



Creating materials banks
from digital urban mining

D4.1 Urban Mining Concept

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Creating materials banks from digital urban mining

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EXECUTIVE SUMMARY

The construction sector is confronted with the necessity of transitioning from a linear “take-make-dispose” model to a circular economy to significantly reduce resource consumption and CO₂ emissions. The concept of “Urban Mining”, which redefines the existing building stock as a valuable material repository, represents a central solution strategy for this purpose. The SUM4Re project addresses the critical hurdle to its implementation—the lack of systematic data on the material composition of existing buildings—by developing a comprehensive digital workflow. This report summarizes the core findings from the application of this workflow at three distinct pilot sites in Svalbard (Nordic pilot), The Hague (Dutch pilot), and Spain.

The methodology applied in the project is based on standardized Pre-Demolition Audits (PDAs) according to DIN SPEC 91484, supported by the use of digital tools. Using the CIRDAX mobile application, material data was systematically captured on-site and subsequently transferred to the Concular analysis platform. There, a Circular Life Cycle Assessment (LCA) was used to determine key performance indicators such as the Circularity Performance Index (CPX), CO₂ reduction potential, and the economic residual value of the materials. This data-driven analysis formed the basis for developing site-specific Urban Mining Concepts.

The application of the workflow at the pilot sites provided quantitative evidence for the ecological and economic feasibility of the urban mining approach:

- **Nordic Pilot (Svalbard):** The analysis of the lightweight timber construction revealed a high potential for reuse (98% of the mass) and a CPX of 33%. The circular strategy results in a saving of 37.1 tonnes of CO₂ equivalents and realizes an estimated residual material value of approx. €580,000.
- **Dutch Pilot (The Hague):** For the heavy mineral construction, the focus was on high-quality recycling (77% of the mass), leading to a CPX of 24%. For this site, CO₂ savings of 53.3 tonnes and a residual material value of over €2.7 million were determined.
- **Spanish Pilot (San Sebastián):** Due to administrative changes, a typological analysis was conducted for a mineral-based building archetype. This confirmed the strategic potential of the workflow even in data-scarce scenarios.

The findings demonstrate that the business case for urban mining is context-dependent but consistently positive. It is driven either by high replacement costs (Nordic) or by the volume of recoverable materials (Dutch).

Based on the insights gained from the pilot projects, three strategic recommendations are derived:

1. **For Construction Practice:** The implementation of a “digital-first” approach for PDAs is fundamental. A hybrid circularity strategy, which initially targets the reuse of high-value, non-structural components (e.g., technical equipment, sanitary fixtures) and is supplemented by material-specific deconstruction protocols, maximizes both economic and ecological benefits.
2. **For CO₂ Reduction and Resource Efficiency:** The direct reuse of components with high embodied carbon (e.g., timber, technical equipment) is the most effective strategy for CO₂ avoidance. In mineral-based buildings, resource efficiency is maximized through the high-quality recycling of large material streams. Digital material passports are crucial to overcome the information asymmetry between supply and demand for secondary materials.
3. **For Policy and Industry:** To scale up urban mining, the policy framework must be strengthened, for instance, by mandating digital PDAs and creating incentives in public procurement. The development of standards for quality assurance and certification for reused components is necessary to build trust in the market and promote acceptance.

In summary, it is demonstrated that a digitized and standardized urban mining process is a crucial prerequisite for unlocking the ecological and economic potential of the existing building stock and advancing the transition to a circular construction economy.

GLOSSARY

Terms, Abbreviations, and Acronyms

BGF:	Brutto-Grundfläche (Gross Floor Area)
BIM:	Building Information Modelling
BRI:	Brutto-Rauminhalt (Gross Volume)
C-BIM:	Circular Building Information Modelling
CEAP:	Circular Economy Action Plan
CENTS:	CEN Technical Specification
CPX:	Circularity Performance Index
DIN SPEC:	Deutsches Institut für Normung - Spezifikation
DMP:	Digital Material Passports
DPP:	Digital Product Passports
EPS:	Expandiertes Polystyrol (Polystyrene)
FOS:	Fibre Optic Sensing
GPR-ECT:	Ground Penetrating Radar – Electromagnetic Compatibility Testing
GWP:	Global Warming Potential
HOAI:	Honorarordnung für Architekten und Ingenieure (eng. Fee schedule for architects and engineers)
iMMS:	integrated Mobile Mapping Systems
IDS:	Information Delivery Specifications
KPI:	Key Performance Indicators
LCA:	Life Cycle Assessment
MBO:	Musterbauordnung (eng. Model building regulations)
MCI:	Master Circularity Indicator
MFA:	Materials Flow Analysis
MPG:	MilieuPrestatie Gebouwen (Environmental Performance of Buildings)
NS:	Norsk Standard (Norwegian Standard)

NTA:	Nederlands Technische Afspraak (Dutch Technical Agreement)
PDA:	Pre-Demolition Audit
PV:	Photovoltaic
RVS:	Roestvrij staal (eng. Stainless steel)
UMI:	Urban Mining Index
XRF:	X-ray Fluorescence

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1. Introduction

The construction industry is a primary global consumer of raw materials and a major contributor to CO₂ emissions and waste generation. The prevailing linear "take-make-dispose" model is increasingly unsustainable in the face of climate change and resource scarcity, creating an urgent need to transition towards a circular economy within the built environment. A central strategy in this transition is the concept of Urban Mining, which reframes existing buildings as valuable "material banks" rather than as waste at the end of their lifecycle. By systematically recovering and reusing components and materials, urban mining offers a direct pathway to reduce environmental impacts, conserve virgin resources, and generate new economic value.

However, the widespread implementation of urban mining is hindered by a critical barrier: the lack of systematic, reliable data on the material composition of the existing building stock. To unlock the potential of these material banks, a structured and digitally enabled workflow is required to identify, quantify, and assess the value of building components before renovation or deconstruction.

The SUM4Re project directly addresses this challenge by developing and validating a comprehensive digital workflow for urban mining. This report presents the core findings from the practical application of this workflow across three distinct pilot sites in Svalbard (Nordic pilot), The Hague (Dutch pilot), and Spain. It focuses on the outcomes of the Pre-Demolition Audits (PDAs) and the subsequent Building Circularity Reports, which serve as the foundational data for developing tailored Urban Mining Concepts for each location. By presenting these results, this work provides a quantitative and qualitative evidence base for the environmental benefits and economic viability of digitally driven circular construction practices.

2. Background and Framework

2.1. Circular Economy in the Built Environment

Circular economy principles in construction represent a paradigm shift from the traditional "take–make–dispose" model towards a regenerative system. In this model, buildings are not only consumers of resources but also *reservoirs of value*, where materials, components, and products circulate within closed loops rather than becoming waste. Applied to the built environment, circularity includes strategies such as design for disassembly, modular construction, reuse of structural elements, and recycling of building materials with minimized downcycling.

A growing body of research underscores the potential benefits of this transition. Studies show that circular construction can significantly reduce embodied carbon, cut lifecycle costs, and generate new business opportunities through secondary material markets (Finamore & Oltean-Dumbrava, 2024). The academic discourse has evolved in three phases: (1) "the key areas of research were mainly related to CE adoption measures, policies, and frameworks at different levels of countries, regions, etc." (2006-2013), (2) "focused on the challenges of CE-enabled design as an early-stage measure to promote circularity, e.g., through design for disassembly and deconstruction using design tools" and "addressing the concerns of sustainability and sustainable development as well as energy and energy efficiency within the context of the building industry" (2013–2018), and (3) "research on introducing potential methodologies for CE evaluation, such as using the [Life Cycle Assessment (LCA)] (framework for evaluating the quantifiable benefits in terms of environmental impacts and associated costs, and materials flow analysis (MFA) for assessing the flow of materials during the entire life cycle after" after 2016 (Norouzi, Chàfer, Cabeza, Jiménez, & Boer, 2021). Today, topics such as *circular cities*, *urban mining*, and *digitalisation* dominate the research frontier, reflecting both technological advances and policy momentum.

Importantly, circularity is not only an environmental strategy but also an economic and social one. By extending the life of buildings and their components, reducing dependence on virgin resources, and creating new value chains for recovered materials, circular construction strengthens resilience and competitiveness across the construction sector. However, achieving systemic circularity requires coordinated efforts between architects, engineers, policymakers, and material suppliers, as well as robust tools to assess and manage circularity indicators across scales.

2.2. Urban Mining and Pre-Demolition Audits

Urban mining operationalises circular economy principles by treating the existing building stock as a "material bank." Instead of viewing end-of-life buildings as waste, this approach identifies and extracts valuable resources – such as concrete, steel, glass, timber, and technical installations – for reuse or recycling. With an estimated 600 million tons of construction and demolition waste generated globally in 2020 and growing each year (Soto-Paz, Arroyo, Torres-Guevara, Parra-Orobio, & Casallas-Ojeda, 2023), the potential of urban mining is enormous.

Central to this process are *PDA*s, systematic assessments of the quantity, quality, and recoverability of materials in a building before demolition or renovation. These audits provide essential data on which components can be dismantled intact, which materials can be directly reused, and which require recycling or safe disposal. In Europe, the Construction and Demolition Waste Management Protocol (European Commission: Directorate-General for Internal Market, et al., 2024) recognise such audits as a cornerstone of resource-efficient construction, supporting both regulatory compliance and sustainable practice.

Urban mining also links directly to the concept of *material passports* and *building circularity reports*. By documenting the properties, location, and potential reuse of materials, these instruments enhance transparency, traceability, and marketability of secondary resources. Advanced methods – including 3D laser scanning, MFA, and life cycle assessment (LCA) – further strengthen the precision and efficiency of audits.

Beyond technical aspects, urban mining has important strategic implications. It supports local economies by creating secondary material markets, reduces environmental impacts by cutting demand for virgin resources, and lowers CO₂ emissions associated with extraction and production. At the same time, it raises logistical and organisational challenges, including the need for new business models, cross-sector collaboration, and scalable digital solutions to match supply and demand for recovered materials.

2.3. Digitalisation and BIM for Circularity

Implementing circular practices at scale requires reliable data on material stocks and their properties. Building Information Modelling (BIM) has emerged as a crucial enabler by digitally representing components, systems, and materials. The emerging concept of Circular BIM (C-BIM) extends BIM's scope to deconstruction and reuse, integrating parameters such as material composition, disassembly potential, and reusability indices. Complementary tools include Digital Material Passports (DMPs), Product Passports (DPPs), and Building Logbooks, which provide structured datasets to support material recovery.

Pre-deconstruction audits already play a vital role in this transition. By systematically recording material types, quantities, and conditions during on-site inspections, these audits generate datasets that can be directly fed into digital models. In practice, this often involves combining manual inventories with technologies such as laser scanning, photogrammetry, and computer vision, enabling the creation of digital twins even for older buildings without prior documentation. This process not only improves the accuracy of material recovery planning but also helps establish digital records that can be updated and reused in future renovation cycles.

Recent research and project experiences demonstrate how PDAs are becoming increasingly sophisticated through a combination of qualitative and quantitative methods. A structured approach typically begins with desk research, reviewing literature, standards, and best practices on material identification and structural assessment. This is followed by defining baseline requirements, addressing technical, legal, and environmental constraints that influence data acquisition and reuse potential. Based on these insights, a scan plan is developed, employing advanced technologies such as iMMS (integrated mobile mapping systems), XRF (X-ray fluorescence), GPR-ECT (Ground Penetrating Radar – Electromagnetic Compatibility Testing), and FOS (Fibre Optic Sensing). These tools enable precise characterisation of material properties and structural conditions that would otherwise remain invisible.

The on-site phase of the audit executes this scan plan, ensuring rigorous documentation of sampling methods, equipment calibration, and data validation. Collected data is then processed and analysed to assess material qualities, structural integrity, and reuse potential. Crucially, the results are integrated into digital platforms such as CIRDAX and CONCLAR, which ensure traceability and enable cross-project assessment. Beyond environmental benefits, these digitalised audit processes also impact labour productivity, as streamlined data acquisition and automated analysis reduce time, costs, and uncertainty in recovery planning.

In this way, PDAs act as an *entry point* for digitising the existing building stock. They convert fragmented or analogue information into structured, interoperable data; facilitate integration into BIM environments; and allow stakeholders to simulate different deconstruction and reuse scenarios. Over time, these practices can establish comprehensive digital repositories of urban material stocks, providing a robust foundation for large-scale urban mining strategies.

2.4. Standards, Indicators, and Policy Context

Several frameworks and indicators have been developed for assessing building circularity, including the Urban Mining Index (UMI) (Rosen, 2025), the Madaster Circularity Indicator (MCI) (Madaster, 2018), and the DGNB Circularity Index (Deutsche Gesellschaft für Nachhaltiges Bauen, 2024). These tools evaluate parameters such as material separability,

recycling potential, and the proportion of secondary materials used. European initiatives such as the Circular Economy Action Plan (CEAP), the Renovation Wave, and the updated Construction and Demolition Waste Management Protocol (2024) (European Commission: Directorate-General for Internal Market, et al., 2024) reinforce the integration of circular principles into national building codes and standards.

In addition to these established frameworks, emerging digital solutions are gaining traction. The Concular platform, for example, applies the Circularity Performance Index (CPX) (Concular, 2023) to measure and communicate the reuse potential and circular value of building components across projects. By combining PDAs data with CPX evaluations, Concular enables transparent reporting and comparability, thus bridging the gap between practical material recovery and policy requirements.

The overarching ambition of the SUM4Re project is to ensure that its solutions – ranging from PDAs to digital integration frameworks – are fully compatible with European directives and national standards in participating countries. By aligning with EU-level initiatives while remaining adaptable to national regulatory contexts (e.g., Dutch MilieuPrestatie Gebouwen (MPG), Norwegian Norsk Standard (NS) standards, Spanish frameworks), SUM4Re aims to create replicable, scalable tools that can be deployed widely across Europe. This dual alignment ensures both policy compliance and industry uptake, supporting the transition towards a truly circular built environment.

2.5. Knowledge Gaps and Opportunities

Despite progress, challenges remain. Barriers include fragmented data, lack of standardised parameters, and limited interoperability across digital systems. Moreover, inconsistencies in methods and indicators hinder comparability across projects. A further difficulty lies in the mismatch between supply and demand of secondary building materials. While PDAs and urban mining can generate detailed information about available resources, markets for these materials often lack transparency, scalability, and trust. This creates uncertainty for both suppliers and buyers. Digitalisation offers a key solution here: by integrating audit results into digital platforms, material availability can be matched more efficiently with demand, fostering new marketplaces for reused construction products.

