b)

Figure 2: The 10R framework. From (Kirchherr et al., 2017)

Figure 3: Comparison of (a) circular economy and (b) waste hierarchy framework. From (Zhang et al., 2022)

Figure 4: BIM Maturity levels (Biblus Editorial Team, 2025)

Figure 5: Overview of the methodology used in this report.

Figure 6: Green roof Van der Sluis transport Buro de Haan. Archive photo. (Buro De Haan Architectuur | Ontwerp Van der Sluis Transport, 2024)

Figure 7: Aluminium windowframes Buro de Haan. Archive photo. (Buro De Haan Architectuur | Ontwerp Van der Sluis Transport, 2024)

Figure 8: Temporary courthouse Amsterdam. (remountable construction: showcase temporary court in Amsterdam | cepezed, 2016)

Figure 9: Disassembling temporary courthouse. (remountable construction: showcase temporary court in Amsterdam | cepezed, 2016)

Figure 10: Elements temporary courthouse. (remountable construction: showcase temporary court in Amsterdam | cepezed, 2016)

Figure 11: New build project of Van der Sluis transport. (Buro De Haan Architectuur | Ontwerp Van der Sluis Transport, 2024)

Figure 8: Temporary courthouse Amsterdam. (remountable construction: showcase temporary court in Amsterdam | cepezed, 2016)

Figure 12: Demountable elements for future reuse at the Van der Sluis transport premises. (Buro De Haan Architectuur | Ontwerp Van der Sluis Transport, 2024)

Figure 13: Visualisations of the Green Hub House. C.F. Møller Architects. Green Hub House. (Green HUB house | Himmerland Boligforening, 2025)

Figure 14: Visualisations of the Green Hub House. C.F. Møller Architects. Green Hub House. (Green HUB house | Himmerland Boligforening, 2025)

References Tables

CircleBIM is co-funded by the European Union (ERDF) under the
Interreg North Sea Programme 2021-2027.

Interreg
North Sea

Co-funded by
the European Union

CircleBIM