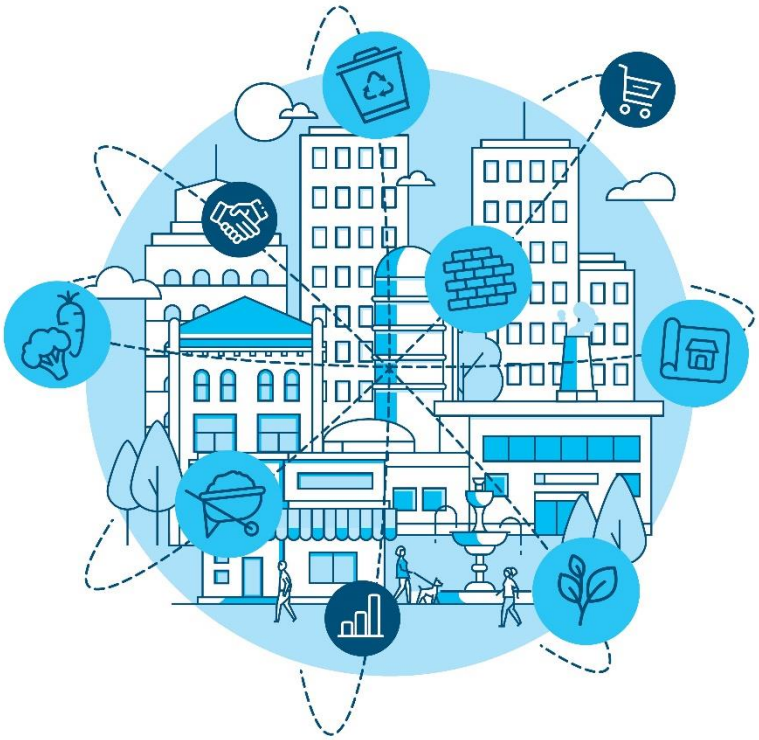
WP2 Concluding report

Deliverable 2.14

Capital Region of Denmark



Version	1.0
WP	2
Deliverable	D2.14: CDW Concluding report
Date	22 September 2023
Dissemination level	Public
Deliverable lead	CRD
Authors	Pernille Kernel and Erik Lauritzen, CRD
Reviewers	Leslie Petitjean, ICLEI
Abstract	This report presents a synthesised overview of the Demonstration Reports, together with reflections and conclusions on this work. It also highlights the main lessons learnt all along the project.
Keywords	The journey of the cities: Circular construction, instruments, demonstration experiences
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WP2 concluding report

Table of content

1. General intro to WP2

WP2 comprises the work with circular construction and handling of CDW in six cities:

- Apeldoorn: Redeveloping the Grieffiersveld area, doing road scans with cameras to identify materials before digging up the old road, establishing physical material banks and reusing gravel and pavers on and off-site.
- Bodø: Demolition of a military airport and construction of a new civil airport and new part of the city, mapping structures and materials for reuse or recycling, and creating a 3D digital visualization used for designing the new city with existing structures and materials.
- Høje-Taastrup: Creating a closed loop for recycling concrete, tearing down apartment blocks, crushing and reusing the concrete to replace 100% of the stones in the concrete for the new City Hall. Developing circular criteria for the sale of the old city hall, which resulted in adaptive reuse of the building for apartments instead of demolition.
- Mikkeli: Screening and selective demolition of Pankalampi Health Centre and Tuukkala Hospital, colllecting data using drone monitoring, creating a digital marketplace and selling materials.
- Roskilde: Partial demolition and transformation of existing factory halls for new purposes, mapping materials and creating a physical material bank, then reusing the materials. Construction of two multi storey parking houses with on-site recycling of concrete, reused materials and design for disassembly.
- Seville: Replacing old pipelines for drinking water and sewage, testing and recycling the crushed concrete when laying down new pipes. Optimizing CDW management in the city with digital flow monitoring tools and connecting wellbeing and waste management with a digital Wellbeing Monitoring Platform.

The demonstration actions implemented within WP2 followed three phases:

- **Inception & preparation** (M1-18) with detailed planning and preparation for the implementation of the demonstration actions, including the development of any instruments (tools, procedures and methods) to be applied and tested

- **Demonstration** (M18 – 44) which covered the full implementation and evaluation of the demonstration actions

- **Replication** (M36 – 44) which covered the assessment, peer review and modification of instruments for wide-scale replication in Europe

In principle the project was designed for the cities to follow the same timeschedule with preparations the first 18 months followed by implementation. However the construction projects used as demonstration actions sometimes moved forward quickly or was delayed, which meant that some instruments was developed alongside the demonstration actions, and some cities finished their demonstration actions early on while other cities overlaps with the “Replication” phase and beyond.

The instruments developed within CityLoops, and the demonstration actions planned in the six cities in WP2 are designed to address different aspects of a new circular value chain for the construction sector, which the project aims to promote – as presented in Figure 1.