At the same time, regulatory harmonisation is advancing as a key strategy to address these challenges. The adoption of DIN SPEC¹ 91484 (DIN SPEC 91484:2023-09, 2023), which standardises data requirements for selective demolition, marks a significant first step towards

¹ A specification published by the German Institute for Standardization

a common European framework. This specification establishes a consistent methodology for the *what*—the identification and documentation of reusable materials.

Building directly on this foundation, the next crucial step is the standardisation of the *how*: the implementation of a "Deconstruction Concept for Existing Buildings" (*Rückbaukonzept für Bestandsgebäude*) (DIN SPEC 91525, 2024), which is currently under development. This forthcoming DIN SPEC will provide general principles for translating the data from PDAs into a binding, value-preserving deconstruction plan. Its core objectives are to create a reliable basis for high-value subsequent use of building components, facilitate their reclassification from waste to secondary products, and ensure legally compliant documentation of material flows. By defining a structured process rather than specific demolition techniques, it ensures that the reuse potential identified during the audit is maximized, thereby addressing the logistical and organisational challenges of Urban Mining.

The wider application of such interconnected standards is essential to overcoming national fragmentation and creating consistent criteria for material quality, traceability, and reuse potential. Addressing these gaps through harmonised standards, improved digital infrastructures, and scalable pilot demonstrators will accelerate the development of a functioning European market for secondary materials and strengthen the transition to a circular construction economy.

Digital tools play a key role in this process:

- **CIRDAX (Block Materials):** Used on-site during the audit to capture building materials systematically. The app allows quick and standardised recording of material categories, quantities, and conditions in the field. (Blockmaterials, 2025)
- **Circular LCA Tool (Concular):** After data collection, audit results are transferred to Concular, where the information is processed and enriched through *Circular Life Cycle Assessment (Circular LCA)*. This enables quantification of embodied carbon, reuse potential, and broader environmental impacts. (Concular, 2025)

In this project, both applications are combined: CIRDAX ensures a structured, reliable data capture in the field, while Concular provides the analytical backend to evaluate circularity performance and align results with policy frameworks.

Basic Information		
Data field	Data	Obligation
Building category	according to HOAI, Annex 10.2	shall
Location	street, town, postcode	shall
Construction/type	selection from: Monolithic construction method, prefabricated construction method, mixed construction method	shall
Year of manufacture	year	shall
Building class	according to MBO ² § 2 Para. 3	shall
BRI (Gross volume)	according to DIN 277	shall
BGF (Gross floor area)	according to DIN 277	shall
Type of use	according to HOAI, Annex 10.2	shall
Information about past renovations	text	shall
Building construction	text	shall
Type of building	according to HOAI ³ , Annex 10.2	shall
History of use	text	shall

²Musterbauordnung (eng. Model building regulations)

³Honorarordnung für Architekten und Ingenieure (eng. Fee schedule for architects and engineers)

Rough access (e.g. lift available, scaffolding possible)	text	shall
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Table 1 - Table 1 - Required data fields for basic building information during a Stage 1 PDA, as specified by DIN SPEC 91484 (DIN SPEC 91484:2023-09, 2023)

Data to be included per building product in stage 1		
Data field	Data	Obligation
Viewing level	text	shall
Designation	text	shall
Location	3d model reference (BIM interface), GIS, drawing viewer, 2D drawing with coordinate reference	shall
Connection types (rough estimate)	text	shall
Quantity	number	shall
Unit	text	shall
Manufacturer	text	shall
Height (in mm)	number	shall
Width (in mm)	number	shall
Length (in mm)	number	shall
Obvious suspicion of pollutants	text	shall
Photos	A precise description shall be given of what is to be represented by photos: Condition of use, material quality, installation situation, location	should
Condition of use -- visual	text	should
Function of the building product in building structure	Selection from: - building envelope - technical building services - finishing parts - others	shall
Further information	Continuous text	can
Potential for high-quality reutilization	Selection from: - Yes - No - No conclusive assessment possible	shall

Justification of the assessment	text	should
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Table 2 - Mandatory ('shall') and recommended ('should') data fields for the preliminary assessment (Stage 1) of a building product, as specified by DIN SPEC 91484 (DIN SPEC 91484:2023-09, 2023). These fields form the basis for the initial classification of reuse potential.

3.2. Circularity Assessment Parameters

Once the material stock is recorded, it is systematically evaluated against circularity criteria. This evaluation enables a ranking of building products and components based on their circular value, forming the evidence base for strategic recommendations in renovation and demolition planning. This circularity evaluation is not performed during the on-site audit itself but is applied after data collection, using Concular's Circular LCA module. It uses indicators such as the Circularity Performance Index (CPX) (Concular, 2023), Urban Mining Index (UMI) (Rosen, 2025), or DGNB Circularity Index (Deutsche Gesellschaft für Nachhaltiges Bauen, 2024). They can be applied to benchmark results and provide comparable reporting based on standardised parameters. Core parameters include:

- **Reuse potential:** Determining whether components (e.g., steel beams, timber structures, façade panels) can be dismantled intact and reused directly. Key criteria include demountability, condition, and standardisation.
- **Recyclability:** Assessment of material separability and contamination levels, indicating whether recycling can occur at high value or with downcycling risks.
- **Embodied carbon:** Calculation of emissions saved by reusing or recycling versus producing virgin materials. This provides a quantitative climate impact assessment.
- Other LCA parameters: ecotoxicity, resource depletion etc.

3.3. Data Processing and Integration

The data collected during PDAs is first structured, validated, and processed to ensure consistency and reliability across all building elements. This step provides the foundation for identifying key opportunities for reuse, recycling, and safe disposal. In addition to the audit findings, 3D scans are performed using technologies such as laser scanning or photogrammetry. These scans generate point cloud models, which enable the creation of highly accurate digital models of the buildings and building components. The models not only provide detailed geometric information but also allow a more precise evaluation of the quality and condition of components, supporting decisions about dismantling strategies and reuse potential.

Once processed, the results are integrated into the digital platforms CIRDEX (Blockmaterials, 2025) and Circular LCA (Concular, 2025), which ensure traceability and facilitate cross-project comparisons. Concular applies the Circularity Performance Index (CPX) (Concular, 2023) as a standardised metric for benchmarking circularity. In addition to CPX values, the platform also calculates CO₂ savings and a material value indicator that quantifies the environmental and economic impact of reuse compared to the use of primary construction products. These additional indicators are crucial for demonstrating both ecological and financial benefits of circular strategies.

The combination of PDA data, circularity indicators and scan-derived 3D-models allows for the creation of digital twins of existing buildings and building components. Digital twins enable stakeholders to simulate various reuse and recycling scenarios, compare intervention strategies, and analyse the implications of selective deconstruction or component retention. To support practical application, the platforms also provide clear exports, dashboards, and decision-support tools that visualise material flows, reuse potential, and associated savings. These outputs simplify the decision-making process and enable stakeholders to make transparent, numbers-based assessments, ensuring that circular strategies can be implemented efficiently and effectively.

3.4. Urban Mining Concept Development

PDA results and the subsequent circularity assessments are synthesised into a comprehensive Urban Mining Concept. These are co-designed with the experience of the relevant construction partners (MOYUA, CTH, NORSKE, AFDECOM) to ensure practical feasibility and alignment with on-site expertise. These concepts provide concrete circular construction strategies for each pilot site which can be directly applied in practice. A particular focus is placed on structural elements such as timber beams, reinforced concrete, asphalt, steel beams, and concrete components. These product groups represent the largest volumes and the highest potential for carbon savings when kept in use within the building cycle.

Within those Urban Mining Concepts, the methodology goes beyond general inventories and applies a prioritisation of high-value materials, identifying which components are most suitable for direct reuse, which require processing before reapplication, and which may be recycled without significant quality loss. This process enables the formulation of tailored recommendations for the main material groups, providing specific guidance on dismantling methods, potential reuse pathways, and opportunities for substitution of virgin resources.

The Urban Mining Concept also includes an estimation of CO₂ reductions and material value gains that can be achieved through reuse and recycling strategies. These quantified benefits not only illustrate the ecological advantages of circular approaches but also strengthen their

economic case, demonstrating how secondary material flows can reduce costs and create added value within local markets.

Ultimately, the outputs of the Urban Mining Concept serve as a decision-support tool for stakeholders. They provide actionable guidance for renovation planning, stakeholder engagement, and policy alignment, ensuring compatibility with both national frameworks and European-level objectives such as the Circular Economy Action Plan and the Renovation Wave. By integrating material-focused recommendations with broader circularity strategies, the concept contributes to retaining as much of the existing building stock as possible, while simultaneously advancing the development of resource-efficient, low-carbon renovation practices.

4. Pilot Sites Overview

4.1. Nordic Pilot (Svalbard)

4.1.1. Pilot description



Figure 2 - Picture of the Nordic pilot – One building of several modular buildings with the same building style (SUM4Re)

The Nordic pilot is situated in Longyearbyen, Svalbard, one of the northernmost settlements in the world and representative of more than 500 Arctic communities expected to face major challenges in the coming decades due to thawing permafrost. These environmental risks are compounded by severe logistical constraints, including high costs for material transport, workforce, and equipment, which make resource efficiency and reuse not only environmentally relevant but also economically necessary.

Arctic buildings are typically lightweight structures composed of timber frames, rock wool insulation, wooden panel cladding, vinyl and parquet flooring, and wooden-framed windows and doors, some of which are made with low-durability materials such as cardboard. Many of the existing buildings suffer from unstable foundations, which have caused issues with structural integrity, doors, windows, and piping systems.

Within SUM4Re, the pilot focuses on Elvegrenda, where 36 apartments (50–60 m² each) will be retained and upgraded through the construction of new foundations and remodelling of elements in good technical condition. This approach demonstrates how reuse and refurbishment can extend the lifespan of vulnerable building stock under extreme climatic conditions.

The goal is to deliver a framework tailored to the local, in this case Arctic contexts, addressing:

1. Mapping of components and materials, and selection of disassembly techniques to increase recycling and reuse.
2. Data acquisition methods and structured workflows for creating Circular BIM (C-BIM) models of the existing stock.
3. Data processing and sharing within C-BIM, including reuse and repair indicators for all building elements and comparison of acquisition methods.
4. Guidelines for decision-makers and planners, focusing on circular building practices in permafrost zones and remote locations, ensuring that knowledge can be scaled to similar Arctic communities.

By combining material recovery strategies with digitalisation, the Nordic pilot exemplifies how circular approaches can help safeguard habitable environments in highly challenging and resource-constrained contexts. (SUM4Re Consortium, 2023)

4.1.2. Overview PDA

A detailed PDA was conducted for a representative "Cube Block" unit at the Nordic pilot site in Svalbard. The resulting material inventory confirms the building's characterization as a lightweight, timber-based construction, which is typical for the Arctic region.

The material composition is dominated by wood and wood-based products, with a total volume of approximately 59 m³. This comprehensive category includes structural timber beams (spruce), OSB, particleboard (e.g., for kitchen units), and MDF panels. A substantial amount of insulation material, crucial for buildings in Arctic climates, was also identified, totaling over 29 m³. This consists mainly of high-performance wood fibre and glass wool insulation.

Technical installations represent another significant group, highlighted by the presence of photovoltaic (PV) cells. While smaller in volume, components like metals (stainless steel, zinc, aluminium), plastics, and sanitary fixtures are also present and documented.

A key finding of the audit is the high potential for direct component reuse (marked as Product Reuse), as specified for a majority of the catalogued items. This applies particularly to sanitary fixtures (toilets, showers), interior and exterior doors, kitchen units, and technical equipment

like PV cells and air conditioning units. Structural timber also shows high potential for reuse if carefully dismantled, aligning with the core objectives of circular construction in remote and resource-constrained environments.

Component Group	Material(s)	Approx. Volume (m ³)	Assumed Reuse/Recycling Potential
Wood & Wood Panels	Spruce, Hardwood, MDF, OSB, Particle Board	59.1	High (Product Reuse)
Insulation	Wood Fibre, Glass Wool, PIR/PUR	29.5	High (Product Reuse)
Technical Equipment	PV Cells, Air Conditioning, Electrical	~1.5	High (Product Reuse)
Metals	Stainless Steel, Zinc, Aluminium, Chrome	~1.3	High (Product Reuse / Material Recycling)
Sanitary & Glazing	Ceramic, Glass, Plastics	~0.4	High (Product Reuse)
Plastics & Foils	PVC, PE, Rubber, Tape	~0.1	Low to Medium (Material Recycling)
Finishing Products	Paint, Adhesives, Sealants	~0.2	Low (Energy Recovery / Disposal)

Table 3 – Nordic Pilot - Audit result sorted by volume grouped by component types

4.2. Dutch Pilot (The Hague)

4.2.1. Pilot description



Figure 3 - Picture of Dutch pilot (SUM4Re)

The second pilot is located in The Hague, within the large-scale urban transformation of *the Binckhorst*, a 130-hectare industrial district currently being redeveloped into a mixed-use residential and business area. Over the course of this long-term project, approximately 15,000 housing units will be added, alongside extensive demolition and renovation works. Within SUM4Re, the case study focuses on two buildings in the sub-area *Mercuriuskwartier*, representing complementary approaches to demolition and renovation.

- Building Sint Barbaraweg 4 (3 floors, 2,029 m²) will be deconstructed to serve as a source for urban mining. Its concrete structural elements and masonry walls constitute the primary material flows, which are designated mainly for high-quality recycling. The concrete is planned to be crushed (on- or off-site) to produce recycled aggregate for use in new concrete or as a sub-base material (material recycling). The masonry will also be processed, with individual bricks potentially being cleaned for direct reuse at the component level, or the bulk material being recycled into crushed brick. These recycling pathways contrast with the potential for direct component reuse identified for elements such as window frames and glazing, which can be carefully dismantled and reinstalled in new projects without significant reprocessing.
- Building Polluxstraat 15 (2 floors, 5,092 m²) is a heritage structure formerly used as dwelling quarters, office, and workshop. In contrast to Sint Barbaraweg 4, this building will undergo renovation, with a specific target of incorporating 50% secondary materials sourced from the demolished building. Its primary material composition also consists of concrete structures and masonry walls, making it particularly suitable for integrating reclaimed components.

