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Joint Action Plan for Circular Economy in Construction

3R – Connect

Interconnected Innovation Ecosystems – Reduce, Reuse and Rethink

3R educe euse ethink

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Setting the Scene for a Circular Economy in CONSTRUCTION

In March 2020, the European Commission introduced the Circular Economy Action Plan (CEAP) as a key component of the European Green Deal. This plan primarily targets sectors that consume the most resources and have high potential for circularity. The construction industry is a major global consumer of energy and raw materials, contributing nearly 40% of emissions and almost a third of all waste generated within the EU.

Currently, only about 40% of construction waste is recycled, often with significant downgrading, and a smaller portion is reused. Recycled construction materials are typically used in secondary construction rather than new building projects. Adopting a circular approach in the construction sector can offer substantial environmental, social, and economic benefits. This requires a reevaluation of building design practices to reduce embedded carbon, use of recycled or bio-based materials, design for material and component reusability, and extend building lifespans through improved maintenance.

A key goal of the CEAP is to "make circularity work for people, regions, and cities." Achieving a circular economy (CE) requires coordinated action and a holistic approach that unites stakeholders from research, industry, public authorities and the broader community and across different regions. This necessitates efficient and interconnected innovation ecosystems to accelerate the adoption of circular innovations.

The 3R-Connect project assessed challenges, capacities, needed actions, and priorities in the regional innovation ecosystems of Greater Copenhagen, which spans parts of Denmark and Sweden, North Portugal, and Flanders in Belgium. However, the scope was extended to include strategies and competencies from the countries as a whole, as well as other regions within and beyond the EU.

Join the Priority Actions

The following three priority actions with the biggest potential impact and highest urgency emerged from the process:

1 INTEGRATION OF DIGITAL TOOLS

Digital tools are crucial for inventorying used construction materials, selective demolition, trading and reuse. Despite several promising solutions, the landscape is fragmented. Integration of digital tools along the lifecycle is needed. It is important to establish a well-structured architecture of tools that is easy to use to ensure full participation of all stakeholders in the value chain.

CREATION OF LOCAL INTEGRATED NETWORKS 2

Far too little construction material is being recovered and reused due to several bottlenecks. These obstacles should be overcomed to maximize the reuse of construction material. Establishing local integrated networks that unite all construction stakeholders to test potential solutions is necessary. Various demolition techniques, cooperation forms, financing schemes, training, and other necessary elements should be examined to define the ideal combination and later replication in other regions and their local networks.

3 SUPPORT FOR PUBLIC PROCUREMENT

Public procurement can significantly accelerate the implementation of innovative solutions, as public stakeholders can develop pilot projects where new techniques are tested at an early development stage. Additionally, public buyers can ensure that market-ready solutions are more widely applied. To achieve this, public buyers need to improve their knowledge about innovation, find their way to suppliers and understand the appropriate legal framework.

Participate in the Priority Actions

Various stakeholders from the ecosystems have already indicated that they actively want to engage in these priority actions. However, to create broad support, more participants are needed. Therefore, we invite you to participate in these actions and their implementation.

We hope this action plan can be used to convene actors from different regions on joint actions for a more circular approach in the Construction Sector!

Sign up here to show your commitment to taking action!

For more information about the actions, please refer to the section on “Priority Actions for Circular Transformation in the Construction Sector”.

How can you use this action plan to engage in future projects and collaborations?

In this action plan, actions refer to activities on different levels:

- On the micro-level, actions are carried out by individual stakeholders. This can for example include bilateral collaboration between two companies.
- On the meso-level, actions are carried out by ecosystem mediators or other supporting organs in the innovation ecosystem such as clusters. Activities can for example include matchmaking between innovative companies and private or public end-users or facilitation of co-creation processes and innovation collaborations between research institutions and other private or public actors.
- In general, the macro level refers to legislation and policy making. However, policy development is not part of this action plan, and macro level actions therefore refer to projects and initiatives which can be used to inform or inspire future policy development, as well as actions which help stakeholders comply with upcoming legislation on circular economy.

How can the action plan be used by different stakeholders?

As a private company you can:

- Gain new project and business opportunities by joining one or several of the actions in the section on "Priority Actions for Circular Transformation in the Construction Sector."
- Identify relevant collaboration partners or best practices from other regions in Appendix 1.

As a public buyer you can:

- Participate in future projects to improve your capacity for public procurement of innovation and circularity by joining Action 3.
- Get inspired by best practices for public procurement of innovative circular solutions and identify promising technologies in Appendix 1.

As a cluster or similar ecosystem mediator you can:

- Gain an understanding of key challenges and needs for the construction sector across different regions in the section on "Cross-regional key challenges and needs."
- View the proposed actions as concepts for future projects to be implemented in collaboration with clusters from other regions. You can also find partners for project development through relevant networks.
- Involve relevant members from your region in one or several of the proposed actions.

As a university or research & technology institute you can:

- Gain an understanding of key challenges and needs for the construction sector across different regions in the section on "Cross-regional key challenges and needs."
- Participate in research or development projects by signing up for one or several actions in the section on "Priority actions for circular transformation in the construction sector."

As a public authority you can:

- Gain an understanding of the priorities and needs of different actors in the innovation ecosystem in the section on "Cross-regional key challenges and needs."
- Get input for policies and prioritization of public funding for circular projects in the section on "Priority actions for circular transformation in the construction sector".

To understand which role you can play in each specific action, please refer to the tables in the section "Priority actions for circular transformation in the construction sector" and sign up to join the actions.

Methodology:
Alignment with national and regional strategies and bottom-up action development

To develop and plan joint actions for a more circular economy within the construction sector, a thorough assessment was conducted of the industry's existing practices and the degree of alignment with circularity principles. This assessment identified key challenges and highlighted opportunities for collaborative efforts and initiatives across the three regions.

The project was organized in different phases:

Phase 1: Mapping Regional Challenges

An assessment was conducted to map regional challenges and potentials in circular economy practices within the construction sector. This process aimed to identify opportunities for enhancing resource efficiency, reducing waste, and promoting circular practices throughout the value chain. To ensure that the actions are rooted in regional/national strongholds, the process took its starting point in already existing strategies and roadmaps. As these strategies and roadmaps have different levels of detail, target groups and time horizons, they were supplemented by desk research to mitigate the differences.

Phase 2: Dialogue with key stakeholders

The consortium involved private, public, and research actors to engage in dialogue about the common regional challenges identified in the first phase. The focus was on sharing information, exchanging applications of innovative techniques, and gaining insight into each other's ecosystems.
Subsequently, the consortium examined which actions were desirable and necessary to address these challenges. The outcome of this phase is summarised in the chapter “Cross-Regional Key Challenges and Needs.”

Phase 3: Setting priorities for cross-regional collaboration

In the last phase, the “needed actions” were prioritized. It was assessed which actions would benefit from cross-regional collaboration, where joint innovation projects could be planned, and how the implementation of the prioritized actions could be prepared.

The 3R Connect Project aimed, not only to address current circularity challenges in these sectors, but also to create a robust network of cooperation that strengthened circular economy practices across multiple regions and countries. More than 200 private, public and research actors were involved in co-developing and prioritizing actions over the 2-year project period. This bottom-up approach was applied to ensure that the actions would gain support from a critical mass of actors.

The process was driven by the three organizations, Clean – The Water and Environment Cluster in Denmark, Smart Waste Portugal and Flux50 with support from regional authorities in the Greater Copenhagen region, Flanders and Northern Portugal. The International Cleantech Network, which convenes 24 clusters worldwide, has been closely involved in the process and will be a key part of the implementation of the actions by convening stakeholders across different regions in joint projects and through matchmaking activities. Similarly, the three partner clusters will continue to gather stakeholders to implement the actions. The clusters will continuously present SMEs and other relevant stakeholders with funding opportunities which can be utilized to implement the actions. Currently available funding opportunities have also been mentioned in this action plan.

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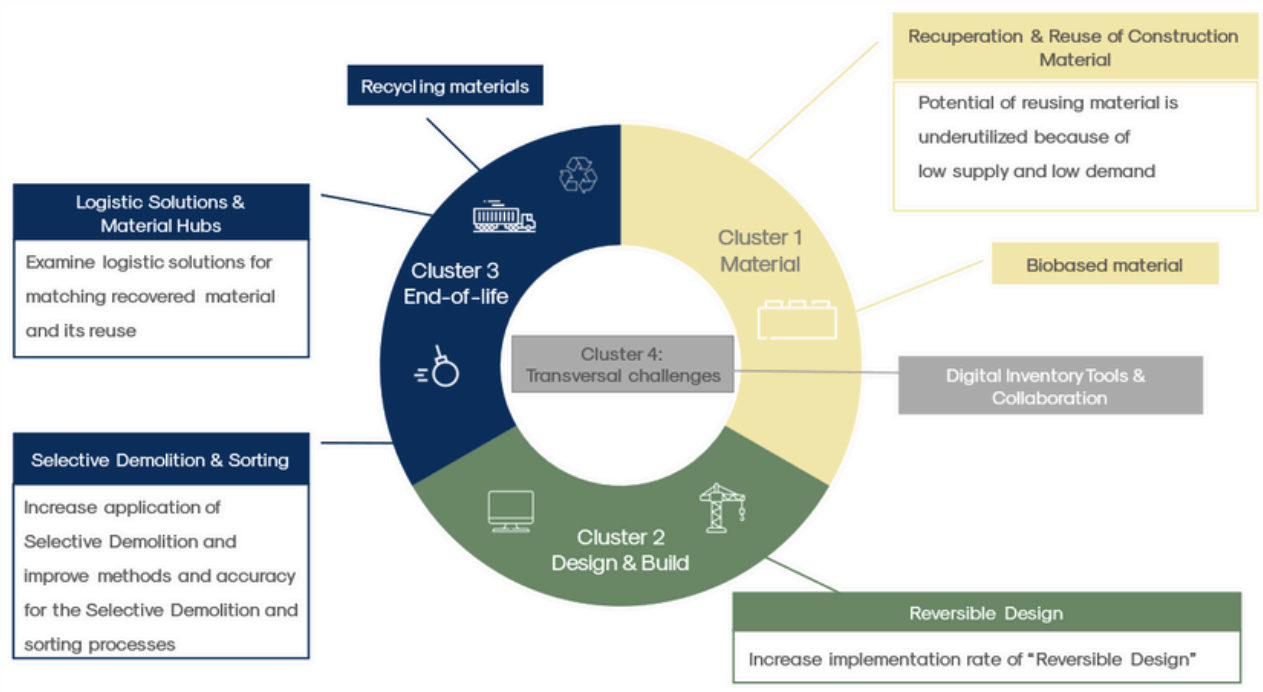
Cross-regional Key Challenges and Needs

Based on a comprehensive assessment of the industry's current state, regional strategies and roadmaps, several common challenges for circular economy in construction were identified (Phase 1). Additionally, private, public, and research stakeholders were consulted to further refine the list of cross-regional challenges and gather input on necessary actions to address these challenges (Phase 2).