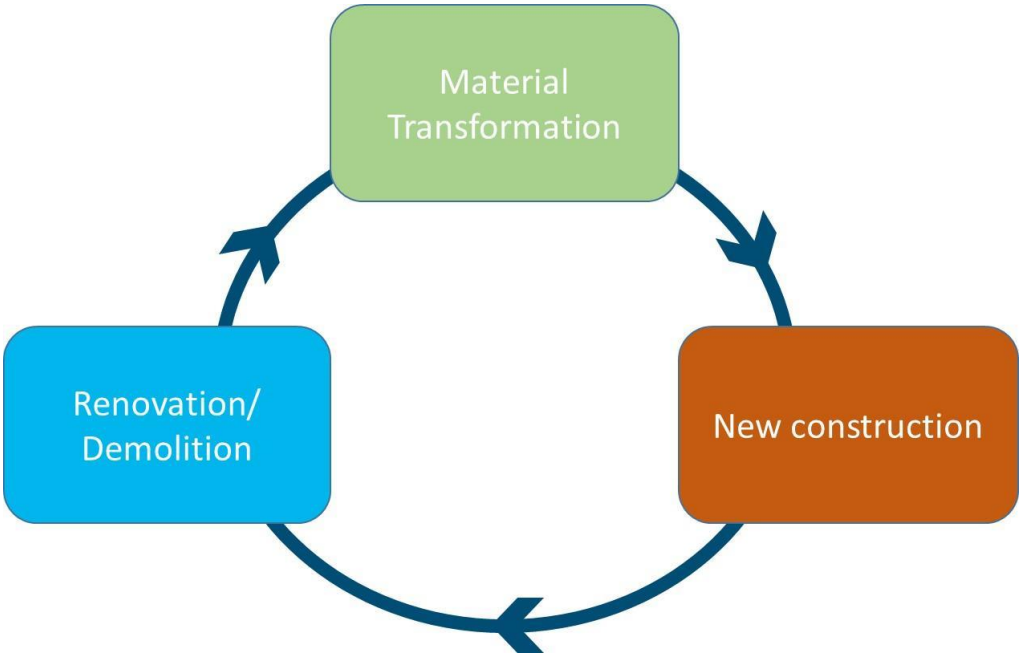


Figure 1. The value chain for circular construction

CityLoops actions in the three phases:

- **Renovation or Demolition** – The Finnish Guidelines for pre-demolition screening have been adapted and put to use in demonstration actions in order to identify existing components and materials in terms of reusability, recoverability and recyclability. Guidelines for selective demolition have been developed and used in demonstration actions, from the tendering and contracting for selective demolition to the demolition itself with soft stripping and on/off-site separation of material types.

- **Material Transformation –** This phase covers the actions necessary to prepare CDW for reuse or recycling, including identification, data and documentation, storage and digitalisation as well as handling: CDW materials in the demonstrations suitable for recycling were identified and selectively demolished in the demolition phase. Different methods have been applied for documenting material flows, collecting and storing data about the CDW (type, quantity, quality, reusability) in order to promote reuse and recycling. The data has been used for 3D Visualization and/or entered into digital marketplaces. Physically the materials have either been stored for reuse/recycling in material banks or delivered directly to the site where they are to be used. Recycling concrete has been described and tested, both as aggregates in new concrete and as filler around water pipelines. A guideline has been developed covering the different steps in recycling crushed concrete as aggregates for new concrete.

- **New construction –** Construction with secondary materials has been tendered and incorporated in new construction projects in some demonstrations, e.g. crushed concrete as 100% aggregate in the new concrete for a City Hall foundation, road pavers for construction of storage sheds or fire stairs applied to a new building. In other demonstrations construction reusing structures or elements has or will take place, e.g. the transformation and partial demolition of old factory halls, the planned adaptive reuse of an old city hall for housing and the planned repurposing of military shelters for civil purposes. Design for disassembly have also been applied in demonstrations, e.g. a multi-storey car park which is built with as little concrete as possible and constructed with elements to be easily taken apart and reused. Urban planning and development and city decision-making frameworks have enabled recirculation of construction materials. Finally instruments for circular soil handling in construction projects has been developed based on the demo-actions, keeping approximately 90% of the excess soil on-site.

1.1. Deliverables and tasks in WP2

Below the list of deliverables and tasks in WP2. All has been completed although some were delayed.

Deliverable and task number	Deliverable Title *Task title*	Lead beneficiary	Due date/ final dissemination
-, T2.1	*Cross-EU collaboration*	CRD	-
D2.1, T2.2	CDW: Stakeholder Engagement Plans *Stakeholder mapping and engagement*	NRI	9/9
D2.2, T2.3	CDW: Sector-wide Circularity Assessments *Sector-wide Circularity Assessments*	MoC	18/43
D2.3, T2.5	Business cases for CDW/soil re-/upcycling *Co-development of business cases*	DACC	18
D2.4, T2.6	Construction/ demolition procurement guidelines *Co-development of procurement guidelines*	RWS	18/47
D2.5, T2.8	CDW: Optimised Implementation Plans *Optimised implementation plans*	CRD	18/18
D2.6, T2.9	CDW: Demonstration Report for Apeldoorn *Demonstration and evaluation*	GA	44/44
D2.7	CDW: Evaluation Reports		Removed and included in

			demonstration reports
D2.8, T2.4 & T2.10	European guidelines on promoting circular construction for local and regional governments *Co-development of planning and decision making guidelines* *CDW: European replication guidance and instrument adaptation*	ICLEI	46/48
D2.9, T2.9	CDW: Demonstration Report for Bodø *Demonstration and evaluation*	Bodø	44/48
D2.10, T2.9	CDW: Demonstration Report for Høje Taastrup *Demonstration and evaluation*	Høje Taastrup	44/48
D2.11, T2.9	CDW: Demonstration Report for Mikkeli *Demonstration and evaluation*	MIKSEI	44/48
D2.12, T2.9	CDW: Demonstration Report for Roskilde *Demonstration and evaluation*	TCR	44/48
D2.13, T2.9	CDW: Demonstration Report for Seville *Demonstration and evaluation*	Seville	44/48
D2.14, T2.9	WP2 Concluding Report *Demonstration and evaluation*	CRD	44/48
D2.15, T2.7 & T2.10	CDW circular toolkit for local and regional governments *Development of instruments and tools* *CDW: European replication guidance and instrument adaptation*	ICLEI/CRD	46

Table 1: List of deliverables and tasks

The number and the content of deliverables were changed during the project, following the completion of the Inception and Preparation phase and the feedback received during the Project Review Meeting following the 1st Periodic Report. The changes related to WP2 was an adjustment of outputs and deliverables to make a clearer separation between deliverables focused on reporting the results of the demonstration actions (Demonstration Reports and Concluding Report), and those focused on providing guidance for potential replication by other European cities and regions (The European Handbook and the toolkits/Replication Packages).

