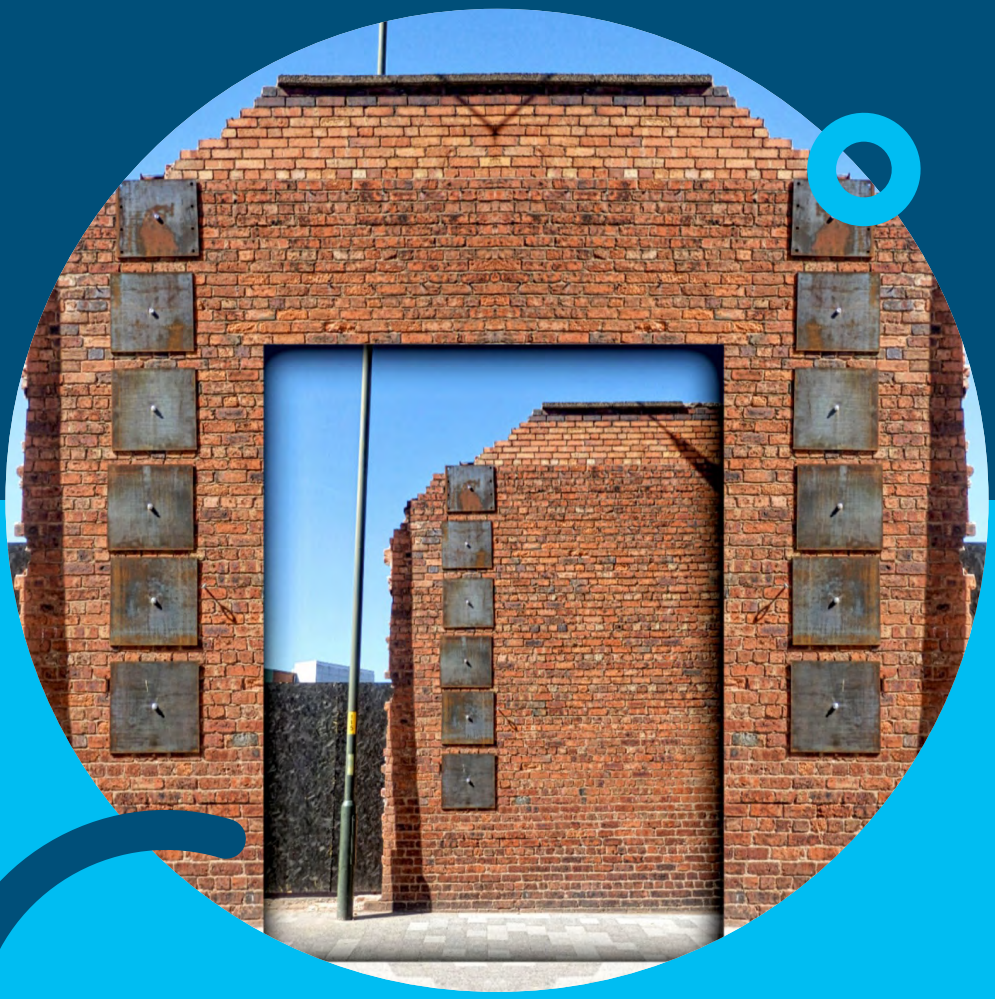
CITYLOOPS



# Circular construction in Europe: handbook for local and regional governments

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# A few words on CityLoops

Cities throughout Europe are increasingly recognising that the transition from a linear to a circular economy is crucial in the fight against climate change and biodiversity loss. In practice, this means that cities need to move away from the take-make-waste approach towards an economy based around closed material loops, where resource consumption is decoupled from economic growth. Aiming to address these challenges, CityLoops brought together seven European cities – Apeldoorn (The Netherlands), Bodø (Norway), Mikkeli (Finland), Porto (Portugal), Seville (Spain), and Høje-Taastrup and Roskilde (Denmark) to pilot a series of demonstration actions to "close the loop" in Construction and Demolition Waste (CDW) and biowaste, identified in the **European Circular Economy Action Plan** as two of the most important waste streams in Europe.

Over the past four years, these seven cities implemented a total of ten demonstration actions, testing over 30 new instruments and processes. These range from instruments for predicting future excavated construction and demolition waste and soil production, to awareness-raising campaigns, and from circularity decision making support tools, to simulation of impacts 3D visualisation tools and procurement guidelines for bio-waste products. The wide variety of these solutions reflect the different needs and contexts of the cities participating in the project. While Bodø was demolishing its old military airport to build a new part of the city in the cleared area, Porto was focusing on making its social economy and tourism sector more circular. And while Apeldoorn was experimenting with soil improver bokashi, Seville was implementing waste collection awareness campaigns for school children. As such, CityLoops has highlighted the great potential of circular approaches, showing that they can be applied effectively in many different industries and with many different objectives.

Apeldoorn, Bodø, Mikkeli, Porto, Seville, Høje-Taastrup and Roskilde have the ultimate aim to become circular cities, where no resource goes to waste. After four years of work in CityLoops, they are not there yet, but the demonstration actions implemented during the project have brought them closer to that goal. They contributed to the further integration of circular principals within municipal policy strategies, an increased use of circular public procurement to increase market demand for circular products and services, and a better understanding of the resources that flow through their city.

The CityLoops handbooks on circular construction, biowaste, and circular procurement aim to provide cities with a comprehensive overview of how the lessons learnt and main insights from the project can be most effectively applied in their own contexts. They feature practical examples outlining how cities implemented the tools they developed, why they made certain decisions, what they could have done differently, and how all this fits into the broader context of European circular strategies and policies. In doing so, these handbooks aim to bring the knowledge, experiences, tools and results of CityLoops to other cities in Europe and to contribute to the further implementation of the circular economy across the continent.

# Executive summary

It goes without saying that the construction sector has to become more sustainable and circular, and cities and local authorities should play a major role in this transition. In line with the EU Commission's Green Deal and Circular Action Plan 2020 and legislative proposals, such as the Fit for 55 package, that set the green and circular transition as a key priority for the EU, the CityLoops project has focused on circular economy solutions for bio-waste and construction and demolition waste, including soil. In CityLoops, six European medium-sized cities - Høje-Taastrup and Roskilde (Denmark), Mikkeli (Finland), Apeldoorn (the Netherlands), Bodø (Norway), and Seville (Spain) - piloted a series of circular economy actions with the aim of achieving material circularity.

Starting in October 2019, the cities implemented different demonstration actions and tested many tools and processes, alongside with specialised partners in this field. Based upon the learnings and outcomes of the CityLoops project, this handbook aims to inspire and guide local and regional European public authorities of all sizes to know more about the different steps to follow, but also private entities that want to know more about the current practices, their role and the opportunities in the transition towards a circular construction sector.

Moving away from the linear model entails overcoming many obstacles. Thus, the question that has led us throughout this handbook has been "*What lessons can we learn from the experimental projects, and what could have been done differently?*". This report is an evidence-based and practical handbook on how to implement a circular construction strategy for those who would like to start this journey, supported with various concrete tools, methods, and case studies for inspiration. It also showcases pioneers' projects beyond CityLoops, to demonstrate that circular construction is a flourishing topic with more and more projects running all over Europe.

The handbook has the following structure: the first chapter aims to explain and understand the context in which the transition to a circular construction sector could happen and the benefits it might bring. The second chapter dives into the role of public authorities and governance approaches, explaining how implementing a circular construction strategy could impact the organisation inside and outside the local authority. Chapter three corresponds to the implementation stage. Following the different steps of the value chain that may be encountered in a circular construction project, it fleshes out each of them by emphasising how they can be rethought aand adapted to meet circularity practices. The last chapter gives an overview on how beneficial circular practices could be with regards to the economic and environmental perspectives and how local authorities should proceed to influence this market shift.

However, this handbook is tailored to provide a first level of information. Many tools, instruments and study cases have been developed all over the four years of CityLoops. In order to provide the most comprehensive and useful resources, we have gathered the instruments, tools, guidance and experiences from cities in some replication packages to delve deeper into specific topics. Those are mentioned throughout the document with this sign  and listed at the end of the document. They can be viewed and downloaded on the **CityLoops website**.

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# Glossary

**Construction and Demolition Waste (CDW)**: one of the two streams addressed within CityLoops alongside bio-waste. Despite the use of this name throughout the project, this category also contains materials still considered as products, and not waste. Indeed, it is important to stress that the **EU Waste Framework Directive** considers reuse as a waste prevention measure. Reuse therefore deals mainly with products, whilst recycling deals with materials that have been discarded as waste. This Directive also mentions "preparation for reuse", which transforms waste back into reusable products.

**Digital marketplace**: online platform that facilitates the exchange of materials from one owner/use to another. It could be called a digital catalogue.

**Digital material passport**: a digital material passport could be at the material and/or building level.
At the material level: identification of a material's history, content, quality (embodied carbon, structural capacity, toxicity), use, maintenance and reuse potential. Unique and linked to an individual object or component. At the building level: compact, but detailed view of the building information and registered on a digital platform. It gives identity to the building and all its separate materials, components and products included. The quality of data that forms the basis of a material passport largely determines the quality and completeness of the material passport for a circular use of building materials, products and components.

**Digital twin tool**: tool that provides a virtual model designed to reflect a physical object.

**Physical material bank**: a place that facilitates the exchange of materials from one owner/use to another. Many expressions could be used to refer to it, including but not limited to: warehouse of materials, salvaged materials depots, reuse centres for building materials, storage facilities for reclaimed building materials, reclaimed materials stocks.

**Reused materials**: According to the **EU Waste Framework Directive** (Art 3.13), " *'re-use' means any operation whereby products or components that are not waste are used again for the same purpose for which they were intended*".

Thus, it considers reuse as a waste prevention measure. By lengthening the use value of a component, waste production is avoided. This practice is therefore considered as a priority over recycling in the hierarchy defined by this Directive (Art 4.1). A reusable material is not (or is no longer) waste. However, in order to avoid classification as waste, the final reuse must be certain. When the context of the operation nevertheless leads to the material being classified as waste (abandonment, error, logistics or multiple-stage processing chain, before reuse is certain...), it goes into the "Preparation for reuse" category (EU Waste Framework Directive - Art. 3.16 - " *'preparing for re-use' means checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing*"). The material is then considered as waste by default, but will regain product status as soon as reuse is certain[1].

**Reclaimed/salvaged materials**: Material and product derived from reclamation which is the act of processing, transport and storage prior to reuse. This activity encompasses the purchase, salvage, processing, storage and sale of reusable materials and products. In the same way, reuse is the act of taking a reclaimed material and installing it in a new location.

**Recycled materials**: By contrast, recycling deals with materials that have been discarded as waste. According to the **EU Waste Framework Directive** (Art 3.17), " *'Recycling' means any recovery operation whereby waste is reprocessed into a product, material or substance for its original function or for other purposes*".

1 Product or waste? - Criteria for reuse - FCRBE project

# 1. A necessary transition towards a circular construction sector

In Europe, the construction sector is one of the most important and resource-intensive sectors, both from an economic and environmental standpoint. It accounts for roughly half of all material extraction, half of energy consumption, a third of water consumption and 40% of all greenhouse gas emissions. The waste deriving from construction and demolition activities - known as Construction and Demolition Waste (CDW) - consists of various materials used in construction (such as excavated soil, concrete, bricks, glass, wood, metals, gypsum, plastic, solvents, and hazardous substances) and represents the largest waste stream in the EU per volume[2]. At the same time, this sector plays an important role in the economy, generating about 9% of the EU's GDP and providing 18 million direct jobs[3].

By changing this unsustainable and harmful linear pattern of 'take-make-dispose' that is jeopardising the sustainability of human life on earth, the circular economy can reduce the negative impacts that the construction sector has on the environment while retaining and enhancing economic value. An approach based on the circular principles creates a closed-loop system in which buildings and resources are kept in use for as long as possible, waste is minimised, and materials are reused, recycled or repurposed at the end of their useful life. Circular buildings are designed to be flexible and adaptable, with the ability to be easily retrofitted, repurposed or deconstructed at the end of their life cycle, which extends beyond traditional construction and demolition processes. They incorporate sustainable materials, energy-efficient systems, and low-carbon technologies, to reduce the environmental impact throughout their lifecycle. With increasing prices of raw materials, the shift from linear to circular practices in the construction sector is crucial to find sustainable alternatives and ease the pressure on natural resources.

The huge toll that the building industry is taking on the environment should be reversed by transitioning to circular construction which can have several environmental, economic and social benefits with cascading and mutually-reinforcing positive effects.

From an environmental standpoint, minimising the use of raw materials and reinjecting in the production what would otherwise be discarded can relieve the pressure on finite resources and reduce both waste generation and dependency on landfills. Reducing material extraction helps avoid environmental damage and tackles nature and biodiversity loss[4] and circular soil management at construction sites can protect soil resources and the ecosystem services they provide. Using resources more efficiently is vital to reduce greenhouse gas emissions (GHG).[5] it has been estimated that in 2050 applying combined circular practices in construction (such as modular design, use of lighter materials, reduced use of steel, recycling of unreacted cement, and increased utilisation of buildings through sharing activities) could reduce up to 80 megatons of GHG emissions in the EU per year[6].

2 Guidelines for the waste audits before demolition and renovation works of buildings

3 European Commission - Internal Market, Industry, Entrepreneurship and SMEs

4 The Nature Imperative: How the circular economy tackles biodiversity loss

5 Cutting greenhouse gas emissions through circular economy actions in the buildings sector

6 The Circular Economy - a Powerful Force for Climate Mitigation

Circular construction practices also give us the chance to revitalise the economy and make it more sustainable and competitive, for instance by protecting construction firms against resource scarcity and connected price volatility or encouraging energy savings. Local economies can benefit from circularity in construction in several ways:

- Local sourcing of materials, which can help support local businesses and create local jobs, while reducing transportation costs and carbon emissions;
- Job creation in areas such as material recovery, re-manufacturing, and refurbishment, which can be highly skilled and can offer employment opportunities to people in the local area[7];
- Economic growth generated by creating new markets for reused materials and transforming existing markets for recycled materials, promoting innovation and entrepreneurship in communities to build more resilient local economies that are less reliant on external resources;
- Reduced waste and associated costs, such as landfill fees and transportation costs, leading to savings for construction companies and their clients.

The social advantages of a circular transition in the built environment are also significant. For instance, repurposing existing buildings and materials allows communities to create new spaces that meet their needs - such as community centres, schools and affordable housing - and promotes community cohesion. The creation of jobs and upskilling required for the transition does not just bring benefits from an economic perspective but also provides an opportunity for social development and reduction of unemployment-related social problems. From creating mixed-use walkable neighbourhoods that strengthen a sense of community among residents to boosting opportunities for professional growth, building cities along circular principles has positive effects on local communities and their wellbeing.

## 1.1 From the European strategy...

The European Union is striving to move the building sector to a higher level of circularity[8]. Alongside institutional efforts, in recent years, circular thinking has taken a greater role in construction companies, consultancy companies and architects, and the sector is willing to move to a more sustainable use of materials. However, the uptake of systematic circular practices is still a distant reality as 70% of the recycled construction material is used for backfilling or as a road base. This means that resources are 'downcycled'; they end up lower down on the waste hierarchy and as a result, value is lost in the process. Moreover, the reuse of building components, such as walls, floor segments and bricks is very low, as the current demand in the building industry for recycled and reused materials still accounts for just 10.6% of the almost 6 tonnes per capita used by the sector annually[9].

To encourage efforts from the different stakeholders, the European Commission has launched a series of regulatory frameworks and initiatives. This strategic level engagement is crucial to drive the implementation at the local scale.


7 Stimulating demand for circular construction skills - a guide for public authorities

8 An overview of the waste hierarchy framework for analysing the circularity in construction and demolition waste management in Europe

9 A guide for circularity in the built environment - The circular city centre (C3)

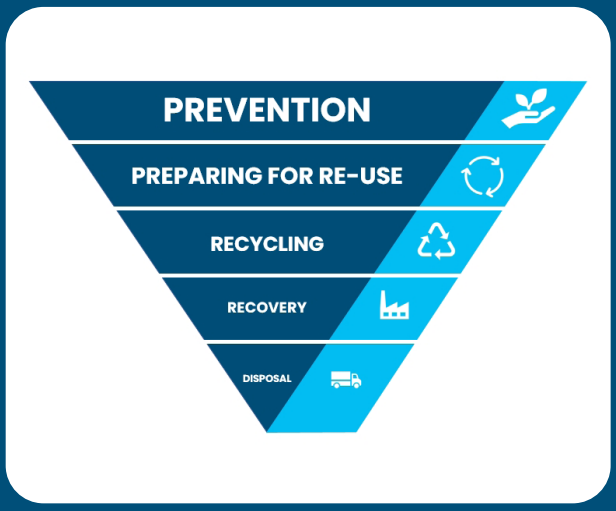
## THE EUROPEAN LEGISLATIVE FRAMEWORK FOR CIRCULAR CONSTRUCTION

The European Union committed to becoming climate-neutral by 2050, and achieving an economy with net-zero greenhouse gas emissions. Regarding the impacts of the building sector, many policy initiatives and incentives have been launched to reduce the building sector's footprint.

The **Waste Framework Directive (WFD) 2008/98**, which introduced the 'waste hierarchy' to ensure disposal of waste is considered as the last recourse, had set a binding target for Member States to prepare for reuse, recycle, and recover 70% of non-hazardous CDW by 2020. The EU also considers the construction sector as one of eight sectors with high potential for circularity in its **second Circular Economy Action Plan** (2020) where it established actions such as promoting the durability and adaptability of buildings, using the EU building sustainability framework Level(s) to integrate life-cycle assessment (LCAs) in public procurement, revising material recovery targets for CDW and reducing soil sealing[10]. This has led to various policy initiatives in the sector, including the revision of the Construction Products Regulation (CPR) and the development of the EU's Level(s) assessment framework for sustainable buildings, to be incorporated into Green Public Procurement (GPP) criteria and technical screening criteria for circularity of buildings in the second phase of the EU Taxonomy for sustainable investments.

Connected to this, the **EU soil strategy for 2030** sets out a framework and concrete measures to protect and restore soils, and ensure that they are used sustainably, considering excavated soil and mineral construction materials represent a big portion of the solid waste in Europe[11].

Prominent EU efforts on the energy impact of construction include 'Renovation Wave', aiming to reduce the carbon footprint of buildings and to create jobs in the construction sector, and the '**Energy Performance of Buildings Directive**' (EPBD), setting out requirements for the energy performance of buildings, including the use of energy-efficient technologies and measures to improve building insulation. The Commission's 2021 "**Fit for 55**" energy and climate package will also reinforce the path towards a more carbon-neutral Europe.




The '**Construction Products Regulation (CPR)**' aims to ensure that construction products placed on the EU market are safe, reliable, and sustainable and includes requirements for the environmental performance of construction products.

In response to EU law and policy initiatives, many countries have embedded circularity principles at the national level, such as[12]:

- **Denmark**: The national Danish strategy for sustainable construction sets $m^2$ requirements for $CO_2$ based on Life Cycle Assessment starting in 2023 for buildings over 1000 $m^2$ and is gradually stricter towards 2030.
- **France**: with its Anti-waste and Circular Economy Law adopted in 2020, France has paved the way to circularity with measures such as a new Extended Producer Responsibility (EPR) for construction products and mandatory pre-demolition diagnosis.

10 Circular Economy Action Plan - For a cleaner and more competitive Europe
11 EU soil strategy for 2030
12 A life-cycle perspective on the building sector - Good practice in Europe

## 1.2 ...to a local implementation

Successful policies are usually a combination of top-down and bottom-up approaches. Whilst European and national circular economy strategies draw the vision, regional and local entities implement actions. Numerous pilot cases have emerged as a result of European, national and local strategies exerting their influence.