The following list is non-exhaustive. Some challenges are specific to certain parts of the value chain, while others are more overarching and transversal.

The diagram below provides an overview of the challenges and actions identified in Phase 1 and Phase 2, grouped into 4 distinct clusters.



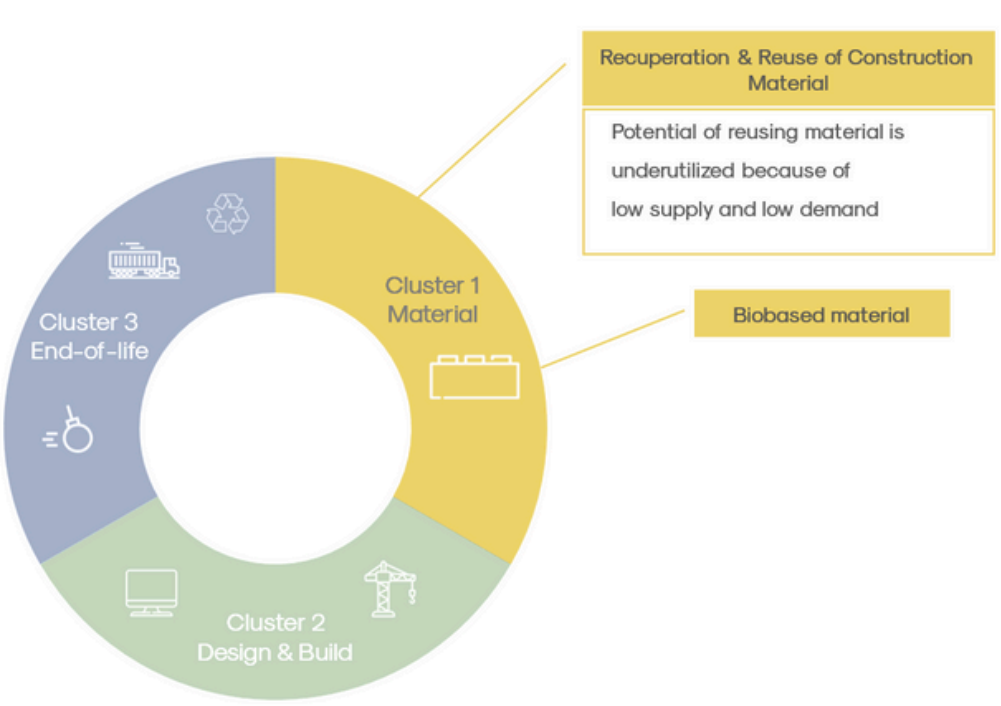
Cluster 1 is focused on **Materials** and addresses challenges and necessary actions related to the low implementation rate of **Re-used materials**.

- **Cluster 2** pertains to the **Design and Building phase**. In the current linear approach, buildings have only one "end-of-life" option (demolition). In a circular approach, the design ensures multiple life options for the building, its systems, products, and materials. This approach implies flexibility for transformations during the building's life cycle.

- **Cluster 3** focuses on the **"end-of-life"** phase of a building. In a circular approach, selective demolition is the norm to recuperate and recycle as much material as possible, allowing materials and systems to have new life options in new construction projects or renovations.

- **Cluster 4** refers to **overarching and transversal challenges**. Digitization can help the construction sector to ease the collection, storing and redistribution of resources as well as providing access to knowledge. The lack of trust, collaboration, and openness toward innovation is another significant issue affecting the entire value chain.

Cluster 1: Material



In this first cluster, we focus on the challenges related to materials that need to be addressed for a transformation towards a more circular construction value chain. The emphasis is on the recovery and reuse of materials and implementation of reused materials in new construction. Biobased construction materials was also a topic of interest for some of the participants, but this topic will not be addressed further within the scope of this report.

Recuperation & Reuse of Construction Material

Challenges

In the current linear approach to construction, there is no large scale systematic process for material reuse, in part due to low supply and demand for reused material.

One major challenge on the supply side lies in the fact that the practice of selective demolition and sorting is applied only in a small percentage of demolition projects. One of the reasons for this limited selective demolition is the significant pressure in terms of time and costs, which affects the demolition process. Clients and contractors often do not allow sufficient time for selective demolition, which is necessary to maximize material recovery.

Another issue is the complex disassembly process. Many materials are not designed for easy disassembly, making it challenging to deconstruct buildings in a way that enables the reuse of materials. This is another barrier for creating a stable supply of reused materials.

Furthermore, the sorting, handling and storage required for selective demolition lead to higher costs, resulting in a higher resale price for these materials. This price issue is a significant obstacle that contributes to the low demand for recuperated materials.

Beyond the price issue, there is uncertainty surrounding the technical performance of recovered materials. Concerns about certification and meeting necessary requirements can deter potential buyers. Additionally, the supply of these materials is often unpredictable in terms of time to market and availability. This inconsistency makes it difficult for construction projects to rely on reused materials, further contributing to the low demand.

Needed Actions

To achieve higher rates of recuperation and reuse of construction materials, several key actions are necessary.

First, improving the operation of the "End-of-life" management in construction is essential. This involves enhancing collection and sorting processes through better disassembly techniques and selective demolition (also see Cluster 3 - End-of-Life). Additionally, the logistics and supply chain need to be more accessible, better organized, and reliable, to ensure a steady supply of reusable materials.

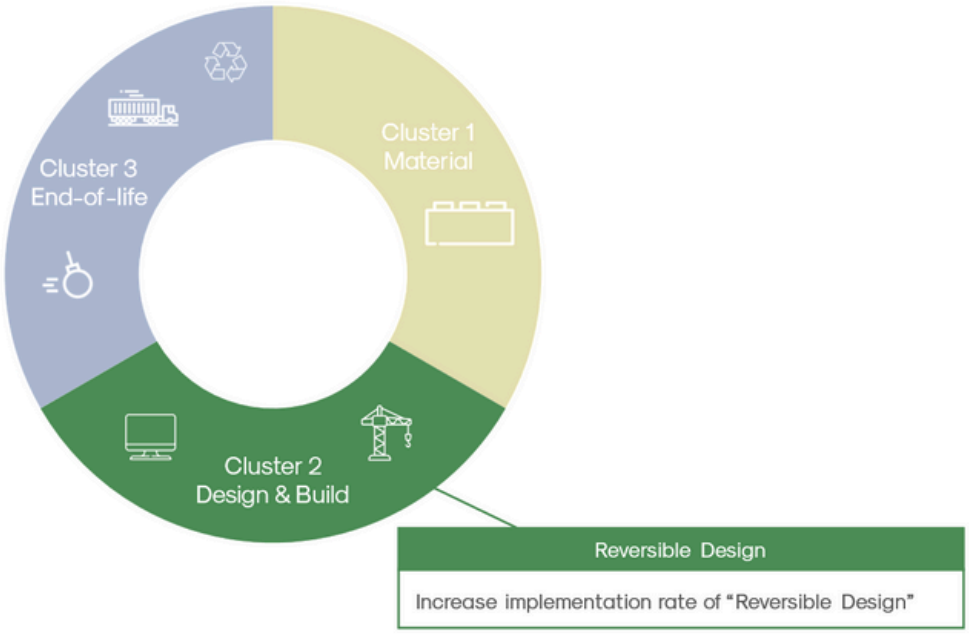
Second, it is important to create support and confidence among buyers and builders for recovered building materials. This can be achieved by demonstrating success stories and sharing good practices. Lowering organizational and administrative bottlenecks will also help build trust and encourage the adoption and use of recovered materials.

Biobased Construction Materials

During the interaction with stakeholders in Phase 2 of the project, biobased materials were also mentioned as a solution to lower embedded CO2 in buildings. Since the stakeholders prioritized the recuperation of materials currently used in existing buildings, we will not delve into this topic in detail. For more information on biobased materials, including references to relevant projects and suppliers, please refer to the Appendix 1.

Cluster 2: Design and Construct

In this cluster, there will be a focus on "Reversible Design" as a guiding principle for the design and construction of new buildings. The principle aims to ensure durable future-proof construction and make buildings adaptable to change.



Reversible Design

"Reversible Design" is based on the idea that buildings, materials, and systems have multiple lifecycles and applications.

After the initial use of materials and systems, they can have a second life, and possibly a third or fourth life in a new building or application. They must be technically flexible and adaptable to new uses, referred to as "technical reversibility."

The same principle applies to the purpose and use of a building. What a building should do and how it is used can change over time. A building that serves as an office today could be repurposed as a residential unit in the future. This requires spatial adaptability and flexibility of buildings, known as the dimension of "spatial reversibility."

It is important to focus on both dimensions of reversibility in the design and construction phases. This approach will facilitate the efficient reuse of materials and systems (see Cluster 1 - Materials) and the repurposing of buildings in the future.