This pilot demonstrates the practical application of urban mining at a local scale, where products recovered from dismantling are directly repurposed into renovation projects within the same district. By linking the two buildings, the case exemplifies how circular strategies can minimise waste, reduce embodied carbon, and preserve cultural heritage, while simultaneously supporting the broader urban transformation of The Hague. It also highlights the advantages of having donor and receiving buildings in proximity, reducing transportation needs and further lowering environmental impact. (SUM4Re Consortium, 2023)

4.2.2. Overview PDA

The PDA of the donor building at the Dutch pilot site (Sint Barbaraweg 4) provided a comprehensive material inventory, with quantities recorded by volume and weight. The data confirms that the building is a heavy construction dominated by mineral-based materials.

The inventory is overwhelmingly characterized by structural concrete, which constitutes the largest fraction with a total volume of approximately 585 m³. This includes load-bearing walls, floor slabs (including hollow-core slabs), and foundations. An additional 41 m³ of non-structural concrete was identified in façade cladding and window sills. The second-largest material group is masonry, with over 280 m³ of brick and sand-lime block used for both structural and non-load-bearing walls.

Other significant material streams identified include:

- Insulation materials, primarily EPS (Polystyrene), with a total volume of about 89 m³.
- Roofing materials, such as asphalt and bitumen, and aggregates like gravel and basalt, together accounting for over 70 m³.
- Metals, including steel profiles, reinforcement, and aluminium frames, represent a smaller volume but hold high value for recycling and reuse.

Components with a high potential for direct reuse (Product Reuse), as specified in the audit, include aluminium window frames, wooden doors, steel railings, and various concrete façade elements. This detailed breakdown allows for a targeted deconstruction strategy to maximize material recovery for the adjacent renovation project (Polluxstraat 15).

Component Group	Material(s)	Approx. Volume (m ³)	Reuse/Recycling Potential (from audit)
Structural Concrete	Concrete	585.5	Material Recycling / Product Reuse
Masonry	Brick, Sand-Lime Block	284.1	Product Reuse / Material Recycling
Insulation	EPS, Foam Glass	88.8	Material Recycling (High Quality)
Roofing & Aggregates	Bitumen, Gravel, Basalt	72.8	Product Reuse / Material Recycling (Low Quality)
Non-Structural Concrete	Concrete (Façade, Sills)	41.2	Product Reuse
Wood Components	Timber, Plywood, Particle Board	18.9	Product Reuse
Steel & Stainless Steel	Steel, Stainless Steel (RVS)	5.0	Product Reuse / Material Recycling
Windows & Doors	Aluminium, Glass, Wood	4.8	Product Reuse / Material Recycling
Other Materials	Aluminium, Lead, Plastics, etc.	~2.0	Mixed

Table 4 - Dutch Pilot - Donor Building - Audit result sorted by volume grouped by component types

4.3. Spanish Pilot (San Sebastián)



Figure 4 - Picture of a part of the Spanish Pilot - Second hall of Anoeta train station (SUM4Re)

The Spanish pilot was originally designed around the renovation and transformation of the old San Bartolome school area in San Sebastián into a new shopping centre. The case study comprised two buildings, with the main structure of 2,000 m² over four floors integrated into the hillside. In the planned redevelopment, this building would expand to nine floors—four designated for retail and five underground for parking facilities. Building interventions included a combination of demolition and renovation.

The existing buildings contained a diverse mix of materials: clay tiles, wooden and glass windows, masonry and concrete walls, protective coating and plaster, reinforced concrete beams and columns, steel beams, and asphalt on access roads. Structural assessments identified typical concrete pathologies, including loss of cohesion, cracking, spalling, efflorescence, excessive deformation in structural elements, and corrosion in reinforced concrete and steel components. Within SUM4Re, the pilot was intended to demonstrate how digital tools and circular practices could simultaneously address structural challenges and support the conservation of historical heritage, while enhancing the area's economic and social value. Planned tasks included:

1. Virtual replica generation of road and structural elements.
2. Real-time monitoring using Fibre Optic Sensing (FOS).
3. Application of inverse techniques for assessing mechanical performance.

4. XR-based virtual interaction for immersive analysis.
5. Decision-making support systems.
6. Integration of results into a material bank.

(SUM4Re Consortium, 2023)

4.3.1. Spanish Pilot Description

As the original Spanish pilot site at the San Bartolome school became unavailable due to unforeseen administrative changes, a new composite pilot was established. It focuses on two distinct deconstruction sites in San Sebastián: the Anoeta train station and the Jolastokieta residential development. This dual-site approach provides a representative cross-section of common material flows from both infrastructure and building demolition in the region.

- **Anoeta Train Station Site:** This site focuses on large-scale infrastructure deconstruction. Key activities include the dismantling of asphalted access roads, the demolition of the old station hall, and the removal of reinforced concrete elements such as diaphragm walls, partly using specialized techniques like hydrodemolition. The primary material flows generated are milled asphalt and crushed reinforced concrete, offering a prime opportunity to analyse strategies for high-quality recycling into new construction applications.
- **Jolastokieta Residential Development Site:** This second site involves the demolition of old buildings characterized by reinforced concrete and structural steel frames. While the concrete provides another source for recycling, the key focus here is on the potential for direct component reuse. The project will employ advanced monitoring techniques, such as Fibre Optic Sensing (FOS), to assess the structural integrity of the steel components during deconstruction, with the aim of validating their suitability for direct reuse in new structures.

4.3.2. Consequent Methodological Adaptation

This shift in the pilot site prevented the execution of a detailed, on-site PDA for a single building within the project's timeframe. Consequently, a direct, data-driven material inventory, as conducted for the Nordic and Dutch pilots, could not be generated for one specific object.

To still meet the project's objectives and develop a valuable Urban Mining Concept for the Spanish context, the methodological approach was adapted. Instead of a single-building audit, the concept will be developed based on the representative building typology provided by the Anoeta and Jolastokieta sites. This approach leverages a combination of data sources to create a robust and transferable framework:

- **Baseline Data from New Pilot Sites:** The material data and deconstruction plans for the Anoeta and Jolastokieta sites (reinforced concrete, asphalt, structural steel) serve as a realistic foundation for typical deconstruction projects in the region.
- **Analysis of building archetypes:** A generalized material inventory will be created based on the common construction standards and practices observed at the new pilot sites, establishing a "typical" material composition and quantity range for comparable projects.
- **Cross-Pilot benchmarking:** Findings and key performance indicators from the detailed audits of the Nordic and Dutch pilots will be used as a reference to estimate potential recovery rates, challenges, and opportunities for the Spanish archetype.
- **Expert Knowledge:** Input from local project partners regarding regional deconstruction practices, available technologies, and secondary material markets will enrich the strategic recommendations.

The resulting Urban Mining Concept will therefore not be a quantitative material passport for a single building, but rather a strategic guideline for common deconstruction typologies in Spain. It will identify the most probable high-volume and high-value material streams, assess their general potential for reuse and recycling, and outline best-practice.

5. Building Circularity Reports (per Pilot)

This chapter translates the foundational data gathered during the PDAs into comprehensive circularity assessments for the pilot sites. The goal is to move beyond a simple material inventory towards a quantitative and qualitative evaluation of the buildings' potential within a circular economy. By applying a standardized assessment framework, this section provides the evidence base for developing and validating the Urban Mining Concepts and circular renovation strategies.

The analysis for each pilot is structured around four key performance indicators (KPIs), calculated using the Concular Circular Life Cycle Assessment (LCA) tool:

- **Circularity Performance Index (CPX):** A holistic, percentage-based score that quantifies the overall circular potential of the assessed building components. It provides a quick and comparable measure of how effectively materials can be kept in circulation (Concular, 2023).
- **Material Flow Analysis:** A detailed breakdown of material quantities channeled into distinct end-of-life pathways: direct product reuse, high-quality material recycling, and final disposal (e.g., incineration or landfill).
- **Environmental Impact Reduction:** The calculated savings in embodied carbon, measured in tonnes of CO₂-equivalents (t CO₂-eq), achieved by implementing circular strategies compared to a linear baseline of demolition and new construction with virgin materials.
- **Economic Value Proposition:** An estimation of the residual material value (€) that can be recovered by reintroducing the components and materials into the market, highlighting the economic case for urban mining.

The following sub-chapters will apply this assessment framework to the Nordic and Dutch pilot sites. By systematically presenting these KPIs, a transparent comparison is enabled, which helps to identify the specific opportunities and challenges inherent in each building typology and context. The overarching objective is to demonstrate how structured circularity assessments can inform evidence-based decision-making and unlock the environmental and economic potential of the existing building stock.

5.1. Nordic Pilot (Longyearbyen)

Based on the material inventory from the PDAs, a detailed circularity assessment was performed using the Concular Circular Life Cycle Assessment (LCA) tool. The analysis evaluated a total material mass of 780.27 tonnes from the representative "Cube Block" unit.

The building achieved an overall Circularity Performance Index (CPX) of 33%, indicating a high potential for circularity.

Wiederverwendungspotential

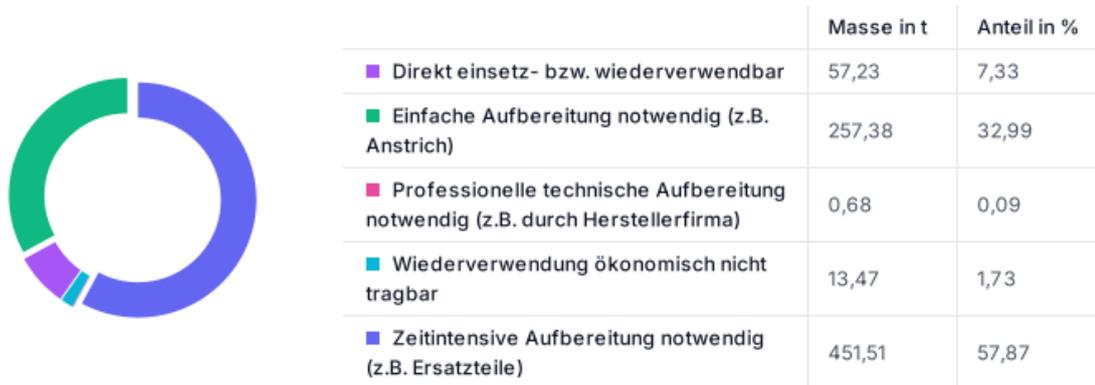


Figure 5 - Re-use potential of Nordic pilot in German. The possible reusable mass is the sum of all applicable categories (APPENDIX B)

The analysis provides a clear breakdown of the material flows into different end-of-life pathways. The results show that most of the the building's mass can be kept in circulation:

- Product Reuse: 766.8 tonnes (98.28%) of the materials are suitable for direct reuse as components in new or refurbished buildings. This includes the necessity for refurbishment of 451.51 tonnes
- Material Recycling: 1.54 tonnes (0.2%) can be directed to high-quality recycling streams.
- Thermal Valorisation/Incineration: Only 11.93 tonnes (1.5%) of the materials require disposal through incineration, primarily consisting of paints, adhesives, and non-recyclable plastics.

The implementation of this circular strategy yields significant environmental and economic benefits compared to a traditional demolition and new-build scenario. The analysis quantifies a total saving of 37.1 tonnes of CO₂ equivalents. This reduction is primarily driven by the reuse of wood components, which avoids emissions from both the production of new timber products and the incineration of the old ones. Furthermore, the recovered materials have an estimated residual material value of €580.163,03, demonstrating the economic viability of the urban mining approach for this pilot.

A closer look at the material groups reveals that wood and wood-based products are the primary contributors to the positive outcome, accounting for the largest share of both the reusable mass and the CO₂ savings. Technical components such as PV cells and high-quality

sanitary fixtures also show excellent potential for direct reuse, further enhancing the circularity performance of the building.

Parameters	Amount	Unit	Per square meter (NFA)
Total building mass	780,27	t	2,16
Circularity Potential Index	33	%	
CO2-Savings (Modul A1-A3)	-982.830	kgCO ₂ -eq	-2715
Residual Material Value	580.163,03	€	1.602,66

Table 5 – Nordic Pilot – Circularity Assessment – Summary Table

5.2. Dutch Pilot (The Hague)

Based on the Building Circularity Report, a circularity assessment was conducted for the donor building (Sint Barbaraweg 4) at the Dutch pilot site. The new analysis, performed with the Concular Circular LCA tool, covered a total material mass of 18,653 tonnes, reflecting a more comprehensive inventory of the building's heavy, mineral-based construction. The building achieved an overall Circularity Performance Index (CPX) of 24%.

Wiederverwendungspotential

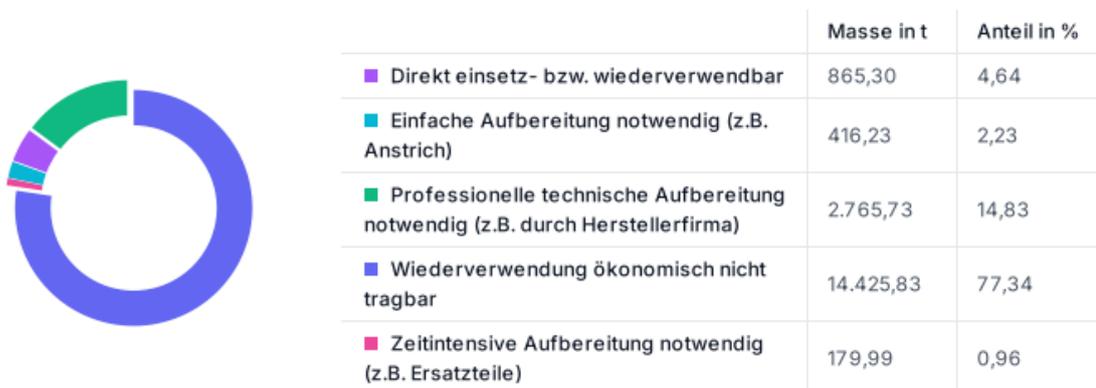


Figure 6 - Re-use potential of Dutch pilot in German language. The possible reusable mass is the sum of all applicable categories (APPENDIX A)

The material flow analysis shows a substantial potential for both high-volume recycling and component reuse:

- Material Recycling: 14,426 tonnes (77.3%) of the materials are suitable for recycling processes. This fraction consists primarily of concrete and masonry from the building's foundation and structure, which are intended for processing into recycled aggregates. An optimized approach to handle this large amount of material is described in Chapter 6.