To ensure this transition to happen and to stimulate new practices, local public authorities have a range of policy levers at their disposal:

- **As a master planner**: local and regional governments are planners for many strategic documents that can embed circular principles. Integrating circular construction (e.g. include targets for reuse and recycling of waste and/or for amount of secondary resources, provide infrastructure for local handling of construction waste, etc.) either in their Sustainable development plan, Climate Action plan, or more specifically in their Circular Economy action plan, puts this topic on the political agenda at the strategic level, making it thus easier to implement those principles at the operational one;

- **As building owners and public procurers**: public authorities are owners of large building assets, large buyers of construction and demolition services and public spaces managers. By stimulating supply and demand for more circular materials and buildings, and by offering local and often directly available materials for reuse purposes, public authorities can lead the transition;

- **As an urban and spatial planner**: urban and spatial planning is a powerful lever in the long-term. Key in upscaling the circular construction is defining clear objectives on the types of constructions and buildings - as well as their environmental properties within spatial planning and zoning documents - and conditioning building permits to comply with these;

- **As a land owner and land manager**: municipalities can own or manage, directly or indirectly, a lot of land. Land and plot allocation through competitions is a very effective way to require circular criteria from the companies who would like to purchase the land;

- **As a network facilitator**: social housing companies, private developers and different local stakeholders can be encouraged by local authorities to change their demolition, renovation and building practices. Many instruments, such as digital platforms, storage platforms, training sessions, performance indicators and dashboards could help to support this transition and scaling-up. Furthermore, by supporting companies which are adopting more circular business models to develop their activities (by offering lower rents or allocating land for certain economic activities e.g. areas for material banks), local authorities may influence the market trend and increase green local economy and non-decentralised local jobs;

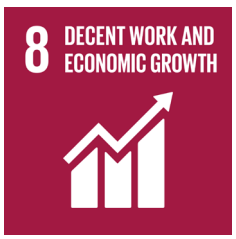
- **As a financial support**: in a new market still adapting its business models, financial grants, subsidies, and tax incentives are also key levers to develop a new economic sector.

Pexels / Boris Hamer

# How could local circular construction strategies help to achieve the Sustainable Development Goals?

## Circular Construction and the Sustainable Development Goals (SDGs)







**SDG 6**
Circular material management in construction - including soil decontamination practices - can reduce water pollution and minimise the release of hazardous chemicals and materials.

**SDG 7**
Many circular actions in construction, i.e. the refurbishment of materials or the use of recycling concrete, encourage energy savings and improve energy efficiency at the local level.

**SDG 8**
Circular business models in construction allow diversifying the economy by focusing on adding value to buildings and encouraging the decoupling of economic growth from environmental degradation.

**SDG 9**
Circular construction boosts resource-use efficiency and the adoption of clean and environmentally sound technologies within the industry while creating quality, reliable, sustainable and resilient infrastructure that supports economic development and human well-being.

**SDG 11**
The design and management of circular buildings can reduce the dependency of cities on construction materials. Also, embedding circularity in city planning and management can enhance inclusive, sustainable and more resilient urbanisation and ensure universal access to safe and accessible green and public spaces.

**SDG 12**
Systematic circularity applied in the construction sector - including companies' adoption of sustainable practices as well as public procurement - improves the sustainable management and efficient use of natural resources. Moreover, it reduces the generation of waste and ensures that chemicals and waste are handled in an environmentally sound manner throughout their life cycle.

**SDG 15**
Integrating circular construction and soil management into local planning ensures that biodiversity values are respected and ecosystem services in the urban environment are protected.

**SDG 17**
The construction sector relies on public and public-private partnerships which can commit to circular infrastructure to facilitate a more effective pursuit of the SDGs.




# 2. The impact of a circular transformation in public organisations

Local governments engage in most construction and demolition activities either as authorities in relation to urban development or in their role as construction clients for public buildings, or again as landowner or land manager. To operationalise the circular economy, new practices must be adopted in city organisations, and it is crucial to secure an implementation across disciplines to promote collaboration. To foster transformation, organisational learning is a key element that also has an impact on structures and strategies.

Public authorities face different challenges in the pursuit of circularity for the built environment which can be addressed by acting on four interconnected fronts:

- **Interdisciplinary collaboration**: it is crucial for the success of a project, to ensure from the early stage that sustainability aspects are taken into account, that stakeholders are involved in a structured manner and that responsibilities and financial resources are allocated clearly. Pursuing interdisciplinary collaboration is also directly linked to goal alignment within local authorities, as it implicates early-stage communication, and it avoids frustration deriving from conflicting agendas across departments;

- **Knowledge and skills**: parallel to interdisciplinary collaboration, securing joint learning as a basis for dialogue and allowing room for experimentation and time for reflection and evaluation are practices that not only support the success of current and future projects but also increase circular thinking within an organisation;

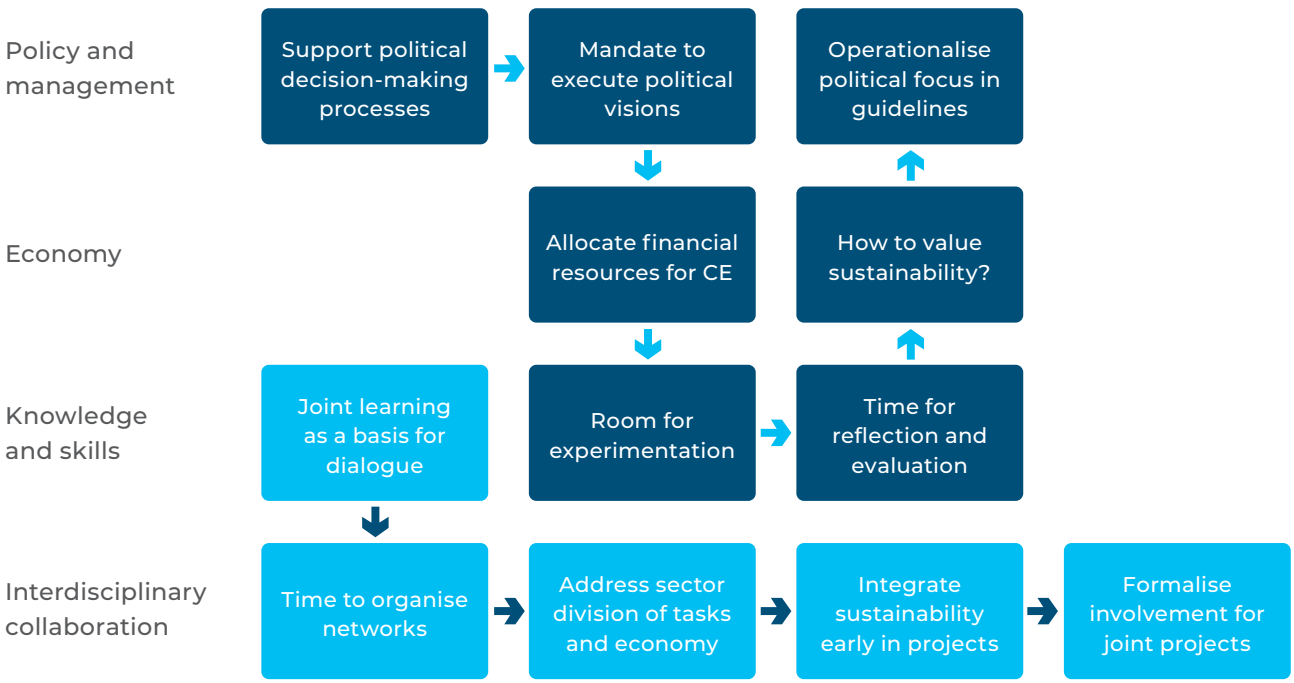
- **Economic measures**: implementing circular projects is strictly dependent upon adequately allocating financial resources, which also takes into consideration the value of sustainability – including a quantification of environmental social benefits - in the economic related decision-making;

- **Policy and management**: political mandate has been clearly identified as an essential precondition for the successful implementation of circular strategies in the built environment, as it secures support in the execution of political visions and facilitates goals alignment between overlapping or competing strategies.

Once political visions and goals are processed, they must be translated into specific guidelines and procedures and gradually adapted, based on practical experiences generated in demonstration projects. To be effective, this has to be reinforced by an active support from management across disciplinary silos for execution and sustained by an allocation of financial resources to experiment and gain operational knowledge.

The figure below illustrates two suggested paths of implementation that can be simultaneously engaged.

**Figure 1: Two proposed paths to engage organisational challenges in local governments**




*" Over the course of the CityLoops project, we have achieved many concrete results. On top of these, we have many ripple effects spanning many departments and roles in the municipality. The mindset is changing, and we are becoming more aware of the importance of planning for effective use of our resources. [...] On an organisational level, an example of the changes in mindset that has already come as a result of CityLoops is the establishment of a municipal sustainability group. The City Council has also recently decided that we should develop a sustainability strategy. This has had the effect both of inspiring others throughout the organisation and making sustainability more visible, and also setting certain structures in place to ensure that sustainable practices are prioritised. "*

**Turan Akbulut**, city council member and chairman for the planning and environment committee in **Høje-Taastrup**

*" Focusing on the pilot actions themselves, the coordination and engagement of the internal staff of each of the organisations has been important. We have learnt that for a change or introduction of a new operation, exhaustive support is required from the organisation's middle management. "*

**Pedro Cruces**, Innovation Manager in LIPASAM, Waste Management Company **City Council of Seville**

*“ Whilst circular economy often takes place in local governments, it is also an exchange of ideas, bringing together business and people from different regions, and co-development, which we have found very effective and inspiring way to develop, also with our local stakeholders, who already in the beginning of the process asked from us to present them good examples and practices from other cities and regions. ”*

**Kimmo Haapea**,
Project Manager in **Mikkeli**

## 2.1 Circular strategies for the built environment

Strategies in the public sector exist on different levels with varying forms and goals. Within the same organisation, multiple competing objectives might exist simultaneously that may arise from perceived needs within the organisation, external organisations or stakeholders, making it challenging to operate against one fixed overarching goal. Goal alignment is then necessary to secure timely and adequate goal attainment.

**Figure 2: Plans and strategies surrounding circular strategies for the built environment**

Circular strategies for the built environment are usually developed by environmental and construction departments in municipalities. These strategies are often integrated into other plans and strategies that have broader policy objectives, such as property, waste management, climate, procurement, and development strategies. Successful implementation of circular strategies for the built environment is highly dependent on goal alignment between different departments and plans within the organisation, ensuring that different departments are working effectively towards the same goals. It also makes it easier to generate political and managerial support and funding for activities and measures.

As mentioned, a clear political mandate facilitates goal alignment between overlapping or competing strategies and plans and ensures a smooth implementation of actions, tasks and activities. As an example, a political mandate in Roskilde Municipality led the construction and properties department to engage in circular construction projects with a focus on reuse and recycling of construction materials, design for recycling and reuse of excavated soil.

As a result, the key steps to ensure goal alignment are:

- Create political support and obtain a clear political mandate;
- Identify overlapping strategies and plan what works towards the same goal;
- Create organisational structures that can facilitate knowledge exchange between departments, such as an internal working group.

*" To secure a strategic mandate for circular innovation, the urban development area Musicon was selected and frame conditions were established to make room for experimentation. Normally it can be a struggle to secure mandate for circularity from project to project, but we embedded levers in the vision for the area, local plan(s), stakeholder agreements and established a secretariat to secure sustained commitment. "*

**Klaus Kellerman**, Senior Consultant Sustainable Construction in **Roskilde**

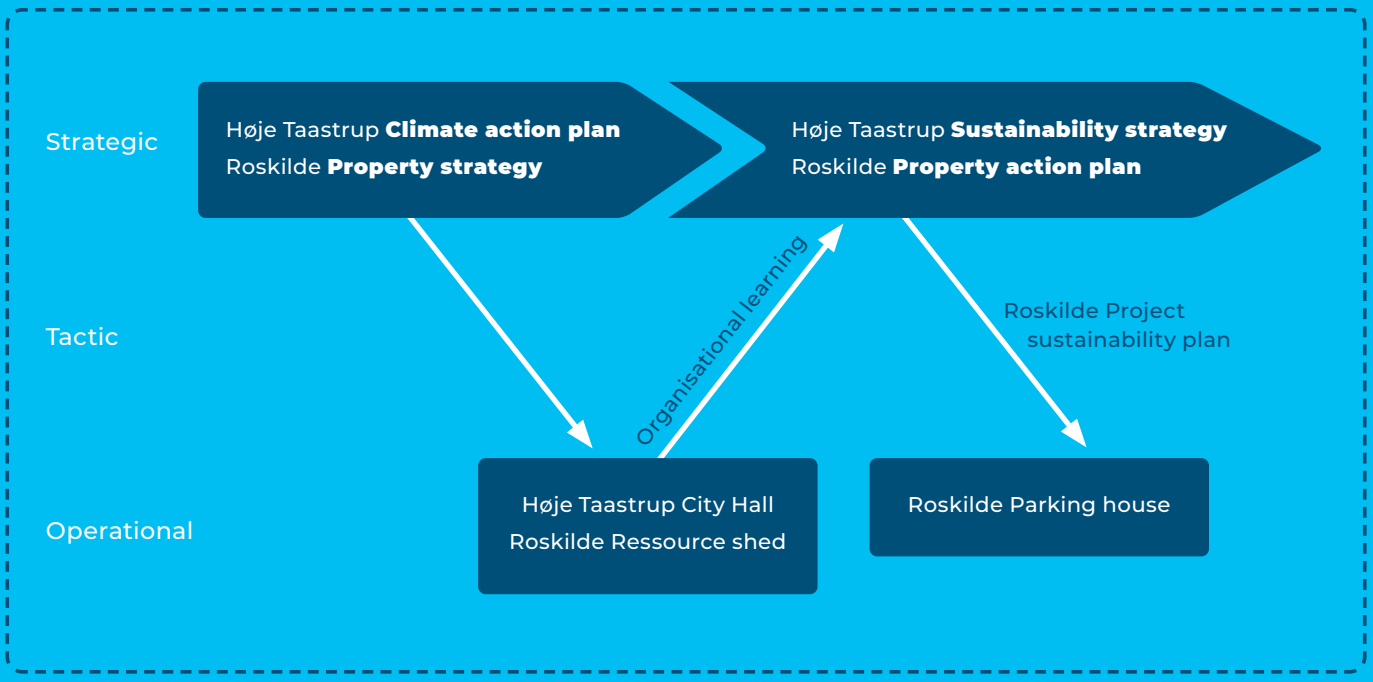

Official inauguration of Høje-Taastrup's new city hall with mayor Michael Ziegler and HRH The Crown Prince Frederik of Denmark.

**Table 1: Examples from the CityLoops project of different types of strategies and their actions**

| City | Type of strategy or plan | Actions in the built environment |
|---|---|---|
| Mikkeli | City strategy | $CO_2$ neutrality targeting construction |
| | Climate action plan | Promote recycling of CDW and soil<br>Consider sustainability in procurement |
| Seville | Waste management program | Comply with waste hierarchy |
| | EMASESA plan (utilities) | Reuse, recycle and reduce use of external resources |
| Høje Taastrup | Housing policy | Promote circularity in urban transformation projects |
| | Climate action plan | $CO_2$ calculation in local plans<br>Circularity and Total Cost of Ownership (TCO) in construction projects<br>Market dialogue for circular construction |
| | Procurement strategy | Promote circularity through TCO and certifications in tenders |
| Roskilde | Climate action plan | Circularity (building material and soil) in construction projects<br>DGNB-certification, lifecycle perspective and TCO<br>Market dialogue and partnerships |
| | Property action plan | Sustainability assessment in projects focusing on circularity<br>TCO and Life Cycle Assessment (LCA) on materials |
| | Waste management plan | Better sorting, focus on hazardous substances and reuse in renovations |
| Bodø | Overall environmental plan | Mass treatment, soil strategy |
| | Procurement strategy | Promote circularity in tenders, early market dialogue and more suitable criteria for circularity. |

DEMO CITY

## GOOD EXAMPLE FROM CITIES:
## **Høje-Taastrup and Roskilde (Denmark)**




The Municipalities of Høje-Taastrup and Roskilde are an example of how the relation between project experimentation and strategy development promotes organisational transformation. Early in the project they embedded circular goals in their climate action plans and, in the case of Roskilde, also in their property strategy. This secured a political mandate to support decision-making in some of the first pilot projects in the cities exploring circular construction. Based on this experience:

- Høje-Taastrup is now developing a sustainability strategy aligning goals and actions across the organisation;
- Roskilde integrated the experiences in a properties action plan, now requiring a sustainability assessment of public construction projects – a so-called Project Sustainability Plan. Such a plan was used to make an early assessment of the circular assessment of their demo project "Parking house" and to directly identify quality criteria in tendering.

**Lessons learned**

*" An important factor to promote circular construction and gradually formalise circular practices across the organisation, has for us been to foster knowledge diffusion. Thus, we have established an interdisciplinary sustainability group across departments in both municipalities for knowledge exchange. in Høje-Taastrup the sustainability group is leading a new politically proposed sustainability strategy.*
*In the strategy we draw actively on CityLoops experiences. "*

**Høje-Taastrup** and **Roskilde**

Learn more about Høje-Taastrup's and Roskilde's experiences by visiting the **CityLoops website**

## 2.2 From the strategic level to the operational one

Circular strategies for the built environment are key to promote circular practices for public sector organisations. However, as strategy alignment is closely related to operational actions, strategy implementation is a dynamic process, continuously integrating operational experiences in strategies and plans.

Promoting circular construction actions in local governments can be taken at the strategic, tactical and operational levels.

A main **strategic action** is needed to secure strategy alignment. Goals and actions across strategies and departments should be synchronised to promote joint action. This can practically be carried out by drafting goals, actions and indicators jointly across relevant departments for direct transfer into sector specific operational strategies. The integration of goals into sector specific strategies should be seen as a dialectic process that can also generate feedback for future revisions of general strategies, since the latter may reveal blind spots when fed into sector strategies.

**Tactical actions** involve adoption of strategies across departments, developing practices and procedures and securing locations and material flows. For the adoption, it is essential to establish a common language and conceptual understanding between departments and translate it into indicators and levers for daily operations. It has to be accompanied by a budget allocation for the implementation of new procedures and early screening of projects. Room for grassroot innovation should also be established to avoid over-bureaucratisation and micromanagement. Circular goals integrated into sector-specific strategies should be converted into concrete guidelines and procedures through implementation plans, which are refined in later revisions based on experiences from pilot projects and knowledge sharing with other cities. To avoid disciplinary silos, departments in municipalities should identify key internal stakeholders and establish a coordinator role responsible for promoting circular practices across the organisation. Identification and selection of a pilot area for circular projects can support possibilities for experimentation. This requires early decisions to create the right frame conditions in land use planning and local plans.

**Operational actions** focus on engagement within and between circular construction and demolition projects. *Within a project*, a first step is to identify and pursue the circular potential through an early screening of potentials based on joint parameters. The specific targets have to be identified at this stage. *Between projects*, monitoring and knowledge sharing is central to secure progress. It requires a systematic evaluation process. The knowledge sharing can be enhanced by developing a platform and templates for inspirational cases. As during projects the right knowledge must be activated at the right time and formal structures for involvement facilitate this. The internal working group can support the identification of agendas, definition of objectives and an overall reflection on procedures.

Pictures from organisational change workshops in Mikkeli, Finland, and Roskilde and Høje-Taastrup, Denmark

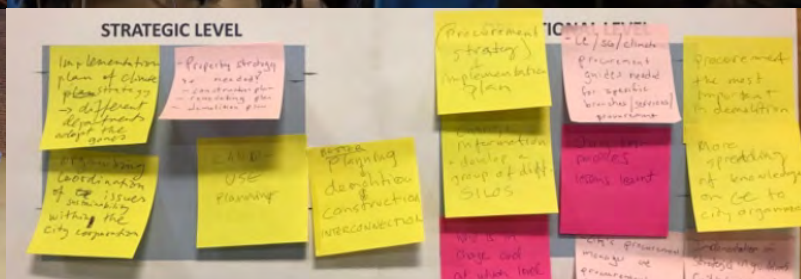


**Table 2: Overview of development actions at the different levels identified in the CityLoops project**

| Strategic actions | Tactical actions | Operational actions |
|---|---|---|
| **1. Strategy alignment**<br>· Develop clear goals and specific actions for each department in central general strategies<br>· Integrate goals and actions from general strategies in sector specific strategies dialectically | **1. Adoption of strategies across departments**<br>· Establish common language and concepts between departments<br>· Allocate budget for circular development costs and early screening of projects<br>· Identify key internal stakeholders and/or assign material flow coordinator<br>· Leave room for grassroot initiatives<br>**2. Practices and procedures**<br>· Develop implementation plans for sector specific strategies<br>· Develop procedures and guidelines for systematic cooperation and circular actions<br>**3. Locations and material flows**<br>· Select pilot areas to initiate circular projects<br>· Establish physical and digital material bank | **1. Circular projects**<br>· Conduct early screening of circular potentials<br>· Initiate projects with a sustainability plan describing targets<br>**2. Knowledge sharing**<br>· Launch a systematic evaluation process for circular construction and demolition<br>· Establish a sustainability group across departments<br>· Formalise the early involvement of internal experts<br>· Develop platforms and templates for inspirational cases<br>**3. Value chain communication**<br>· Establish a market for local construction works<br>· Develop a paradigm for external communication of political focus |

In addition, value chain communication is essential to promote circular construction practices and developing a model for communication (i.e. for private developers) could be a strong market incentive. It demonstrates a clear priority and demand for circular solutions, and supports the establishment of a market for local construction works.