Challenges

There is currently a very low implementation rate for "Reversible Design" in the construction sector.

The construction sector is generally conservative and risk-averse, resulting in little openness to new methods and techniques. There is a predominant focus on initial construction costs, with the long-term returns of reversible construction methods rarely factored into decisions. Builders are often not affected by the long-term effects and, therefore, are not focused on these factors. Additionally, there is a lack of a sufficient product range of reusable and interchangeable standardized construction materials.

Needed Actions

To address these systemic obstacles, it is essential to develop new projects that allow for innovation, experimentation, and contextual design to demonstrate their effectiveness. Sharing best practices from different living lab projects is crucial to building trust and can help to determine the most efficient solutions. Follow-up during the use phase and end-of-life is vital to optimize the long-term practical applicability of these solutions.

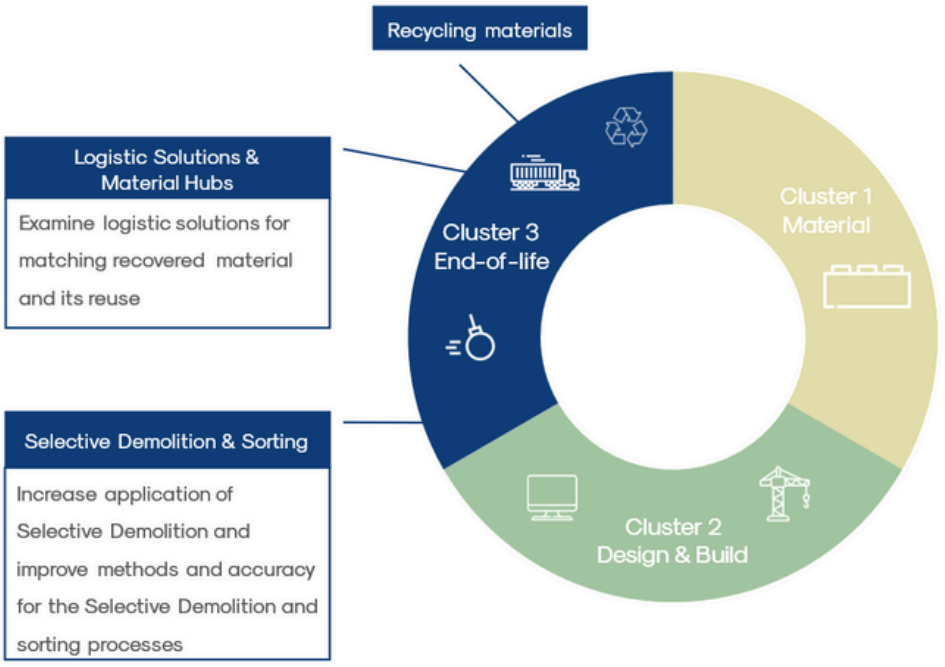
Demonstrating long-term returns can also help convince architects and contractors to apply reversible design.

It is also important to connect SMEs with innovative solutions to explore whether innovative elements and systems can be combined. Additionally, new business models should be examined to determine if they can guide stakeholders towards "reversible" materials and systems.

Cluster 3: End-of-Life

In Cluster 1 (Material), the challenges surrounding the reuse of building materials have been addressed, highlighting issues of small supply and low demand. For the limited materials that do become available, reverse logistics have not been well-established. Material banks have been established in some cases to ensure that used materials are made available for a new life cycle. However, multiple challenges remain for them to be widely implemented on a big scale.

In this cluster, there is a focus on improving the demolition and sorting processes and finding logistical solutions for material reuse. This section will also highlight how improvements in these processes can benefit recycling efforts.



Selective Demolition and Sorting

Challenges

As mentioned before in relation to the low supply of reclaimed materials, building owners are often unwilling to pay extra for highly selective demolition, and clients often do not provide contractors with sufficient time. Even when selective demolition is conducted, there is often no monitoring system, leading to a lack of standards and compliance. Selective demolition requires different skills and qualified personnel, which are in short supply (a challenge that extends to the entire construction sector). On-site space is crucial for selective demolition, especially in urban areas where space is limited.

Material sorting faces similar obstacles, requiring time, skilled labor, monitoring, and resources, all of which add to the costs.

Needed Actions

To address the challenges in selective demolition and sorting, several actions are necessary. First, it is essential to develop a policy framework for the certification and monitoring of selective demolition to ensure that standards are maintained and compliance is effectively monitored.

Second, a detailed analysis of the logistical and organizational processes involved in selective demolition and sorting should be conducted. This analysis will help determine the optimal processes, such as whether on-site sorting is preferable to off-site sorting, taking into account both efficiency and cost minimization.

Third, implementing digital inventories, such as building passports, can provide demolition contractors with valuable information about the materials to be processed. Additionally, these digital inventories can be used by demolition contractors to add information about the condition of the reclaimed materials during the demolition process.

Finally, methods such as robotics, automation, scanning, and AI with visual recognition should be explored to speed up and refine process, and reduce the costs of manual handling. Visual recognition, in particular, can enhance sorting in construction and is also being explored for automated sorting in plastic, packaging, textiles, and other sectors, which can be discovered further in the action plans for circular textiles and construction from the 3R Connect project. The needed actions to examine and develop automated sorting techniques could therefore be conducted through intersectoral collaboration.

Logistic Solutions for Reclaimed Materials such as Material Hubs

Challenges

Ideally, materials from selective demolition should be reused directly on-site to eliminate commercial and logistical operations and costs. However, this is feasible in only a limited number of cases.

Therefore, optimal logistical solutions must be found for reclaimed materials. Material hubs can serve as logistical centers that connect supply and demand, potentially also operating as sales channels. Material banks, a type of material hub, are emerging as a popular solution. These pilot initiatives quickly reach a stage where further professionalization and scaling are necessary to ensure profitability.

Cost factors in the logistical process include the distances that need to be covered, the time and space required for storage, and the efficient matching of supply and demand. These costs are in addition to those incurred from the selective demolition and sorting processes.

Needed Actions

It is essential to optimize all processes involved in selective demolition, sorting, logistics and sales to minimize related costs as much as possible. Therefore, different solutions should be examined, developed, compared and assessed.

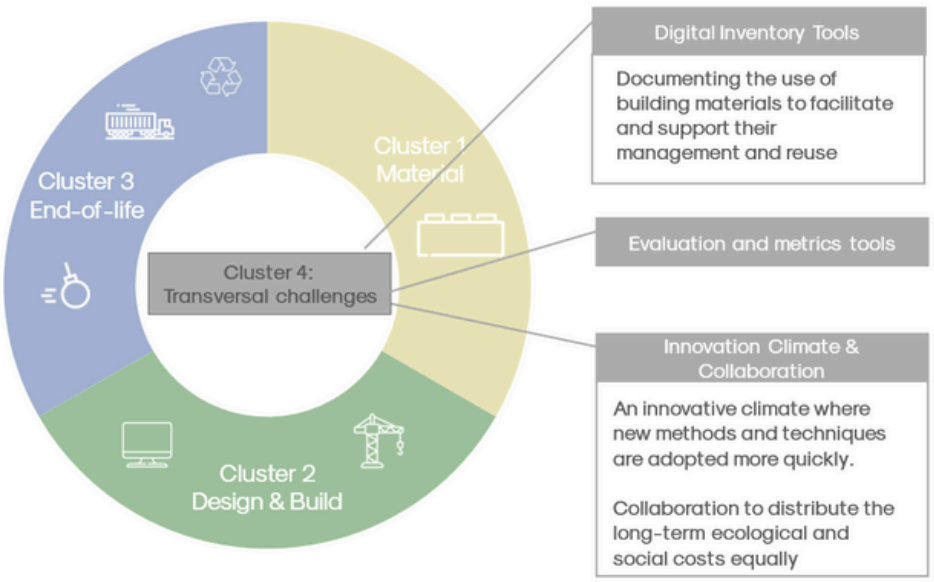
Recycling

The limited application of selective demolition and sorting, along with the lack of reverse logistics, also creates obstacles for materials that are not reused but could be recycled in a "closed loop" system. Several of the manufacturers who participated in the 3R Connect process (e.g. for glass, brick etc.) are exploring take-back programs to use their own material streams as the base raw material for their new production. However, this proves to be very difficult due to the limited supply of their specific recovered fragments, mainly because the demolished material is not sufficiently separated, sorting is not thorough enough or because there are not sufficient reverse logistic systems in place.

Cluster 4: Overarching and Transversal Challenges

Both from Phase 1, mapping the regional challenges, and from interactions with key stakeholders in Phase 2, digitalization emerged as a key factor in transitioning to a more circular construction sector. Digital tools can support and simplify certain processes, potentially saving time and reducing costs.

Another significant challenge that emerged from the assessment and interactions with stakeholders is the need for a cultural change within the sector. Currently, the sector is characterized by a rather conservative, risk-averse culture. As a result, there is little openness to innovation and limited willingness to collaborate within the value chain. However, fostering an open, innovative culture and encouraging collaboration are crucial for initiating and accelerating the transition toward a circular construction sector.



Digital Inventory Tools

To enable better management of the life cycles and flows of construction materials and components, digital inventory tools can make a significant contribution. Especially with a view towards the future recovery and reuse of materials (or even closed-loop recycling through take-back programs), it is crucial to have information about the previous use, including technical product details, design, application and maintenance.

These tools can enhance the efficiency of selective demolition and sorting processes, help in assessing potential future performance and facilitate the remarketing of products.

At a meta-level, collective data from digital inventories could support predictive models of when and where materials will become available. This can improve the continuity and predictability of the supply of reclaimed materials, addressing a concern often faced by designers and builders.

Challenges

Despite several promising solutions, the landscape of digital inventory tools remains fragmented, and significant challenges persist. No single tool has emerged as the dominant market standard.