The new deliverables were:

- Demonstration Reports per city – combining the previous implementation and evaluation reports in a single document, and separating these per demonstration city

- A Concluding Report from each WP, produced by the WP lead and synthesising the findings of the demo actions
- A toolkit of resources, named Replication Packages, collecting the various instruments being tested in each city, and following a peer review and adaptation process
- An overall guidance document on how local and regional governments can promote circularity for the respective material stream

Several deliverables were delayed, and many felt the consequences of COVID changing the progress of construction projects as well as plans of physical workshops and preventing meetings. Below comments about the delays of individual deliverables:

- The Sector-wide Circularity Assessments created a lot more work than expected to find the necessary data, so it was hard for the cities to find the time to do so which created a serious delay. The reports were finally finished by all cities in collaboration with MoC. Since then the deliverable has been evaluated and changes been made before the final dissemination.
- Developing business cases proved to be very hard, as the details about the economic transactions between the different contractors in the projects were difficult for the cities to get access to or extract, and several cities needed further progress of the demonstration actions. Thus, a template guiding the development of business cases was created in the beginning of the project, and business cases for each city has afterwards been developed.
- Developing procurement guidelines for the cities also proved difficult. In practice most demonstration cities were by M18 not ready for applying the recommendations of the circular procurement assessment into sets of practical guidelines for their specific situation or found it difficult to apply these in their local situation. Instead, the cities developed internal guidelines over a longer period based on a template provided by the city of Mikkeli. The final deliverable was done as a collection of guidelines from the individual cities.
- Four out of six demonstration reports for the cities were delayed. In all cases it was due to delays in the construction projects. The two cities who finished on time also had the more simple construction projects; Mikkeli focusing on screening and demolition rather than the whole value chain and Apeldoorn focusing on a road renovation project.
- The concluding report was also delayed, partly due to the amount of extra work that arose from the added task on developing and reviewing the replication packages, partly due to delays of the demo reports.

The overall conclusion would be that we did not fully anticipate the workload and complexity of the many CityLoops tasks, the need for direct support for the cities to carry them out or the constant changes in the progress of construction projects. In future projects, a recommendation would be fewer tasks and more direct dialogue and support in completing the tasks, connecting the other WPs more to supporting the actual demo actions rather than extracting knowledge from the demo actions, which strained the cities limited resources.

2. Development of instruments and tools

The circular construction demonstration actions require a large amount of work as the procedures differ from construction or demolition as usual and thus more planning is needed, and new knowledge and new methods need to be implemented. In this chapter is an overview of the instruments developed in CityLoops and a description of them and a description of the demonstration actions is found in chapter 3.

2.1. Introduction to the work with instruments and tools

To support the circular demolition and construction projects a series of instruments and tools have been developed for application and testing within the demonstration actions.

The development of the instruments has been closely followed at cross-consortium meetings and sub-groups were formed focusing on instruments related to pre-demolition, soil, flow tracking, stakeholders and city development. For each instrument developed, a factsheet was produced, providing a quick introduction to the tool/methodology, it's purpose, format and target audience. These factsheets were used as communication tools. To enhance further collaboration on the instruments and tools a workshop focused on knowledge transfer and replication of instruments between the cities was part of the general assembly in 2022.

The ultimate goal of CityLoops is for the instruments and demonstration actions to be used and replicated by other cities across Europe. To this end all instruments has gone through a peer review process with CityLoops partners and replicator cities in the first half of 2023. The aim was to identify necessary adaptations and adjustments to allow the instruments to be replicated, before finally being included in the CityLoops Replication Packages: Digital toolboxes covering 9 different topics of circular construction, presenting CityLoops lessons learned, instruments and demonstration experiences on the specific topic. The Replication Packages are described in chapter 4.2.

As the instruments vary considerably in nature the final output included in the Replication Packages varies. In some cases the instruments are guidelines (e.g. the pre-demolition screening and selective demolition guidelines or the soil reuse guidelines) or tools (e.g. the CO2 emissions calculation tool). In other cases the output is a "blueprint" describing how to replicate this approach (e.g. the flow-monitoring and data collection done by drones in Mikkeli or the 3D visualisation model of structures and materials in Bodø). Finally, some outputs are reports describing experiences which other cities can learn from, rather than a direct set of recommendations (e.g. in the case of databanks, material passports and marketplaces the

output is a Replication Package describing and comparing different approaches to handle documentation and digitalisation of CDW for reuse or recycling).

To improve the replication of the instruments, they went through a peer-review process in the first half of 2023. Each instrument and the connected Replication Package was reviewed by relevant CityLoops demonstration cities and partners as well as replication cities. The partners were chosen to review selected instruments and Replication Packages because they had already tested it, were interested in using it or had valuable experiences related to the instrument and topic. The peer-review process focused on the usability of the Replication Packages and instruments in other cities: Whether they could be replicated directly or needed adaptation, as well as how easy is was to test and use the instrument. The peer-review helped improve the Replication Packages and the instruments, to make it as easy as possible for others to read, understand and replicate.

The table below holds an overview of all the instruments developed in WP2 with links to the Replication Packages where the instruments can be found.

Table 2. CityLoops CDW instruments developed to support demonstration actions. The instruments are sorted under the Replication Package topics with a link to where they can be found. The first columns shows the instruments including the original name in () if changed. The second column shows the lead partner responsible for developing the instrument, and the following columns show the partners who has used it.

Instruments developed in CityLoops (Original name in the proposal, if changed)	**Lead**	**Used the instrument**
Decision making and planning https://cityloops.eu/construction-demolition-waste/planning-and-decision-making		
Decision-making and planning guidelines (Planning and decision making guidelines)	RUC	A B H M R S
Circular Procurement https://cityloops.eu/construction-demolition-waste/circular-procurement		
Circular Procurement Handbook (Circular construction procurement guidelines)	RWS	A B H M R S
Business Cases https://cityloops.eu/construction-demolition-waste/business-cases		
Business Cases for Circular Construction & Demolition Projects (Circular business case model)	DACC	A B H M R S
Developing a circular business model for the municipality of Apeldoorn (Not originally in the proposal)	A	A