*" We have done several workshops and seminars for the wider audience, even outside of Mikkeli's area and together with colleagues in other regions to replicate what is going on in our area, learn from other regions and to underline the importance of doing things together. "*

**Kimmo Haapea**,
Project Manager in **Mikkeli**

Learn more about the impact of a circular transformation in public organisations by visiting the **CityLoops website**

# 3. Implementation - across the value chain

Two main positions within local and regional authorities can drive the transition through different actions:

- **Asset managers**: public authorities are owners of large building assets and buyers of construction and demolition contracts. Through public procurement, public authorities can stimulate the demand for more circular buildings on their own assets and thus lead the transition;
- **Facilitators**: local governments can drive local stakeholders that demolish, renovate and build on the territory through a wide range of actions (including training programmes, tools development, land allocation, urban and spatial planning, etc.). With this local facilitator role, public administrations could act at a bigger scale, beyond their own assets, by involving even more building stakeholders in the changing curve.

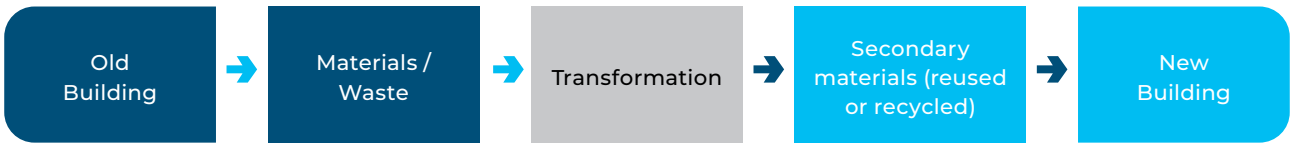
> *" We contacted the stakeholders in the Mikkeli area right at the beginning of the project. We held many workshops directly with the key stakeholders to discuss the circular economy aspects of the demolition projects in detail, in order to find a common understanding. "*
>
> **Kimmo Haapea**,
> Project Manager in **Mikkeli**

The crosscutting nature of the circular construction calls for the need to mobilise a diversity of stakeholders with various missions and skills. It needs the involvement of all the constituents in a city's development to be effective. It implies co-develop building projects from their design stage, through implementation, construction and use, until the end of the projects' lifespan. This co-development process also needs to involve the private entities. On the one hand, the public sector shapes the operating environment, while companies design and provide solutions. On the other hand, the public sector needs to better understand what kind of solutions the market already offers in order to best take advantage of those. It has to be an on-going and open dialogue.

The most difficult aspect of creating material loops is connecting the actions of demolition and construction, which today are separated, to form a properly functioning secondary materials market. Compared with primary and raw resources and new materials on the market, the secondary resources and materials have another supply chain and logistics. The sourcing and streams of natural resources and new materials are market-adapted, whilst the streams of reused and local recycled resources depend on the current availability of construction and demolition materials in the right quality and quantity, and at the right time to meet the demand for using secondary materials in new buildings and construction.

The circular resource flow is illustrated in this simplified value chain below, which covers the flow of materials from an existing building that is to be (partially) demolished to the use of secondary materials in a new building.

**Figure 2: Simplified version of value chain for transformation of resources from an old building to a new one**

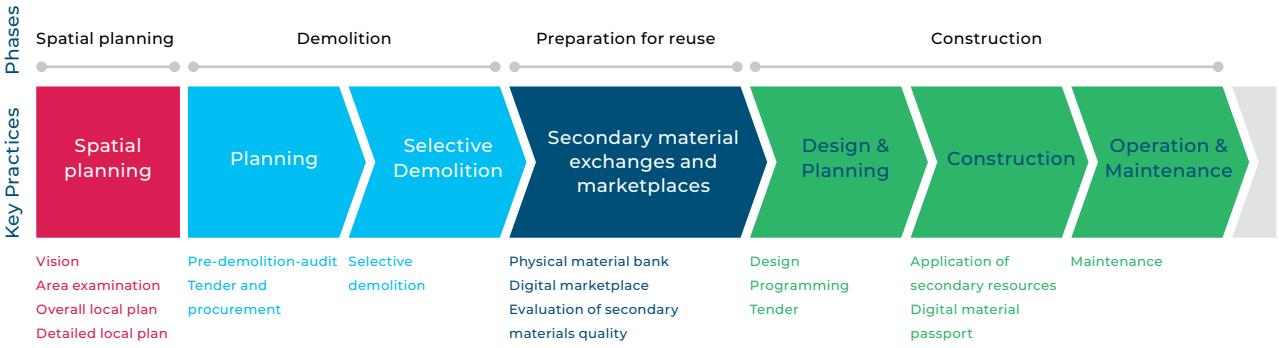



Traditional demolition and recycling are focused on the demolition process and handling of the construction and demolition waste for the lowest price without specific consideration of the use of recycled materials.

Creating a circular flow means including the process of preventing waste through the retaining of existing buildings, the salvage and reuse of building elements, and transforming materials from waste to resources and/or secondary materials. It must consider the optimal opportunities with respect to the waste hierarchy (meaning for instance that it is better to consider first the possibilities for reuse and only afterwards for recycling), the economic balance, as well as environmental protection and sustainability.

To create a functioning circular material flow, several steps need to be followed in different parts of the value chain:

**Figure 4: Phases and key practices of circular demolition and construction value chain**




The phases should not be seen as a fixed linear process, as phases may overlap and processes take place simultaneously.

## Description of value chain elements

### Spatial planning

Prior to the individual demolition and construction projects, when transforming an urban area, a framework for its development is conducted, describing the purpose, land use, aesthetics, etc. This phase entails formulation of general strategies and local plans and provides the opportunity for an overview and early planning to connect the future projects.

### Demolition (and renovation)

- **Planning**: it is the step where alternatives to new construction and demolition can be considered, such as better utilisation of existing assets through renovation and retrofitting. This phase also includes the assessment of the potential use and market of the materials that will be demolished by identifying their future use and owners. This phase entails:
  - **Pre-demolition audit**: an inventory of reusable, reclaimable and recyclable components and materials, hazardous content and recoverable value carried out by an expert during renovation/demolition planning. This information could be then integrated in a material passport, where data on the materials - including origin, composition/contamination, quality, reusability and expected lifetime - is digitised to allow traceability, transformation and future uses.
  - **Procurement**: the tendering and contract, including the design of partial and/or selective demolition and specifications for material salvage and waste handling and recycling.
- **Selective demolition**: based on the pre-demolition audit, this step includes the component and material dismantling as well as the phased, on-site separation of fractions to preserve their value and functionality to the largest extent possible.

### Secondary materials market

*Please note that the expression "secondary materials" is a general expression. It encompasses reused materials, reclaimed/salvaged and recycled ones. They all have specificities that could not be detailed in this graphic (for instance, it would not be the same quality stamp for reused materials as for reclaimed materials).* ***See the glossary*** *for more information.*

- **Physical material banks**: the temporary or permanent places to transform, handle and store the materials in order to sell them for a second life.
- **Digital marketplace**: the online platform for advertising available materials, including the description of material properties, location, timing, cost, etc.
- **Evaluation of secondary materials quality**: the development of reliable information on the reused products and materials to ensure their capacity to be reintroduced in a new construction.

### (New) Construction

- **Planning**: aiming at incorporating specific recovered materials in the design phase (based on available secondary – reused and recycled – resources) and design for disassembly.
- **Procurement**: the tendering and contract, including the requirements defined at the planning stage and the risk management.
- **Digital material passport**: the creation of a building passport with documentation of all materials of the building, including information on compound, technical specifications, Life Cycle Assessment (LCA) data, and the opportunities for waste handling and recycling.
- **Operation and maintenance**: to extend the lifetime of the building, a focus should be put on the maintenance optimisation, which can be improved by prioritising high durability in materials and construction elements, and designing for repair.

Following this pathway, this chapter aims at clarifying the different steps for a circular construction process. It also provides good examples and tools that might help cities that are eager to set up their own circular construction projects.

## 3.1 Spatial planning

For all the different stakeholders who have experimented with circular construction projects, the motto has always been 'the earlier, the better'. Moving towards circularity is still an innovative process, and that means we cannot do 'business as usual'. The project timeline, the overlapping of the different steps of the project, the stakeholders' interaction will be different, and some stages will be more time-consuming. Early planning might help to be well-prepared for all the steps of the project, to identify resources for each challenge that might be encountered on the path and to build a stronger team to enable and reinforce the collaboration all throughout the project.

*" The adoption of a co-design process to align stakeholders in the road renovation project was a good decision. At an early stage, it brought stakeholders to the table and multiple opportunities to facilitate a circular project were identified. It resulted in applying new road scanning technologies, a proper inventory of materials, ideas for marketplaces and, later on, in a better collaboration with the contractor. "*

**Bram Entrop**, Associate Professor Circular and Energy Transitions in the Built Environment at **Saxion University**, who has worked with Apeldoorn municipality over CityLoops project

**Recommendation**

*" The earlier the better. "*

Before carrying out demolition and construction projects as part of the transformation of an urban area, a development framework is developed to define the purpose, land use, aesthetics, and other aspects of this area. This initial phase is critical for setting a basis for decision-making, establishing political priorities, and creating a mandate for experimental practices. The development framework entails the creation of local plans and strategies. Since it is crucial to narrow the gap between demolition and construction projects, this phase offers an opportunity for early planning and a comprehensive overview to connect future projects.

*" At the beginning of the project, a face-to-face workshop was held with interested parties, economic operators and local social agents in order to discuss the circular construction issues. Later, we promoted a collaborative learning network (CLN), inviting local and regional parties. These meetings have been highly appreciated by the participants, to exchange experiences and to steer some of the decisions made in the development of the CityLoops projects. These meetings have also served to discuss and evaluate the strategies and approaches of the organisations that made up the Seville cluster regarding the circularity management of this material flow. "*

**Pedro Cruces**, Innovation Manager in LIPASAM, Waste Management Company, **City Council of Seville**

Therefore, when elaborating such a project at the planning stage, many questions should be asked that cover a wide range of perspectives (not exhaustive list):

- **Urban planning strategy**: which criteria are embedded in the urban and spatial planning documents? Have we prioritised the repurposing and renovation of buildings and remediation of brownfield sites?
- **The knowledge on the resources availability**: have we mapped the materials available within and around the territory? Are there secondary materials?
- **Stakeholders' engagement**: have we pre-identified the local companies and the solutions on the market? Are there already existing databases, online and/or physical platforms for secondary materials we could use? Are there companies which might be interested in the materials we will reclaim for demolition?
- **Public procurement**: do the tenders integrate circular clauses to recruit companies that could meet our needs?
- **Capacity building for other departments**: have we involved the relevant departments within the local authority? Are they sufficiently trained to cope with the project?
- **Buildings programme**: do we really have to demolish this building or could it be retrofitted? What materials do we want to reuse or recycle to achieve our environmental goals?

At the local level, developing circularity means closing, or at least narrowing, the gap between production and consumption places, considering cities as a stock of resources and changing production to rely on locally available resources. Thus, **rethinking urban planning strategies** - such as land policies for materials storage, environmental rules for building demolition, retrofitting and construction - will be key to developing closed city loops.

Defining clear environmental and circular objectives on the types of buildings within urban planning and zoning documents is one of the most impactful actions in the long term to develop circular cities. These documents impact the way that buildings and construction materials are used and reused as well as their physical character. They define which areas of a city or region will be repurposed. By means of spatial planning, local authorities can divide and classify the physical environment in a way that promotes circular resource management, for instance by creating industrial symbiosis parks or physical marketplaces, where resource flows are maximised and stocks are preserved.

As a result, launching actions to develop materials loops has an impact on the regulation of supply and demand at a local scale. Therefore, being aware of the local resources (materials resources, but also companies) by carrying out an urban circularity assessment could be the first step to engage circular projects. However, launching such a process can be time- and budget-consuming. it is important to bear in mind that this step is not mandatory to conduct an experimental circular project, but it is relevant when it comes to developing a circular strategy at scale.


Unsplash / Jason Goodman

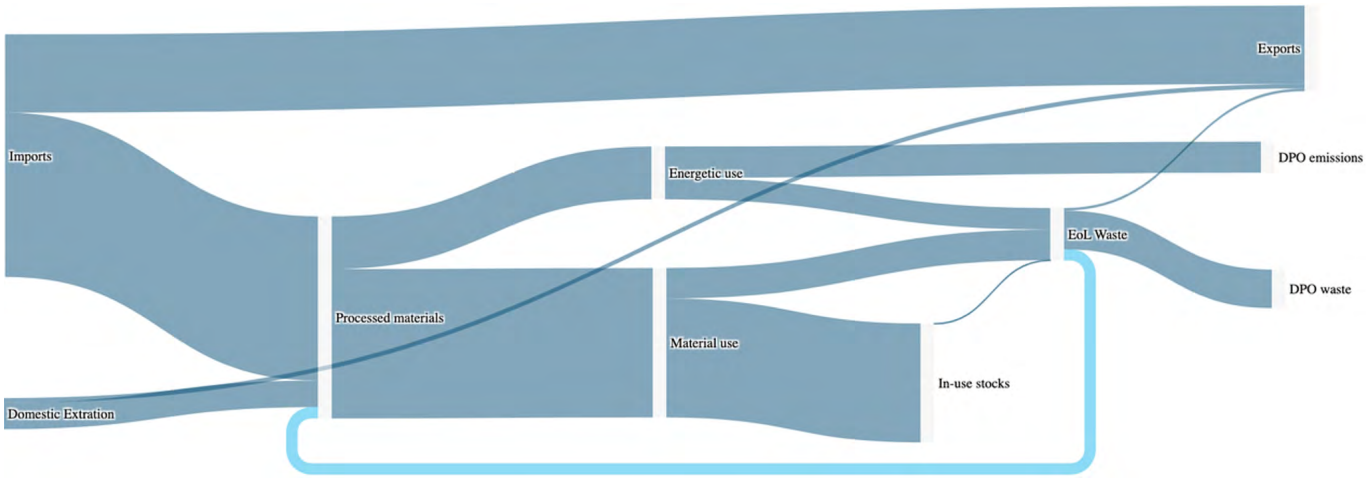

Unsplash / Jeriden Villegas

## ABOUT THE SECTOR-WIDE CIRCULARITY ASSESSMENT (SCA)

Developing circular strategies goes hand in hand with searching for spatial proximity in the supply of materials for the construction sites. Carrying out this action requires a good knowledge of the quantities and the location of resources, and activities of materials extraction and production on the one hand, as well as the use of materials and their end-of-life destiny on the other hand.

The Sector-Wide Circularity Assessment (SCA), also named urban metabolism study, Material Flow Analysis (MFA) or urban circularity assessment, is a framework to quantify and visualise material inflows and outflows from a city, by considering it as a living organism. It helps to grasp the key material streams and is often recommended as a first step to develop a circular economy strategy within the local authority. Sometimes a SCA is carried out together with a stakeholders mapping. Having an overarching view on what a city consumes and disposes of, and the local actors active in this field, is relevant when it comes to identifying material loops to develop and reduce. It is also a good departure point to establish monitoring indicators for the circular economy strategy.

Conducting an urban metabolism study at an early stage is insightful in providing policy makers with relevant information and for developing monitoring indicators. However, it can also be time- and budget- consuming, especially when local data is scarce.




Sankey diagram from the **Urban Circularity Assessment of Bodø**

*" The urban metabolism study gives quickly to decision-makers or citizens an overview of the key issues on where to focus in the circularity development projects. It also gives important information on the amounts of different waste streams and the development of those in time. "*

**Kimmo Haapea**, Project Manager in **Mikkeli**

## ABOUT THE SECTOR-WIDE CIRCULARITY ASSESSMENT (SCA)

The CityLoops cities which have conducted Sector-wide and/or Urban Circularity Assessments that rely on MFA raise this issue, and point out that carrying out such studies is not a prerequisite to launch an experimental project. However, they stress the interest to map the stakeholders for an efficient implementation of an experimentation. In addition, to continuously update the outcomes of the study and to monitor the strategy progress, involving the data-management department has to be kept in mind.

All in all, an urban metabolism study is useful and can provide relevant insights. For a first experimental project it is not absolutely necessary. It can be relevant when it comes to building a long-term circular construction strategy, by developing monitoring indicators, assessing the building stock within the territory, the upcoming material needs, and mapping the stakeholders' ecosystem. Moreover, it is an effective way to raise awareness on this new topic of circular economy in the construction sector to non-experts, people from other departments, local councillors, citizens and other stakeholders, and to demonstrate a municipality's dependency on, and relationship with resources sourcing, consumption and disposal.

*" When a flow analysis runs in parallel with a co-design process at the beginning of a circular economy project. your data collection, ambitions and activities can collide in a lovely trajectory. The raw materials analysis provides an overview of where your raw materials come from and are going to, and the co-design process exposes the 'human flow analysis', targeting who will be working on what, when and which connections between stakeholders could be made. This process has taught the municipality of Apeldoorn that the availability of materials, as well as human resources both need to be transparent as early as possible. When having the total overview, it enables you to switch, make connections and make adjustments along the way, resulting in an adaptive circular management needed for a circular economy. "*

**Bram Entrop**, Saxion University for **Apeldoorn City**

*" Accessibility of valid data is crucial for overall validity of Urban Metabolism. In Roskilde we experienced difficulties in obtaining sufficient data, which led into less usable models. For us, a more case driven approach would be more appropriate. "*

**Klaus Kellerman**, Senior Consultant Sustainable Construction in **Roskilde**

*" Bodø has conducted an Urban Circularity Assessment. Outputs are useful in many ways: getting data to support the decision-making process, moving away from silo's to holistic thinking, justifying why we need transitioning, focusing on what we are currently consuming, stressing within the municipality that data quality is important, quantifying existing building stock and prolonging the lifecycle as much as possible by predicting when and which materials will be available. In addition, Sankey diagrams show us that almost all of the materials are lost and that we currently cannot keep materials in the loop in our case. "*

**Tor Gausemel Kristensen**, Project Manager in **Bodø**

Learn more about conducting a Sector-wide Circularity Assessment and the cities' experiences on the **Metabolism of Cities website**

DEVELOPED WITHIN CITYLOOPS

TOOLBOX

First step towards circularity:

# Free tools and methods for a Material Flow Analysis (MFA) with CityLoops' partner Metabolism of Cities

There are quite a number of tools to carry out a material flow analysis. The choice of the appropriate tool depends on the type of MFA and the user. To begin with, an MFA is typically carried out in accounting spreadsheets, such as Excel. For CityLoops, various templates were developed to carry out a **SCA (Sector Circularity Assessment)** and/or a **UCA (Urban Circularity Assessment)**.

In addition, the Online Material Flow Analysis Tool (OMAT) exists. It is a free and open source tool developed by Metabolism of Cities that is supposed to facilitate a Material Flow Analysis (MFA) online.

It is recommended to contact Metabolism of Cities (**info@metabolismofcities.org**) to receive a copy and instructions for the SCA, the UCA and use of the OMAT.