These tools are not widely adopted by actors within the value chain and often cover only parts of the process, leaving some steps entirely uncovered. To ensure information remains accurate and accessible throughout the material's lifecycle, it is crucial that all links in the chain—production, design, construction, maintenance, etc.—adequately inventory information and log data.

All input data should flow smoothly through the chain and be easily accessible.

Needed Actions

To fully exploit the potential benefits of digital inventory tools, integration of inventory tools across the whole value chain is essential. Data generated at different steps in the lifecycle must be connected.

Steps in the value chain where no digital inventory is currently done or where tools are unavailable must be incorporated into the digital flow, and solutions and tools for these blind spots must be developed.

The various existing initiatives need to be coordinated and connected, with a widespread and common language serving as the foundation. The information architecture should be aligned to standardize connections and avoid custom solutions.

Evaluation and Metrics Tools

Economic costs often dictate building practices in the linear economy, leading to short-term visions and project time pressures, while long-term ecological and social costs are overlooked.

Standardized evaluation criteria and tools are essential for calculating these long-term ecological and social costs. Digital evaluation tools can assist architects, designers, and contractors in making informed choices about sustainable solutions, raising awareness of the social and environmental impacts. Aggregated data can help governmental bodies track the evolution of the transition and adjust policies accordingly.

It is important to highlight the role of digital “evaluation” applications in this context. However, before effective implementation is possible, many challenges concerning the undelying evaluation methods need to be overcomed. But this topic must be considered as it may interact with the process of developing digital inventory tools. It can also lead to different interpretations regarding the benefits and impact of material reuse compared to recycling or the use of alternative materials such as biobased options.

Given the technical nature of these subjects and the ongoing research, delving into them within this report would be excessive. Furthermore, we want to avoid diverting attention from the primary challenges and necessary actions identified in the project. Therefore, while acknowledging their importance, we will concentrate on the challenges and actions which received the most interest from the participating ecosystems.

Cultural Shift Towards an Innovative Climate and Collaboration Within the Sector

Challenges

Circular innovation struggles to gain traction within the construction industry. Executives and investors tend to avoid the risks associated with new building techniques and often revert to traditional construction solutions. They face a complexity of technical and legal regulations and standards, which leaves less room for failure compared to past practices. Contractors, project developers, and manufacturers fear that circular construction paradigms, such as reversible design and the reuse of building components, will result in increased regulations and standards regarding technical performance, environmental impact, and health, thereby raising the risk of failure.

Furthermore, the expectations of building owners and users are increasing. They demand higher levels of comfort and adaptability to individual preferences, as well as more extended guarantees on the quality of construction products over their lifecycle.

Finally, companies and organizations encounter internal resistance to change and innovation, a challenge that is not unique to the construction sector.

There is a lack of trust and collaboration among various stakeholders at both ends of the value chain, primarily because organizations and diciplines still operate based on individual interests. This short-term thinking results in little to no incentive for cooperation between construction professionals at the front end of the value chain (such as producers, suppliers, architects, engineering firms, contractors, investors, and project developers) and stakeholders involved in reverse logistics (such as demolition contractors, urban miners, sorting centers, recycling facilities, and second-hand centers). It is created by mechanisms for self-protection against potential failures to meet technical and legal standards or against claims from building owners regarding unmet quality expectations. Additionally, there is a structural lack of user-friendly platforms and forums for sharing knowledge and experiences among construction professionals and building owners.

Creating an innovative climate in the construction industry is crucial for allowing new methods, techniques, and products designed with "reversible design" principles to gain traction. Testing and applying innovations should be encouraged to convince both early and late adopters with a sufficient number of successful applications. The speed of transformation needs to increase, as the long-term impact of decisions only becomes visible decades later.

Collaboration throughout the value chain is essential to promote choices that offer better collective long-term benefits over those that provide individual short-term gains today.

Needed Actions

To address these challenges, it is necessary to rapidly develop demonstrator cases and pilot projects where research and practice converge. In these projects, multiple techniques and combinations can be tested simultaneously, involving different parts of the value chain and encouraging them to collaborate. The government plays a crucial role as a driving force behind the development of these pilot projects through public procurement.

Another solution to stimulate an innovative climate and projects is the establishment of a Risk or Innovation Fund. This fund can protect contractors willing to apply innovations in their projects against potential claims, failures, and economic liabilities.

Through these pilot projects, examples of better collaboration among actors are built. New collaboration methods, such as construction teams and the role of a central construction director, can be explored and evaluated within these projects. Also the concept of dividing responsibilities along the value chain (Extended Chain Responsibility) can be assessed to see if it enhances collaboration.

The pilots can also function as temporary action knowledge centers, creating a platform or forum for sharing knowledge and experiences among construction professionals and building owners.

Moreover, the ongoing development of new methods and techniques is necessary, independent of pilot projects. Lessons learned from the pilot projects though can provide valuable insights for further improvements and new approaches.

Priority Actions for Circular Transformation in the Construction Sector

The previous chapter outlined common cross-regional challenges and necessary actions identified from the mapping of Phase 1 and the stakeholder interactions during Phase 2. These challenges were investigated with stakeholders from different regions, finding common ground in shared knowledge, competencies and perspectives on these issues.

In Phase 3, this organic selection was further refined and translated into preliminary implementation plans. Priority actions have been developed in areas where a cross-regional solution guarantees a better chance of replication, dissemination and further implementation than a regional solution.

The necessary competencies to realize these actions are either regionally or cross-regionally available, although specific competencies may still need to be further developed. Additionally, some actions are considered urgent and a priority because they are essential for enabling breakthroughs in other areas.

Action 1: Integration of Digital Inventory Tools

Digital inventory tools can significantly improve the management of construction materials throughout their life cycle by enabling documentation from the design phase to be tracked and updated during construction and maintenance. This enhances end-of-life material management and identifies the most appropriate subsequent use, whether reuse, recycling, or another application.

This report primarily focuses on the recovery and reuse of materials and components. A thorough inventory of buildings, including systems, techniques, and materials, is crucial. A high-quality digital inventory serves as a valuable reference and simplifies the work for demolition companies by assisting in pre-demolition audits, supporting selective demolition, and making sorting processes more efficient.

Digital tools can also support manufacturers in providing recommended dismantling techniques and inform demolition actors about take-back programs for specific materials or components. Materials scheduled for release could be pre-reserved for new projects, allowing direct transfer from the site to their new destination, minimizing intermediary logistics.

Additionally, digital tools enhance the marketing of reusable materials through digital market platforms.

For assessing quality and estimating future performance, digital information is invaluable. It allows verification of how long a material or component was used, in what application, and whether any maintenance was performed. This information makes it easier to determine suitable secondary uses.
Finally, there are meta-level benefits for analyzing material flows and creating predictive models.

However, to ensure broad implementation of these digital tools in the construction industry, there is a need for:

Cooperation Across the Entire Value Chain

For the information to remain accurate and accessible throughout the material's lifecycle, all previous links in the chain (production, design, construction, maintenance, etc.) must adequately inventory and log data. All input data should flow smoothly through the chain and be easily accessible.

Integration and Filling in Blind Spots

It is necessary that the different tools are integrated throughout the value chain so that information flows smoothly from one step to the next. Data generated at different steps in the lifecycle must be easily connected. Blind spots in the value chain, where no digital inventory is currently done or where tools are unavailable, must be incorporated into the digital flow, and solutions and tools for these blind spots must be developed. The various existing initiatives need to be coordinated and connected with a widespread and common language serving as the foundation. The information architecture should be aligned to standardize connections and avoid custom solutions.

Steps for Implementation

To ensure integration of these digital tools, it is crucial to:

Develop Common Information Architecture and Data Structure

Digital tools covering various steps in the value chain should seamlessly communicate and exchange information. To achieve efficient integration, an analysis should be conducted to determine the most effective information architecture. Different information architectures can be implemented, such as a single overarching tool that vertically integrates all steps, or an interface that ensures smooth data flow and synchronization between separate databases.

Intermediate solutions are also possible, where certain steps are integrated by one tool, and interfaces are built to manage transitions between other steps.

Uniform data structure is crucial for efficient integration. Differences in information structure, composition, the type of registered characteristics, and terminology can make integration complex and costly. Greater uniformity in language and structure simplifies connections, reduces costs, and enhances user convenience.

A functional data structure should have standardized language and names for products and elements, consistent naming for product characteristics, minimum criteria for each product or element, and uniform ways to qualify and quantify product characteristics.

Fill in Blind Spots

During the interactions with the stakeholders in the 3R Connect process, they indicated that there is a demand to specifically address certain blind spots:

- **Release Date:** Incorporating the time aspect into tools can help designers estimate demolition dates, better planning for reuse, and reduce logistical costs.
- **Certification:** Including assessment and certification processes in the digital chain can lower barriers to reusing construction materials. Digital follow-up can smoothen the process and reduce administrative burdens.

- **Log Information about Service Life:** Data on the service life (e.g., maintenance and adjustments) must be registered digitally to ensure materials and components can be reused or recycled. Several initiatives already exist (e.g. from the University of Antwerp, Mosard), and there is a need to further support and scale up promising solutions.

Make the tools market-ready and develop a viable and scalable business model

To ensure that the tools are eventually adopted by the market, several aspects need to be considered, such as usability, training on how to work with the tools, a good business model, and a legal framework for determining data ownership and the potential trading of this data. To this end, it is key to:

- Ensure that tools are easily accessible and user-friendly, requiring easy and quick data input as well as intuitive interfaces.
- Raise awareness about the importance of these tools and to organize the necessary training for their effective use.

The participants in the 3R Connect process emphasized the need for economically viable business models to be developed and implemented. Specifically, there is a need to ensure that the benefit for the users is high enough for them to be willing to cover the costs related to (further) development and integration of the tools – for example through licencing agreements.

Such costs at the system level relate for example to the establishment of a common data architecture and data structure, uniform terminology, classification and an agreed set of product characteristics. For individual developers, costs encompass software development, support, maintenance, updates, hardware for running apps and storing information, security and commercialization.