Stakeholder engagement https://cityloops.eu/construction-demolition-waste/stakeholder-engagement		
Stakeholder engagement plans	NRi	A B H M R S
CityLab stakeholder platform	B	B
City simulation platform and well-being monitoring tool	S	B S
Co-design process for public space	A	A
Circular demolition https://cityloops.eu/construction-demolition-waste/circular-demolition		
Pre-demolition Audit Guide (Pre-demolition screening procedure)	M	A B H M R
Guide for selective demolition (Selective demolition procedure)	CRD	A B H M R
Data and material passport https://cityloops.eu/construction-demolition-waste/data-and-material-passports		
Material Passport definition (Construction material passport and CDW material databank)	SAX	A B H M R S
Procedure to obtain material passport (Not originally in the proposal)	R	R
Blueprint for drone scan and 3D modelling tool (3D modelling to track onsite CDW flows based on drone scan)	M	A M
Replication report for 3D visualization solutions - Digital Twin (3D GIS Visualisation of structures and materials in old airport)	B	B
Guide for replication of road scan and data storage (Street scans of materials with cameras on vans)	A	A
City simulation platform (CDW flow optimisation to/from the city´s recycling stations)	S	S
Material banks and marketplaces https://cityloops.eu/construction-demolition-waste/material-banks-and-marketplaces		
Cities that have worked with material banks and marketplaces		A B M R
Blueprint: Databank and digital marketplace for recovered materials (Databank and digital marketplace for recovered materials)	M	M
The digital marketplace DuSpot in Apeldoorn (Not originally in the proposal)	A	A

Recycling concrete https://cityloops.eu/construction-demolition-waste/recycling-concrete		
Cities that have reused or recycled concrete		A B H M R S
Guide: Recycling of concrete – from pilot project to permanent change of practices (Not originally part of the proposal)	R	H R
CO2e calculator for 11 fractions of CDW (CO2 calculators for concrete, soil and mixed CDW)	R	A B H M R
Quality assessment tool for the use of recycled aggregates in water and sewage infrastructures (Quality assessment for crushed concrete used round water pipes)	S	S
Circular soil handling https://cityloops.eu/construction-demolition-waste/circular-soil-handling		
Roadmap for circular soil handling (Framework for developing a circular soil strategy)	CRD	B H R
Instrument for predicting future excavated soil	CRD	H R
Methodology for on-site soil reuse (Tool/methodology for assessing soil reuse potential + Tool/methodology for identification and assessment of sites/projects fit for soil reuse)	CRD	B H M R

Legend: A(peldoorn), B(odø), H(øje-Taastrup), M(ikkeli), R(oskilde), S(eville), NRI Norland Research Institute, RUC Roskilde University, SAX Saxion University, CRD Capital Region of Denmark, DACC Danish Association of Construction Clients, RWS Rijkswaterstaat

The table shows that all instruments from the proposal plus a few extra have been developed and turned into guidelines, tools, blueprints or reports which are now available in the Replication Packages. Regarding soil, two instruments were merged into one.

The table also shows that some instruments have been used by several cities while others have been developed and used by one city. When we designed CL circular construction was still virgin land, and we needed instruments and tools to be able to navigate – e.g. to be able to selectively demolish a building, to learn how to effectively recycle concrete as aggregates in new concrete or how to establish digital material banks, enabling reuse or recycling of the materials.

CL chose some general framework instruments to be developed and used by all cities, led by one of the partner organizations (planning and decision making, stakeholder involvement, procurement and business cases). The cities prepared for the demonstration phase by

developing specific instruments needed to support their circular demonstration actions. This resulted in a wide range of instruments and tools supporting the different steps along the value chain of circular construction. The table also shows how several cities are working within the same topic, maybe even sharing an instrument within this topic (e.g. Material passport definition) but also developing their own case specific instruments (e.g. Blueprint for drone scan and 3D modelling).

Retrospectively I think we were a bit naïve thinking that we could both have the cities develop instruments and tools for testing in the large scale demonstration actions, which they were preparing alongside the instrument development – and still have enough time for the other cities to put these tools to use in their demonstration actions, which were being planned at the same time.

In some cases the tools developed by the cities were easy to apply to other demonstration actions – e.g. CO2 calculations and to some extent screening and selective demolition, so they were used in multiple demonstration actions. But in the case of more complicated instruments and actions you will need to implement them in a construction project at the early planning stages, so it becomes part of the plan, is entered in the tendering and becomes integrated in the project. For example Bodø has developed a digital twin 3D modelling to visualize the materials for reuse and recycling, thus managing flows and design of the new city using these materials. This is a great demonstration action to replicate for other cities, but it was not possible for other CityLoops demonstrations to integrate such an instrument in already planned or ongoing demonstration actions. Here the direct replication or uptake lies in future circular construction projects.

In the case of the more complex instruments or actions, our focus in WP2 has been to create as much knowledge exchange as possible between both demonstrators and replicators with deep dives into topics, instruments and demonstrations at the monthly WP2 cross consortium meetings for both partners and replicators, focused topics at the half-year expert workshops and dialogue at the city-to-city meetings, either between partner cities wanting to learn about a specific experience or topic, or between partner-replicator cities..

2.2. Development and description of CityLoops instruments

In this section the development and content of the instruments outlined in Table 1 are described.

2.2.1. Instruments concerning framework conditions

Planning and decision-making

Deliverable 2.8, Task 2.4

Planning and decision making is where the greatest potential for circular activities can be realised: It is both easier and cheaper to implement circular actions if circularity becomes part of the plan for the project and if the decisions made consider circularity. To support this process a set of decision-making and planning guidelines was developed, indicating when decisions should be taken, which stakeholders should be involved, and what knowledge inputs are needed during different stages of the process. To engage decision-making and planning in promoting circular practice, the task was divided into two overall tracks of activities focusing on Co-developing a framework for mapping processes of decision-making and planning and Operationalising the new practices of decision-making and planning in the organisations.

The decision-making framework and guidelines were developed in a co-development process between partners from Roskilde University, Gate21, Roskilde Municipality and Høje-Taastrup Municipality through a series of dedicated workshops. The decision-making framework was afterwards used/tested against the decision-making process related to the demonstration activity in Høje-Taastrup and Roskilde. The two tests were based on a series of interviews and work meetings combined with an analysis of documents (plans, work documents, tenders etc.) related to the demonstration activities. The decision-making framework was further tested during a series of online meetings and workshops in Mikkeli, and later on workshops with Bodø and Seville.

The co-development process for the decision-making framework identified a need to work with organisational transformation alongside the development and implementation of the decision-making framework and guidelines. Results from the early work in the demonstration projects in Roskilde, Høje-Taastrup and Mikkeli suggests that implementation of the decision-making framework and guidelines is likely to require organisational changes within the cities administration to function (e.g. internal coordination of decision between departments within the municipalities). The scope of the work with the co-development of the decision-making guidelines were therefore expanded to also include organisational changes and an additional series of workshops were designed.