Experts or advanced users can use this software to carry out a substance flow analysis:
**https://stan2web.net**

Finally, a Sankey diagram is usually produced to visualise the results of a Material Flow Analysis. This free tool can be used through this software:
**https://sankeymatic.com/build**

However, like most other Sankey tools or software, this one does not have a function to display circular flows. Therefore, Metabolism of Cities has developed a code that can import the UCA data from the template and transform it into a Sankey diagram with circular flows. **A webinar explains how to use it.**

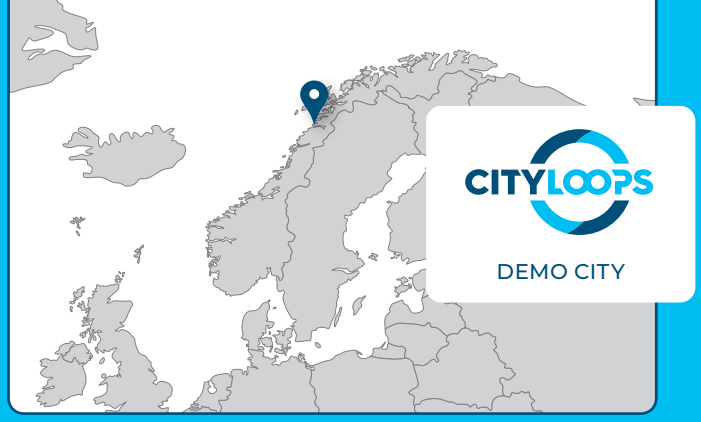
To discover the Sector-wide Circularity Assessment and the Urban Circularity Assessment methods, the CityLoops cities in collaboration with Metabolism of Cities have developed their own reports:
**https://cityloops.metabolismofcities.org/reports**

Learn more about conducting a Material Flow Analysis on the **Metabolism of Cities website**

Find out more about SCA **existing reports**

## 10 SECTOR-WIDE CIRCULARITY ASSESSMENTS


CITYLOOPS METABOLISM OF CITIES




GOOD EXAMPLE FROM CITIES:

# Visualising data of the Urban Circularity Assessment with a 3D GIS visualisation tool in Bodø (Norway)

Bodø (Norway) is one of the demonstration cities in CityLoops. In Bodø, an old military airport has been demolished and a new part of the city will be built in this area, while a new airport will be built in another area. This gave the city a great opportunity for a series of on-site circular demonstration actions.

To support a data-driven and holistic understanding of the city's resources and sustainability indicators, and to allow the information to be visualised in a more accessible way to decision makers and citizens along the city planning process, the city needed a digital solution.

Bodø then engaged in a RnD-contract with the UN Partner Augment City, which provided a digital twin city solution that met the foreseen functionalities. This tool visualises all city structures, materials, emissions and flows such as energy use in real time. It integrates qualitative data such as Sustainable Development Goals (SDG) indicators.

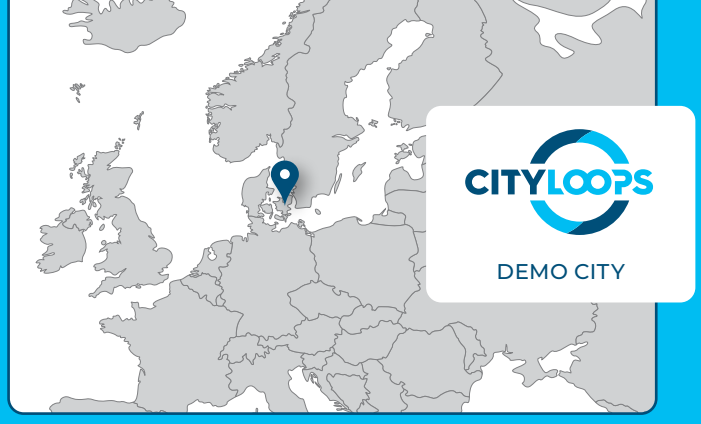
Learn more about **Bodø's experience on gathering data** and the **3D GIS Visualisation tool**

**Lessons learned**

*" 3D technology can visualise data related to materials, emission, soil, traffic, and different structures' reusability. Complex data is easier to understand if it is visualised, and correlations between different factors are probably easier to identify. This enables policy makers to take decisions for a sustainable development of the city. In addition we have seen how such tools can be used for stakeholders and citizen involvement. "*

*" Whilst the 3D GIS visualisation tool is used by the business and development and the technical department, we should possibly work more with the building and property department. Plus, the tool meets the needs for city planning, communication and scenario building, but calculations should also be made directly within the software. "*

**Tor Gausemel Kristensen**,
Project Manager in **Bodø**




GOOD EXAMPLE FROM CITIES:

# Early and participative urban planning process in Roskilde (Denmark)

Roskilde (Denmark) is one of the demonstration cities in CityLoops. Musicon is the demonstration area, a 200,000 m² former concrete factory and gravel pit, which Roskilde Municipality bought in 2003. The ambition is to create a new neighbourhood like no place else. No grand 'master plan' that locks the development of the area in a specific direction has ever been made. Instead, the different projects are created step-by-step in collaboration between citizens, developers, architects, cultural institutions, local businesses and the municipality, which means that Musicon is a dynamic site in constant movement and change. In Musicon, existing buildings are being refurbished or demolished and structures, construction materials and soil are being used in new constructions.

Roskilde wants to develop a new urban district centred around the theme of music, hence Musicon. This district will encompass a blend of residential and commercial spaces, including shops, cultural and leisure activities, fostering a lively atmosphere throughout the day. The district's purpose is to generate value for the entire city and region by attracting new flagship businesses, offering quality housing options, establishing inspiring park areas, and showcasing cultural attractions. Ultimately, this endeavour strives to enhance the overall livability of Roskilde. Musicon, in particular, aspires to become a national hub for nurturing artists, designers, musicians, creative companies, and individuals seeking unconventional settings.

The following steps have been taken:

- Identification of key actors involved in the project;
- Comprehensive mapping of interests to ensure alignment among stakeholders;
- Assistance provided for the establishment of businesses and initiatives within the district;
- Creation of a framework that enables self-grown ventures to thrive within the district;
- Cultivation of critical mass by fostering collaboration and synergy among various entities;
- Iterative testing of physical frameworks, cooperative models, and business potentials to optimise outcomes.

**Lessons learned**

*" If we could go back in time and change one thing, I think we should have worked more directly with circular business plans from the start. Involving business partners early in the process could have strengthened the communication about our goals. "*

**Klaus Kellerman**, Senior Consultant Sustainable Construction in **Roskilde**

Learn more about how gathering data might help to plan circular construction projects and/or strategy on the **CityLoops website**

## 3.2 Demolition (or deep renovation)

One of the main challenges towards circular construction is to develop a new mindset where waste is considered as a resource. For a long time, the building sector's goal was to build and demolish fast. Because of this, demolition was mostly about getting rid of the materials to have a virgin land to build something new. Times have changed, and resources and land scarcity made building sector stakeholders consider the building renovation and the reuse of building materials as solutions that have to be improved. Urban developers and builders should then be aware of the building stock within their territory, including the materials embedded in the buildings. Buildings have now to be considered as infrastructures that could be kept in place, with the possibility to be adapted for new uses with minor adaptations. Then, if they come to be demolished, they have to be perceived as "urban mines" that could provide secondary materials.

Shifting this mindset will lead to creating and pushing the accessibility of reused materials, which appears to be the first milestone to develop a supply chain for reused materials and synergies between demolition and construction site.

### Planning

In a circular construction project, the timeline differs from a classic one. The programming and the pre-demolition audit often takes place in parallel or with overlapping phases, to provide prior examination for this decision. The programming phase determines the objectives of the project and the scope of work, whilst the pre-demolition audit provides an understanding of the amount and content of materials in the building. Thus, the audit might provide information that has to be mentioned in the tender. For instance, if the audit has concluded that there is a high reuse potential for specific elements (such as doors, timbers, metal structure, etc.), those will have to be selectively dismantled by the contractor. This requirement therefore has to be mentioned in the call for tenders to hire the demolition company.

**Recommendation**

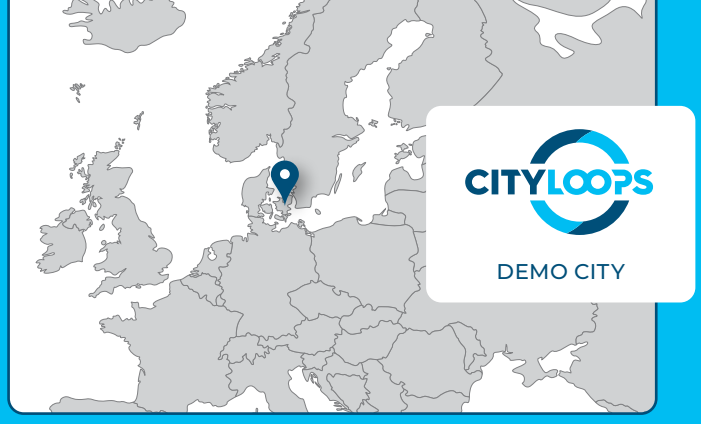
*" Consider buildings as a material bank. "*

As the saying goes, the greenest energy is the energy we do not consume. The same principle also applies to waste. Considering that the greenest waste is the waste we do not generate, it should be decided whether to demolish the building or retrofit it before designing the demolition project. Oftentimes, a renovation could be perceived as more expensive than a new construction. However, different projects tend to demonstrate that renovation is often less expensive - both economically and environmentally[13].

If $CO_2$ savings are also counted, the economic balance becomes even better, as it will likely be possible to save a minimum of 50% of the Life Cycle Analysis (LCA) calculated $CO_2$ emissions when renovating a building instead of building new. Knowing that about 75% of the buildings that will make up the housing stock in 2050 already exist today[14], cities could encourage building renovation in their urban planning regulation. For instance, London has developed its '*Circular Economy statement requirements*' which means that the building owner has to provide justification for demolition and consider options to retain and refurbish as part of the planning conditions.

13 INDU-ZERO is a project that developed a Blueprint for an innovative factory that will be able to produce 15,000 renovation packages per year for half of the current price

14 The circularity gap report 2019 - Closing the circularity gap in a 9% World




## GOOD EXAMPLE FROM CITIES:
## **Do not demolish!**
## **Høje-Taastrup (Denmark)**

Høje-Taastrup (Denmark) is one of the demonstration cities in CityLoops. Two of its demonstration sites are the old city hall and the new city hall.

A need for extensive renovations of the old city hall as well as the plan to develop a housing area in its location led in 2016 to the decision to demolish the old city hall, build houses, and build a new city hall in another neighbourhood in the municipality. Functionally, however, demolition and construction were not in themselves necessary components in order to achieve this: the functional requirement was establishing housing for new residents and having a place for municipal employees to work together.

Formulating the needs in this way was not possible to do at the time the initial decision was made, but other global and market factors led to a change in the project in this direction. Today a new city hall has been built with a recycled concrete foundation, but the old city hall still stands and will now be converted into housing instead of being demolished. Compared with demolishing, this leads to savings of roughly 20.000 tonnes of natural resources as well as 2000 tonnes of $CO_2$.

Looking back, the upper management of the municipality reflects that if the decision regarding the old city hall were to be made today, the conclusion from the beginning would most likely have been not to demolish. This is a strong indicator of how circular ideas have begun to take root in the municipal operations.

**Lessons learned**

*“ Our strongest lesson from this project is: if you can avoid demolishing or avoid building a new building, that is what you should prioritise. It gives the biggest environmental savings by orders of magnitude as well as avoiding the logistical challenges of coordinating material flows between different building projects.”*

**Erika Yates**, Environmental Project Manager in **Høje-Taastrup**

**Formulate the functional question, identify exact needs**

A key element of circular procurement is to formulate the functional needs rather than being too technical in the specifications. A key step in the planning process is to take inventory of existing buildings to identify if the necessary functions can be fulfilled by the existing building mass. Avoiding demolition and construction and instead renovating or converting existing buildings is the most cost-effective, easy, efficient and accessible way of implementing circular economy and provides the most environmental and CO2 savings.

Høje-Taastrup’s old city hall © Claus Bjørn Larsen

GOOD EXAMPLE FROM CITIES:

# Deep renovation in Paris (France)

The City of Paris has renovated **Les Canaux**, a former administrative building from 1882, to host social and solidarity companies, with an objective of 100% reused materials, bio-geo-sourced and/or containing 15% recycled material. It has involved over 40 local companies to handle and transform the different materials (including metal structures, floors, sanitary fittings, interior elements).

Since the tender preparation, Paris' goal was clear: to build a demonstrative building to showcase the possibility to renovate a building by embedding low environmental impact materials. Paris' contractor, the architecture agency Grand Huit, brought together companies – especially local ones - committed to the circular, social and solidarity economy. Many partners (including local authorities and social housing companies) also took part in this project by creating synergies and by giving materials and products to the City of Paris (e.g. metal beams, landing doors, benches, furnitures, etc.).

Paris city also took advantage of this project to develop proper training on circular construction, the "**Circular building pathways**" training. They relied on the building site to train Paris' technicians as carpenters, masons, and apprentices on new circular construction techniques.

**Lessons learned**

*❝ It is necessary to invest enough time at the early stage of the project. Looking for some secondary materials has been time-consuming, since we have been through different channels (including digital marketplaces, call to partners and on-site materials identified with a pre-demolition audit). ❞*

*❝ The secondary materials market is not structured yet. It turned out some materials that were first identified were not available in the end. Therefore, the flexibility and the close collaboration with the contractor were key for the project to succeed. ❞*

**Isabelle Lardin**, Circular economy and study cost Project Manager in **Paris**

Les Canaux, a demonstration project for the City of Paris with reused materials - On the right, the reused metal structure of the terrace is provided from a demolished building closeby. © The City of Paris


If the demolition is necessary, the objective and the goals must be defined at the early stage of the project, ideally by bringing together most of the stakeholders, for instance in an early market dialogue. Thus it is possible to identify innovative solutions and ensure the market can meet expectations. This phase includes the assessment of the potential for reusing the materials coming from the demolished building (on-site reuse, donations, buyers for new buildings, etc.) aiming for the highest possible level of the waste hierarchy. For instance, in the case of concrete, it might be considered whether it is possible to reuse concrete elements, recycle crushed concrete as aggregate in new concrete or as unbound materials for road construction. When dealing with masonry instead, the focus can be on the possibility to reuse bricks, façade masonry elements, and crushed masonry in bearing layers.

Finally, the logistics, handling and storage are also crucial points that must be considered as early as possible, especially in urban and dense areas where land is expensive and coveted.

As an example, if one of the project goals is to reuse concrete from a demolition site to use it as recycled aggregate in a new building, the contracting authority must take into account many parameters:

- timelines of the demolished and the new buildings;
- mapping of concrete quality and amounts of the possibilities for selective demolition, including extra time and cost;
- testing concrete quality for the targeted purposes;
- managing logistics, handling and storage: is there a possibility to crush, store and use the concrete on-site or is it needed to crush it elsewhere and store it before recycling it into new concrete?;
- companies that could be able to provide this work (selective demolition, crushing, storage, mixing of recycled concrete on/off-site);
- the project economic balance.

### Pre-demolition audit

With regards to the waste hierarchy, public authorities must ensure that demolished and heavily retrofitted buildings are selectively deconstructed. Proceeding this way will then provide materials that can be reused or recycled, on or off-site, for the same or for a new purpose.

Conducting a pre-demolition audit is then required to prepare for selective demolition by providing a detailed assessment of building material fractions with respect to their amount, quality, purity, and suitability for circularity (reuse, recovering, recycling). It should be applied when planning demolition projects, with sufficient time and coordination among actors, to make a pre-demolition screening and subsequent selective demolition required in the procurement of a demolition contractor.

The screening procedure aims to recognise reusable and recyclable materials and building elements and to give recommendations on how to handle them. Identification of materials, as containing harmful substances or as having residual value and potential for other uses, is the key first step to preventing their treatment as waste and securing potential future secondary material.

The owner of the property may carry out this audit, but it is recommended to be supported by an external expert. Once done, the audit should be attached to the tender to recruit the demolition company in order to embed criteria on selective demolition (what elements to recover and which materials to recycle, possibly also with an expected recovery rate, for instance 80% of the bricks to be qualified for reuse) and criteria for the handling of those materials (for instance not allowing to drive away the bricks).

TOOLBOX
## First step towards circularity: **Conducting a pre-demolition audit**

As a crucial step to increase circularity in the building sector, guidelines have been developed throughout European projects to conduct such procedures and audits.

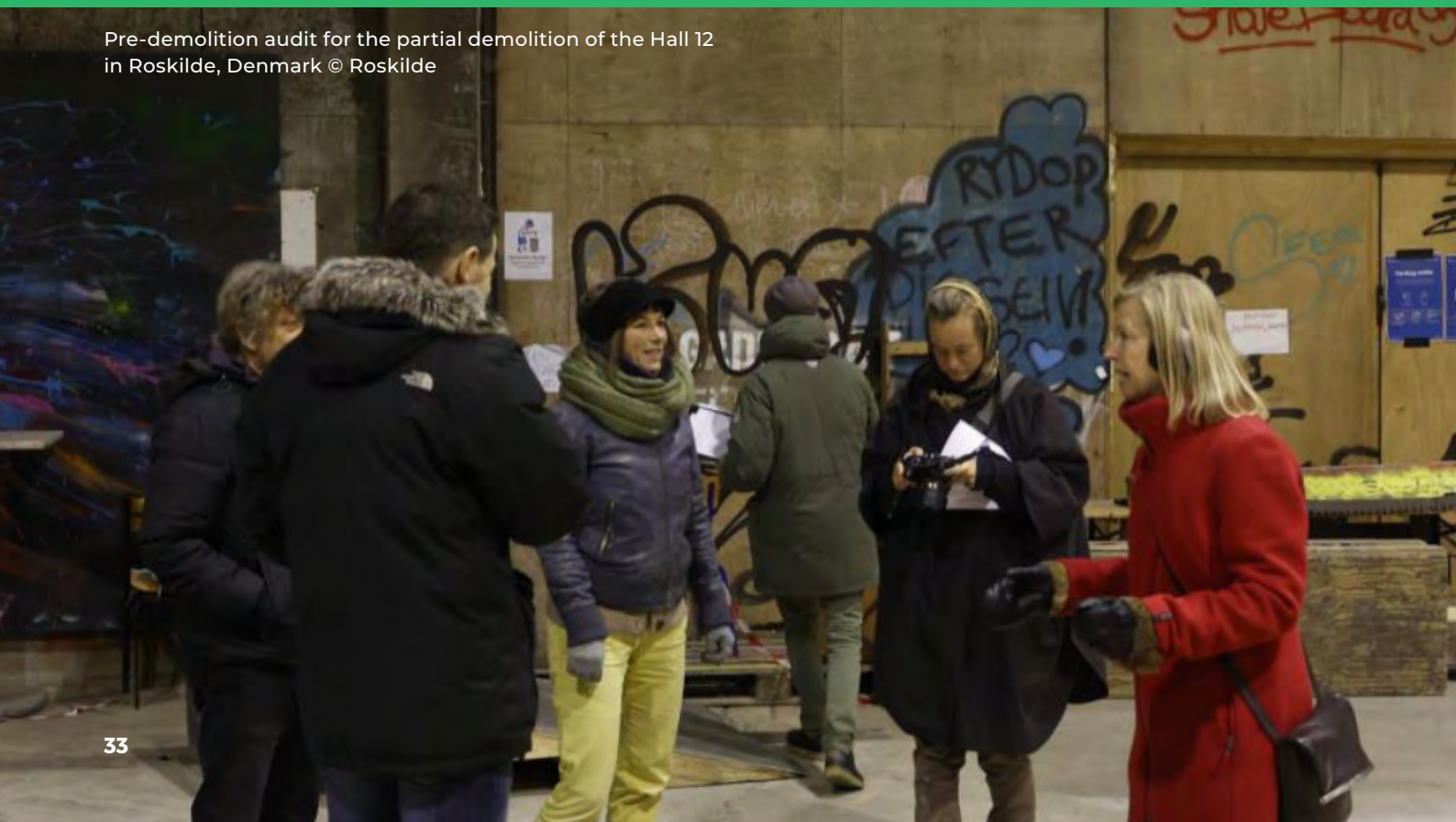
CityLoops: the
**pre-demolition screening procedure**

This procedure explains how a pre-demolition inventory and material audit can be conducted to identify building components and materials with reuse or recycling potential. The screening procedure details how to identify and evaluate the residual value of a component. Screening for hazardous waste is already a requirement, but this procedure also includes screening for salvageable materials and how to selectively disassemble them, preserving their value and utility for future uses.