User benefits, on the other hand, include better end-of-life management of products towards reuse or recycling and potential economic benefits through efficiency gains in logistic-, handling- and trading costs.

It is crucial to ensure that the system is beneficial for all parts of the value chain to ensure that the chain is not broken, as this would reduce the advantages for users in later stages.

Additionally, a legal framework is necessary for tools and associated data to determine who manages and stores different types of data, data ownership and the right to sell data to third parties, privacy and GDPR compliance for users and clients and necessary data security measures.

Actors and roles

To contribute to a system level shift from a linear to a circular economy, the lines of action require concerted efforts from many different types of stakeholders simultaneously.

Therefore, it is necessary to specify which roles the different actors need to take to contribute to the implementation of the actions. To support the integration of digital inventory tools, the following actors should be involved (non-exhaustive list):




Companies in the construction sector value chain — **Technology providers** — **Interdisciplinary teams** — **Data Information Architect**

Companies in the construction sector value chain

Mapping the information needs of all stakeholders in the chain.

Technology providers

Sharing lessons learned and best practices with other stakeholders and collaborate with developers from other regions to scale up or replicate successful technologies in other regions or (co-)develop new solutions to fill out the gaps and blind spots (e.g. though hackathons, co-creation workshops and/or R&D collaborations).

Interdisciplinary teams

It is important that developers work closely with people from construction practice. In each development phase, consideration should be given to the other phases in the value chain.

Data Information Architect

The data information architect must take into account the practices of the construction sector in order to make the right choices – for example regarding the common language and characteristics. They must also be able to translate this into an efficient data structure that provides a solid foundation for developers of apps and tools.

2 Action 2: Create Integrated Local Reuse Networks across the EU

As stated in Cluster 1, the potential for material reuse is immense. However, it continues to be underutilized as a wide array of challenges for material reuse still persist. Therefore, this action suggests establishing integrated local reuse networks as way to address various challenges and unlock new opportunities.

The objective of these networks is to significantly increase the reuse of recovered construction materials by experimenting with different solutions for existing bottlenecks in logistics, selective demolition, sorting, sales channels, business models, and forms of collaboration. These tests can be conducted within a set of regional test-pilot networks. After evaluating the test results, better insights can be gained into the most optimal solutions for implementation. These solutions can be consolidated into step-by-step guides and scenarios for setting up multiple local networks across the EU.

Continued exchange between the test-pilots and emerging networks in subsequent phases will ensure ongoing optimization of organization and methods. The combination of well-functioning local initiatives with cross-regional knowledge sharing can enhance the effectiveness and scalability of material reuse, contributing to more sustainable construction practices on a wider scale.

In these networks, different solutions should be tested at various pilot sites, and existing solutions should be considered while new ones should be developed as needed.

Testing Supply Side Solutions

On the supply side, solutions should aim to:

- Increase monitoring and standards for selective demolition.
- Simplify the disassembly process.
- Enhance the competencies of the workforce.
- Invest in better sorting techniques, such as automated sorting, to reduce labour intensity and improve accuracy.

To improve the matching between supply and demand, streamlining supply chains by optimizing transport and storage is necessary. Rationalizing and improving fragmented trade platforms will help create a more unified market with well-known and efficient sales channels for reclaimed materials.

Testing Demand Side Solutions

On the demand side, there is a need to develop robust certification and assessment methods to mitigate liability issues and create a more consolidated and easily accessible marketplace for existing and upcoming recuperated materials. Incorporating long-term social and ecological costs into the price of virgin materials would also be preferable, to push for reused and recycled materials to become more price competitive with virgin materials.

Creating Trust in Innovative Solutions

Initiatives to address the lack of trust in innovative circular solutions within the industry should also be examined. Facilitating the sharing of experiences, lessons learned, and knowledge will drive continuous improvement.

Ensuring Critical Mass and Geographical Scale

Ensuring a critical mass within the right geographical range is essential to optimize economies of scale. Testing in pilot networks can help determine the right range and needed critical mass. By leveraging these opportunities, the construction industry can significantly improve the reuse rate of materials, leading to more sustainable practices and enhanced resource efficiency.

Steps for Implementation

To establish one or a set of integrated local reuse network(s) following steps should be carried out:

Engage stakeholders across the value chain

Engage a comprehensive array of local stakeholders for each phase of the lifecycle and value chain. This engagement should involve regular consultations and collaborative workshops to align project goals. The listing of all the stakeholders that should be involved and how they should be involved can be found in the table of Actors and Roles.

Scaling-up selective demolition and improved sorting techniques

To enhance material recovery and reuse, it is essential to scale up and improve existing selective demolition and sorting techniques. This effort requires capacity building and training for staff to implement selective dismantling and proper on-site sorting effectively. Initiatives should also introduce advanced automation technologies, such as AI-driven visual recognition systems, to assist in the sorting process, reduce labor intensity, and increase precision.

Implement structured processes where demolition companies coordinate with transport providers to efficiently move materials to sorting facilities. At these facilities, further sorting and assessment can ensure materials meet quality standards for reuse. Engaging material producers early in the process is crucial, as their product knowledge can help formulate sorting criteria and participate in take-back schemes where they recondition and reintroduce materials into the market or keep them for recycling.

Despite the established nature of selective demolition, the demolition industry faces significant barriers to widespread adoption of selective demolition. One major challenge is that selective demolition, accurate sorting, logistics and storage of materials are costly procedures. While disposal in landfills is often cheaper. Testings of new and advanced sorting techniques should result in methods that reduce costs and improve accuracy.

The benefits of scaling up these techniques include significant waste reduction, future social and ecological cost savings from reduced disposal in landfills and the creation of a sustainable supply chain for reclaimed materials.
By refining these processes, the construction industry can achieve higher material recovery rates, leading to more sustainable practices and fostering a circular economy. However, to make this transition viable, it is crucial to address the economic challenges and create incentives that make reuse a competitive option compared to traditional disposal and the use of virgin materials.

Develop adapted methods for assessment of technical performance for reclaimed material

Most construction products on the European market are required to have a performance declaration prepared by an authorized laboratory or institution. This performance declaration allows builders or architects to compare construction products and assess their technical performance, enabling them to determine which product is suitable for specific applications.

By signing the performance declaration, the manufacturer takes responsibility for the product's performance and for all the products coming out of their production. Therefore conditions during the production process should be kept standarised with intermediate quality controls.

The technical declaration ensures that the builder or architect can rely on the declared performance without being held personally liable later.

Since the extensive costs of these authorized assessments of technical performance can be spread over a large number of produced products, these certification studies remain feasible.

For products that are not produced under factory conditions or are reclaimed, it is however challenging to substantiate their technical performance. With proper substantiation, these products could be used with confidence by architects and builders in new projects.

The lack of this substantiation is a significant barrier for architects and contractors to reuse reclaimed materials, as they remain liable for the technical performance in a new project without such an official declaration of performance.

Therefore, there is a need for new and pragmatic methods for assessing the technical performance of reclaimed materials after reconditioning.

Various tailored proposals and models are in development or have already been developed. The pragmatic and adapted evaluation methods for reclaimed materials that are available can already be tested in the different pilot projects. The results of these tests can serve to refine the methods and later also be a recommendation for the government for the general standardization of methods for reclaimed materials at the EU level. Conducting a detailed investigation, drafting, providing legal underpinning, and converting these into regulations for standardized methods is beyond the scope of this action. This task belongs to the EU institutions and legislators established for this long-term work. Once again, agile practical tests could facilitate this work and provide better direction for their work.

Test Different Logistics Management Models and Roles

To effectively address logistic bottlenecks for material reuse, it is necessary to test various logistic models in different pilot reuse networks. These pilots can experiment with different transportation strategies starting from the demolition site, determining who is responsible for "reverse logistics" and how intermediate storage will be managed if necessary. Additionally, these pilots can assess whether material hubs that combine logistics management and storage of both virgin and reclaimed materials function well.

The tests should provide sufficient data to optimize transport and storage costs in conjunction with demolition and sorting processes. For instance, offsite sorting by a specialized company might lead to a more time- and cost-efficient process but would require at least two additional transportation steps. Various combinations can be tested to gather actual data on time and cost efficiency.

Furthermore, it is essential to examine and test which actor is best suited for each part of the logistic chain. For example, it can be tested whether demolition companies can provide vertically integrated services that extend to the role of material hubs. Alternatively, it should be examined what happens if wholesalers and retailers offer downstream services, managing material hubs, sales channels, and the collection of sorted, reclaimed materials.

Additionally, producers utilizing a Materials-as-a-Service model or setting up take-back schemes can also play a role in the logistics of marketing the reuse of reclaimed material. In this model, producers collaborate with designers, contractors, property managers, and demolition firms, maintaining ownership of materials throughout their lifecycle. They provide services such as maintenance, reconditioning, and eventual take-back for recycling or reuse. This approach can be tested by having material producers engage in end-of-life processes to assess the feasibility and sustainability impact of reuse or recycling. By involving producers in these tests, it is possible to gain valuable insights into the feasibility and advantages of different end-of-life options for construction materials.

The pilots of local reuse networks could also test the implementation of a "Central Coordinator Function," where a central stakeholder, such as a cluster or government entity, oversees and coordinates the local network. This central actor could ensure stakeholder engagement and oversee the smooth operation of the reuse network.