The replication instrument is a *guidance on planning and decision-making* that supports the systematic internal incorporation of circularity. It is based on a framework to map key decisions across the phases of demolition and construction, and it consists of 1) a visual mapping framework - designed to identify when key decisions in urban transformation projects are to be taken, which stakeholders are involved, and what knowledge inputs are needed during different stages of the planning process and 2) an operationalisation of the planning and

decision-making framework, focused on how to engage organisational change on the strategic, operational and competencies levels.

It facilitates the establishment of an ongoing network/ group to embed organisational transformation and thus securing a sustained commitment, avoiding a fallback to business as usual.

The instrument can be found here: https://cityloops.eu/construction-demolition-waste/planning-and-decision-making

Circular procurement

Deliverable 2.4, Task 2.6

Procurement plays a central role in all construction projects and is a mayor lever towards circularity. Thus procurement guidelines (D2.4) was developed in cooperation with the demonstrator cities, providing an outline for CityLoops partners to follow in the delivery of their demonstration projects in the field of CDW. The guidance summarises approaches taken within each CityLoops partner's specific project. These range from large-scale, long term complex redevelopment projects (as in Bodø, Norway) through to smaller scale demolition and newbuild works for a single building (e.g. Hoje-Taastrup, Denmark). These specific approaches are supplemented by existing guidance on circular construction and resource efficiency. The guidance forms an overview of the approaches taken by individual partner cities in the CityLoops project. Therefore some elements of the guidance may not be relevant to all projects. The guidance adopts the approach discussed with partner cities namely, to provide an overview document that enables specific cities to adapt to their circumstances. This follows the approach used in Mikkeli where responsibility for developing detail is devolved down to municipality and project level. This keeps the guidance to a manageable length but also means it only provides a broad overview as a basis for further action.

The instrument for replication is the *Circular Procurement Handbook,* based on lessons learnt across all the demonstrator projects. It includes small reports from each demonstration city to provide clues on how to adjust procurement approaches to help promote circularity. The handbook also includes a series of case studies taken from other EU projects and recommendations for European policymakers.

The experiences from the cities and Circular Procurement Handbook can be found here: https://cityloops.eu/construction-demolition-waste/circular-procurement

Business cases

Deliverable 2.3, Task 2.5

The professional market of circular use of CDW and soil is relatively new but growing. To push the market in a circular direction, demand and positive business cases are crucial, and therefore all CityLoops citiew in WP2 have been working with this.

To bring a common understanding of the market elements and the influence of these elements in the material flow and the pricing - and in the end the business case - a circular market model has been described in detail. The model and description are based on literature studies, surveys and dialogue with both demonstration managers and external market actors. In the Optimised Implementation Plans the cities identified potential business cases deriving from their demonstration actions. The business case model template (D2.3) was used to develop these in the demonstration phase.

Online meetings and workshops were carried out in each city, where the market conditions and concrete business cases have been discussed with the key actors related to the demonstration cases. The purpose of these meetings and workshops was to reach a common understanding of the subject and substance of how to deal with business cases in a sustainable way, looking into both environmental, economic, cultural and social benefits and perspectives, and to test the business case model where each business case can be analysed commercially as well as socially. Focus has been on dialogue on how to build-up a business case for a CDW product or material, which can compete at the free market, and at the same time secure benefits for the (local) society.

Business cases on selected CDW flows from each demonstration city have been developed as part of the demonstration reports.

The main replication instrument is the report *Business Cases for Circular Construction & Demolition Projects*, from the Danish Association of Construction Clients. It is an introduction to the circular economy and market in the construction sector. It includes a comparison to the conventional linear market and introduces a two tracked business case mode. This model looks at both the economic/commercial value chain and a broader value chain seen from a societal point of view with environmental, social, and economic aspects of the business case – as two sides of the same coin.

Another instrument is the report *Developing a circular business model for the municipality of Apeldoorn*, from SAXION University, is an academic analysis of The Triple Layered Business Model Canvas.

The instrument and the cities business cases can be found here: https://cityloops.eu/construction-demolition-waste/business-cases

Stakeholder engagement

Deliverable 2.1, Task 2.2

Stakeholder engagement is mandatory to create support and ownership and to change habits and practices. Thus, each city developed a stakeholder mapping and engagement plan (Deliverable 2.1). For each of the planned demonstration activities, the plans identify relevant stakeholders and stakeholder groups, describe stakeholder engagement methods to be used in CityLoops and who is responsible for engaging the stakeholders. It further describes key

risks and risk mitigation measures related to the stakeholder mapping and engagement process.

The plans were developed based on a guidance document provided by Nordland Research Institute (NRI). In addition to providing a template for the plans, the guidance document reviewed and presented relevant methods for stakeholder identification and engagement, and based on this, proposed methods and gave guidance for the cities in the development of the stakeholder engagement plan.

NRI guided each city in the development process through a series of web-meetings and email communication. This contributed to a more common understanding of the stakeholder identification and engagement process, and a more uniform content and layout of the reports across cities and material flows.

Stakeholder activities foreseen in the plan was carried out by the demonstration cities in their demonstration projects.

Three cities have developed instruments for stakeholder engagement: Apeldoorn, Bodø and Seville:

Co-design process for public space: Apeldoorn has used this instrument to develop a process journey, which is an overview of the involved actors per process phase with the roles and tasks of each actor in each deliverable. Thus, the process journey can be used as a manual to accomplish circularity in a project.

The CityLab stakeholder platform in Bodø: a physical and virtual platform for stakeholder engagement on city development. It integrates the 3D visualisation of structures and materials in the old airport area, making it possible to virtually design the new city using these structures and materials. The idea is to stimulate imagination and opinions on the city's future development. The platform offers an information portal to solicit inputs from citizens, civil society organisations and local businesses to involve them in planning and decision making. The CityLab is supported by a communications and social media strategy for recruiting stakeholders (such as professionals, local businesses, or civil society organisations) and citizens.