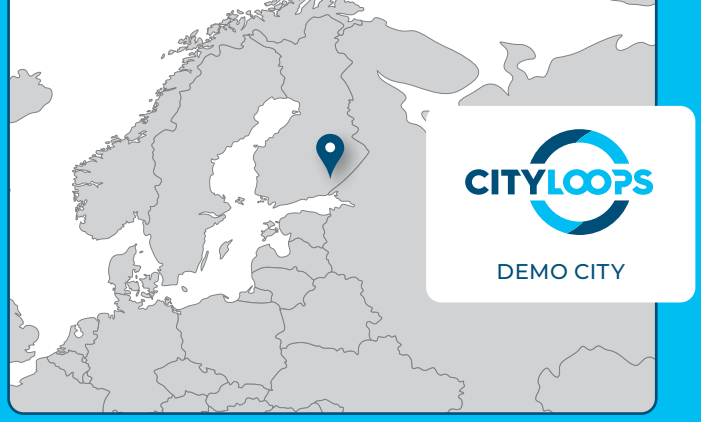
Learn more about how conducting a pre-demolition audit by visiting the **CityLoops website**

FCRBE (Facilitating the circulation of reclaimed building elements in Northwestern Europe):
**A guide to inventory the reuse potential of construction products before demolition**

This manual presents a method on how to conduct these audits. It addresses building professionals and any stakeholders involved in the (de)construction process: building owners, contractors, architects and engineers, etc. It provides guidance on the most frequently asked questions: when should a reclamation audit be conducted and by whom? How can it be combined with other pre-demolition audits? How do you assess the 'reuse potential' of a building material? How do you conduct it? What important information should be collected and how should it be structured? When completed, how should the inventory be used? The manual also includes some annexes, providing practical information, examples and tutorials.



Pre-demolition audit for the partial demolition of the Hall 12 in Roskilde, Denmark © Roskilde




GOOD EXAMPLE FROM CITIES:
## Pre-demolition audit in Mikkeli (Finland)

Mikkeli (Finland) is one of the demonstration cities in CityLoops. Four cities within the CityLoops project - Bodø (Norway), Mikkeli (Finland), Roskilde and Høje-Taastrup (Denmark) - have used pre-demolition inventories and material audits to identify building components and materials with reuse or recycling potential.

Mikkeli has demolished two public buildings, Pankalampi Health Care Centre and Tuukkala hospital, using circular material management methods, including digital tools, headed by the Building Services Department. The sites have been scanned thanks to a 3D tool developed within the CityLoops project. A pre-demolition audit has identified potentially recoverable materials and their characteristics. Following the selective demolition procedure, salvaged materials have been incorporated into a digital databank and construction materials marketplace to offer and to obtain secondary construction materials to private and public actors.

Learn more about **Mikkeli's** and **other cities' experiences** on how they have conducted a pre-demolition audit on the **CityLoops website**

**Lessons learned**

*"The pre-demolition audit should be done well in advance of the demolition and in cooperation with various stakeholders, so that the recycling of reusable materials can be connected to the design processes."*

*"Reuse cannot be promoted without a proper pre-demolition audit."*

*"We have developed a digital pre-demolition audit tool (databank), from which the reusable items can be selected and moved to the digital marketplace. The tool can be localised to other countries and cities."*

**Kimmo Haapea**,
Project Manager in **Mikkeli**

Overview of Tuukkala Hospital (on the left) and Pankalampi health centre (on the right) © Esa Hannus, Xamk

## Selective demolition

A selective demolition will preserve the value of the building components and materials with reuse or recycling potential, following a series of chronological steps to dismount components or materials without damaging them.

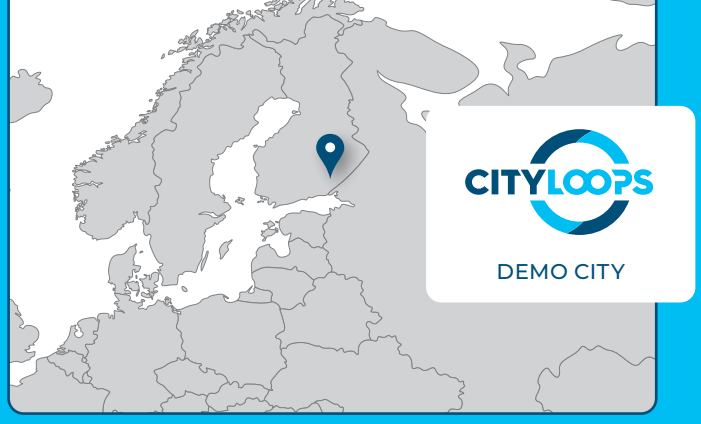
This method ensures the best opportunities for sorting out hazardous materials and circular resources. By removing harmful substances and salvaging construction materials with reuse value, it reduces the total waste production on site and creates secondary construction material supply. The soft stripping phase must be executed promptly after the last user of the premises has moved out and the organisation of the reuse of items should occur before moisture and vandalism ruin them.

Once construction materials are selectively demolished, they should be handled and managed in a way that preserves their value and utility.

The selective demolition can be more expensive than traditional demolition, since it takes more time and workforce to be achieved. Nevertheless, there are cost savings in waste management and material recovery. Financial and management models should account for the redistribution of costs and savings accordingly.

Based on the recommendations of the pre-demolition audit, tenders and contracts for selective demolition works should also include planning and logistics for circular site preparation and selective demolition, with soft stripping and on-site separation of material types.

Selective demolition of buildings: The Rockefeller-Centre, The National Hospital, Copenhagen 2018-2021. The photo on the right shows dismantling of roof tiles for reuse. The photo on the left shows interior locations after stripping of loose items, insulation etc.




GOOD EXAMPLE FROM CITIES:

## Selective demolition of Pankalaampi HealthCare Center and Tuukkala Hospital in Mikkeli (Finland)

Within CityLoops, Mikkeli has demolished two public buildings, Pankalampi Health Care Centre and Tuukkala hospital, using circular material management methods. After having conducted a pre-demolition audit, a selective demolition has been required in the tender.

The demolition was prepared and performed in accordance with the **CityLoops Selective Demolition guide**. Different waste fractions were sorted at both demonstration sites and the amount of mixed construction and demolition waste was minimal, as the legislation and waste prices guided sorting. However, it was interesting to see the variation in the implementation of selective demolition between the different contractors and demolition sites.

For an efficient selective demolition, it is important to state in the demolition contract the waste fractions that must be sorted at source and this should be monitored during the implementation. Additionally, the soft stripping procedure must be formalised with clear roles and duties for each participant. Selective demolition was implemented well in the two demonstration projects in Mikkeli and the sorting rate in the demonstration sites was over 99%.

**Lessons learned**

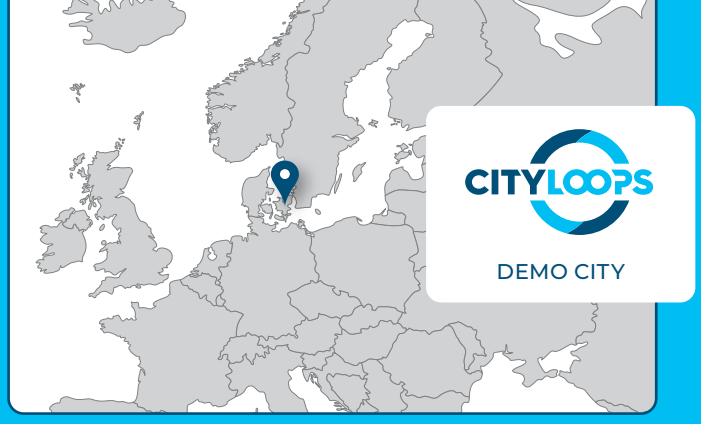
*“ In Mikkeli it is common that the city owns buildings that can stand empty for years, even more than 10 years, because there is low pressure for new construction here. This means that also the materials that could be recycled or reused from the stripping phase will probably be ruined. The benefit of a separate stripping contract is that the timeframe for the work could be more relaxed and would allow on-site sales of items and temporary storage of dismantled parts.”*

*“ The stripping phase does not need a demolition permit, which reduces the bureaucracy and time. The separate contracting would benefit local companies. The concept of separating the soft stripping, indoor demolition and heavy demolition contracts can be replicated by any city, taking into consideration the optimal timeline for each phase and available tenderers.”*

**Kimmo Haapea**,
Project Manager in **Mikkeli**

Learn more about **Mikkeli’s** and **other cities’ experiences** on how they have conducted a selective demolition on the **CityLoops website**

Unused furniture and items from the Tuukkala Hospital ©Kimmo Haapea




GOOD EXAMPLE FROM CITIES:

# Tendering criteria for selective demolition in Høje-Taastrup (Denmark)

In 2016 it was decided that Høje-Taastrup should build a new city hall due to the need for extensive renovations in the existing city hall. It was then decided that the municipality will sell the old city hall, and that the area should be developed into a residential area suiting the nearby old village of Høje-Taastrup. Høje-Taastrup municipality is the owner of the old city hall and was thus responsible for selling it. The municipality signed a pre-purchase development agreement with a private developer, IKANO, which showed a great interest in circularity and sustainability.

The municipality had the opportunity to impose circular conditions in the tender about how the demolition should take place and how soil should be handled. The aim was to impose criteria ensuring that as much building material as possible should be reused and as much soil as possible should be kept on-site.

However, due to market conditions as a result of increasing prices, IKANO has temporarily paused the development of the area, and is considering changing the whole project into transforming the existing buildings into housing instead of demolishing them. This will require a new urban plan, and therefore postpone the project significantly.

Høje-Taastrup's environmental department has drafted a revised version of the circular criteria which come into effect if IKANO goes forward with the plan to leave the majority of existing structures standing. The updated criteria specify that structures do not need to be demolished, but the components that are still demolished or stripped still need to be demolished selectively with maximum direct recycling. It also specifies that structures that remain standing will be counted as 100% recycled. A final decision is expected in autumn 2023.

Learn more about **Høje-Taastrup's experience** on circular procurement on the **CityLoops website**

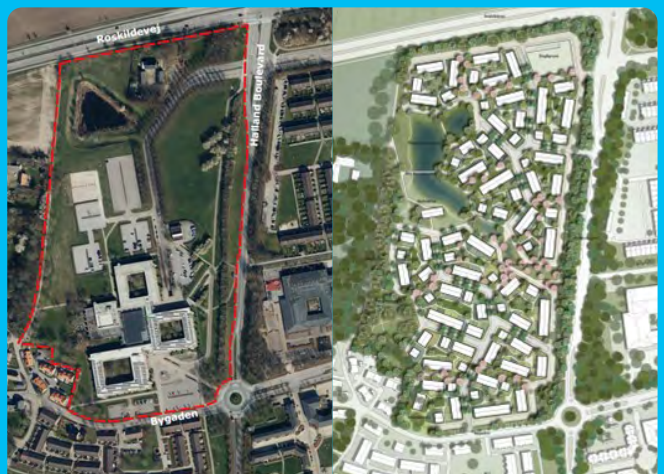
**Lessons learned**

*"The collaboration and understanding between the urban development department, the urban planners and the environmental department was a great advantage in the process of formulating the circularity criteria to the tendering material. The collaboration helped break down barriers between possible municipal silos."*

*"Although the criteria were intended to be relatively specific, the developer and the municipality are in the process of specifying how circularity criteria have to be documented and evaluated."*

*"The successful implementation of circularity criteria was to a strong degree dependent on the involved staff at important times. To ensure that circularity criteria will be implemented in future similar cases and/or projects, a more structured approach should be attempted. This approach will be suggested in the future citywide sustainability strategy and action plan which the environmental department is in charge of."*

**Laura Heron Jessen**, Environment Project Manager in **Høje-Taastrup**




Existing city hall (on the left) and map from the urban development plan showing the suggested plan for the upcoming project.

## 3.3 Creation of a secondary materials market

The “selectively demolished” materials suitable for reuse and recycling must be handled and managed for demanded materials in new constructions. Here, the issue is to match supply and demand. This is one of the biggest challenges in setting up a local supply chain for reused materials.

To connect demolition sites (supply) and construction sites (demand) and to transform a “freshly dismantled” material into a “ready to re-use” material requires stakeholders’ will, skills, logistic and management tools to sort, clean, transform, cut to new dimensions, document, transport, store, and track materials. Most of these activities entail a lot of manual labour, which in Europe is still more expensive than buying new products from abroad. The tipping point to mainstreaming circular building materials will be thus reached when these will be economically competitive. To do so, amount, volume and quality are crucial.

In this transition, local authorities have a major role to play by developing or supporting the development of physical material banks and digital marketplaces.

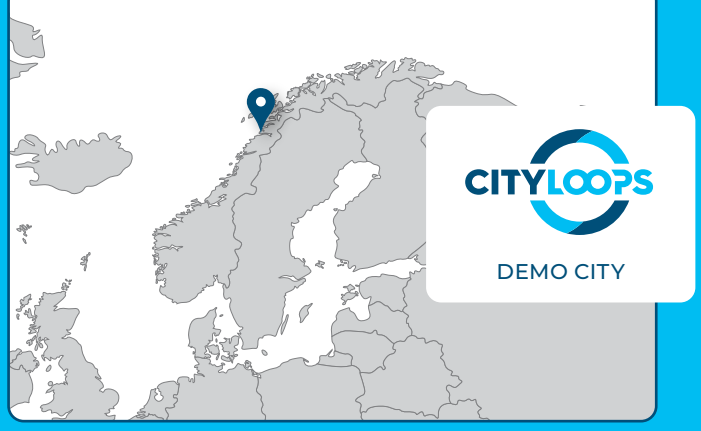
### Physical material banks

Regarding the tight and overlapping timelines in the construction industry, storage of secondary materials is necessary until their destination and onward use are confirmed. Local authorities may allocate space and explore local sites according to their possibility of providing storage space as part of a reuse hub.

Nevertheless, saving lands for this purpose remains a critical issue. In urban and dense areas, lands are rare, and highly coveted. In response to this, many business models are currently under development, such as land provided by local authorities, temporary land use prior to an urban project, private landlords and public-private cooperation. For instance, developing such activities could be led by a local company, increasing the social impact of the circular economy policy by creating jobs and stimulating economic development in the environmental field.

**Recommendation**

*“ Find a method for digitising data and choose an existing and well-known digital marketplace to upload them. ”*




## GOOD EXAMPLE FROM CITIES: **Intermediate storage for soil in Bodø (Norway)**

Bodø (Norway) is one of the demonstration cities in CityLoops. Bodø has worked on a mass handling management strategy, including soil, and has developed a sustainable soil management roadmap. Soil should be transported over the shortest distances possible and only be unloaded once, back in the project it came from, or directly reused in another destination project. However, supply and needs for soil do not often match in time, making intermediate storage a necessity. In order to develop an intermediate storage and sorting area for soil and masses, different areas have been considered, but the city faced some obstacles in converting these to physical material banks.

As a result, the option of establishing intermediate storage at the local landfill in Langskjæret site came up as a good alternative, thus an application was made to the pertinent authority. Earlier, this was used only as a landfill site, but the intermediate storage use has now been established. Even though this location is further from the city centre than preferred, it is still a good alternative. The co-location of landfill and intermediate storage also gives some benefits. Less investment and operational costs are needed because the site is already operational. It is also possible to leave the soil in the intermediate storage while waiting for laboratory results for contamination, potentially allowing more reuse of soil that would otherwise be landfilled because of uncertainty. Much of the soil in Bodø is contaminated and needs landfilling with today's regulations. The intermediate storage makes it possible for the transporters to bring soil back to the project site when returning from the landfill, reducing transport of new soil.

**Lessons learned**

*" In the overall municipal area plan (Kommuneplanens arealdel) for Bodø four areas are reserved for intermediate storage for soil. Neither of the options are, however, central or practically useful without cleaning, and the establishment of infrastructure for heavy transport and operation. There is a need for more central and suitable intermediate storages, as well as more experience with the establishment of new and temporary intermediate storages within the municipality. "*

**Tor Gausemel Kristensen**,
Project Manager in **Bodø**

Learn more about **Bodø's experience** on intermediate storage and sorting area for soil and masses on the **CityLoops website**

Intermediate storage facility at Langskjæret, Bodø
© Espen Kringlen

GOOD EXAMPLE FROM CITIES:
# Material bank in Leuven (Belgium)

**Materialsbank Leuven** is a store for recovered or circular building materials, with a focus on wood, in the Leuven region. Materialenbank Leuven is an initiative of the City of Leuven and *Atelier Circuler*, a non-profit organisation, in cooperation with *Living and Working Employment* and several other partners, with the financial support of the Horizon 2020 project **Pop-Machina**.

In line with its Circular economy strategy, the city wants to enhance the secondary material use within their building construction programmes. Therefore, Leuven has established an "urban mining" agreement between the city and *Atelier Circuler*, that allows them to have the priority to take materials from the city's demolition sites they could refurbish and sell for reuse.

Circular principles have been integrated in a few pilot projects so far. It still remains an ongoing learning process that the city could gradually scale up throughout 2023 and beyond.

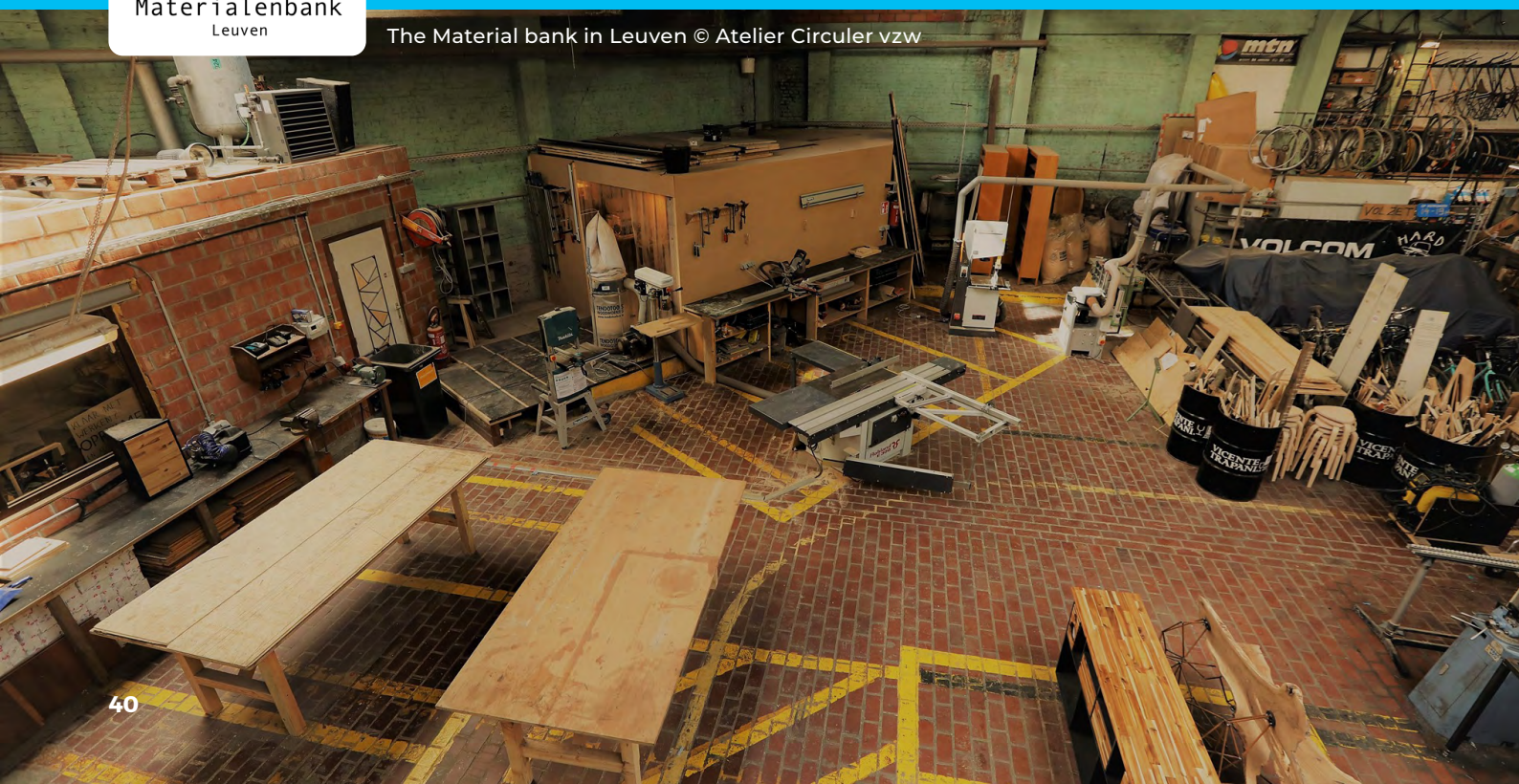
**Lessons Learned**

*"About the procurement process, we still have a lot of work to do. In parallel, we have developed a circular building action plan with 8 main topics and 16 action points. A core team, consisting of the built environment department, the city development department and the circular department, developed the plan and is responsible for carrying out the different actions."*

*"For the built environment, it is important to engage all relevant stakeholders in the ecosystem. This means that architects, contractors or commercial actors also need a seat at the table. A complete partnership to scale up and make a bigger impact."*

**Liene Blancke**, CIrcular Economy project manager in **Leuven**

Materialenbank Leuven




The Material bank in Leuven © Atelier Circuler vzw

### Digital marketplaces

Digital marketplaces are essential drivers for tracking and mapping resources as the number of suppliers and procurers increases. As a complement of physical material banks, the digital marketplace enables matches between suppliers and procurers, by facilitating materials visibility and availability (namely where and when they are available), and providing information on quantity, quality and cost.