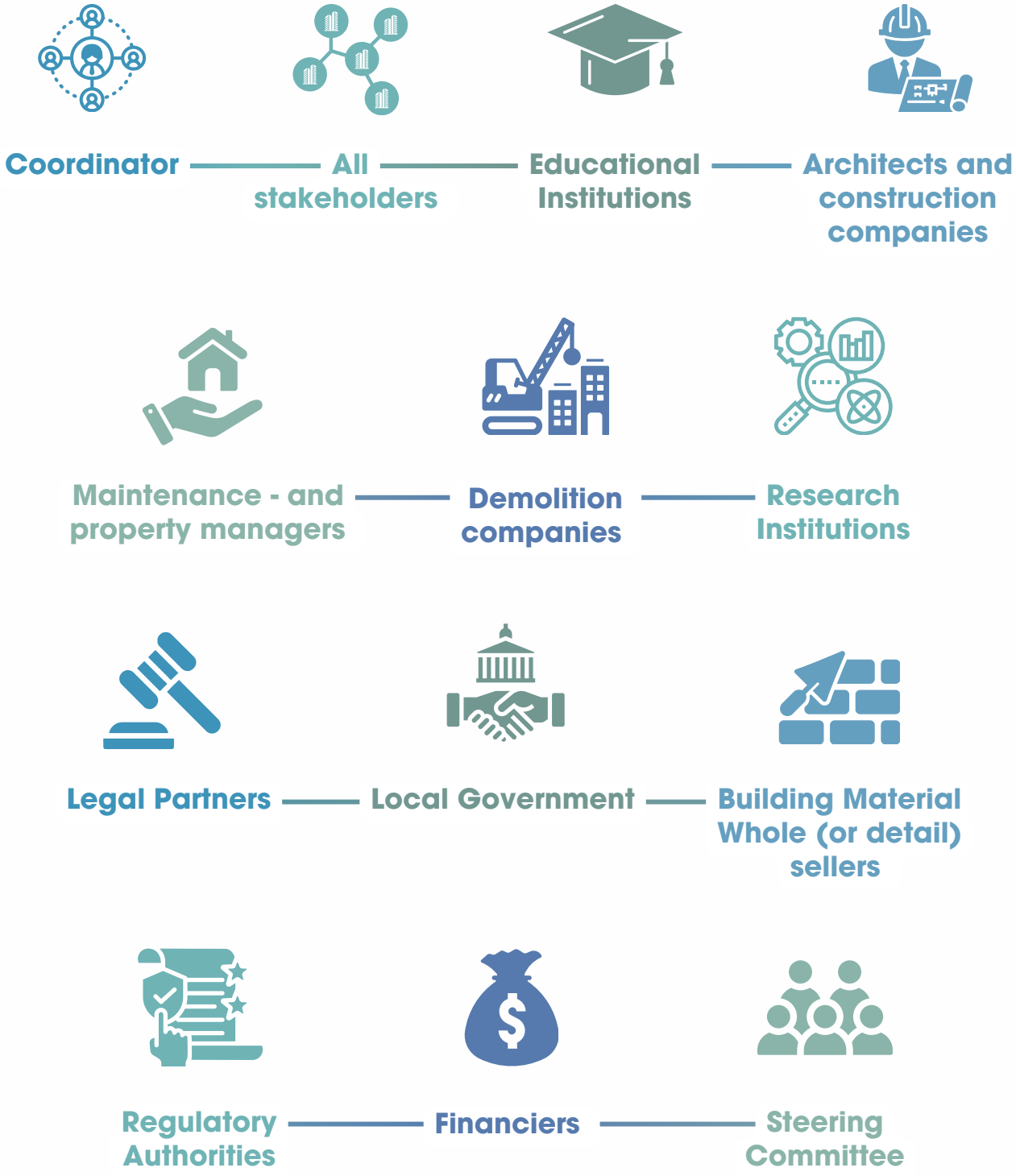
Create Knowledge-Action Hubs Within Integrated Networks

Within integrated reuse networks, it is important to foster and maintain collaboration. Knowledge-action hubs could be created to serve as platforms for collaboration and learning. These hubs would allow stakeholders to exchange insights, refine practices, and advance sustainable construction techniques. Efforts should focus not only on enhancing skills and knowledge but also on accelerating the adoption of material reuse practices. It is crucial to designate an actor responsible for the smooth functioning of the action-knowledge hub, including fostering collaboration and facilitating extensive knowledge sharing.

Training institutions could be actively engaged in these action-knowledge hubs. Their involvement ensures that expertise in material reuse is integrated into their own curricula and passed on to the next generation of construction professionals. This could be achieved through training sessions focused on the assessment and reconditioning of reclaimed materials.To effectively address logistic bottlenecks for material reuse, it is necessary to test different logistic models in various pilot reuse networks. These pilots can experiment with different transportation strategies starting from the demolition site, determining who is responsible for "reverse logistics" and how intermediate storage will be managed if necessary. Additionally, these pilots can assess whether the model of material hubs that combine the logistics management and storage of both virgin and reclaimed materials functions well.

Actors and roles

To implement reuse systems for take-away and retail packaging, the following actors should be involved (non-exhaustive):



Coordinator

A party responsible for the recruitment of local stakeholders. This can be a temporary role or continue into the director role for the remainder of the pilot project.
Ensuring continued engagement of the stakeholders.
Overview of the theoretical choices and the practical execution.
Monitor operations in the network and keep track of difficulties and successes.

All stakeholders

Better understanding of each other's activities and challenges.
Agreements on the choice of platforms and information tools.
Agreements regarding the choice of:

- Collaboration forms
- Logistics
- Business model(s)
- Assessment method(s) for recovered materials
- Frequent meetings to exchange experiences on the decisions made and provide adjustments

Educational Institutions

Participation in local reuse networks in order to acquire knowledge from pilots and integrate it into educational programs. This will also provide students with access to the physical pilots and opportunities to engage with professionals from the construction value chain.
Participation in setting up a knowledge hub.

Architects and construction companies

Be actively involved in design and planning meetings to incorporate reclaimed materials.

Maintenance - and property managers

Participate in ongoing assessments to ensure the long-term viability of reused materials.

Demolition companies

Coordinate closely with transport providers to streamline the logistics of material recovery.

Research Institutions

Conducting research and providing advice on:

- Stakeholder involvement
- Forms of collaboration
- Comparing and designing new logistical models
- Cost calculation (LCA)
- Analyzing improving assessment methods for recovered materials

Legal Partners

Legal advice on collaboration forms.
Framing alternatives or flexibility around the framework for the liability for reused materials (e.g. setting up a Liability Fund).

Local Government

Client in public procurement incorporating material reuse in their own projects.

Building Material Whole (or detail) sellers

Play a role in the value chain as a material hub, logistic partner or even the “Central Director”.
Share knowledge and organisational skills.
Be a gateway to their network.

Regulatory Authorities

Finally, local and regulatory authorities should be involved in developing and adapting policies that encourage and facilitate material reuse.

Financiers

Must be engaged to develop and support innovative funding models that make reuse economically viable.

Steering Committee

Besides the local connectedness of the ecosystems, interconnection between the ecosystems will also be necessary.
Involved actors:

- Coordinating parties or the “Central Directors” from the various pilots
- An overarching research institution or collaboration of different centres to coordinate, measure, and compare the possible organizational, economic, ecological, social, and logistical alternatives used in the various pilots. This with the aim of formulating the ideal constellation

3 Action 3: Support public procurement of innovative solutions for circular economy within construction

Public procurement can be a significant driver for the development, testing and broad implementation of innovative circular solutions. Pilots conducted by public actors can be crucial in the initial phases of technology development through early stage testing of new solutions, while more market-ready solutions can be more widely applied through public procurement of circular technologies, materials and techniques. To increase public procurement of innovative circular solutions, it is crucial to:

- Ensure sufficient awareness of and access to innovative solutions and suppliers
- Apply the necessary framework and procedures for innovative procurement

In this action, future projects and collaborations will be planned to enable public buyers to procure innovative circular solutions which contribute to a circular economy within construction. Throughout the 3R Connect process, the aim has been to identify opportunities for future projects by assessing which topics public actors have an interest in pursuing.

Steps for Implementation

Implementation of this action requires steps to:

Share knowledge, best practices and inspirational cases for innovation procurement

To increase the uptake and drive the demand for innovative circular solutions, there is a need to continuously showcase inspirational examples through networks and cross-regional collaborations between public buyers to ensure that best practices can be replicated in other regions. Examples of best practices can be found in the Appendix 1.

Facilitate capacity building on innovation procurement

It is also necessary to build competencies among public buyers to change traditional procurement practices and procure alternative solutions.
A distinction should be made between different strategies for innovation procurement depending on the availability of solutions:

- If the solutions are commercially available, a simple approach can be taken.
- If the needs can only be met by solutions which are not yet developed, a more explorative approach is needed.
- If only parts of the solution are available, adaptation and further development may be necessary.
- A more strategic co-development approach can be taken for critical materiel.

This calls for procurement experts and innovation brokers to set up networks and joint programs to support public actors in the change of processes and showcasing best practices. Several successful initiatives and projects on public procurement of innovation already exist and should be drawn on for inspiration (e.g. FCRBE, ProCirc, BRINC and other European projects)

Establish connection between public buyers and innovators through cross regional matchmaking and launch of joint innovation challenges

To ensure that public buyers are aware of the circular solutions which already exist on the market, there is a need for innovation brokers, such as clusters, to identify and showcase promising market ready solutions. Similarly, there is a need for procurement experts and innovation brokers to support the adaptation and co-creation of new solutions to match the needs of public buyers.

Based on surveys which were shared with public stakeholders and other actors working with innovation procurement, a set of innovation challenges and needs for innovative and circular solutions have been identified as common across different EU regions. These priorities will therefore be the focus in future projects on public procurement of innovation with the aim of accelerating the demand for circular solutions and products as well as sustainable materials. The joint priorities and topics of interest are:

- To set-up material banks or local reuse networks to support the re-use of construction material. Especially storage options are of interest in this regard.
- To set minimum requirements for recycled or biobased content in materials for new buildings.
- Reversible design for new buildings or renovation.

Other topics also received interest among the public buyers and could also be explored in future projects facilitated by the partner group and in the International Cleantech Network. This includes for example optimized storage options for used construction materials, renovation and repurposing of buildings as well as tools for traceability and resource mapping.