City simulation platform: Seville has created a centralized virtual hub for software tools and datasets to support its sustainability goals. It features a CDW Flow optimization instrument that supports managers on deciding new locations for future clean points, while giving citizens access to a map with the location of the optimal clean points. It also features a Wellbeing monitoring tool that determines the relationship between wellbeing and indicators on e.g. waste management. The tool is focused on circularity, giving mangers access to a simulation framework that quantifies the influences of circular actions on well-being, while providing citizens with data about the well-being circularity indicator, demonstration actions, and impact estimations on the city´s well-being.

Combining these tools in a platform supports cross-sectoral dialogue and facilitates data exchange between municipal departments, research institutions, and relevant business

partners. The platform can be used during stakeholder engagement events to form an informed, flexible, and balanced transition to circularity.

The instruments can be found here: https://cityloops.eu/construction-demolition-waste/stakeholder-engagement

2.2.2. Instruments concerning the material flow across the value chain

Circular demolition

Deliverable 2.15, Task 2.7

Demolition as usual is demolishing a building without regard for the possible reuse or recycling of materials. Circular demolition focus on reuse and recycling. To this end, elements, structures and materials with potential for direct reuse or recycling are mapped for the demolisher to remove and separate them in a way that keeps their value.

At the time of the proposal guidelines for pre-demolition audits and selective demolition was badly needed. Thus these instruments were developed:

The Pre-Demolition Audit Guide helps 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. It is based on the Finnish guidelines, which have been adapted, translated and tested in Mikkeli, Roskilde, Høje Taastrup and Bodø. Apeldoorn has also done pre-demolition screenings.

The Guide for Selective Demolition explains how a selective demolition can be conducted to select and preserve the value of building components and materials with reuse or recycling potential. The guidelines describe the steps of selective demolition and gives a summary of the principles of selective demolition compared to traditional demolition, as well as an overview of experiences from other EU countries. They have been developed and tested in Roskilde, Mikkeli, Høje Taastrup and Bodø. Together with Apeldoorn they are being adapted to also fit infrastructure projects.

The Guide to Quality assessment for CDW as recycled aggregates in water and sewage infrastructure has been developed and tested in the process of replacing the old freshwater and sewage pipes in Seville. The concrete was crushed and used to replace gravel around the new water pipelines. The output is a technical report describing the aspects of the quality assessment.

The instruments can be found here: https://cityloops.eu/construction-demolition-waste/circular-demolition

Data and material passports

Deliverable 2.15, Task 2.7

Data and material passports are essential to document the quality and usability of materials to be reused or recycled.

The demonstration actions have been developing and testing different methods for gathering and digitalising data on CDW for reuse or recycling, either based on the municipality´s own or their collaboration partners digital systems or practical solutions that they could easily apply. It quickly became apparent that here “one size does not fit all” municipalities or projects. Thus knowledge transfer has been ensured by creating both a focus group on this topic as well as having several deep-dives into this at WP2 cross-consortium meetings. The Replication Package describes and compares the different approaches to handle documentation and digitalisation of CDW for reuse or recycling. The following instruments can be found in the Replication Package:

Material passport definition: Five requirements for a material passport were developed in the CityLoops report “Construction material passports and databanks”, which also describes different approaches to material passports. Furthermore, the report dives into how a material passport can be applied to a circular road renovation project.

Procedure for CDW to obtain a Material Passport: 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 visualization solutions (Digital Twin): The digital twin of the city of Bodø 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 identified loose sediments and potential sea level rise at the demonstration site. Bodø has mapped the masses and structures of the old airport and entered the data into BIM software that includes the quantity, quality and type and reusability of the building, thus enabling 3D design of the new city using the existing structures and materials. The tool can be used to model how different structures can be demolished in order to reuse its building components. An LCA tool has been embedded and gives the user a visual representation on how many emissions transport will create. The instrument can represent historical, present and future data – enabling the user to compare values, and make scenarios based on statistical data. The instrument is a report which describes the software and equipment used, the technical and physical requirements as well as the gathering and visualization of data. In order to replicate Bodø’s activities, it is not necessary to be in possession of the tools mentioned here. However, it is necessary to use tools that can geographically place data. In extension of this, the replicator should be in possession of a software that can manage data e.g., Excel.

Blueprint for drone scan and 3D modelling tool: Mikkeli used a drone and a 3D modelling tool to monitor demolition waste flows. This proved to be a cost-effective alternative in evaluating

the amounts of material flows on-site when compared to traditional methods, e.g., tachymeter. The data capturing process with drones on the demolition sites demonstrated in the project takes on average less than an hour. Mikkeli carried out screening procedures before and during the demolition of the demonstration buildings to find out the recycling and reuse possibilities of the demolition materials, to test 3D drone modelling to track material flows, and to monitor the health and environmental effects of the demolition. They have entered the data from drone-scans in their own databank designed to handle three layers of data: demolition sites, material lots, and materials. A digital marketplace was created and put into use in August 2021. Ads of material items from Toimintakeskus and Metsäsairila have been put on the website in 2021.

Guide for replication of road scans and data storage: Apeldoorn collected data on materials from the road through detailed scans using innovative screening procedures assessing the amount and quality of materials available. The municipality's GBI databank was adapted to store the data, and the materials are visualised in an ARCGIS system. 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. Apeldoorn is now testing Mikkelis drone scan method to compare it with their road scans.

Roskilde conducted a manual resource inspection of the buildings to be partly demolished, identifying materials for reuse or recycling. They then used a colour-code excel sheet as a first version of a material passport and databank which holds data on CDW for reuse/recycling, describing each materials lifespan, what kind of testing it has to go through, and where it could end up in future uses. This is a very simple, cheap and low-key solution that is easy to replicate. However, the data would need to be uploaded digitally if the materials were to be added to a marketplace.

The instruments and experiences can be found here: https://cityloops.eu/construction-demolition-waste/data-and-material-passports

Material banks and marketplaces

Deliverable 2.15, Task 2.7

Physical material banks are necessary in order to safely store and handle materials for reuse or recycling. The digital marketplaces are used to showcase and donate or sell the available elements and materials for new constructions.

Four of the cities (Apeldoorn, Bodø, Mikkeli and Roskilde) have established physical material banks and/or digital marketplaces, using the data generated with the instruments described in the previous section. The two instruments in this section covers digital marketplaces. The experiences with establishing and running physical material banks are described in the demonstration actions.