- **Product Reuse:** 4,227 tonnes (22.7%) of components were identified as having potential for direct reuse, although this often requires some form of professional refurbishment (~15.8%). This category represents a significant portion of the building's components.
- **Thermal Valorisation/Incineration:** No significant mass was allocated to this pathway in the revised analysis.

Despite the revised CPX, the circular strategy for this heavy construction offers considerable environmental and economic advantages. The analysis quantifies a total saving of 53.3 tonnes of CO₂ equivalents compared to a linear demolition and new-build scenario. The economic assessment reveals an exceptionally high estimated residual material value of €2,745,904. This significant value is primarily driven by the large volume of high-value metals and mineral materials destined for recycling, supplemented by the components intended for direct reuse.

The updated results for the Dutch pilot confirm that urban mining strategies for heavy mineral constructions are highly effective. While the high-volume recycling of concrete and brick is crucial for reducing landfill waste and saving primary resources, the analysis now also highlights a significant potential for component reuse that plays an equally important role in the overall circularity and economic performance of the project.

Parameters	Amount	Unit	Per square meter (NFA)
Total building mass	18.653,08	t	10,22
Circularity Potential Index	24	%	
CO₂-Savings (Modul A1-A3)	9.257.820	kgCO ₂ -eq	5070
Residual Material Value	2.745.904,30	€	1.503,78

Table 6 – Dutch Pilot – Circularity Assessment – Summary Table

5.3. Spanish Pilot (San Sebastián) - Typological Potential Analysis

As no PDAs could be conducted for the Spanish pilot, this section provides a strategic circularity potential analysis based on a representative building archetype. This archetype is defined as a mid-20th-century public or commercial building in the Basque Country, reflecting the characteristics of the original San Bartolome school site. The structure is assumed to be predominantly mineral-based, similar to the Dutch pilot, with a reinforced concrete frame and masonry infill walls. The following KPIs are therefore illustrative estimates intended to demonstrate the applicability of the SUM4Re framework in data-scarce scenarios.

- **Estimated Circularity Performance Index (CPX):** For a heavy mineral-based structure, the CPX is expected to be in a similar range to the Dutch pilot, likely between 55-65%. The primary circularity pathway would be material recycling, with targeted component reuse.
- **Projected Material Flow Analysis:** The material flow would be dominated by high-volume recycling. It is estimated that over 95% of the building's mass, primarily concrete and masonry, would be destined for recycling into secondary aggregates. A smaller but high-value fraction, likely 1-3% of the mass, would be suitable for direct product reuse, including wooden interior doors, metallic components, and potentially some non-structural façade elements.
- **Estimated Environmental and Economic Potential:** While a precise CO₂ calculation is not possible, the potential for emissions reduction is significant and directly proportional to the building's mass. By ensuring high-quality recycling of mineral components, substantial virgin material extraction can be avoided. The economic value proposition would similarly be driven by the sale of large quantities of recycled aggregates, supplemented by the higher per-unit value of reusable components. The Spanish regulatory context, which includes national strategies for a circular economy, provides a supportive framework for realizing this potential (SUM4Re (VTT, THUAS, SINTEF, TECN, BLOCKM), 2025).

This typological analysis confirms that the SUM4Re methodology is adaptable and can provide valuable strategic guidance even without a detailed building-specific audit. It highlights that the key challenge in the Spanish context is not the lack of potential, but the need to systematically implement digital audits and foster local markets for secondary materials to turn this potential into reality (SUM4Re (SINTEF, RAFTER), 2025).

6. Urban Mining Concepts and Component-Specific Strategies

This chapter provides a detailed analysis of the most significant building component groups identified in the Nordic and Dutch pilot audits. Based on their mass, circularity potential, and economic value, specific recommendations are formulated to guide the deconstruction and subsequent reuse or recycling processes. These component-specific strategies form the core of the Urban Mining Concepts developed for each pilot.

6.1. Nordic Pilot: Lightweight Timber Construction

The material inventory of the Nordic pilot is dominated by lightweight, high-value components, making it an ideal candidate for a reuse-focused circularity strategy.

6.1.1. Wood and Wood-Based Products

Constituting the largest material fraction by mass (over 65%), wood components are the primary asset of this building type. This group includes structural timber beams, OSB and particleboard panels, and interior doors.

- Recommendation:** A non-destructive deconstruction approach is critical. Structural timber elements should be carefully dismantled, denailed, and visually graded on-site for potential re-certification and reuse in new load-bearing applications (SUM4Re (SINTEF, BLOCKM, VTT), 2025). Wood-based panels and doors, if in good condition, can be directly reused in the refurbishment of the retained apartments, significantly reducing both costs and the carbon footprint.

6.1.2. Insulation Materials

Insulation accounts for the largest volume after wood products and is crucial for the building's thermal performance. The pilot contains both wood fibre and glass wool insulation.

- Recommendation:** Where accessible and dry, wood fibre insulation should be carefully removed for direct reuse, as it retains its insulating properties. Glass wool is more challenging to reuse but can be sent to specialized recycling facilities where available. Given the remote location, on-site reuse strategies for lower-grade applications should also be considered to avoid transportation emissions.

6.1.3. Technical Equipment (PV Cells & HVAC)

Though small in mass, technical components like the photovoltaic panels and air conditioning units hold a high economic and environmental value.

Recommendation: These components should be de-installed by qualified technicians prior to any structural deconstruction. Their high potential for direct reuse makes them prime candidates for resale on secondary markets or for redeployment in other local building projects. A functional assessment is crucial to guarantee performance and secure their residual value.

6.2. Dutch Pilot: Heavy Mineral Construction

The Dutch pilot is characterized by high-mass mineral components, where the primary circularity strategy revolves around high-quality recycling supplemented by the targeted reuse of valuable finishing components.

6.2.1. Mineral Components (Concrete & Masonry)

Accounting for over 98% of the building's total mass, concrete and masonry are the most significant material flows. This includes reinforced concrete from the structure and masonry from infill walls.

- Recommendation:** The primary strategy is source separation during deconstruction to prevent contamination for high-quality recycling into aggregates (SUM4Re (SINTEF, BLOCKM, VTT), 2025). However, a more ambitious strategy with even greater CO₂-saving potential should be explored: the direct reuse of structural concrete elements. As outlined in the project's analysis of standardization (SUM4Re (VTT, CONC, THUAS, TECN), 2025), non-destructive testing protocols can be used to assess the quality and structural integrity of concrete. This would enable suitable elements, such as precast slabs or beams, to be cut out and reused directly in new structures, representing a major step beyond conventional recycling.

6.2.2. Finishing and Façade Components

This group includes concrete façade elements, aluminium window frames with double glazing, and wooden doors. Although they represent only a small fraction of the total mass (under 2%), they hold significant potential for direct reuse.

- Recommendation:** These components were identified in the audit as having a high "ProductReuse" potential and should be dismantled with care before the main demolition begins. Their reuse in the renovation of the neighboring building (Polluxstraat 15) directly contributes to the project's goal of incorporating 50% secondary materials and offers substantial cost and CO₂ savings compared to purchasing new elements. The value lies in preserving the functional and aesthetic integrity of the components.

6.2.3. Metallic Components

Structural steel profiles, reinforcement bars, and various smaller metallic elements (railings, fasteners) were identified.

- Recommendation:** All metallic elements should be rigorously segregated due to their high recycling value. Larger structural steel profiles should be assessed for their potential for direct structural reuse, which offers the highest environmental benefit. As demonstrated in D1.3 of this project, the pathway for reusing structural steel is well-supported by existing national standards (e.g., NTA 8713) and developing European technical specifications (e.g., CEN/TS 1090-201) (SUM4Re (VTT, CONC, THUAS, TECN), 2025). This provides a clear, standardized process for quality assessment, testing, and re-certification, which builds the necessary trust for their safe reintegration into new load-bearing structures. All other metals should be directed to dedicated metal recycling streams.

6.3. Spanish Pilot: Strategic Concept for a Mineral-Based Typology

Given the absence of a site-specific audit, the recommendations for the Spanish pilot are based on the representative building archetype of a mid-20th-century, mineral-based public building. The strategies are therefore transferable to a wide range of similar buildings in the region.

6.3.1. Mineral Components (Concrete & Masonry)

This group is assumed to represent the largest material mass. The primary strategy must be the transition from low-value backfilling to high-quality recycling.

- Recommendation:** Implement selective deconstruction protocols to separate reinforced concrete from masonry, avoiding contamination from plaster or other materials. This enables the production of certified recycled aggregates that can be used in new concrete applications, a practice supported by Spanish and EU regulations (SUM4Re (VTT, THUAS, SINTEF, TECN, BLOCKM), 2025). Test deconstructions should be performed to assess the feasibility of reusing whole bricks, which offers an even higher circularity potential.

6.3.2. Metallic and Finishing Components (Steel, Windows, Doors)

This category represents the highest potential for direct reuse and value creation.

-
- **Recommendation:** Structural steel elements should be prioritized for non-destructive testing and potential reuse. As highlighted in the project's review of standardization (SUM4Re (VTT,CONC, THUAS, TECN), 2025), established frameworks exist to verify the mechanical properties of reclaimed steel, ensuring it meets the performance requirements for new applications. Non-structural elements like wooden interior doors, window frames, and sanitary fixtures should be targeted for careful removal. The creation of a digital inventory for these components is the first and most critical step to making them available on local or national reuse platforms, thereby bridging the gap between supply and demand, which is a known challenge in the region (SUM4Re (SINTEF, RAFTER), 2025).

7. Cross-Pilot Analysis and Comparative Insights

This chapter synthesizes the findings from the individual pilot sites to derive overarching insights and transferable lessons for circular construction. By comparing the experiences from the Nordic, Dutch, and Spanish contexts, this analysis identifies common challenges, highlights shared opportunities, and evaluates the broader applicability of the SUM4Re urban mining methodology.

7.1. Common challenges and opportunities across the pilots

Despite their significant differences in climate, construction typology, and project execution, the pilot sites revealed a set of recurring challenges and opportunities that are central to implementing urban mining in practice.

7.1.1. Challenges

The practical work across the pilot sites confirmed several of the key challenges previously identified in the literature (Section 2.5), demonstrating the gap between theoretical potential and on-the-ground implementation. A primary challenge across all pilots was the acquisition of reliable and complete data. This was most evident in the Spanish pilot, where the unforeseen site change prevented an on-site audit entirely, necessitating a shift to a methodology based on building archetypes. Even where audits were conducted, as in the Nordic and Dutch pilots, significant uncertainties remained regarding concealed components in older structures that often lack precise as-built drawings. While advanced scanning methods like Ground Penetrating Radar (GPR-ECT) and Fibre Optic Sensing (FOS) are designed to inspect hidden elements such as reinforcement or structural defects, their large-scale application remains complex and resource-intensive. This highlights a fundamental uncertainty in urban mining: the true condition and quantity of embedded materials can often only be fully verified during the deconstruction itself.

This challenge of data uncertainty is compounded by the practical complexities of the deconstruction process. Both the lightweight timber construction of the Nordic pilot and the heavy mineral-based structure of the Dutch pilot underscored that selective deconstruction is inherently more complex and time-consuming than traditional demolition. While timber frames are easier to disassemble for reuse, challenges remain in separating components without damage and dealing with composite materials. Conversely, heavy materials like reinforced concrete require specialized equipment and processes to be prepared for high-quality recycling, posing logistical and financial hurdles. Beyond these technical aspects, a final significant challenge lies in the market integration for secondary components. A recurring theme was the uncertainty regarding the demand for recovered materials. While digital

platforms provide a marketplace, the broader construction industry is still adapting to sourcing second-hand components. Establishing trust in the quality of reused materials and creating stable demand remain significant hurdles for scaling up urban mining from individual pilot projects to a mainstream practice.

7.1.2. Opportunities

Conversely, the cross-pilot analysis revealed several significant and recurring opportunities, foremost among them the validation of a digitally driven workflow as a key enabler for urban mining. For both the Nordic and Dutch pilots, the use of digital tools—from on-site scanning and the CIRDAX app to the Concular assessment platform—was crucial for transforming a building from a potential liability into a structured, quantifiable material bank. This process of digitalization makes the invisible value of existing resources tangible and creates a reliable data foundation for decision-making.

This digital foundation, in turn, allowed for a clear demonstration of both the environmental and economic viability of a circular approach. Despite their distinct material compositions, both pilots proved that urban mining is beneficial. The analyses yielded high Circularity Performance Index (CPX) scores and resulted in significant CO₂ savings (37.1 t in the Nordic pilot, 53.3 t in the Dutch pilot) alongside a substantial residual material value (€580,163.03 and €2,745,904.30, respectively). These results consistently demonstrate that urban mining constitutes a viable business case, driven either by high replacement costs in remote locations (Nordic) or by the sheer volume of recoverable materials (Dutch). Furthermore, the audits consistently highlighted a particular opportunity in the high-value reuse of non-structural components. Items such as sanitary fixtures, doors, windows, and technical installations (e.g., PV panels) showed high potential for direct reuse with minimal reprocessing. Targeting these components offers a reliable and economically attractive entry point for circular practices, regardless of the primary building structure.

7.2. Differences due to Geography, Building Typology, and Regulatory Context

While the pilots shared common goals, their distinct contexts led to significant differences in the focus and outcomes of their circularity strategies. These variations underscore that urban mining is not a one-size-fits-all approach but must be adapted to local conditions.

7.2.1. Geographical and Economic Drivers

The most striking contrast exists between the Nordic and Dutch pilots. Geographically, the remote Arctic location of the Svalbard pilot imposes extreme logistical constraints and high costs for importing new materials. Consequently, the primary driver for circularity is economic necessity, favouring on-site or local product reuse to maximize self-sufficiency. In contrast, the

Dutch pilot in The Hague is situated in a dense urban environment with well-established waste management and recycling infrastructures. Here, the strategy was driven by the large volume of mineral-based materials, where the main goal was not component reuse but high-quality material recycling of concrete and masonry into aggregates.