Procurement of innovative solutions

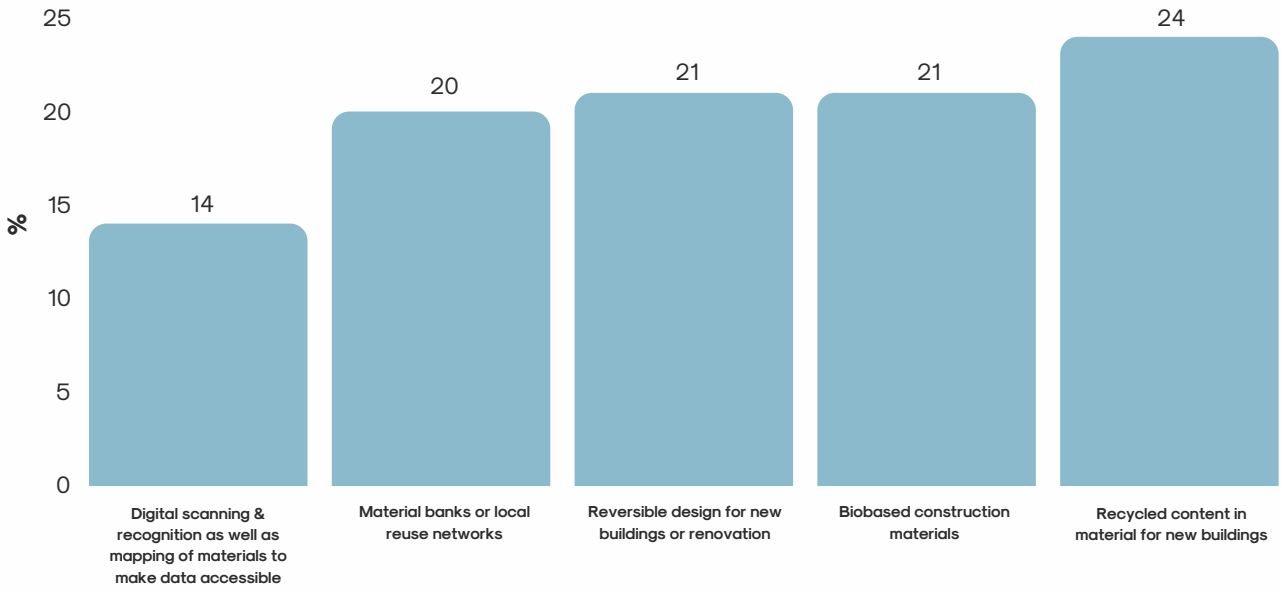
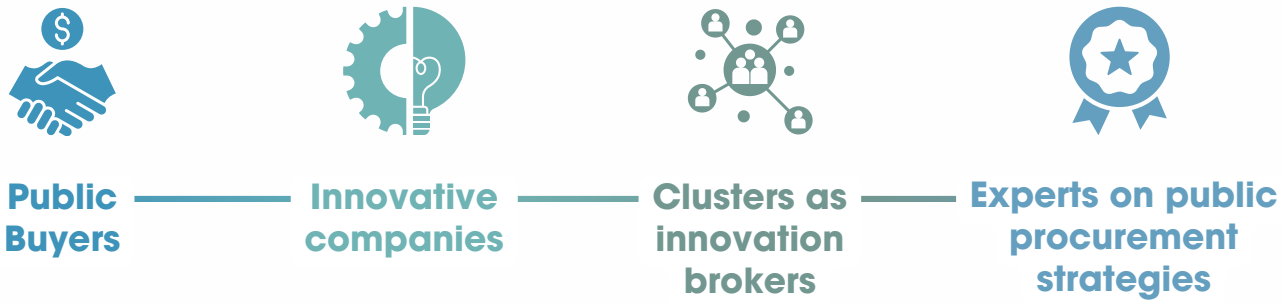


Image 1 - Percentage of participants interested on the procurement of innovative solutions.

A set of "needs statements" should be launched jointly in collaboration between municipalities and other public stakeholders within the topics that were deemed most relevant. The innovation needs from public buyers will be matched with innovative circular solutions from different regions, and in the cases where the required solutions do not already exist, they will be (further) developed in collaboration between relevant stakeholders. A common denominator for most of the prioritized topics is that the required solutions are sold to both public and private buyers. This should be considered in the co-development of new solutions.

Actors and roles

To implement reuse systems for take-away and retail packaging, the following actors should be involved (non-exhaustive):



Public Buyers

Be willing to change internal processes and policies to procure innovative solutions, and introduce circular requirements.

Innovative companies

Engage in matchmaking and co-creation processes, and be prepared to adapting solutions to fit the needs of public buyers.

Clusters as innovation brokers

Facilitate the establishment of networks and knowledge sharing between public buyers.
Clusters can function as brokers between public actors and innovators – specifically through matchmaking and facilitation of co-creation processes.

Experts on public procurement strategies

Support public buyers on innovation procurement processes. As legislation and policies differ from country to country, projects should provide access to legal expertise from all involved countries.

How can the actions for the construction sector be funded?

- The consortium and the International Cleantech Network will develop proposals to implement these actions through relevant funding schemes. In example, Interreg Europe as well as region-specific Interreg programs can be utilized.
- Joint Interreg projects can for example ensure training and support for public actors in innovation procurement, matchmaking and co-creation of circular solutions within the selected topics and adaptation of processes and policies for public procurement in the participating municipalities and public institutions. Additionally, calls within the European Built4People Partnerships will be considered for further development.
- Eureka Eurostars: A matchmaking process has been initiated for innovative SMEs, universities and research centers focusing on implementation of the developed actions.
- Euroclusters: The International Cleantech Network will develop an application for the Euroclusters programme to provide cascade funding for the implementation of the actions.

Sign up here to show your commitment to taking action!

Appendix 1: Best practices and regional competences

Recuperation and Reuse of Construction Material

Projects:

- FCRBE: Facilitating the Circulation of Reclaimed Building Elements in Northwestern Europe
- Outcomes of Opalis
- SURA Impact: Circular Economy Living Lab MASCO
- Combination of Collective Renovation & Circular Material: Renolab
- CIRCuIT: Circular Construction Collaboration

Companies:

- BC Materials
- Opalis: Database of Dealers in Recovered Building Materials in Belgium, The Netherlands, and France
- Rotor DB: Material bank and research/projects on reuse of materials
- The Future is HERE | ZIN: Example of public procurement applying circular renovation with material recovery
- Werflink: Online Platform to Match and Share Building Materials
- Gamle Mursten
- Cirkularitet & Genbrug
- Genbyg.dk

Other Countries:

- Salvo Web: Database of Dealers in Recovered Building Materials for UK and Ireland
- The Netherlands: Private initiative of material bank as part of a demolition company: Gebruikte Bouwmaterialen and Oogstkaart

Biobased Materials

Projects:

- https://www.interreg2seas.eu/en/CBCI
- https://www.vub.be/arch/project/reconstruct
  - Material innovation
  - Design for deconstruction and digitalization
- https://www.stacks.ucll.be/
- Værdiforøgelse af byggeaffald
- Forædling af Byggematerialer
- Circle House

Companies:

- https://theexplodedview.com/materials-methods/materials/
- https://bcmaterials.org/: Turn excavated earth into building materials; earth-building
- https://www.kampc.be/explodedview
- https://www.woonder.be/over-woonder-materialen: Cooperation for “natural building”
- https://www.recticelinsulation.com/be-nl/impact: Incorporation of biomaterial
- https://inhout.be/: Bio-ecological building company
- https://gramitherm.eu/?lang=en: Insulation from grass
- https://vlaanderen-circulair.be/nl/doeners-in-vlaanderen/detail-2/ldg-4
- https://vlaanderen-circulair.be/nl/doeners-in-vlaanderen/detail-2/bc-architecten
- https://www.c-bouwers.be/producten: List of construction materials that are biobased, recycled, bio-degradable, upcyclable, and healthy
- Homepage - Søuld (sould.dk)

Reversible Design and New Techniques

Projects:

- https://vlaanderen-circulair.be/nl/doeners-in-vlaanderen/detail-2/sensiparti
  - https://www.vub.be/arch/project/userstories
  - Outcome of this project is https://www.ecobouwers.be/

- https://www.vub.be/arch/project/ateliercirculair
- https://www.vub.be/arch/project/reconstruct
- https://www.vub.be/arch/project/checklist
- https://ideamechelen.be/circular-interior-design-guide/
- https://www.vlaio.be/nl/projecten/circulaire-economie/brug
- How circular is your construction project?: https://circularbuilt.be/nl
- Housing Cooperations for hybrid housing: https://www.vlaio.be/nl/projecten/circulaire-economie/hybride-wonen
- https://endeavours.eu/en/knowledge/publication/belevingsonderzoek-compact-wonen : Compact living
- https://rebelgroup.com/en/projects/cesco-xl-a-new-circular-living-concept/ : ESCO principles applied on circular houses
- https://northsearegion.eu/procirc/pilot-projects/demonstration-box-for-circular-construction-within-de-potterij/project applying flexible ecodesign
- https://www.vlaamsbouwmeester.be/nl/subsite/terug-in-omloop (reuse of contaminated land and old industrial sites. Not specifically ecodesign, but principles of repurposing in sustainable manner)
- Minimizing resource consumption on the construction site

Companies:

Architects involved in projects:

- https://www.nav.be/contact/ - Federation of Architects
- https://buur.be/project/pilootproject-potterij-mechelen/
- https://tekenarchitectuur.be/projecten/
- https://eaplus.eu/
- http://www.blaf.be/blaf_architects
- https://www.a-tract.be/architect-circulair-bouwen/
- https://www.maatschap.net/
- UPCYCLING ORANGERIE - RIISHØJVEJ - Nord asNord AS (nord-as.dk)
- Anders Mainz ApS - Nederland | Timmerwerk & Bouw | Duurzaam bouwen
- Projects – ADKPT
- Toegang – Aaen Engineering (aaen-engineering.com)
- https://lendager.com/
- https://www.sweco.dk/en/
- https://www.procesl.pt/