Blueprint for replication: Databank and digital marketplace for recovered materials: Mikkeli created their own databank and marketplace. It combines data from the 3D scanning tool (using drone imaging) and Miksei's demolition planning on construction materials (CDW) 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. Ads of material items from Toimintakeskus and Metsäsairila have been put on the website.

The digital marketplace DuSpot in Apeldoorn: Different possibilities were investigated by the municipality, and they ended up choosing to use the existing digital material bank "DuSpot". DuSpot is already used by several municipalities in the Netherlands. 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.

As a development which was not in the CityLoops proposal Bodø is looking at buying access to a digital marketplace. The marketplace will be finished outside CityLoops.

Also after the Excell-sheet based registration of resources done in Roskilde, they have moved on to using the Upcycling Forum databank and marketplace. They have made an agreement with Upcycling Forum about making a joint venture with other municipalities on gathering CDW materials for reuse in an online platform.

The instruments and experiences can be found here: https://cityloops.eu/construction-demolition-waste/material-banks-and-marketplaces

2.2.3. Instruments concerning circular handling of concrete and soil

The two main fractions of construction are concrete and excess soil. In CityLoops instruments for creating circular flows of these specific fractions have been developed and tested.

Recycling concrete

Deliverable 2.15, Task 2.7

Concrete is the main fraction of CDW – except from soil. All CL cities have been working with reuse or recycling of concrete. In Roskilde and Høje Taastrup they created closed loops for recycling concrete as aggregates in new concrete, replacing 100% of the stones. In Seville the crushed concrete was used to replace gravel around new water and sewage pipelines. In Mikkeli the concrete from demolition was sorted and delivered for the waste management company to sell. In Apeldoorn and Bodø concrete structures was/will be reused: In Apeldoorn the pavers from the road was either reused for parking areas or as walls in shelters, while in Bodø large concrete slabs will be reused in the future city.

The reuse is described in the demonstration reports, whereas the recycling has led to development of the instruments Guidelines for recycling of concrete and the CO2-calculator.

Guide: Recycling of concrete – from pilot project to a permanent change in practices: The guide is aimed and 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 on the same location. It includes examples of requirements for recycled concrete that can be directly incorporated into tendering material. The guide was not one of the original instruments to be developed in CityLoops, but was developed by Roskilde Municipality as an add on, based on the experiences from CityLoops demonstration projects in Roskilde and Høje Taastrup.

CO2e calculator for 11 fractions of CDW: The CO2 calculator for concrete allows cities to estimate the potential CO2-reductions in their specific project 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. The CO_2 calculator is an easily accessible and usable excel sheet tools with guidance notes. Roskilde, Høje Taastrup and Mikkeli have used CO2 calculations as is, Apeldoorn has adapted and used it and in Bodø CO_2 calculations are integrated in their 3D modelling.

The instruments can be found here: https://cityloops.eu/construction-demolition-waste/recycling-concrete

Circular soil handling

Deliverable 2.15, Task 2.7

Excess soil from construction sites surpasses the amounts of CDW. It is excavated in urban development or construction projects. The soil tools make it possible to make a roadmap for circular soil handling in the municipality, predict future amounts of excess soil in order to plan for their handling and guides construction owners and other parties in keeping and using the soil on-site.

The development of the soil tools on soil reuse potential and assessment of sites fit for soil reuse was integrated with the practical experiences from a test area, and they were developed alongside the developments in the test area. It was hard to find test areas, which meant that these instruments were finished towards the end of the project. They were developed and tested by the Danish partners and several CityLoops cities and replicators followed this work with interest.

Roadmap for sustainable soil management: The roadmap is a simple interactive diagram to be filled in by the municipality. It addresses soil reuse at process and policy level and 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. It was developed in collaboration with other Danish municipalities and consultants and was used in Roskilde and Høje Taastrup and in Bodø. The first step in developing the instrument was to interview stakeholders (construction companies, consulting companies, builders/developers) to identify barriers for local reuse of excavated soil. Then a collaborative learning network with municipalities in the Capital Region was established. It quickly became apparent that management in individual municipalities needed "the big picture" to better understand organisational implications of soil management initiatives. This led to the development of the Roadmap for sustainable soil management. The roadmap represents a one pager for identification of relevant (soil) stakeholders and with a description of individual stakeholder's tactical procedures and operational actions. When testing the roadmap Roskilde and Høje Taastrup Municipalities mapped departments with soil related activities, e.g. where the municipality acts as a construction client, as a planning authority, as a construction authority, as an environmental authority or as a service and utility provider etc. The roadmap is generic and may also be adapted by private developers, construction companies and project organisations to provide a picture of relevant ways to analyse, plan and perform sustainable soil management.

Guidelines for sustainable soil management and assessment of reuse potential of excavated soils: The guidelines describe how projects can be adapted to minimize 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 impact on ecosystem functions; maximizing on-site reuse of excavated soil; and local reuse of excavated soil. It furthermore provides an overview of whether a specific soil type is suitable for a particular purpose. The guidelines cover the physical aspects of reusing soil on-site, addressing both soil quality and assessment of soil reuse potential. It combines the two previously planned instruments "Methodology for assessing soil reuse potential" and "Methodology for identification and assessment of sites/projects fit for soil reuse". The methodology was developed from the experiences at two large on-going urban development projects. The first project is "Nærheden Øst", where one particular developer has managed to keep 90% of the excavated soil on-site. The second project is the site of the old city hall in Høje Taastrup. In September 2022 HT sold the old city hall site to a developer. The sale of the old city hall for adaptive reuse is a CityLoops demonstration project, where the developer has to meet certain demands in relation to reuse/recycling of CDW and soil management. The developer currently working on the circular soil management plans for the area in cooperation with the municipality.

Prognosis predicting future excavated soil production: 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. It has been developed and tested in Høje-Taastrup and Roskilde, and is being applied to more Danish municipalities.

E.g. it was used for the urban development project "Nærheden Øst", where one particular developer has managed to keep 90% of the excavated soil on-site. For this development area the municipal prognosis tool for production of excavated soil indicated that around 1.000.000 tons of excavated (excess) soil would probably be produced in a business as usual-scenario. However only 75.000 tons are to be disposed of ex-site, thanks to circular actions taken at this site.