7.2.2. Influence of Building Typology on Circularity Potential

These geographical factors are directly linked to building typology. The Nordic pilot's lightweight timber frame (total mass: 780.27 tonnes) is inherently suited for disassembly, which is reflected in its high CPX of 33 and its focus on component reuse. The Dutch donor building, a heavy mineral-based structure (total mass: 18,653 tonnes), naturally has a lower potential for direct product reuse (22.7% of mass), resulting in a lower CPX of 24. However, its absolute CO₂ savings are substantially higher due to the immense volume of mineral material diverted from landfill into recycling streams, demonstrating that both typologies offer significant, albeit different, circularity benefits.

7.2.3. Impact of Regulatory and Administrative Frameworks

Finally, the regulatory and administrative context proved to be a critical factor. The Spanish pilot exemplifies how administrative hurdles can fundamentally alter a project's course, forcing a shift from a data-driven audit to a model based on building archetypes. This highlights the need for flexible methodologies that can adapt when ideal data is unavailable. The Dutch context, with its clear regulatory incentives for sustainable construction (e.g., the MPG), provides a more stable framework for implementing and economically justifying large-scale urban mining and recycling initiatives, thus fostering a more mature market for secondary materials.

7.3. Lessons Learned on Urban Mining Applicability

The collective experiences from the SUM4Re pilots provide several key lessons regarding the practical applicability and scalability of urban mining. Firstly, a digitally-enabled workflow is non-negotiable. The success of both the Nordic and Dutch audits hinged on the ability to systematically capture, assess, and manage material data. Without digital tools to create a structured "material bank," the economic and environmental value of building components remains largely invisible and inaccessible, making strategic deconstruction unfeasible.

Secondly, the business case for urban mining is highly context-dependent but consistently positive. The pilots demonstrate that economic viability is not tied to a single circularity pathway. In remote regions like Svalbard, the business case is driven by cost avoidance through the reuse of components, circumventing expensive logistics for new materials. In dense urban areas like The Hague, viability is driven by revenue generation from the high-

volume recycling of mineral aggregates, supported by established markets and regulatory frameworks. This proves that urban mining can be profitable under different economic conditions, provided the strategy is tailored to the local context.

A third lesson is the importance of a hybrid circularity strategy. While building typologies may favour either reuse (lightweight timber) or recycling (heavy mineral), an optimal outcome is achieved by pursuing both pathways simultaneously. The Dutch pilot, despite its focus on recycling, identified high-value components for direct reuse. Similarly, the Nordic pilot will rely on recycling for materials not suitable for reuse. A pragmatic approach, which often begins with the "low-hanging fruit" of high-value, non-structural components (e.g., technical equipment, sanitary ware), is most effective for maximizing both environmental and economic returns.

Finally, the project underscores the need for methodological flexibility and market development. The Spanish pilot demonstrated that real-world projects are often constrained by imperfect conditions. A robust urban mining framework must therefore include strategies for data-scarce scenarios, such as the use of building archetypes. However, for urban mining to scale beyond individual projects, the technical potential identified in these pilots must be supported by broader market development, including building a skilled workforce for selective deconstruction and fostering trust and demand for secondary construction materials.

8. Recommendations and Strategies

The insights gained from the cross-pilot analysis form the basis for a set of transferable recommendations designed to accelerate the adoption of urban mining and circular construction practices. These strategies are aimed at key stakeholders, including building owners, contractors, planners, and policymakers. This chapter consolidates the primary lessons learned into actionable guidelines for maximizing material reuse, enhancing resource efficiency, and shaping a supportive policy and industry landscape.

8.1. Guidelines for Maximizing Material Reuse and Circular Renovation

The successful transition from a linear to a circular model in the construction sector hinges on a systematic and data-driven approach to deconstruction and renovation. Based on the findings from the pilot projects, the following guidelines are recommended to maximize the recovery and reuse of building components.

8.1.1. Prioritize a Digital-First PDA

A comprehensive digital PDA is the non-negotiable starting point for any successful urban mining project. As demonstrated in both the Nordic and Dutch pilots, a digitally managed inventory transforms a building from an unknown entity into a quantifiable "material bank." This process should go beyond simple material lists and integrate structured data from the outset, following established standards (SUM4Re (VTT, THUAS, SINTEF, TECN, BLOCKM), 2025). The use of mobile applications (e.g., CIRDAX) for on-site data capture ensures consistency and prepares the data for seamless integration into assessment platforms and, ultimately, into a C-BIM environment. This creates a reliable "single source of truth" for all subsequent planning, addressing key challenges of data standardization and interoperability (SUM4Re (VTT, CONC, THUAS, TECN), 2025).

8.1.2. Implement a Hybrid Circularity Strategy: Target High-Value Components First

While the overall building typology dictates the primary circularity path (reuse for lightweight timber, recycling for heavy mineral), a hybrid strategy consistently yields the best results. A pragmatic and economically effective approach is to first target high-value, non-structural components, as these often offer the highest return on investment for the effort of selective deconstruction. The audits consistently identified items such as sanitary fixtures, interior and exterior doors, technical installations (PV panels, HVAC units), and metallic elements (railings, window frames) as ideal candidates for direct reuse. By prioritizing these "low-hanging fruits," a project can secure early economic gains that help offset the higher costs associated with the more complex dismantling of structural elements (SUM4Re (SINTEF, RAFTER), 2025).

8.1.3. Adopt Material-Specific Deconstruction and Quality Assessment Protocols

Maximizing the value of recovered materials requires careful, material-specific handling. As demonstrated with the timber components in the Nordic pilot (6.1.1) and the mineral components in the Dutch pilot (6.2.1), generic demolition must be replaced by selective deconstruction protocols. For timber components (Nordic pilot), this means carefully documenting and dismantling load-bearing structures to preserve their integrity for structural re-certification. For mineral components like concrete and masonry (Dutch pilot), the focus must be on avoiding contamination to enable high-quality recycling into new aggregates, rather than low-value backfilling. Crucially, a systematic quality assessment protocol must be part of the audit process, documenting not just the material type and quantity, but also its condition, dimensions, and connection types, as this data is essential for determining its real-world reuse potential and marketability (SUM4Re (SINTEF, BLOCKM, VTT), 2025) (SUM4Re (SINTEF, RAFAER), 2025).

8.2. Circular material strategies for demolition and renovation planning

8.2.1. Impact of circular material strategies on demolition planning

Conventional demolition approaches are typically driven by speed and cost-efficiency. Buildings are dismantled rapidly using bulk processing methods, with limited differentiation of material streams. This results in high landfill rates, significant downcycling, and the loss of embedded environmental and economic value. In contrast, circular demolition emphasizes selective deconstruction, guided by systematic Pre-Demolition Audits (PDAs) and the use of Digital Material Passports (DMPs). The objective is to retain material quality and maximize reuse potential, thereby transforming end-of-life buildings into material banks rather than waste sources.

To achieve this, several key measures are required:

Pre-Demolition Audits serve as the cornerstone, providing a digital-first approach to documentation capturing material type, condition, and connection methods. By doing so, they create a reliable foundation for circular demolition planning and targeted deconstruction strategies.

The prioritization of components plays a decisive role to result in a strategic order of dismantling. High-value and easily recoverable elements - such as windows, doors, steel beams, HVAC systems - are removed first, before progressing to structural materials.

Different material categories also demand tailored handling. For mineral-based materials such as concrete, contamination must be prevented to enable their use in high-quality recycling. Timber and metals, on the other hand, require careful dismantling to preserve their integrity for reuse.

Throughout the process, on-site quality assessments and traceability mechanisms are necessary: Continuous monitoring during deconstruction ensures that recovered components meet safety and quality requirements. Certification processes are vital for enabling recovered components to be classified as secondary products rather than waste.

Finally, effective circular demolition depends on integrating the recovered resources into digital marketplaces and material banks, which makes it possible to match supply with demand and ensures that materials re-enter local value chains.

Compared to conventional demolition, circular deconstruction requires longer planning horizons and more complex execution compared to conventional demolition. It demands specialized skills, dedicated equipment, and collaboration across multiple stakeholders. However, it yields substantial benefits: higher recovery rates, significant CO₂ and resource savings, reduced landfill disposal and associated costs, and improved residual material value.

8.2.2. Impact of circular material strategies on renovation planning

In the context of renovation, circular material strategies introduce two additional planning dimensions. The first is the systematic integration of reclaimed materials as a substitute for new products, thereby reducing the reliance on virgin resources. The second is the design of renovations with future reuse in mind, ensuring that interventions today do not limit but rather enable future circularity. This represents a shift from renovation as repair towards renovation as material recirculation.

To embed circular strategies effectively, both design and planning practices must adapt. A relevant planning maxim is Design for Disassembly (DfD): Renovation plans should prioritize modularity and reversible connections, for example bolted rather than glued or welded joints, to facilitate future dismantling, reducing cost and potential damage.

Digitalization also supports a reuse friendly renovation: The use of Digital Material Passports (DMPs) and Circular Building Information Modelling (C-BIM) provides traceability and supports the integration of secondary materials into design workflows.

The standardization of dimensions and components plays a crucial role in making secondary materials interchangeable and simplifying their reuse across different projects. Harmonizing specifications increases their applicability across different building types.

Following quality and safety re-certification protocols are also necessary to guarantee that reused components meet performance and regulatory requirements, creating confidence among both practitioners and clients.

In practice, many projects adopt hybrid strategies, combining reclaimed and new materials to balance technical performance, cost-effectiveness, and aesthetic considerations while ensuring that adequate supply is available.

In conclusion, the adaption of circular strategies has potential far-reaching impact on the renovation process: Architects and planners must adapt workflows to incorporate the results of PDAs already in the design phase, which may require adjustments to schedules and compensation models. Renovation projects will increasingly depend on collaboration with demolition contractors and suppliers of secondary materials to align design decisions with the availability of reclaimed resources. This shift is crucial to the adaption of circular construction and offers both ecological as well as economical advantages: it enhances the preservation of valuable materials, lowers embodied carbon, reduces overall costs, and contributes to a more resource-efficient and sustainable built environment.

8.3. Strategies for CO₂ Emissions Reduction and Resource Efficiency

The quantitative results from the pilot assessments confirm that urban mining delivers significant CO₂ savings, but the most effective strategies for achieving these reductions vary by building typology. The key to maximizing both resource efficiency and climate benefits is to tailor the approach to the specific material composition of a building.

8.3.1. Focus on Component Reuse to Avoid Embodied Carbon

A primary strategy for CO₂ reduction is the direct reuse of components with high embodied carbon. The Nordic pilot exemplifies this approach, where the reuse of structural timber, PV panels, and other technical equipment directly avoids the high emissions associated with manufacturing new products (GWP of modules A1-A3). This strategy offers the highest CO₂ saving per kilogram of material and represents the most resource-efficient circular pathway. Pursuing the reuse of load-bearing elements and technical systems should therefore be the main priority in lightweight constructions or buildings rich in high-value components.

8.3.2. Leverage High-Volume Recycling for Mineral-Based Structures

For buildings dominated by mineral materials, such as the Dutch pilot, the greatest impact on resource efficiency is achieved through the management of high-volume material streams. While the CO₂ savings per tonne from recycling concrete into aggregates are lower than from direct component reuse, the immense scale of these materials (thousands of tonnes) leads to substantial overall emission reductions. The primary strategy here is to implement deconstruction processes that prevent the contamination of concrete and masonry, enabling their use as high-quality secondary aggregates and significantly reducing the demand for virgin raw materials like sand and gravel (SUM4Re (SINTEF, BLOCKM, VTT), 2025).

8.3.3. Utilize Digital Material Passports to Enable Efficient Planning

Both strategies are fundamentally dependent on the availability of reliable data. The creation of digital material inventories and Building Circularity Reports within the SUM4Re workflow effectively serves as a "material passport" for the building. This structured data is crucial for resource efficiency, as it provides planners, architects, and engineers with the necessary information to confidently specify secondary materials in their designs and procurement processes. By bridging the information gap that currently hinders the market for reused components, this digital matchmaking is the key to turning potential resources into realized CO₂ savings and enhanced resource efficiency (SUM4Re (VTT, CONC, THUAS, TECN), 2025) (SUM4Re (SINTEF, RAFTER), 2025).

8.4. Policy and Industry Recommendations

To scale the benefits observed in the pilot projects, a supportive ecosystem is required. The following recommendations are aimed at policymakers and industry bodies to accelerate the transition to a circular built environment.

8.4.1. Strengthen and Harmonize Regulatory Frameworks

Policy is a key driver for circularity. It is recommended that public authorities mandate digital PDAs for all major renovation and demolition projects, a practice that is already gaining traction but needs to be standardized across Europe (SUM4Re (VTT, THUAS, SINTEF, TECN, BLOCKM), 2025). Furthermore, setting clear targets for the use of secondary materials in public tenders (Green Public Procurement) would create a stable demand for recovered components. Financial incentives, such as reduced taxes for reused materials or subsidies for selective deconstruction, can help offset higher initial costs and level the playing field against virgin materials, as discussed in the regulatory analysis (SUM4Re (VTT, THUAS, SINTEF, TECN, BLOCKM), 2025) (SUM4Re (SINTEF, RAFTER), 2025).

8.4.2. Foster Market Development and Build Trust

A significant barrier to reuse is the lack of a mature and transparent market for secondary building components (SUM4Re (SINTEF, RAFAER), 2025). It is recommended that industry associations, in collaboration with research institutions, develop standardized quality assurance and certification processes for reclaimed materials. This would build trust among planners and clients regarding the performance and safety of reused components. Establishing regional material hubs—both digital platforms and physical storage facilities—can further professionalize the market by consolidating supply, ensuring quality control, and simplifying logistics for both suppliers and buyers.

8.4.3. Promote Digitalization and Interoperability Standards

The full potential of urban mining can only be realized through seamless digital data flows. Policymakers and industry bodies should actively promote the adoption of open, interoperable data standards for circularity in the built environment, such as the Circular BIM (C-BIM) frameworks and Information Delivery Specifications (IDS) explored in the project (SUM4Re (VTT,CONC, THUAS, TECN), 2025). Integrating digital material passports as a standard requirement in building permits and logbooks would ensure that valuable material data is preserved throughout a building's lifecycle. This would not only streamline future renovations but also create a comprehensive, data-rich cadastre of the urban mine for strategic, city-level resource planning.

9. Conclusion

The SUM4Re project set out to address a critical barrier to the circular economy in the built environment: the lack of a systematic, data-driven workflow for unlocking the material value of existing buildings. Through the practical application of a comprehensive urban mining methodology across three distinct European pilot sites, this report has demonstrated that a digital-first approach is not only feasible but also environmentally and economically compelling. The findings confirm that existing buildings represent vast and valuable "material banks," whose resources can be systematically identified, assessed, and reintegrated into the value chain.