There are two main types of marketplaces, depending on the degree of preparation of the materials:

- Advertising platforms, which are websites that showcase available materials in buildings scheduled for demolition. In this case, the materials are often still on-site and it is up to the interested buyer to negotiate the reclamation;

- Webshops, which are online catalogues where you can find what material is available in a physical storage place. More and more professional reclamation dealers have an online vitrine to complement their on-site showroom.

Despite the important role they can play, digital platforms do not have to be developed by local authorities themselves. Many of them are already led by private companies and sometimes by public entities, so it is highly recommended to plug in to an existing and already widely known one, to avoid time and budget waste.

To upscale the volume of materials that could be exchanged and/or sold on these platforms beyond the own city asset, local authorities have a role to play in supporting competence development and private-public collaboration on material flows with the stakeholders of the value-chain. They can do so through training materials, workshops, network facilitation with local stakeholders (such as professional reclamation dealers, social housing companies, private developers, construction companies, etc.).

### Evaluating quality of reclaimed materials

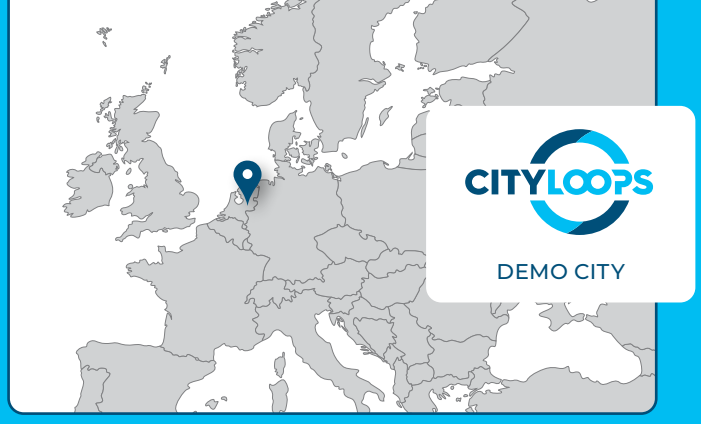
Though boosting demand and supply in reused materials will be key to shift from a linear to a circular construction value chain, the lack of reliable information about these products and the lack of a quality stamp remains a major obstacle. Reused materials do not follow the classical value chain production and are not - for the time being - produced in an industrial way[15]. Thus they usually do not have detailed product datasheets, unlike most new construction materials.

Usually, when there is an intended new use for a reclaimed material, one of the value chain stakeholders has to make sure that it meets the requirements set for this use. To do so, different approaches are possible and depend on the expected use: careful visual examination, investigations into the history of the element, laboratory tests, etc. Although the requirements set for the expected use are identical whether you use reclaimed or new products, the pathways to demonstrate the fit for purpose of the products are different. Most of the time, standardised quality assessments - as those used in the mass production of industrial materials - are of very little use when dealing with reclaimed elements. New approaches are being developed on this issue[16].

However, this lack of standardisation of the information on technical and environmental properties leads to a lack of confidence in reclaimed materials, and stakeholders have to bear the responsibility when using them. As a result, tests and qualification of reused material properties to certify that they are safe and fit for purpose in new uses need to be mainstreamed. This is actually a common challenge that every stakeholder of the value chain has to tackle. One of the stakes is therefore to increase the confidence of the potential users of reused materials by recognising the know-how of the actors that transform and/or sell them. Alongside other stakeholders, like regulators, insurances, building technical centres, etc., local authorities can take part in this progressive change to mainstream use of secondary materials by leading or contributing to more and more construction projects with reused materials.

15 Statistical analysis of the building elements reclamation trade in the Benelux, France, the UK and Ireland - Interreg NWE FCRBE

16 Evaluating the technical performance of reclaimed building materials




## GOOD EXAMPLE FROM CITIES: **Digital marketplace in Apeldoorn (Netherlands)**

Apeldoorn (Netherlands) is one of the demonstration cities in CityLoops. The main demonstration project in the municipality of Apeldoorn has been the circular design and the renovation of a residential road called Griffiersveld. More than 4.600 m² of concrete pavers were taken out and put to reuse directly on site and on nearby farms.

Before renovating the street and launching the construction works, the road materials were scanned to identify quantities and quality. This information has been stored in Apeldoorn's asset management software. The first plan was to develop their own digital marketplace, and in the meantime, collaborate with existing ones. It turned out that recruiting visitors to a new platform was a hard task. Thus they focused on the existing ones, including DuSpot.

DuSpot is an online matching tool that specifically focuses on materials in civil construction projects. The Dutch municipalities of Amsterdam, Rotterdam, The Hague and Enschede were four customers that helped in launching DuSpot. By the end of this renovation project, an agreement between Apeldoorn and DuSpot was sealed and Apeldoorn's materials were published on the platform.

Learn more about **Apeldoorn's** and other cities' experiences on the digital marketplaces used within CityLoops on the **CityLoops website**

From now on, the materials required for or becoming available in projects undertaken by the municipality of Apeldoorn will be listed on this platform.The materials available in the material depots of the municipality are also shown through this matching tool.

### Lessons learned

*" Setting up a completely new site means that you will start at zero regarding visitors and, therefore, potential buyers. It will take time and money to attract visitors to your new website."*

*" Although much effort was put into developing and adopting online marketplaces, the biggest contribution to reuse materials comes from the eager civil servants and the contractor."*

**Bram Entrop**, Associate Professor Circular and Energy Transitions in the Built Environment at **Saxion University**, who has worked with the Apeldoorn municipality on the CityLoops project

Screenshot from the online marketplace "DuSpot" in the Netherlands used by Apeldoorn.

TOOLBOX
First step towards circularity:
## Professional reclamation dealers are near you...

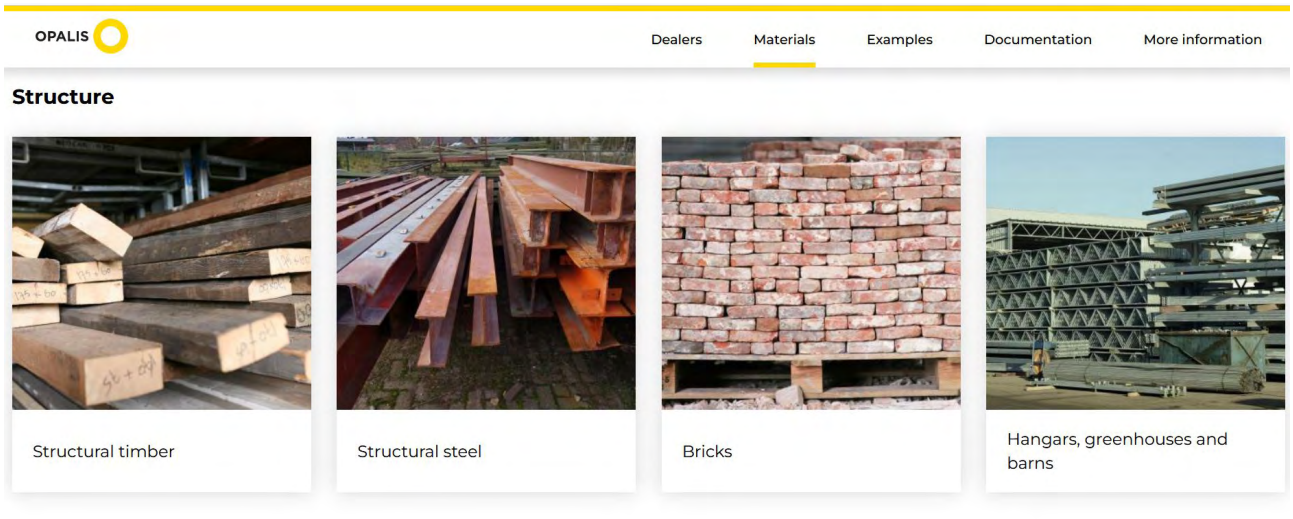
Reclaimed materials can rarely be reused immediately after their dismantling. There are several reasons for this. For instance there could be mortar, glue or another residue on their surface which makes it difficult to re-install them. Or they are not the right size for their new application, or some parts are missing or need to be repaired.

The professional reclamation dealers can perform the necessary product operations on their materials, allowing them to be reintroduced to the market and to be easily placed. Depending on the material and the supplier, certain operations are standard, while others are only carried out on demand.

Learn more about the physical material banks and the digital marketplaces piloted in CityLoops on the **CityLoops website**

Professional reclamation dealers can be very useful allies in many construction projects. They usually hold a stock, they know the materials quite well and how to condition them properly for reuse, they are an infinite source of knowledge about salvaged materials and they have developed solid business models to ensure the profitability of salvaging specific building elements.

You can find these actors almost everywhere in Europe. The online catalogue **Opalis.eu** has collected information on professional reclamation dealers since 2011, although with a bigger representation of countries from North-West Europe. A **sandbox section** on Opalis has been recently opened to the public, to list known professional reclamation dealers all over Europe and beyond, identified also through workshops with local students, personal trips, etc. If you wish to contribute to this work, please contact **Opalis administrator**.



## IMPROVING SAFETY AND TRUST TOWARDS REUSED MATERIALS TO UPSCALE CIRCULARITY

### At the European level: the Construction Product

The European Commission presented in March 2022 a package of European Green Deal proposals to make sustainable products the norm in the EU and boost circular business models. As announced in the Circular Economy Action Plan, the Commission proposes new rules to make almost all physical goods on the EU market more friendly to the environment, circular, and energy efficient throughout their whole lifecycle from the design phase through to daily use, repurposing and end-of-life, including the construction materials with the revision of the Construction Products Regulation.

This revision will strengthen and modernise the rules in place since 2011. It will create a harmonised framework to assess and communicate the environmental and climate performance of construction products. New product requirements will ensure that the design and manufacturing of construction products is based on the state of the art to make these more durable, repairable, recyclable and easier to re-manufacture. New rules have also been proposed for reused materials, allowing them not to follow the same certification process as new ones, which is an encouraging step for the sector.

Extract of the "Proposal for a Regulation laying down harmonised conditions for the marketing of construction products"[17]:

"*Construction products that have already been assessed and are reused should not be subject to the rules that apply to new construction products. However, used construction products that have never been placed on the Union market before, should be subject to the same rules as new construction products, given that such products have never been assessed.*"

This proposal is currently being negotiated at the European Council and Parliament.

### Belgium

Insurance issues are at the core of current reuse practices. There are still many open questions: how can we get insurers to cover the use of reused materials? How can risks be assessed and responsibilities be shared? What are the new roles for each stakeholder (including contracting authorities, architect, technical controller, etc.)? When and how is insurance information to be communicated between project members?

Many initiatives are running to tackle these barriers:

- SECO Belgium, an independent technical expert for the construction industry, in collaboration with different stakeholders (builders, developers, contractors and insurers), has launched a research project to address the insurability of circular projects in the building sector. The project will develop recommendations for insurers and policymakers to overcome the obstacles related to the insurability of circular constructions, by working on the availability of reliable and relevant technical information for reusing materials.
- Safety circularity certification: this certification, developed by partners specialised in reused materials, aims to increase trust of owners, project managers and prescribers (architects, research departments...) in the capability of recovery actors to propose safe and reliable reused materials. It presents companies specialised in materials refurbishment a way to control their internal processes and a certificate to recognise their ability to declare reliable information on the materials concerned, delivered by an external party. As a result, the certification provides project owners, architects and contractors a quality guarantee towards the company they are working with.

### France

The CSTB (National Scientific and Technical Building Center) and three other partners have launched the **SPIROU project** ('Securing Innovative Reuse Practices via a Unified Offer'). The aim of this project is to secure the reuse of materials until they are reintegrated into new structures, by defining shared and recognised operating methods. They agreed on 10 products/equipment/materials:

- Wooden door units and wooden fire door units
- Ceramic bathroom fixtures
- Carpet tiles
- Industrial wood framing (truss)
- Water radiators (cast iron and/or steel)
- Electrical cabinets and modular protections
- Light fixtures
- Lime mortar bricks (<1970)
- Mineral siding
- Galvanised rigid ventilation ducts

More than 20 criteria were taken into account to choose them, including the amount of the deposits, the demand from the project owners, the performances to assess for their reuse and the existence of documented feedback among others.

Once these procedures are developed, they will be submitted to the sector stakeholders to help them structure and upscale their activities in the reuse field. This project marks the beginning of a new operational phase to move toward recognition of reuse practices.

17 Proposal for a Regulation laying down harmonised conditions for the marketing of construction products, amending Regulation (EU) 2019/1020 and repealing Regulation (EU) 305/2011

## 3.4 (New) construction

(New) construction should be foreseen as the last step of a circular project. When new construction is required, buildings should be designed to minimise the quantity of new material utilised, and prioritise the reuse and recycling of existing materials. They should be designed so that they can be disassembled, with materials which can be reused or at least recycled at the end of life of the building. To reach this goal, the planning phase and architectural design is crucial.

**Design**

The design phase has to embed circularity at the earliest steps. New construction or renovation works can become more circular by incorporating secondary materials, which may come from a demolition site (on or off-site), or from marketplaces. Connecting with local stakeholders, especially those who have conducted pre-demolition audits might help here to target, identify and integrate materials within the design phase. Sourcing from online databases and physical marketplaces also has to be considered.

Another main principle for circular construction is to design buildings for disassembly and flexible programming. The building has to be as modular and flexible as possible to avoid premature demolition. The building's end-of-life phase also has to be conceived from the planning stage. Buildings are thus no longer perceived as a static object, but rather as a temporal and dynamic storage of materials that can be disassembled and reused for new purposes. Materials should be thoroughly documented, with quantitative and qualitative data necessary to facilitate their transition to future applications. In addition, to ensure materials data storage and traceability, digital material passports should also be developed and the information stored in a Building Passport, as BIM (Building Information Modelling).

All these practices require early planning to ensure they will be fully integrated in the construction tenders. These principles are still quite innovative, and therefore, they have to be embedded as specific clauses or criteria within the tenders to recruit the contractor.

**Recommendation**

*" Retrofit and designed for the end-of-life. "*

*" Design follows resources. "*

TOOLBOX
First step towards circularity:
**Design for disassembly**

The **BAMB project** (Buildings As Material Banks) aims to limit resource consumption in the building sector by developing multifunctional buildings, and thereby extending buildings' lifespans and limiting premature demolition.

BAMB is creating ways to increase the value of building materials, through digital material platforms. Dynamically and flexibly designed buildings serve a circular economy where materials in buildings sustain their value and lead to waste reduction and the use of fewer virgin resources.

More information and all the different publications and reports are accessible **here**.

## GOOD EXAMPLE FROM CITIES:
## **A temporary courthouse in Amsterdam (The Netherlands)**

The **Amsterdam temporary courthouse** has been designed with a Design, Build, Maintain & Remove (DBMR) assignment of the Government Buildings Agency. Important selection criteria were the prevention of waste and the maximisation of the residual value of the building after its initial period of use.

On every scale, the architect and the engineering firm searched for possibilities to reduce, reuse and recycle materials. But reuse does not just concern the components, it even applies to the entire building. After the first period of use, it can be disassembled and reassembled in its entirety at a different location, and if desired also in a different configuration. Indeed, the building has been designed as a kit of parts that can as easily be assembled as disassembled and reassembled, to facilitate changing uses, users and locations.

After five sustainable years of service, **the building was dismantled in 2022 to be remounted in 2023 in Enschede**. From the outside, it will look the same but the layout will be different inside due to its new function.

The temporary courthouse in Amsterdam.
© cepezed | Léon van Woerkom

TOOLBOX
First step towards circularity:
## Embedding circular clauses and criteria in public tenders

As key economic actors on the demand side, local authorities and other public bodies could use public procurement as a potentially powerful strategic mechanism to promote a circular economy within their territories. Though public procurement has to follow rules to allow competition in the single market, it is a tool that procurers should regard as instrumental when it comes to achieving environmental goals. However, there are necessary pre-conditions for the successful circular building procurement:

- **Knowledge of the market**: market research to understand capabilities and maturity of the supply chain, and especially the local companies, helps to design the project and the procurement process related to it. For instance, it could be very useful to rely on a network of companies that could do resources matchmaking and that knows quite well the marketplaces for buying reused or reclaimed material;

- **Starting early market dialogue and creating space for informal or formal dialogues to reach out to the right network of suppliers**: in an immature market, identifying as soon as possible the companies that could meet the procurers' needs is essential. Suppliers should be perceived as partners in innovative circular projects. Thus, to define the criteria and clauses in the tender, and to adjust the expectations all along the project, an early and continuous dialogue between the procurers and the suppliers is recommended;

- **Working with the relevant departments by breaking silos**: an internal collaboration between e.g. the procurement department, urban development department, environmental department and properties department can help to select the best process, based on the level of innovation that your project requires, on the maturity of the market, etc. This collaboration enables the defining of common objectives to reach in the tender;

- **Choosing and defining the appropriate procurement process and circular criteria**: a wide range of processes and criteria (technical, evaluation and performance aspects) exists to achieve the set goals and finding the appropriate contractor. It is also the moment for setting objectives, like targets for $CO_2$ savings, targets for the application of circular principles such as Design for separation or the degree of use of reused and/or recycled materials in the building. A relevant example is what has been done in Høje-Taastrup, with the pre-purchase development agreement with IKANO. This private developer has passed a selection process and has then signed a pre-purchase development agreement with the municipality. This has resulted in a very fruitful collaboration with a practical and targeted vision of how the area could be developed with high criteria regarding circular construction.

- **Starting an early and transparent dialogue with the contractors**: defining at the early stage of the project the visions and the ambitions will be essential to settle an easy and collaborative dialogue between the procurer and the contractor all along the project. For instance, working on a circular construction project can be associated with several practical challenges, since secondary building materials will not always be thoroughly tested and most construction processes are still relatively new. An early collaboration is particularly important in such a construction project to define the framework for innovation and the challenges, including the risk management. This should therefore already be discussed at the negotiation meetings. This dialogue is then the prerequisite for the complete assessment of circular principles in construction from both an environmental point of view and architectural value, costs, quality, etc.

- **Not giving up and keep trying**: from a common voice, CityLoops' cities claim that the hardest step is the first project. Once you manage to do circular procurement in one project, this can be the basis for embedding it in wider procurement practices within the municipality, until it will become the norm.

Learn more about how to procure circular buildings in the **CityLoops procurement handbook** and on the **CityLoops website**

GOOD EXAMPLE FROM CITIES:

## Circular criteria in tenders in Tampere (Finland)

Tampere is a pioneer Finnish city in the circular economy. They have adopted the circular economy concept as a strong part of all the city's infrastructure building activities. In compliance with this strategy, investments are made in innovative solutions and procurements in the planning, development and construction of infrastructure projects, by replacing virgin earth and stone materials with recycled materials.

Therefore, the city has developed new public circular economy procurement procedures, criteria and co-operation methods with companies for the construction of streets. The new circular economy procurement methods were first tried out in the procurement of Yliopistonkatu, one of the central streets of Tampere. It is the first time in Finland this type of circular economy procurement criteria is applied. The aim is to promote and apply in practice the city's sustainability goals in a commercially profitable way. At the heart of the procurement process is a new principle based on business cooperation (Design and Building): the city sets circular and other sustainability and safety goals for the construction site, but companies can influence how these goals are achieved through designing the project. The contractor is responsible for the recycling and procurement of the material used in the project, under the supervision of the customer.