Construction companies & real estate developers:

- https://skilpod.com/en/past-projects: prefab “standard” container houses
- https://hahbo.be/ : prefab, “standard” container houses

- https://en.kozo.co/housing/concept : prefab, “standard” container houses
- https://www.revive.be/en/
- https://democogroup.com/en/democo/greendesk
- https://www.beneens.be/circulair
- Our Story | BuildUp (buildupoffsite.com) (offsite production)
- https://labland.be/hoe/projectbegeleiding-circulair-bouwtraject/
- https://www.mosard.eu/
- https://endeavours.eu/en/about : cooperative of construction workers
- https://www.bopro.be/about-us#sdg
- https://nrep.com/about-us/
- Sustainability - Casais Group
- Innovative and Sustainable Projects - Blufab
- https://www.garcia.pt/pt/
- Vision, Mission and Values - Mota-Engil
- https://www.teixeiraduarte.pt/
- https://mth.dk/Kort-om-MT-Hoejgaard
- https://ojas.dk/kompetencer/baeredygtigt-byggeri/
- https://www.sj.dk/
- Expertise → PLH Arkitekter
- https://www.niras.com/
- Frandsen & Søndergaard
- Sonae Sierra | Open mind Greater value

Construction:

- https://www.facadeclick.be/
- CLT-S – Wat is CLT : system for wood wall building
- https://woodinc.be/
- https://www.claerhoutaluminium.com/en/products/products-cat/roof-verges-roof-verge-systems/roofingclips.htm (modular roofing clips)
- https://havnens-h.dk/
- https://scanunderlay.dk/
- Secil Portugal | Building Materials
- REXCON ReBLOCK - A Circular and Modular Construction system.
- https://greendozer.com/
- https://purcity.com/
- About - PurCity (Stay healthy, Stay Pure)

Interior modularity & reuse:

- https://www.baoliving.com/: modular “block” system of furniture for kitchen, bathroom, storage, etc.

- https://www.staenis.com/en-150/HowItWorks : Modular floor construction, substructure)
- https://www.circulator.eu/browse-the-cases/detail/vitsoe
- https://www.openstructures.net/about: Open-source system for modular construction of furniture
- https://www.juunoo.com/: modular wall system
- https://burntwood.nz/
- Our Approach | Tarkett (tarkettsee.com)
- https://flow-loop.com/

Demo-projects:

- https://vlaanderen-circulair.be/nl/doeners-in-vlaanderen/detail-2/graphene-een-uitgesproken-circulair-bedrijfsgebouw
- https://www.impactfactory.be/impact-community/

Selective Demolition

Policy framework:

- https://interregeurope.eu/karma

Monitoring and certification of selective demolition:

- https://single-market-economy.ec.europa.eu/news/eu-construction-and-demolition-waste-protocol-2018-09-18_en
- https://www.3ciencias.com/en/libros/libro/analysis-of-european-Context-in-demolition-audits/
- https://keep.eu/projects/18915/Construction-demolition-was-EN/
- https://norden.diva-portal.org/smash/get/diva2:1294662/FULLTEXT01.pdf

Set-up analysis to determine best logistic and organisational approach to sorting within selective demolition:

- https://www.tracimat.be/over-ons/wie-zijn-we/
- Scope - Iceberg (iceberg-project.eu)
- https://vlaanderen-circulair.be/en/cases/detail/living-lab-circular-demolition-teams

Material Banks as Material Hubs

Projects:

- https://www.bamb2020.eu/about-bamb/
- https://www.grondbank.be/nl/over-ons/voorstelling/
- Circle Bank
- The Resource Bank project, Sweden
- Reuse guide
- Material bank Porto:
  - https://museudoporto.pt/recurso/banco-de-materiais/
- Material bank Leuven:
  - https://opalis.eu/en/dealers/materialenbank-leuven
  - https://ce-center.vlaanderen-circulair.be/en/publications/publication/a-materials-bank-for-circular-leuven-how-to-monitor-messy-circular-city-transition-projects
- Material Bank Antwerp:
  - https://www.buurmanantwerpen.be/over-de-materialenhal
    - Link with
      - https://www.buurmanutrecht.com/
      - https://www.buurmanrotterdam.nl/
- Material Bank Brussels:
  - About us | Rotor Deconstruction – Reuse of building materials made easy (rotordc.com)
    - BBSM (ucl.ac.be)
- Sint-Niklaas: Ambition to open material bank
  - https://www.sint-niklaas.be/actueel/persberichten/sint-niklaas-ontvangt-circubuild-award-voor-circulair-pionierswerk
- Material Bank Charleroi
  - https://www.cornermat.be/
- Material Bank Aalborg
  - https://raatoggodt.dk/materialebank/
- Upcycling Bank
  - Upcycling Bank
- https://www.smartsymbiose.com/#/aanbod/zoeken

Companies:

- https://bcmaterials.org/about-us
- https://opalis.eu/en/: Database of dealers in recovered building materials in Belgium, The Netherlands & France

- https://www.rotordb.org/en
  - Material bank
  - Research & projects on reuse of materials
- werflink: online platform to match and share building materials and surplus of materials (by https://www.floow2.com/about-us.html)

Other Countries:

- https://www.salvoweb.com/salvo-directory/fcrbe: database of dealers in recovered building materials for UK and Ireland
- The Netherlands: private initiative of material bank: https://zakelijk.gebruiktebouwmaterialen.com/ part of demolition company. https://www.oogstkaart.nl/

Recycling

Projects:

- Scope - Iceberg (iceberg-project.eu
- https://www.puresmart.eu/
- https://www.circular-concrete.be/resultaten/praktijkgids/
- https://vlaanderen-circulair.be/nl/aan-de-slag/tools-en-platformen/tool-2/proremat: list of construction materials with recycled content.
- https://www.proremat.be/: products with recycled or biobased content
- https://windowsforcircularbuildings.com/en/project
- Cirkulær beton – Udvik
- Forædling af Byggematerialer
- Fremtidens cementprodukter

Companies:

- Carbonation | Orbix: CO2 and Carbinox® combine to act as a binder, instead of cement. That makes these products extremely long-lasting and environmentally friendly, since they ensure a unique, permanent storage of a substantial quantity of CO2.
- https://bcmaterials.org/: Transform excavated earth - officially a 'waste' - into circular building materials, without having to burn them

- https://www.vandersanden.com/nl-be/pirrouet
- Recyclageservice rotswol isolatie ROCKWOOL
- https://www.circulator.eu/browse-the-cases/detail/gyproc-saint-gobain
- https://www.circulator.eu/browse-the-cases/detail/deceuninck-cyclefoam
    - https://vlaanderen-circulair.be/nl/doeners-in-vlaanderen/detail-2/deceuninck-cyclefoam-r
    - https://www.deceuninck.be/nl-be/deceuninck-recycling
- sapabuildingsystem.com: Hydro CIRCAL 75R
- https://www.isoltechnics.be/thermische.html : Windows from recycled aluminium
- https://vlaanderen-circulair.be/nl/doeners-in-vlaanderen/detail-2/clean-site-circulair : Recycling packaging film at construction site
- https://www.circulator.eu/browse-the-cases/detail/derbigum
- https://www.circulator.eu/browse-the-cases/detail/econation-light-energy: only for industrial projects. But also interesting for collective renovation. Is ESCO-model.
- https://www.forbo.com/flooring/nl-nl/duurzaamheid/take-back-service/p7jjid : With the 'Take Back Service' for Marmoleum & vinyl, Forbo Flooring offers the opportunity to recycle cut-remnants of Marmoleum and vinyl, End of Life Marmoleum and loose lay Vinyl floors. After these materials are received back, Forbo sorts and recycles the materials into a new raw material that is incorporated into new flooring at our production sites in Assendelft (Marmoleum) and Coevorden (vinyl).
- https://www.circulator.eu/browse-the-cases/detail/desso : carpet tiles with take back offer. Offer ESCO for interior tiles
- https://www.circulator.eu/browse-the-cases/detail/interface: carpet production from recycled modular carpet tiles, take back system, manufacturer products from recycled carpet
- Recycling (interface.com)
- https://www.unilin.com/ : products with regained and recycled wood
- https://nnof.be/en/services/ : interior design for workspace with max reuse of existing furniture
- https://akoestiekfabriek.be/ : recovery of insulation panels to make acoustic panels
- https://www.facebook.com/SCRAPvzw/ : upcycling van used wood
- https://www.circulator.eu/browse-the-cases/detail/recup-design
- Labeur Atelier - Labeur – Met hart en stiel : interior design and furniture by reuse of wood
- https://www.resourcelab.be/realisaties/doucheflux/

- https://morecircular.com/ : lamps from plaster(boards) waste
- Carbon Saving Adhesive-Free Flooring | Sustainable Flooring (al0tro.com)
- Ragn-Sells' view on a circular economy (ragnsells.com)
- Over ons - Solum
- http://www.rcd.pt/
- https://hockerup.dk/
- https://www.legaloffice.be/ : legal firm participated in project about legal aspects of working with new/recycled materials

The Netherlands

- About us | C2C-Centre: cradle to cradle knowledge

Digitisation

Projects:

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

Companies:

- https://www.nti.biz/
- https://weuse.dk/en/
- milva.dk
- https://www.theupcycl.com/mission

Innovation procurement and acceleration

Pilot Cases:

- Circular Cities
- CityLoops

Circular Public Procurement:

- https://northsearegion.eu/procirc/
- BRINC
- Big Buyers Working Group
- https://nordic.climate-kic.org/success-stories/circular-cities-project/
- https://www.circubuild.be/nl/aanbesteden/cabrio/

3R reduce reuse rethink

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