9.1. Principal Findings

The core achievement of the SUM4Re project is the successful validation of a standardized, digitally-enabled workflow for urban mining. The application of Pre-Demolition Audits (PDAs) according to DIN SPEC 91484, combined with digital tools for data capture (CIRDAX) and circularity assessment (Concular), provided a robust and replicable framework. This process effectively transformed complex building structures into transparent, quantifiable material inventories, forming the essential evidence base for strategic decision-making.

A key finding across all pilots is that urban mining delivers significant, measurable benefits. The quantitative analyses consistently revealed substantial potential for CO₂ emissions reduction (e.g., 37.1 t CO₂-eq in the Nordic pilot and 53.3 t CO₂-eq in the Dutch pilot) and the recovery of considerable economic value (e.g., €24,310 and €2,745,904, respectively). This demonstrates that circular construction is not merely an environmental ideal but a viable business case. The economic drivers vary—from cost avoidance in remote locations to revenue generation in dense urban markets—but the positive outcome remains consistent.

Furthermore, the cross-pilot analysis highlighted the profound influence of building typology and geographical context on the optimal circularity strategy. The Nordic pilot's lightweight timber construction proved ideal for a reuse-focused approach, achieving a high CPX of 75%. In contrast, the Dutch pilot's heavy mineral structure naturally led to a recycling-focused strategy (77.3% of mass) with a lower CPX of 24%, yet yielded immense absolute CO₂ savings and economic returns due to its scale. This underscores a crucial insight: there is no single "best" circularity pathway. Success lies in adapting the strategy to the specific material composition and local conditions of the building.

9.2. Limitations of the Study

Despite the successful outcomes, the project encountered real-world challenges that constitute important limitations. The most significant was the unforeseen administrative change at the Spanish pilot site, which prevented a building-specific PDA and necessitated a methodological shift to a typological analysis. While this demonstrated the adaptability of the SUM4Re framework, it also highlighted the vulnerability of research projects to external administrative hurdles and the inherent difficulty of generating a direct, comparative dataset for Spain.

A second limitation is the persistent uncertainty in material data acquisition. Even with advanced digital tools, concealed components, undocumented historical renovations, and the precise condition of embedded materials pose challenges. While technologies like GPR can reduce this uncertainty, a complete picture can often only be achieved during the deconstruction itself. This underlines that PDAs provide a highly reliable but ultimately probabilistic assessment of a building's material stock.

Finally, while the project successfully quantified the *potential* for reuse and recycling, the study did not extend to tracking the recovered materials to their final end-of-life destinations. The successful market reintegration of these materials depends on external factors like local demand, client acceptance, and the existence of a mature market for secondary components—conditions which are still developing across Europe.

9.3. Future Outlook and Scalability

The findings of the SUM4Re project provide a clear and optimistic outlook for the future of urban mining. The demonstrated workflow, grounded in emerging standards like DIN SPEC 91484 and the forthcoming DIN SPEC on deconstruction concepts, offers a scalable model for the construction industry. To realize this potential, however, several key steps are necessary.

First, the regulatory landscape must continue to evolve. Mandating digital PDAs for all major renovation and demolition projects and integrating targets for secondary material use in public procurement would create the necessary market pull. Harmonized, pan-European standards are essential to overcome national fragmentation and build a unified market.

Second, the industry must invest in building capacity and trust. This includes developing a skilled workforce for selective deconstruction and establishing robust quality assurance and certification processes for secondary materials. Digital platforms that connect supply and demand will be crucial, but they must be supported by physical infrastructures, such as regional material hubs, to manage logistics and quality control.

Ultimately, the SUM4Re project is showing that the transition to a circular built environment is within reach. By embracing digitalization, adapting strategies to local contexts, and fostering a supportive policy and market ecosystem, the construction sector can systematically turn its legacy of existing buildings from a potential waste problem into a valuable resource for a sustainable future.

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Creating materials banks
from digital urban mining

APPENDICES

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LIST OF APPENDICES

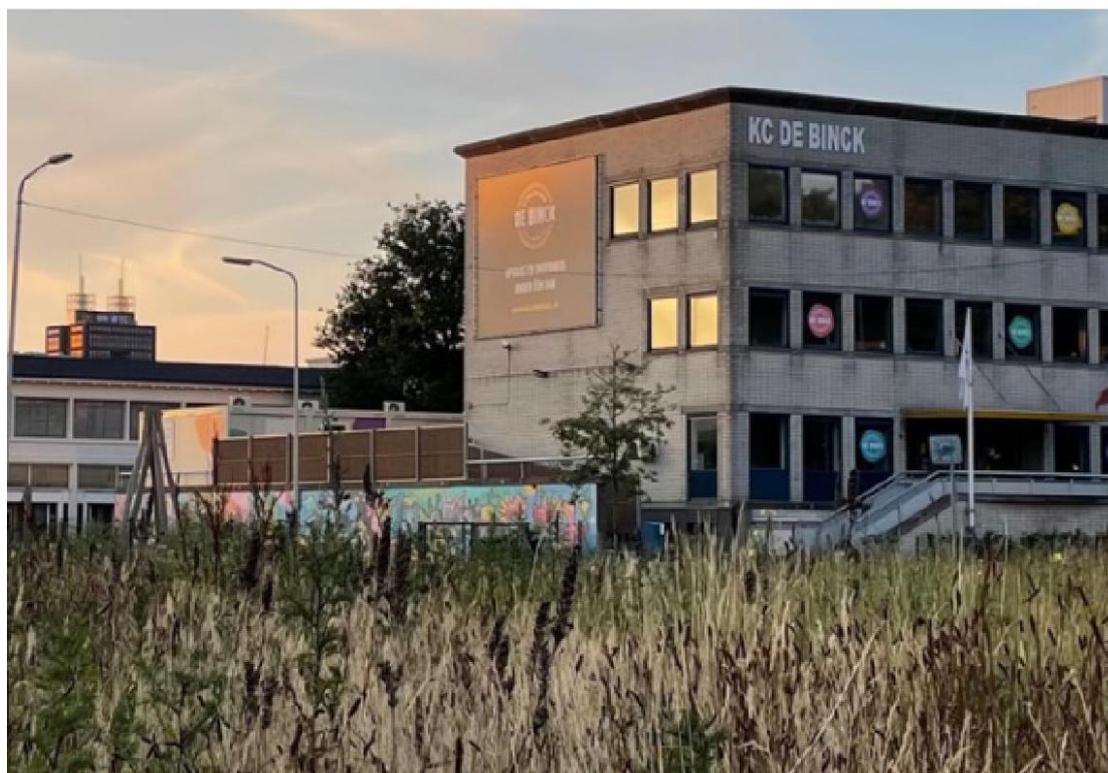
APPENDIX A	BUILDING CIRCULARITY REPORT DUTCH PILOT	59
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APPENDIX A Building Circularity Report Dutch Pilot

Concular

10.9.2025

Building Circularity Report



SUM4Re_Pilot_NL

Adresse	Erstellt von	Erstellt am
Sint Barbaraweg 4 Den Haag 2516 BT	Concular	10.9.2025

Gebäude als Materiallager der Zukunft

Für den langfristigen Werterhalt und die Steigerung des Immobilienwerts ist eine transparente Dokumentation von Ressourcen unverzichtbar. Sie erleichtert die Umsetzung von Effizienzstrategien wie Urban Mining und sichert die Zukunftsfähigkeit des Gebäudes.

Der Building Circularity Report (Gebäuderessourcenpass) bietet eine umfassende Dokumentation der Nachhaltigkeit und Kreislauffähigkeit von Gebäudebestandteilen – sowohl auf Material - als auch auf Bauteilebene. Er bewertet wirtschaftlich und ökologisch die Potenziale für einen kreislaufgerechten Umbau oder Rückbau und bildet eine entscheidende Datengrundlage für zukünftige Wiederverwendungs- und Recyclingstrategien.

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Building Circularity Report | SUM4Re_Pilot_NL

Gebäudeangaben



Baujahr

Nicht verfügbar

Flächen

Bruttogeschossfläche	Nettoraumfläche
2.029,00 m ² _{BGF}	1.826,00 m ² _{NRF}

Quelldateien & Methodik

Dieser Building Circularity Report enthält ausschließlich Bauteile (folgend Objekte genannt), die in den hier aufgelisteten Dateien enthalten sind. Ausschlaggebend für die Qualität des Passes sind die Produktverknüpfungen und die Dimensionen der Objekte. Die Kombination aus beidem ermöglicht das Anreichern von Massen, Kategorisierungen, Umwelteinflüssen, Materialwerten, Zirkularitätsbewertungen und Aufzeigen von Materialströmen.

1 Dateien

Konforme Tabelle CircularLCA DE (1).xlsx

Konform verknüpfte Objekte

2412 / 2412

100,00 %

Objekte mit Dimensionen

2409 / 2412

99,88 %

Konform verknüpfte Objekte mit passender Dimension

2229 / 2412

92,41 %

Berechnungsmethodik

Nicht verfügbar

Nicht verfügbar

Zugrundeliegende Methodik

DIN EN 15804 / DIN EN 15978

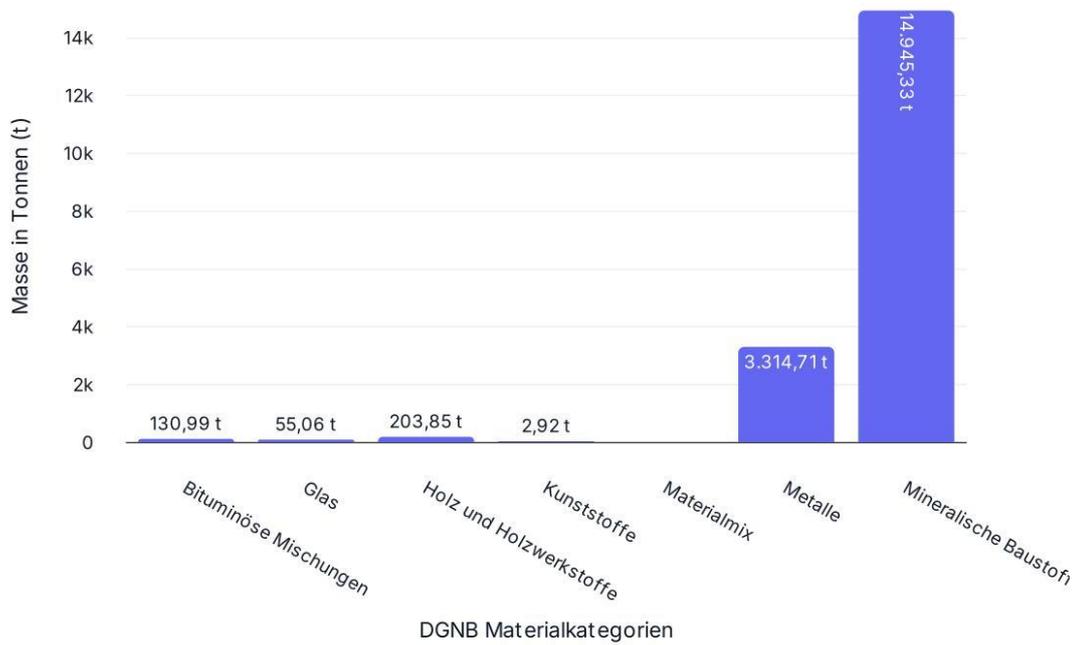
Nicht verfügbar

Nicht verfügbar

Massenauswertung

Gesamtmasse Masse pro Quadratmeter (NRF)
 18.653,08 t 10,22 t/m²_{NRF}

Massenauswertung nach DGNB Materialkategorien



Massenauswertung

Massenauswertung nach DIN 276 Kostengruppen



Zirkularitätsbewertung (CPX)



24

Der **Circularity Performance Index (CPX) von Concular** bewertet zwei zentrale Lebenszyklusphasen eines Bauteils: die Materialherkunft (Pre-Use) und die Verwertung (Post-Use). Dadurch wird sowohl die Zirkularität während der Nutzung eines Bauteils als auch dessen Rückführung in den Ressourcenkreislauf umfassend berücksichtigt. Mehr Informationen zum CPX unter concular.de/cpx

Pre-Use



14

Materialherkunft

Die Materialherkunft eines Bauteils wird grundsätzlich auf materieller Ebene bewertet, außer im Falle der gleichwertigen Wiederverwendung.

Post-Use



16

Demontierbarkeit

Der Faktor Demontage evaluiert in qualitativer Weise die Perspektive, das entsprechende Bauteil im Gebäude zurückzubauen. Einbauweise und benötigtes Werkzeug für den Rückbau sind hierbei ausschlaggebende Aspekte für die Bewertung.



34

Rezyklierbarkeit

Der Faktor Recycling wird anhand aktueller Recyclingquoten und verfügbarer Datenlage dynamisch bewertet. Mit zunehmender Detailtiefe wird die Recyclingart (z. B. thermische Verwertung, Downcycling) berücksichtigt. Bei Materialmischungen erfolgt die Berechnung pro Material.



85

Trennbarkeit

Trennbarkeit beschreibt die Möglichkeit, Materialien eines Bauteils zur Weiterverwertung in Stoffströme zu separieren. Entscheidend sind dabei Reinheit sowie der ökonomische und praktische Aufwand zur Gewinnung neuer Rohstoffe.



18

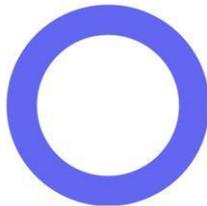
Wiederverwendungspotential

Der Faktor Wiederverwendung bewertet den Aufwand für die Wiederinstandsetzung eines Bauteils, einschließlich aller Maßnahmen, um es für den Einsatz in einem anderen Bauprojekt nutzbar zu machen.