More info can be found **here**

**Lessons learned**

*❝ When co-developing new things, it is important to take and give time for the development phase and include as many professionals as possible. It takes many brains to figure new things out.❞*

*❝ The use of the Design & Build model and scoring criteria in the construction contract was new for the city, but the experience was good. With the new procurement model and criteria we were able to procure the most cost effective and the most ambitious offer in terms of the circular economy.❞*

*❝ Prices for recycled materials are competitive in the road industry (which is not yet the case in the building industry), so it is even a bigger opportunity for public authorities to work on this.❞*

**Karoliina Tuukkanen**,
Project manager in **Tampere**

Yliopistonkatu, one of the central streets of Tampere ©Petri Leppänen

Pushing circularity in construction public tenders on local authorities' own assets or delivering these recommendations to local building stakeholders will then play a big role to develop a local supply chain, as it will push demand on reused materials and send a clear signal to the market.

Learn more about how to procure circular buildings in **CityLoops procurement handbook** and on the **CityLoops website**

### Construction

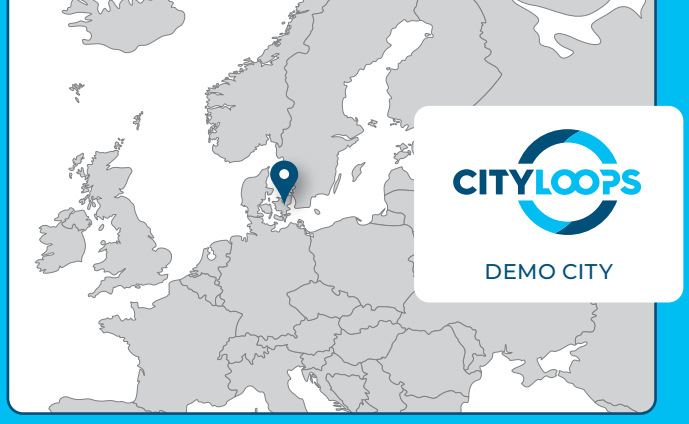
In the construction phase, the secondary materials are integrated. In this phase, the documentation, ideally as a material passport from the demolition is important to ensure quality and application of the materials. In addition, it is also important to make sure that the reclaimed or recycled materials do meet the requirements of the expected use. All the documentation that has been collected earlier on, either stored in a material passport or any other format, now comes into use.

To make the circular construction a success, the client's role is important to address possible risks in the projects, thereby accommodating economic and legal barriers in collaboration. The agreements on collaboration taken before the execution should be continuously coordinated among stakeholders during the whole construction phase.

### Operation and maintenance

In the use phase of a building, a maintenance plan is also recommended to extend its lifespan. Focus is on optimising maintenance, which can be improved by high durability in materials and construction elements and design for repair (part of Design for Disassembly) in the construction phase.

In this phase, concepts like performance-based contracts and Extended Producer Responsibility can be introduced. Besides decreasing resource consumption on the construction, this should also be applied for inventory. During its lifetime, the building information models and material passports must also be continuously updated.



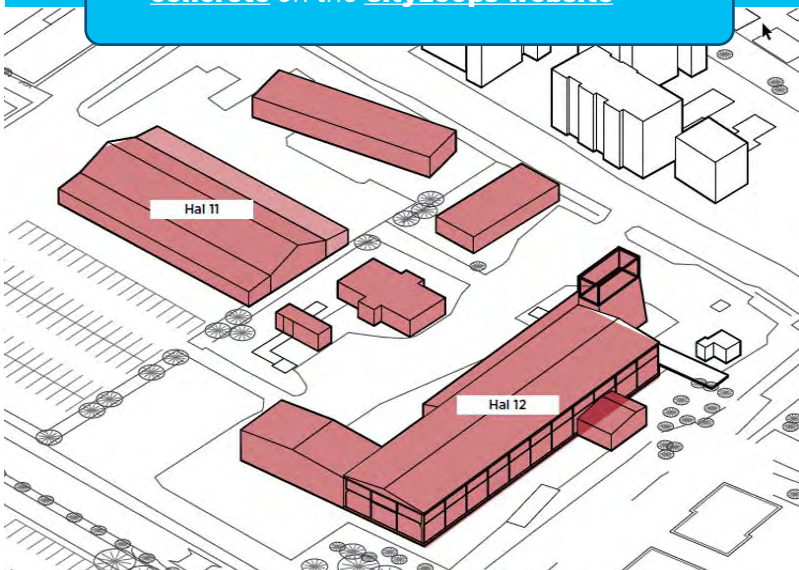

GOOD EXAMPLE FROM CITIES:
## Construction with recycled concrete in Roskilde (Denmark)

Hall 11 is a building situated in the demonstration area of Roskilde. It has been demolished and materials from the demolition will be incorporated into other construction projects. Concrete from the demolition has been crushed for recycling into new concrete in the construction of a parking house, Indfaldet, built by the city.

Large concrete blocks that were discovered during preparation work have been crushed and used for material layers below the concrete, replacing virgin gravel. 100% recycled coarse fraction and 50% recycled fine fraction of recycled concrete went into the foundation for the parking house.

Based upon this experiment, Roskilde has developed a guide on how to recycle concrete locally. It describes the process, legal framework, pitfalls and opportunities where the entire process of recycling concrete as aggregate for new concrete takes place in the same location. It includes examples of requirements for recycled concrete that can be directly incorporated into tendering documents.

Learn more about **Roskilde's experience** and **the guides developed on recycling concrete** on the **CityLoops website**



## SOIL: STILL A TOPIC TO DIG INTO!

Soils extracted from construction sites are by far the biggest source of waste produced in Europe every year (five times the amount of household waste, according to Eurostat[18]). Excavated soils are currently considered waste under European law and are therefore disposed of in landfills. There is also very little data on the excavated soil volume and lack of traceability and database does not help to draw a clear picture about soil issues.

At the European level, soil is still a quite new topic but many policies and programmes are running to pave the way to healthy and protected soil, notably the **EU soil strategy for 2030** and the **EU Mission: a soil deal for Europe**. The Circular Economy Action Plan also mentioned the need "*to increase the safe, sustainable and circular use of excavated soils*", among other actions in the construction sector.

Urban planners, developers and builders are not always aware of the importance of ecosystem functions of natural soils, nor the environmental and economic value of excavated soil. However, if treated properly, excavated soil may be used for a wide range of purposes of considerable value.

At the city level, the goal for a circular soil management is to excavate minimum soil and to use excess soil locally, thereby reducing handling and transport of soil. Three cities within CityLoops, Apeldoorn, Høje-Taastrup and Roskilde, have experimented with soil reuse on large ongoing urban development projects. They have been supported by the Capital Region of Denmark, which has developed these open-source tools:

- **Instrument for predicting future excavated soil production**: it can be used to predict how much soil will be excavated in relation to construction works and urban development in a city for the next 12 years. It can be used for strategic planning at a territorial scale, or in the project planning phase for a particular construction or demolition site;
- **Guidelines for sustainable soil management and assessment of reuse potential of excavated soils**: it describes how projects can be adapted to minimise impact on ecosystem functions of soil and, if treated properly, how excavated soils may be used for a wide range of purposes of considerable value. The guide describes approaches for reducing the impact on ecosystem functions, maximising on-site and local reuse of excavated soil. Furthermore it provides an overview of whether a specific soil type is suitable for a particular purpose;
- **Roadmap for sustainable soil management**: it can support the implementation of sustainable soil management by providing an overview of strategic objectives of a project as well as identifying the stakeholders needed to achieve such objectives. The one-pager can be used to plan and support the implementation for a wide range of projects – from strategically anchored efforts to specific projects with concrete objectives.

Learn more about the circular soil handling on the **CityLoops website**

18 Eurostat Data browser: Generation of waste by waste category, hazardousness and NACE Rev. 2 activity

## EXPERIENCE FROM HØJE-TAASTRUP

FB Gruppen, a private developer, is developing a large area in the eastern part of the urban development area Nærheden in Hedehusene for an expected 3000 residents. In order to reduce amounts of excess soil when developing the area, FB Gruppen has performed an early soil calculation, in the interest of both economy and sustainability.

The soil calculation is based on planned future terrain elevation, location of future buildings, expected excavation depths, etc. In addition, geotechnical drillings were also performed with the purpose of estimating the reuse potential of the identified soil types around the area. Furthermore, FB Gruppen performed lime stabilisation under future parking areas further reducing the amounts of excess soil. The soil is reused on site to adjust and model the terrain prior to construction.

Based on the calculation (the project is still ongoing), more than 90% of the excess soil would be kept on site in the FB Gruppen's area. The estimated amount of excess soil saved is more than 700.000 tonnes, meaning avoiding the emissions of more than 1.000 tonnes of $CO_2$ – and of course a substantial economic saving depending on market prices for soil deposit. Even though the project is not yet complete, it shows the potential savings when soil issues are taken into consideration at an early stage when developing an area.

*"This project helped us to increase awareness of soil masses produced and transported in general. When the amounts are converted into truckloads of soil (estimated 35 tonnes of soil per truck), it becomes very clear that soil is an important parameter to consider – not solely as a result of $CO_2$ emissions, but also traffic safety, road wear and tear, noise pollution."*

*"Being able to pinpoint the expected amounts of excess soil at an early stage often is advantageous, since it raises awareness to the developer, and lets him seize the opportunity to reduce amounts of excess soil by reusing as much as possible on site. In addition, to highlight the environmental benefits, the $CO_2$ calculator will easily reveal the $CO_2$ emissions saved and assess the impact when circular soil handling is prioritised in new development areas."*

*"It is very important to identify potential local reuse opportunities in the urban planning process - otherwise the soil will be transported off site."*

**Laura Heron Jessen**, Environment Project Manager in **Høje-Taastrup**

Learn more about **Høje-Taastrup** and other cities' experiences on circular soil handling on the **CityLoops website**

The urban factory has opened in September 2021 © Cycle Terre

### To go further... Build new materials from the soil

A new kind of in-town factory Earth Cycle has been built in the northeastern Parisian suburb of Sevran. Supported by the **Urban Innovative Action** program, it has set up an innovative industrial process to reuse soil extracted from excavation sites of the new subway and other construction sites as a raw material. The significant innovation lies in the creation of an industrial process using extracted soil as raw material. Three kinds of materials are produced (bricks, clay panels, wall plastering/rendering) and used in construction sites in urban areas after having received appropriate technical certification.

# 4. Business cases and risk management in the circular market

In the green transition, the market plays an important role. The industrial sector has traditionally optimised each step of the production system in the linear market model, without accounting for environmental and social damages. Moving towards a circular economy requires new economic activities and a shift in value chains, leading to shifts in the roles of their actors. Demolition companies become material suppliers, as do the contracting authorities when they demolish a building and reuse some materials from it.

Decision-makers and procurers can be divided into two main categories: *public or semi-public* and *private*, which are usually not drawn by the same motivations. Although there are some nuances, public/semi-public actors mainly seek environmental benefits like reductions in $CO_2$ emissions and social gains, suppliers and private actors focus more on profit. When it comes to handling and commercialising construction waste or excavated soil in a circular economy, the actors involved must consider several factors in their business case assessment. These include access to secondary resources, the market value of these resources compared to virgin raw materials, and the willingness of end-users to pay for different materials and outcomes.

Formulating circular business cases that lead to unequivocal results is challenging because there are still unknown factors for which the market lacks definitive solutions. Additionally, in a competitive environment, actors may make choices that seem economically illogical. For instance, a client on the demand side may be willing to pay more for secondary materials due to 'cultural' or branding reasons that cannot be immediately quantified. Similarly, suppliers may offer a lower earnings ratio than usual to secure a project that can help sustain their operations during a period of reduced orders.

Setting up a formula for circular business cases for commercial actors might look like this:

**Formula**

*Costs of procured material resources* **+** *processing* **+** *storage* **+** *transport* **+** *marketing and sales* **+** *potential risks regarding unsettled conditions* **=** **≤** *0, where 0 (zero) represents break-even with alternatives*

The formula for circular business cases is similar to the traditional supplier markets, except that there are often fewer actors involved in the circular value chain, potentially reducing profit accumulation and giving secondary materials a competitive advantage. The most important unknown factors in the circular business case are the built-in potential risks, which must be handled early in the process. Thus, to succeed in the circular market, it is crucial to stay up-to-date with market developments and gather experiences to make necessary adjustments.

Whilst the formula for commercial actors entails mostly the economic aspect, the one for non-commercial actors (public and semi-public organisations such as local and regional authorities, social housing companies, etc.) is more complex, as it includes more factors. In addition to economic factors, public actors have a broader range of responsibilities and must balance user, environmental, cultural, and social considerations.

The formula might thus be summarised like this:

**Formula**

*Costs associated with procurement of secondary material resources* ***+/-*** *climate, environmental, cultural, economic, and possibly social effects / consequences* ***+*** *potential risks regarding unsettled conditions* ***= ≥≤ 0****, where 0 (zero) represents break-even with alternatives*


In Taastrupgård, a social housing building neighbourhood in Høje-Taastrup, the concrete from the demolished building has been crushed to serve as aggregate for the foundations of the New City Hall.

©Høje-Taastrup

## 4.1 CityLoops' business cases

It is essential to consider larger societal aspects when evaluating business cases in circular economy projects. The examples from the CityLoops project highlight the need to address market barriers and incentives to promote a circular economy. For instance, local monopolies on waste management, lack of regulations that reflect negative environmental effects, and market actors using artificially low prices can hinder the development of circular business cases. In addition, the lack of resource sites and material banks can limit the commercial operation of circular economy projects.

In CityLoops, business cases from different demonstration actions have been developed, looking at cost structures and revenue streams, identifying potential customers, or end-users, and evaluating internal capacity. They also rely on market assessments, in particular in comparison to linear alternatives, and include environmental, climatic and social evaluations. Even though the contexts, the cases, the steps of the value chain and the materials were different, there are common rules to underline:

- **Cooperation with private companies, willing to innovate**: innovation is easier to implement when public and private entities work hand in hand. Although the drivers can be environmental, local authorities also need to rely on companies that develop competitive solutions. The successful business cases demonstrate that partnerships between local authorities, public clients and private companies willing to develop circular solutions are a key factor of success;

- **Early market dialogue**: as a result, early market dialogue is required. It ensures the pre-selection of companies that public procurers can cooperate with once the tendering process is launched;

- **National context and demand**: the national regulatory framework plays an important role in promoting circular profitable business models. By pushing demand, it drives suppliers to develop competitive circular products or services and to align the prices on linear solutions. In a free market, it is important to give incentives to shape the national market. Local authorities have the capacity to influence the national context and regulatory framework. By leading the transition with experimental projects, the demand for circular products and buildings will increase, and the market will become more and more ready accordingly;

- **Circular competitive business cases already stand there**: depending on factors such as the national context, the material stream and the business model developed by the companies, some demonstration actions have proved that circularity could be economically competitive:

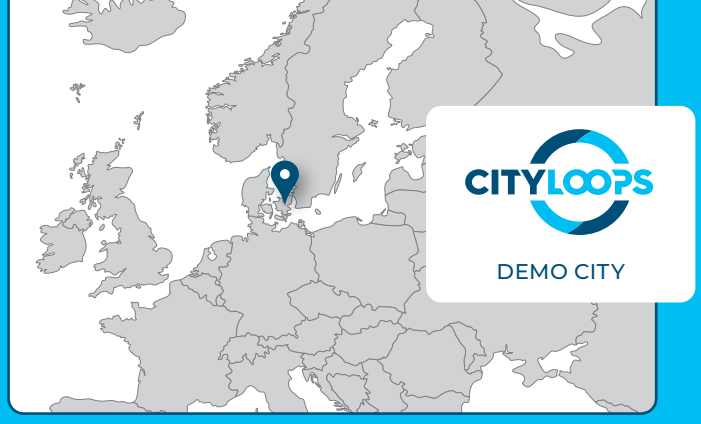
  - Soft stripping and proper organising can create business cases for reuse of demolition items of a certain quality – often competitive with new items;

  - Recycling concrete can either be done for approximately the same cost as new, or it can generate savings if crushed and reused on-site;

  - Keeping soil on-site or reusing it locally generates large economic and $CO_2$ savings from reduced transport;

  - Using a local deposit for intermediate storing of masses can be a good business case.

Demonstration actions have been the support for studying business cases on the ground. To ensure replicability and to highlight the challenges faced and the success factors, reports on different materials and steps of the value chain have been produced. Learn more about the business cases developed in CityLoops on the **CityLoops website**




GOOD EXAMPLE FROM CITIES:

# Recycling of crushed concrete as aggregate in a new construction project in Høje-Taastrup (Denmark)

The new city hall of Høje-Taastrup has been built using recycled concrete in the building foundation coming from the demolition of eight apartment blocks at Taastrupgård owned by KAB, a social housing company.

Before CityLoops, Høje-Taastrup participated in an EU Interreg project, Cleantech TIPP. In this project the municipality engaged in a dialogue with KAB regarding the reuse of material coming from the demolition of apartment blocks in Taastrupgård neighbourhood. As an outcome of this project, the tests made on the quality of concrete from the foundation of Taastrupgård apartment blocks revealed that this was suitable to be integrated as recycled aggregate in the production of new concrete (note that a Danish law which came into effect in 2021 allows to use until 100% recycled aggregate in the concrete for construction purposes, whilst the European norm remains at 30%).

KAB was open to the idea of the concrete being recycled. After extensive dialogue, KAB and the municipality agreed to include an option in the tender which involved the uncontaminated concrete being transported to a location determined by the municipality, that will be the new city hall construction site, and received at no cost (the savings for future construction companies purchasing this aggregate and the reduced transport distance were allocated to cover the cost).

On this project, there were savings for the demolition client (KAB) and for the demolition company (Søndergaard Nedrivning). For the contracting authority of the city hall (Høje-Taastrup municipality) and the contractor, the project was price-neutral. Costs were incurred by Norrecco (the waste processing facility which crushed the concrete) and Unicon (the concrete mixing facility), but both parties considered these investments in product development. Costs were incurred related to extra testing of the concrete, and these were absorbed by CityLoops. Outside of a CityLoops context, the parties would need to agree where these costs would lie, but it is also clear that these costs will diminish over time, considering that, as we gain experience with recycled concrete, the requirements for extra testing will decrease.

For more information on the experiences of the involved stakeholders, **read this interview**.

Learn more about **Høje-Taastrup's experience** on the **CityLoops website**

| "Business as usual" / linear model | | Circular model | |
|---|---|---|---|
| **Step** | **€ per tonne** | | **€ per tonne** |
| Entry price (KAB > Søndergaard)* | 0 | New concrete for foundation with virgin aggregates (market price) | 250 |
| Handling and transport to handling to Norrecco (crushing on-site was not an option) | 15 | | |
| Handling, testing, production and storing of recycled aggregate at Norreco (agreed price) | 25 | | |
| Production, testing and deliverance of concrete with partly recycled concrete from Unicon | 200 | | |
| Total | 240 | Total | 250 |

* Demolition costs are not included in the calculation as it was meant to be done anyway

*KAB*: the social housing company that owns the demolished building where the concrete comes from
*Søndergaard*: the demolition company, KAB's contractor
*Norrecco*: the waste processing facility which crushed the concrete
*Unicon*: the concrete mixing facility

## 4.2 Risk management and responsibility analysis

Effective risk management is a critical component of the planning process in circular projects. The client, possibly in collaboration with an advisor, should conduct a risk mapping exercise at the outset of the project to identify any risk elements, highlighting the responsibilities, risks and consequences along the project.

Based on this framework, the responsible actor should be determined, and opportunities to neutralise risks should be evaluated. However, rigidly placing responsibilities on actors can inhibit the possibility of proactive solutions and neutralisation of risk elements. Therefore, an open view and dialogue between the different actors aware of the nature of the individual risk and alternative placement of responsibility should better be considered. This might help to minimise the negative impacts of a triggered risk. It is recommended to maintain this open dialogue with key actors in the value chain proactively and transparently since the early stage of the project. These actors in the circular construction are – at least in this transition period – looking at risks differently than in traditional construction. Therefore, it is better to give responsibility to the actor who has the potential to mitigate a given risk.