Massen-Zirkularitätsbewertung (CPX)

Pre-Use

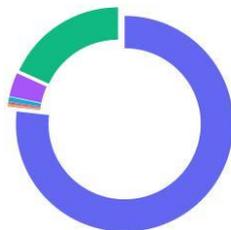
Materialherkunft



	Masse in t	Anteil in %
■ Primärrohstoff	18.653,08	100,00
Wiederverwendet	0,00	0,00
Rezyklat verwendet (>50%)	0,00	0,00
Rezyklat verwendet (<50%)	0,00	0,00

Post-Use

Demontierbarkeit

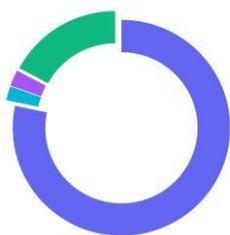


	Masse in t	Anteil in %
■ Betoniert	14.331,16	76,83
■ Geklebt	58,05	0,31
■ Gemörtelt	668,20	3,58
■ Geschraubt	3.390,06	18,17
■ Geschweißt	51,18	0,27
■ Klemmverschluss	0,00	0,00
■ Lose Auflage	23,44	0,13
■ Warmnietung	130,99	0,70
Druckverschluss	0,00	0,00
Reissverschluss	0,00	0,00
Drehverschluss	0,00	0,00
Magnet	0,00	0,00
Klettverschluss	0,00	0,00
Spannverschluss	0,00	0,00
Schnappverschluss	0,00	0,00
Genagelt	0,00	0,00
Gelötet	0,00	0,00
Kaltnietung	0,00	0,00

Massen-Zirkularitätsbewertung (CPX)

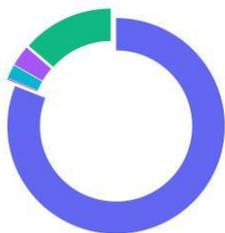
Post-Use

Rezyklierbarkeit



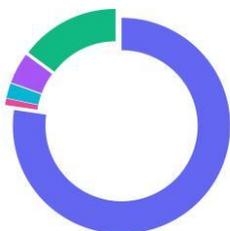
	Masse in t	Anteil in %
0-25% Anteil an Abfall der recycled wird	394,30	2,11
25-50% Anteil an Abfall der recycled wird	14.598,90	78,27
50-75% Anteil an Abfall der recycled wird	452,59	2,43
75-100% Anteil an Abfall der recycled wird	3.207,29	17,19
kompostierbar	0,00	0,00
75-100% Anteil an Abfall der recycled wird	0,00	0,00

Trennbarkeit



	Masse in t	Anteil in %
Chemische Trennung möglich	34,18	0,18
Kein Werkzeug notwendig oder keine maschinelle Trennung	15.115,48	81,03
Maschinelle Trennung mit festverbauten Maschinen (im Werk)	578,58	3,10
Maschinelle Trennung mit tragbaren Geräten (Handwerkzeug)	387,53	2,08
Verlustfreie Trennung unmöglich	2.537,30	13,60

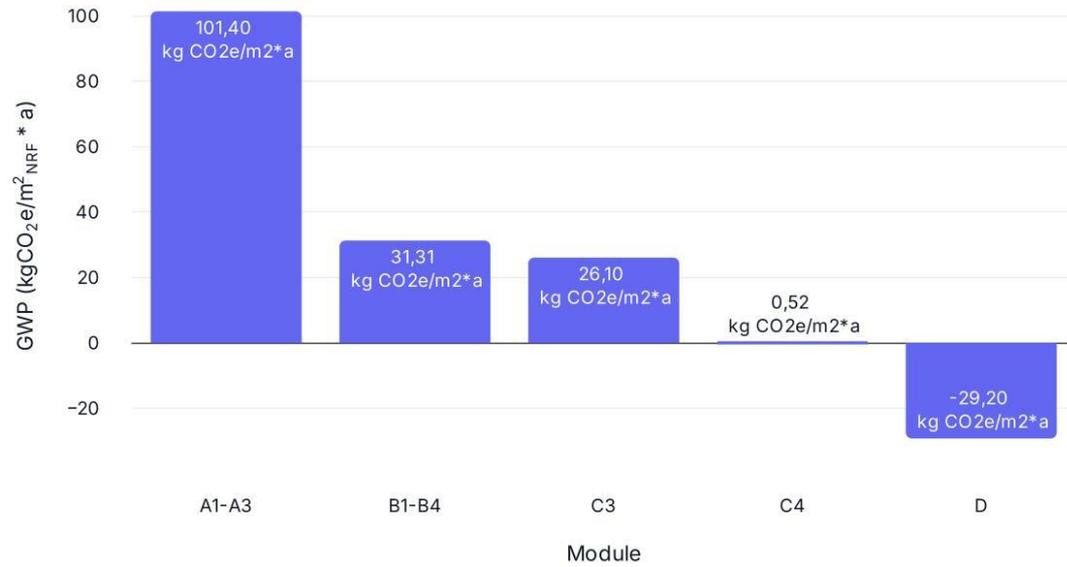
Wiederverwendungspotential



	Masse in t	Anteil in %
Direkt einsetz- bzw. wiederverwendbar	865,30	4,64
Einfache Aufbereitung notwendig (z.B. Anstrich)	416,23	2,23
Professionelle technische Aufbereitung notwendig (z.B. durch Herstellerfirma)	2.765,73	14,83
Wiederverwendung ökonomisch nicht tragbar	14.425,83	77,34
Zeitintensive Aufbereitung notwendig (z.B. Ersatzteile)	179,99	0,96

Umwelteinfluss

Graue Emissionen (GWP) über den gesamten Lebenszyklus



Weitere Umweltindikatoren

ADPE

0,00 kg Sbe/m²_{NRF} * a

FW

0,45 m³/m²_{NRF} * a

ODP

0,00 kg CFC-11e/m²_{NRF} * a

PERT

296,18 kWh/m²_{NRF} * a

AP

0,43 kg SO₂e/m²_{NRF} * a

GWP

128,02 kg CO₂e/m²_{NRF} * a

PE

663,97 kWh/m²_{NRF} * a

POCP

0,36 kg C₂H₄e/m²_{NRF} * a

EP

0,00 kg PO₄e/m²_{NRF} * a

GWP fossil

125,98 kg CO₂e/m²_{NRF} * a

PENRT

367,79 kWh/m²_{NRF} * a

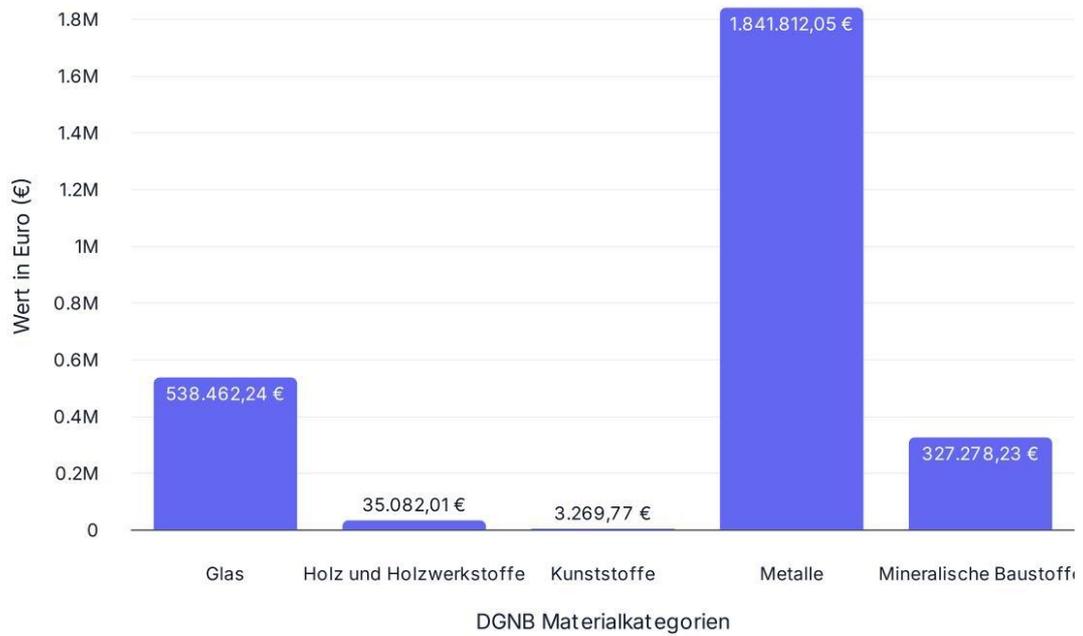
Concular

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Materialwert

Total
2.745.904,30 €

Pro Quadratmeter (NRF)
1.503,78 €/m²_{NRF}



APPENDIX B Building Circularity Report Nordic Pilot

Concular

11.9.2025

Building Circularity Report



SUM4Re_Pilot_NOR

Adresse	Erstellt von	Erstellt am
Longyearbyen 9170	Concular	11.9.2025

Gebäude als Materiallager der Zukunft

Für den langfristigen Werterhalt und die Steigerung des Immobilienwerts ist eine transparente Dokumentation von Ressourcen unverzichtbar. Sie erleichtert die Umsetzung von Effizienzstrategien wie Urban Mining und sichert die Zukunftsfähigkeit des Gebäudes.

Der Building Circularity Report (Gebäuderessourcenpass) bietet eine umfassende Dokumentation der Nachhaltigkeit und Kreislauffähigkeit von Gebäudebestandteilen – sowohl auf Material - als auch auf Bauteilebene. Er bewertet wirtschaftlich und ökologisch die Potenziale für einen kreislaufgerechten Umbau oder Rückbau und bildet eine entscheidende Datengrundlage für zukünftige Wiederverwendungs- und Recyclingstrategien.

Haftungsausschluss

Dieser Building Circularity Report wurde ohne Mitwirkung von der Concular GmbH erstellt. Er basiert ausschließlich auf den von Benutzenden bereitgestellten und importierten Daten. Die importierten Daten umfassen Informationen zu den enthaltenen Bauteilen, Materialien, Mengen und Dimensionen. Sämtliche Angaben im Building Circularity Report, einschließlich der Auswertungen und Exporte, beruhen zu 100 % auf diesen Daten. Die Qualität des Gebäuderessourcenpasses hängt von folgenden Punkten ab: Genauigkeit und Vollständigkeit der importierten Daten, Vollständigkeit und Sinnhaftigkeit der Produktverknüpfung und die Genauigkeit und Sinnhaftigkeit der verknüpften Produkte. Benutzende sind allein verantwortlich die genannten Punkte sicherzustellen. Daher übernimmt Concular keinerlei Haftung für ungenaue, unvollständige oder fehlerhafte Eingaben der Nutzenden.

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Gebäudeangaben

**Baujahr**

Nicht verfügbar

Flächen

Bruttogeschossfläche398,00 m²_{BGF}**Nettoraumfläche**362,00 m²_{NRF}

Quelldateien & Methodik

Dieser Building Circularity Report enthält ausschließlich Bauteile (folgend Objekte genannt), die in den hier aufgelisteten Dateien enthalten sind. Ausschlaggebend für die Qualität des Passes sind die Produktverknüpfungen und die Dimensionen der Objekte. Die Kombination aus beidem ermöglicht das Anreichern von Massen, Kategorisierungen, Umwelteinflüssen, Materialwerten, Zirkularitätsbewertungen und Aufzeigen von Materialströmen.

1 Dateien

NOR_Sum4Re_Konforme Tabelle CircularLCA DE 2.0.csv

Konform verknüpfte Objekte

1387 / 1387

100,00 %

Objekte mit Dimensionen

1387 / 1387

100,00 %

Konform verknüpfte Objekte mit passender Dimension

1307 / 1387

94,23 %

Berechnungsmethodik

Regelwerk nach DGNB

ENV 1.1 - Klimaschutz und Energie - Version 2023

Zugrundeliegende Methodik

DIN EN 15804 / DIN EN 15978

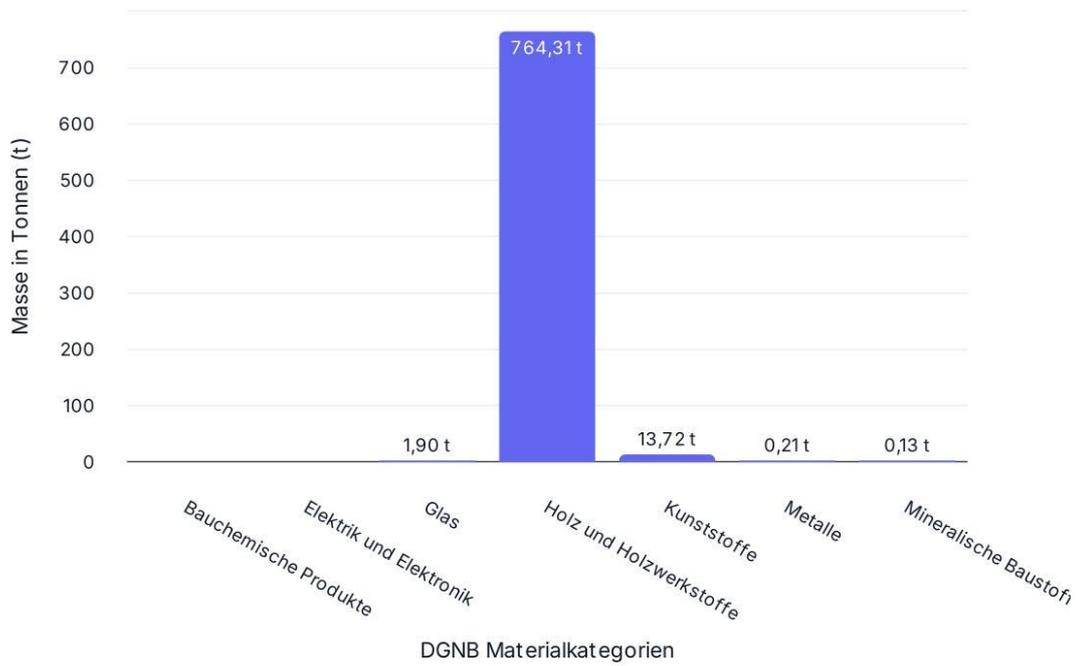
Datenbasis

OBD_2024-I (+ optional spezifische EPDs)