This can be designed from the tendering phase, by planning that bidders will have to identify the risk elements that affect their responsibility and which they do not immediately have the opportunity to influence. This enables risk management to be dealt with already in connection with contract negotiations. As a result, negative impacts on the bidder's business are minimised. During the construction process, new risk elements may arise, or known risk elements may change in nature and require different handling. Thus, in connection with offers, a process description must be included that explains how the emerging risk is handled in the construction process while respecting all parties involved.

Both a presentation of known risk elements and a description of the handling of emerging risk must be included in a proposal for a risk management plan when submitting an offer, so it can be included in the bidder's, as well as the client's or procurer's business case estimation.

**Isolation of potential risks in the early phase and managing risks in close and transparent dialogue between the involved actors in the process will have a positive effect on any business case**

**ISOLATION OF RISK**

Early in the planning process, risk elements are identified.

It is assessed whether they can be separated from the primary construction activity.

**TIME**
**RESPONSIBILITY**

→

**EARLY DIALOGUE**

Early market dialogue ensures greater understanding of how risk is handled in the most efficient way.

Risk for the client is not the same as risk for the contractor or consultant.

**OPTIMISATION**

→

**BUILDING PHASE**

Throughout the building period, close dialogue and transparency between actors is ensured.

It is agreed how to react to changes in risk.

**RESPONSE**
**COOPERATION**


Good example from cities:

## Risks management in Roskilde (Denmark)

The demonstration project, "Indfaldet", is an above-ground, multi-storey parking house, made as a steel structure, with 240 parking spaces. The construction was started by the winning contractor in April 2020, and delivered to the client (Roskilde Municipality) in 2022.

Recycled concrete has partly compensated new gravel fills for bottom protection of the new parking house, and as aggregate in new concrete in the ground floor deck. Both reuse processes were handled on site by using mobile crushing and separation facilities.

Risks are often a blind mate in construction projects, especially when the projects are including non-conventional methods, materials etc. In this case, risk management has therefore been included as a central aspect in the planning process of the project.

Learn more about **Roskilde's experience** on the **CityLoops website**

**Lessons learned**

*" Through our participation in CityLoops we have substantially developed our risk management. We now operate with a risk mapping with three key elements:*
*- Isolation of risk*
*- Early dialogue*
*- Building phase: dialogue and transparency*
*This means that instead of operating in a "black box", we now operate with a clear idea of the risks involved and how to overcome them."*

*" It is always hard to face difficult discussions with contractors and advisors regarding risk. But if we would have done that from the beginning, many other discussions could have been avoided."*

**Klaus Kellerman**, Senior Consultant Sustainable Construction in **Rosklide**

All in all, being an active actor in the circular market means opening partnership and collaboration with the different actors and accepting a greater openness about the finances of the projects and the offers made compared to the usual one.

The same applies to risk management. Collaboration and dialogue with the potential bidder enable a much better and safer process when potential risks in the projects are identified, and followed up by solid agreements on how risks would be handled when they arise.

# CityLoops instruments and experiences

This handbook aims to give a first level of information about what has been done in CityLoops and the whole current context regarding the actions local authorities can carry out on circular construction. To learn more on what has been achieved over the four years of CityLoops, replication packages have been produced with detailed information, available on **CityLoops' website**. Each replication package relates to a specific topic. For each, you will find the instruments developed all along the project, as well as reports on the cities' experiences.

The table below presents these instruments and the most relevant experiences carried out by the demonstration cities for each replication package.

| Replication package | Instruments | Experience from cities |
|---|---|---|
| Planning and decision making | **Planning & decision-making guidelines**<br>This tool consists of two parts: a workshop format with a visual mapping framework and an operationalisation of the planning and decision-making framework. These guidelines focus on how to engage organisational change on the strategic, operational and competencies levels. | Experience from Bodø<br><br>Experience from Mikkeli<br><br>Experience from Høje-Taastrup |
| Stakeholder engagement | **CityLab stakeholder platform**<br>Bodø has used a physical and virtual platform for stakeholder engagement on city development. It integrates the 3D visualisation to stimulate imagination and opinions on the city's future, and offers an information portal to solicit inputs from citizens, civil society organisations and local businesses to involve them in planning and decision-making. | Experience from Apeldoorn: co-design process<br><br>Experience from Bodø: different actions on stakeholders involvement<br><br>Experience from Mikkeli: workshops with stakeholders<br><br>Experience from Seville: seminars and City Simulation Platform<br><br>Experience from Roskilde: circular soil handling in Musicon |
| | **Co-design process for public space**<br>This can be used to develop a process journey, which is an overview of the involved actors per process phase with each actor's roles and tasks per deliverable. The process journey can be used as a manual to accomplish the project circularly. | |
| | **City simulation platform**<br>Virtual hub designed by Seville for software instruments and datasets developed by a city to support its sustainability goals. It includes instruments for data-driven planning of collection and treatment of various waste fractions, for evaluation of citizen satisfaction and policy effectiveness, and for simulation of future scenarios of city development. | |
| Circular demolition | **Pre-Demolition Audit Guide**<br>This guide helps to prepare selective demolition and covers both the environmental audit focusing on identification of hazardous materials and the circular audit focusing on elements for reuse and materials for recycling. | Experience from Roskilde: Partial demolition of factory Hall 12<br><br>Experience from Høje-Taastrup: Circularity requirements in sale of town hall for demolition |

| Replication package | Instruments | Experience from cities |
|---|---|---|
| Circular demolition | **Selective Demolition Guide**<br>This guide explains how a selective demolition can be conducted to select and preserve the value of building components and materials with reuse or recycling potential. | Experience from Mikkeli: demolition of Pankalaampi HealthCare Center and Tuukkala Hospital<br><br>Experience from Apeldoorn: demolition of a paved road |
| Data and material passports | **Material passport definition**<br>Five requirements for a material passport have been developed in the CityLoops report "Circular approach for neighbourhood renovation; Construction material passports and databanks", which also describes different approaches to material passports and dives into how a material passport can be applied to a circular road renovation project. | Experience from Bodø: 3D visualisation in a digital twin<br><br>Experience from Mikkeli: Drone scan of buildings and construction site<br><br>Experience from Apeldoorn: Road scan with cameras<br><br>Experience from Roskilde: Simple data registration in excel-sheets |
| | **Procedure for CDW to obtain a Material Passport**<br>Roskilde has developed a simple five-step procedure for demolition materials to obtain a material passport and be approved for use in future construction. | |
| | **Replication report for 3D visualisation solutions**<br>The digital twin of the city has proven to be a useful tool for urban planners, policymakers, and researchers alike. It holds mass quality data from demonstration sites, material data from buildings on demonstration sites and pilot buildings, visualisation of transport, infrastructure and emission data and identification of loose sediments and potential sea level rise at the demonstration site. This report describes the software used, technical and physical requirements and equipment as well as the gathering and visualisation of data. | |
| | **Blueprint for drone scan and 3D modelling tool**<br>The use of a 3D modelling tool by Mikkeli to monitor demolition waste flows can be a cost-effective alternative in evaluating the amounts of material flows on-site when compared to traditional methods. The data capturing process with drones on the demolition sites demonstrated in the project takes on average less than an hour. This blueprint will explain how to perform the drone scan and use the 3D modelling in 3D modelling tool for tracking the flows of on-site CDW. | |
| | **Guide for replication of the road scans and data storage**<br>Road scans can provide additional insights in the status of road materials, but developments are still needed to interpret the data and automate data storage. The LiDaR system with high resolution imaging seems to be able to provide data that is closer to the traditional process of a visual inspection on site. It was not possible to assess data on lifetime expectancy and re-use options of materials, products, and components from the street scan. A guide for replication of the road scans and data storage can be found in the report "Collecting and storing data in a circular road renovation process". | |

| Replication package | Instruments | Experience from cities |
|---|---|---|
| Material banks and marketplaces | **Blueprint for replication: databank and digital marketplace in Mikkeli**<br>The databank combines data from the 3D scanning tool (using drone imaging) and Mikkeli's demolition planning on construction materials from demolition sites around the city of Mikkeli. The databank stores information on materials such as volume, location, date available, material composition and basic characteristics. This data about material stocks is then fed into the digital marketplace. | Experience from Apeldoorn: physical material bank for soil and DuSpot digital marketplace<br><br>Experience from Bodø: intermediate storage and sorting area for soil and masses |
| | **Blueprint on Apeldoorn DuSpot marketplace**<br>This blueprint describes Apeldoorns considerations about digital material banks and their choice of DuSpot. DuSpot is used to facilitate the reuse of materials needed and becoming available from Apeldoorn's construction projects in public space. DuSpot is also used to show the inventories of the material depots Apeldoorn is operating. | Experience from Mikkeli: material banks and marketplaces<br><br>Experience from Roskilde: reusing materials locally and exchanging them with neighbouring municipalities |
| Recycling concrete | **Recycling concrete**<br>The guide is aimed at public owners and describes the process, legal framework, pitfalls and opportunities in Danish cases where the entire process of recycling concrete as aggregate for new concrete takes place in the same location. It includes examples of requirements for recycled concrete that can be directly incorporated into tendering material. | Experience from Roskilde: on-site crushed concrete for the foundation of a parking house<br><br>Experience from Høje-Taastrup: recycled concrete for the foundation of a new CityHall<br><br>Høje-Taastrup's actors interviews |
| | **$CO_2$ calculator for concrete and 11 fractions of CDW**<br>The online $CO_2$ calculator for concrete allows cities to estimate the potential $CO_2$-reductions in their specific projects for "No circular actions", "Local recycling" or "General recycling". The calculator can be used when data on the amount of crushed concrete and the distances from the gravel pit, landfill, location for the recycling and the name of the concrete producer is available. The calculator targets 11 different fractions of CDW, including concrete. | |
| Circular soil handling | **Instrument for predicting future excavated soil production**<br>This instrument can be used to predict how much soil will be excavated in relation to construction works and urban development in a city for the next 12 years. It can be used for strategic planning at a territorial scale, or in the project planning phase for a particular construction or demolition site. | Experience from Høje-Taastrup: circular soil handling in Nærheden<br><br>Experience from Bodø: soil roadmap<br><br>Experience from Apeldoorn: soil and sand trajectory |
| | **Guidelines for sustainable soil management and assessment of reuse potential of excavated soils**<br>This guide describes how projects can be adapted to minimise impact on ecosystem functions of soil and, if treated properly, how excavated soils may be used for a wide range of purposes of considerable value. It describes approaches for reducing impact on ecosystem functions and maximising on-site and local reuse of excavated soil. It furthermore provides an overview of whether a specific soil type is suitable for a particular purpose. | |

| Replication package | Instruments | Experience from cities |
|---|---|---|
| Circular soil handling | **Roadmap for sustainable soil management**<br>It can support the implementation of sustainable soil management by providing an overview of strategic objectives of a project as well as identifying the stakeholders needed to achieve such objectives. The one-pager can be used to plan and support the implementation for a wide range of projects – from strategically anchored efforts to specific projects with concrete objectives. | |
| | **CO2 calculator for soil**<br>This instrument calculates the CO2 emissions from depositing soil or reusing it locally, thus making it easy to estimate CO2 reductions from local soil reuse. | |
| Circular procurement | **Circular procurement handbook**<br>This handbook draws upon the CityLoops demonstration actions to outline key takeaways. It aims to inspire and guide local and regional European public authorities of all sizes, policy-makers, procurement professionals, as well as private entities that want to know more about the current procurement practices, to use their purchasing power in their transition towards a circular economy. It offers practical guidance for project implementation and includes examples from the CityLoops demonstration cities and the tools they developed to incorporate circular procurement practices during the pre-tender, tender, and post-tender activities. Finally, it outlines methods to ensure the scalability and integration of these activities as the new norm within any city organisation. | Experience from Roskilde: procurement and risk management<br><br>Experience from Mikkeli: selective demolition<br><br>Experience from Høje-Taastrup: selling the old city hall<br><br>Experience from Bodø: a new sustainable procurement strategy<br><br>Experience from Apeldoorn: procurement within an already existing framework<br><br>Experience from Seville: renovation of pipelines with circular standards |
| Business cases | **Business Cases for Circular Construction and Demolition Projects**<br>Developed by the Danish Association of Construction Clients, this report is an introduction to the circular economy and market in the construction sector including comparison with the conventional linear market. The report also introduces a two tracked business case model looking at both an economic/commercial value chain and a broader value chain seen from a societal point of view with both environmental, social and economic aspects of the business case, as two sides of the same coin. | Experience from Apeldoorn<br><br>Experience from Bodø<br><br>Experience from Høje-Taastrup<br><br>Experience from Mikkeli<br><br>Experience from Roskilde |
| | **Developing a circular business model for the municipality of Apeldoorn**<br>Developed by SAXION University, is a locally pointed, academic analysis of The Triple Layered Business Model Canvas. | |

# Useful resources

| Initiative / Document / Project | Description |
|---|---|
| **Circular Cities and Regions Initiative** | Launched and funded by the EU as part of the Circular Economy Action Plan, the Circular Cities and Regions Initiative (CCRI) focuses on implementing the circular economy across Europe's cities and regions. The CCRI aims to increase synergies among projects and initiatives, disseminate relevant knowledge, and give greater visibility to best practices. Combining this knowledge sharing with technical and financial support, it offers comprehensive support to stakeholders across Europe's cities and regions. |
| **Circular Cities Declaration** | The European Circular Cities Declaration is designed to help accelerate the transition from a linear to a circular economy in Europe, and thereby create a resource-efficient, low-carbon and socially responsible society.<br>It has been developed by a broad partnership of stakeholders to ensure that the vision and commitments contained are ambitious, yet achievable, and reflect the needs of all. |
| **The Circular City Centre** | The Circular City Centre (C3) is a competence and resource centre within the European Investment Bank, which aims to support EU cities in their circular economy transition. The C3 can help cities address many of the linear problems they struggle with today, and make their cities more regenerative, resilient, clean, liveable and attractive to both citizens and companies. The Centre has been established with the support of the European Commission through the European Investment Advisory Hub to advance circular action in cities, including facilitating access to advisory and financing for circular projects. |
| **Circular Building Coalition** | The Circular Buildings Coalition (CBC) brings together stakeholders from the built environment to overcome barriers and embrace sustainable practices. The challenges of transitioning to a circular economy in the built environment are vast, with roots at local, national, and European levels. However, many impact-driven organisations worldwide are already addressing these challenges. As a coalition, the CBC aims to amplify their efforts and lead the way forward. |
| **Stimulating demand for circular construction skills - a guide for public authorities**<br>Author: ICLEI - BUS<br>Go Circular project | The EU-funded BUS-GoCircular project aims to address and overcome the challenges of stimulating demand for a circular construction skilled workforce, along with the hands-on capacity building to increase the number of skilled professionals within the workforce across the value chain. Local and regional governments can use a wide range of policy levers to stimulate this demand. Through good practice and replicable examples from Europe and beyond, this document aims to raise awareness among practitioners and policymakers about their ability to promote a more circular construction sector and upskill professionals. It also highlights the various levers at the disposal of local and regional governments and public administrations to support this transition. |
| **PARADE - Best practices for Pre-demolition Audits ensuring high quality Raw materials** | The PARADE project develops life-long education materials on best practices for pre-demolition waste audits. The aim is to provide an harmonised approach for performing waste audits, making references to legislation, and benefitting from existing studies and information on best practices collected in previous projects. The planning of the education material takes into account the current gaps and knowledge needs identified in the European member states. |
| **Strategies and methods for implementing circular economy in construction activities in the Nordic countries**<br>Nordic Council of Ministers<br>2020 | The aim of this study was to identify and present cases and experiences from the implementation of circular economy concepts at the local level in the Nordic communities with a focus on construction, renovation and demolition. Information was mainly collected from Denmark, Finland and Sweden and to a limited extent from Norway. The project evaluates how the national strategies in the Nordic countries have an influence on the implementation of circular economy concepts at local levels. |

| Initiative / Document / Project | Description |
|---|---|
| **Construction and Demolition Waste: challenges and opportunities in a circular economy**<br>Author: Evelien Dils, Date: 2020 | Through selected illustrative examples, the report explores how circular economy-inspired actions in the built environment can directly contribute to increasing the prevention, reuse and recycling of construction and demolition waste. |
| **Background data collection and life cycle assessment for construction and demolition waste (CDW) management**<br>Publisher: Publications Office of the European Union, Date: 2022 | The goal of the study was to calculate, document and compare the environmental impacts of different treatment options for selected priority fractions of CDW. The assessment of the single fractions was done for both 2020 and 2050. The results for the four fractions in general came to the same conclusion, i.e. the environmental impacts followed the waste hierarchy, although with some exceptions. Reuse of concrete waste is the pathway leading to the highest saving potential, followed by PVC, EPS-insulation and wood. The study also provides a detailed techno-economic characterisation of emerging and established technologies and processes for the management of CDW. |
| **Implementation of circularity, whole life cycle carbon and life cycle costing in public construction projects**<br>Author: Irish Green Building Council (IGBC) - CIRCULARlife project, Date: 2022 | This handbook presents some of the key green indicators that should be applied within the procurement of public construction projects in addition to the energy efficiency requirements in Building regulations. These include Circularity, Whole Life Carbon assessment and Life Cycle Costing. It explains why these are important to integrate in projects, and how there is now a standardised EU approach to the application of the indicators through the EU framework for sustainable buildings: Level(s). |
| **Procurement strategies - Integrating reuse in large-scale projects and public procurements**<br>Author: Bellastock-ROTOR FCRBE Project, Date: 2022 | These complete guidelines aims at fostering the integration of reclaimed materials and products in new projects, especially in the context of large-scale developments and public tenders. This deliverable provides a set of methods, advice and recommendations to assist building owners, architects and construction professionals. It also lists within the annex the different consultation procedures. |
| **Statistical analysis of the buildings elements reclamation trade in the Benelux, France, the UK and Ireland**<br>Author: Centre Scientifique et Technique du Bâtiment (CSTB) - FCRBE Project, Date: 2021 | The building elements reclamation trade in Europe is not well documented in terms of quantitative data. The aim of the statistical survey is to fill this gap and to enhance the visibility of the economic activities specialised in the reclamation and supply of reusable building elements. They tend to be overlooked by official statistics and, by consequence, by public authorities. This survey seeks to give a comprehensive overview of the activities of this trade, backed up with quantitative data. It provides a description of the main activities carried out by reclamation and salvage dealers, and an estimation of the type and quantities of materials they reclaim, their turnover and the amount of jobs associated with these activities. |
| **Evaluating the technical performance of reclaimed building materials**<br>Author: Belgian Building Research Institute and Centre Scientifique et Technique du Bâtiment (CSTB) - FCRBE Project, Date: 2021 | This is one of a series of seven booklets that have been produced to serve as a taste of what the FCRBE project aims to achieve. The subjects span the broad spectrum of reuse, covering considerations before, during and after with useful information to guide and inspire working with reclaimed materials. The booklets also highlight environmental benefits, clarify grey areas and frequently asked questions regarding best practices, whilst sparking curiosity for a future where use is reuse. |
| **Material sheets reuse toolkit**<br>Author: Rotor - FCRBE Project<br>Date: 2021 | This sheet is intended for designers, specifiers and other members of construction project teams wishing to reuse this building material or product. It is part of a collection of sheets aimed at bringing together the available information to date that is likely to facilitate the reuse of building materials and products. |
| **Sustainable construction guidelines for public authorities – A circular economy perspective**<br>Author: ACR+, Date: 2019 | This study is meant to describe some relevant instruments that local and regional authorities can implement to trigger, make durable and replicate sustainable circular economy processes in the construction sector.<br>The document is divided into two main parts. The first one refers to an overview of what the sustainable construction sector stands for, starting from the current state of play and moving to the circular economy principles. The second part introduces approaches, principles, and examples. Boxes with good practices and experiences on specific topics turn the narrative into concrete examples. |
| **A life-cycle perspective on the building sector - Good practice in Europe**<br>Author: BPIE (Buildings Performance Institute Europe), Date: 2022 | Integrating a life-cycle perspective into the building and construction sector is crucial to decarbonise the European building stock. It will allow to account for carbon emission along the building's life-cycle (whole-life carbon, WLC) and introduce circularity principles in construction. This report showcases ample examples in the EU pm how to reduce embodied emissions and improve circularity in the building sector. |

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