Massenauswertung

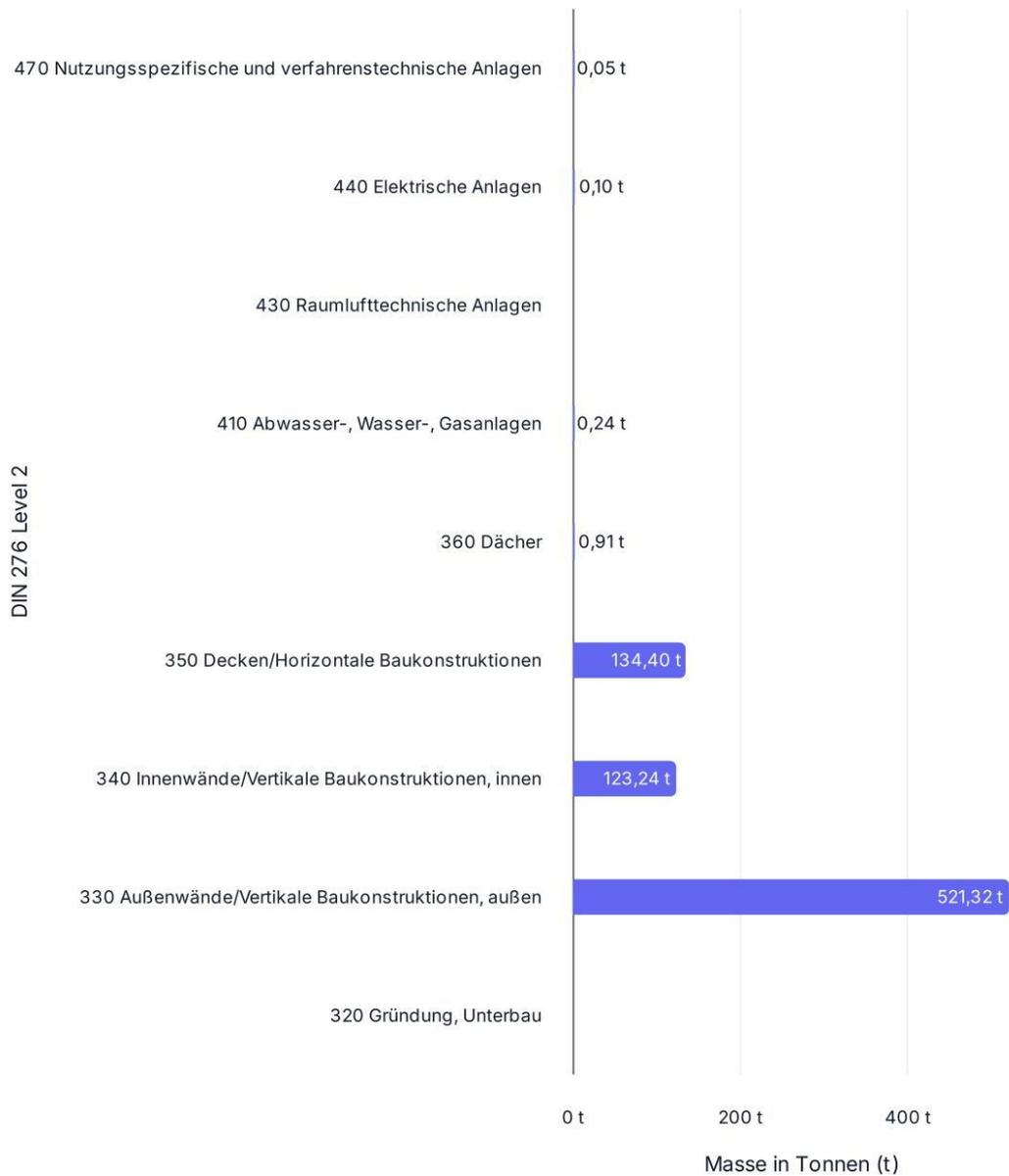
Gesamtmasse Masse pro Quadratmeter (NRF)
 780,27 t 2,16 t/m²_{NRF}

Massenauswertung nach DGNB Materialkategorien



Massenauswertung

Massenauswertung nach DIN 276 Kostengruppen



Zirkularitätsbewertung (CPX)



33

Der **Circularity Performance Index (CPX) von Concular** bewertet zwei zentrale Lebenszyklusphasen eines Bauteils: die Materialherkunft (Pre-Use) und die Verwertung (Post-Use). Dadurch wird sowohl die Zirkularität während der Nutzung eines Bauteils als auch dessen Rückführung in den Ressourcenkreislauf umfassend berücksichtigt. Mehr Informationen zum CPX unter concular.de/cpx

Pre-Use



0

Materialherkunft

Die Materialherkunft eines Bauteils wird grundsätzlich auf materieller Ebene bewertet, außer im Falle der gleichwertigen Wiederverwendung.

Post-Use



73

Demontierbarkeit

Der Faktor Demontage evaluiert in qualitativer Weise die Perspektive, das entsprechende Bauteil im Gebäude zurückzubauen. Einbauweise und benötigtes Werkzeug für den Rückbau sind hierbei ausschlaggebende Aspekte für die Bewertung.



0

Rezyklierbarkeit

Der Faktor Recycling wird anhand aktueller Recyclingquoten und verfügbarer Datenlage dynamisch bewertet. Mit zunehmender Detailtiefe wird die Recyclingart (z. B. thermische Verwertung, Downcycling) berücksichtigt. Bei Materialmischungen erfolgt die Berechnung pro Material.



97

Trennbarkeit

Trennbarkeit beschreibt die Möglichkeit, Materialien eines Bauteils zur Weiterverwertung in Stoffströme zu separieren. Entscheidend sind dabei Reinheit sowie der ökonomische und praktische Aufwand zur Gewinnung neuer Rohstoffe.



83

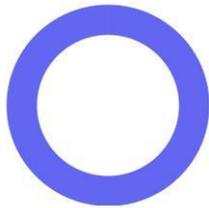
Wiederverwendungspotential

Der Faktor Wiederverwendung bewertet den Aufwand für die Wiederinstandsetzung eines Bauteils, einschließlich aller Maßnahmen, um es für den Einsatz in einem anderen Bauprojekt nutzbar zu machen.

Massen-Zirkularitätsbewertung (CPX)

Pre-Use

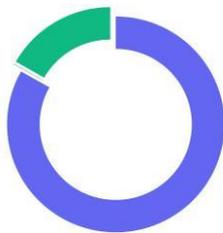
Materialherkunft



	Masse in t	Anteil in %
■ Primärrohstoff	780,22	99,99
■ Wiederverwendet	0,04	0,01
Rezyklat verwendet (>50%)	0,00	0,00
Rezyklat verwendet (<50%)	0,00	0,00

Post-Use

Demontierbarkeit



	Masse in t	Anteil in %
■ Betoniert	0,09	0,01
■ Geklebt	130,78	16,76
■ Gemörtelt	0,27	0,04
■ Genagelt	0,23	0,03
■ Geschraubt	648,89	83,16
■ Lose Auflage	0,02	0,00
Druckverschluss	0,00	0,00
Reissverschluss	0,00	0,00
Drehverschluss	0,00	0,00
Magnet	0,00	0,00
Klettverschluss	0,00	0,00
Spannverschluss	0,00	0,00
Schnappverschluss	0,00	0,00
Klemmverschluss	0,00	0,00
Gelötet	0,00	0,00
Geschweißt	0,00	0,00
Kaltnietung	0,00	0,00
Warmnietung	0,00	0,00

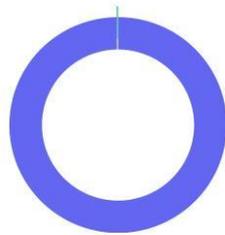
Concular

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Massen-Zirkularitätsbewertung (CPX)

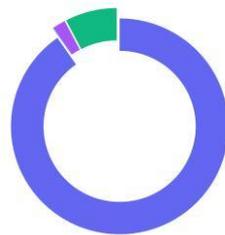
Post-Use

Rezyklierbarkeit



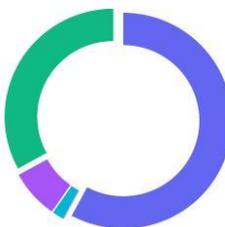
	Masse in t	Anteil in %
0-25% Anteil an Abfall der recycled wird	778,74	99,80
25-50% Anteil an Abfall der recycled wird	1,39	0,18
75-100% Anteil an Abfall der recycled wird	0,14	0,02
Invalid	0,00	0,00
kompostierbar	0,00	0,00
75-100% Anteil an Abfall der recycled wird	0,00	0,00
50-75% Anteil an Abfall der recycled wird	0,00	0,00

Trennbarkeit



	Masse in t	Anteil in %
Chemische Trennung möglich	15,24	1,95
Kein Werkzeug notwendig oder keine maschinelle Trennung	704,53	90,29
Maschinelle Trennung mit festverbauten Maschinen (im Werk)	0,00	0,00
Maschinelle Trennung mit tragbaren Geräten (Handwerkzeug)	60,06	7,70
Verlustfreie Trennung unmöglich	0,43	0,06

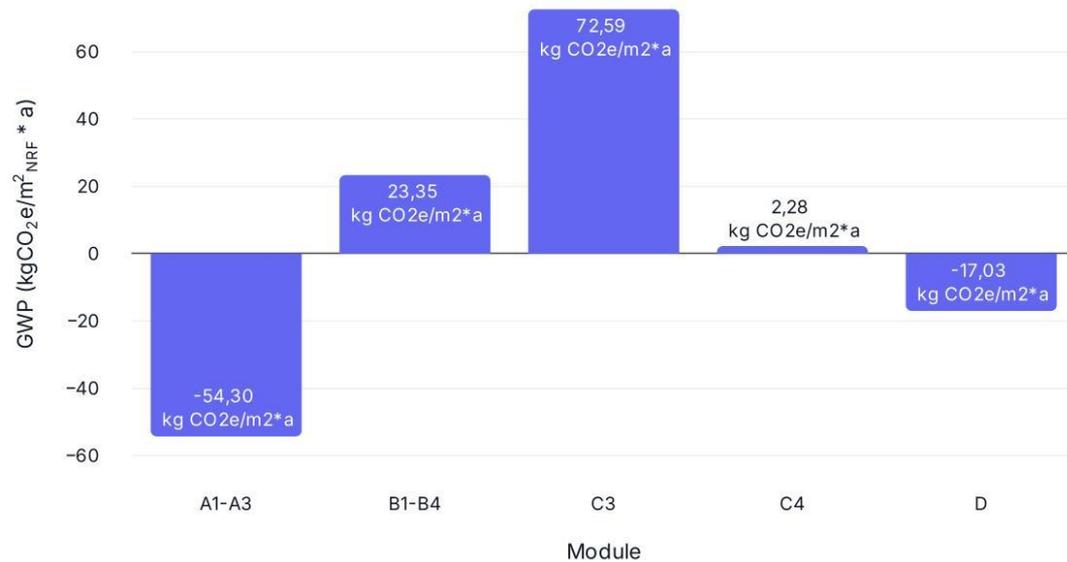
Wiederverwendungspotential



	Masse in t	Anteil in %
Direkt einsetz- bzw. wiederverwendbar	57,23	7,33
Einfache Aufbereitung notwendig (z.B. Anstrich)	257,38	32,99
Professionelle technische Aufbereitung notwendig (z.B. durch Herstellerfirma)	0,68	0,09
Wiederverwendung ökonomisch nicht tragbar	13,47	1,73
Zeitintensive Aufbereitung notwendig (z.B. Ersatzteile)	451,51	57,87

Umwelteinfluss

Graue Emissionen (GWP) über den gesamten Lebenszyklus



Weitere Umweltindikatoren

ADPE

0,00 kg Sbe/m²_{NRF} * a

FW

0,20 m³/m²_{NRF} * a

ODP

0,00 kg CFC-11e/m²_{NRF} * a

PERT

177,32 kWh/m²_{NRF} * a

AP

0,12 kg SO₂e/m²_{NRF} * a

GWP

43,92 kg CO₂e/m²_{NRF} * a

PE

331,01 kWh/m²_{NRF} * a

POCP

0,18 kg C₂H₄e/m²_{NRF} * a

EP

0,00 kg PO₄e/m²_{NRF} * a

GWP fossil

44,69 kg CO₂e/m²_{NRF} * a

PENRT

153,69 kWh/m²_{NRF} * a

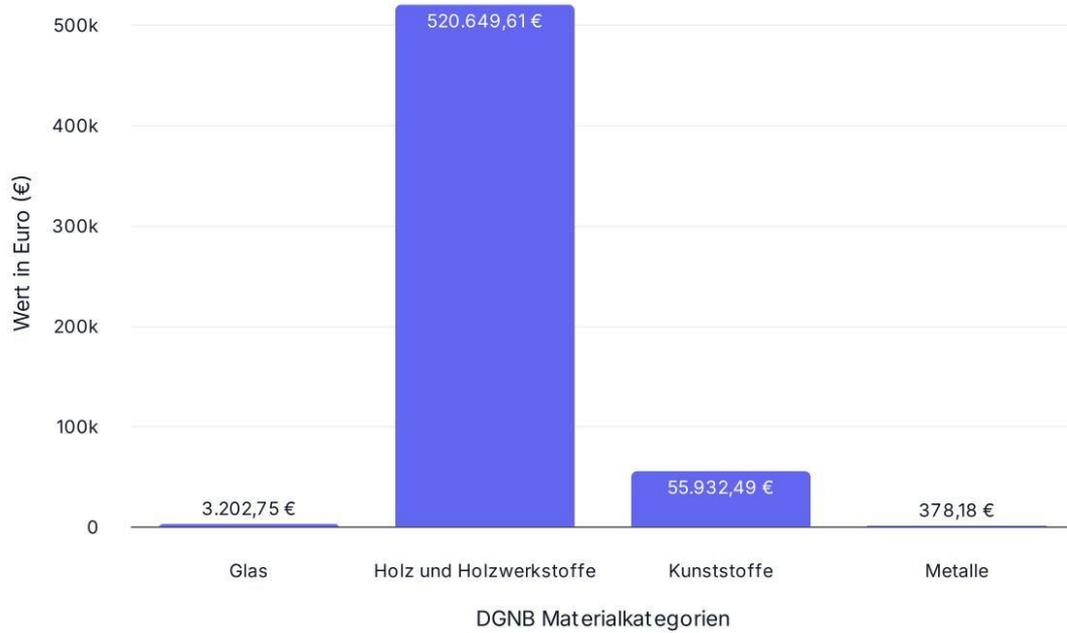
Concular

Building Circularity Report | SUM4Re_Pilot_NOR

Materialwert

Total
580.163,03 €

Pro Quadratmeter (NRF)
1.602,66 €/m²_{NRF}



SUM4Re

Creating materials banks
from digital urban mining

Universida deVigo

tecnal:a
MEMBER OF BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

THE HAGUE
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