CO2 calculator for soil: 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. The CO_2 calculator is an easily accessible and usable excel sheet tool with guidance notes. Roskilde, Høje Taastrup and Mikkeli have used them as is, and in Bodø CO_2 calculations are integrated in their 3D modelling.

The instruments can be found here: https://cityloops.eu/construction-demolition-waste/circular-soil-handling

3. Demonstration actions

CL has demonstration actions on circular handling of CDW in six European cities:

- *Apeldoorn:* Redeveloping the Grieffiersveld area, doing road scans with cameras to identify materials before digging up the old road, establishing physical material banks and reusing gravel and pavers on and off-site.
- *Bodø:* Demolition of a military airport and construction of a new civil airport and new part of the city, mapping structures and materials for reuse or recycling, and creating a 3D digital visualization used for designing the new city with existing structures and materials.
- *Høje-Taastrup:* Creating a closed loop for recycling concrete, tearing down apartment blocks, crushing and reusing the concrete to replace 100% of the stones in the concrete for the new City Hall. Developing circular criteria for the sale of the old city hall, which resulted in adaptive reuse of the building for apartments instead of demolition.
- *Mikkeli:* Screening and selective demolition of Pankalampi Health Centre and Tuukkala Hospital, colllecting data using drone monitoring, creating a digital marketplace and selling materials.
- *Roskilde:* Partial demolition and transformation of existing factory halls for new purposes, mapping materials and creating a physical material bank, then reusing the materials. Construction of two multi storey parking houses with on-site recycling of concrete, reused materials and design for disassembly.
- *Seville:* Replacing old pipelines for drinking water and sewage, testing and recycling the crushed concrete when laying down new pipes. Optimizing CDW management in the city with digital flow monitoring tools and connecting wellbeing and waste management with a digital Wellbeing Monitoring Platform.

During the demonstration phase each city supported by CRD and ICLEI performed the chosen demonstration actions, testing and fine-tuning the instruments and tools – and learning from each other.

The instruments developed within CityLoops, and the demonstration actions planned in the six cities in WP2 are designed to address different aspects of a circular value chain for the construction sector, which the project aims to promote. See figure 2 below.

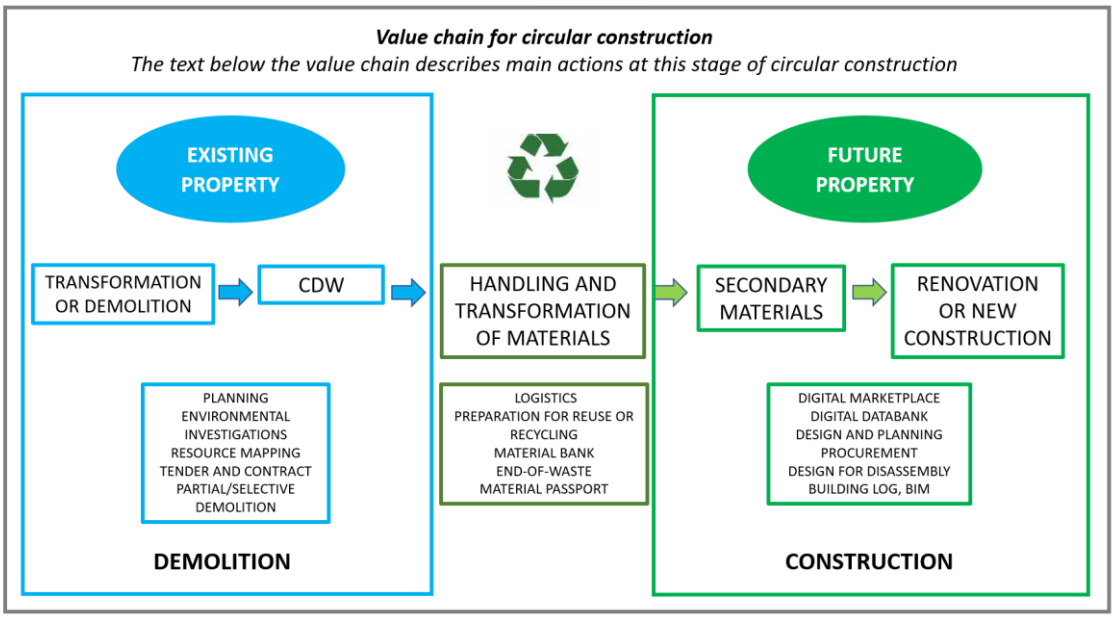


Figure 2: Value chain for circular construction from existing to new buildings. In traditional demolition and construction the blue and green boxes exist separately – circular construction aims to connect them via the transformation step.

In the demonstrations the partners are testing the developed instruments, tools and guidelines on pre-demolition, circular soil handling, material flow-tracking and management, stakeholder engagement and city development. An overview of the instruments is found in Table 2 in the previous chapter.

The work with the demonstration actions was framed by the development of Optimized Implementation Plans (OIPs) early in the project, describing the demonstration actions in detail. In the implementation phase each city described the progress of the demonstration actions in a log, the template building on the OIP. The cities made a draft demonstration report by month 36, an updated version by month 45 and a final demonstration report by month 48.

WP2 cross-consortium meetings were held once a month outside the holidays, covering general CityLoops information, status updates from demo managers, deep-dives into the demo actions and presentations and discussions about topics relevant across the consortium e.g. procurement, business cases or material passports. To enhance exchange of knowledge and experiences from the demonstration actions a study visit was arranged in each of the six cities in 2022/23.

The facilitation of cross-collaboration with deep-dives into topics as well as demonstration actions and study visits has created extensive knowledge about the other cities demonstration actions and dialogue about the challenges they have faced, how they have overcome those

and which solutions are being tested. This has also highlighted the different points of departure and the differences between the cities and countries as well as the likenesses and possibilities.

3.1. Innovation, implementation and lessons learned

The circular construction demonstration actions required a large amount of work as the procedures differ from construction or demolition as usual and thus more planning is needed, and new knowledge and new methods needed to be implemented. Below is a short description of the demonstration actions and the implementation. A detailed description of the work in each demonstration action is found in the demonstration reports for each city (D2.6 & D2.9-13).

Figure 3 shows which parts of the value chain was addressed in the six demonstration cities.

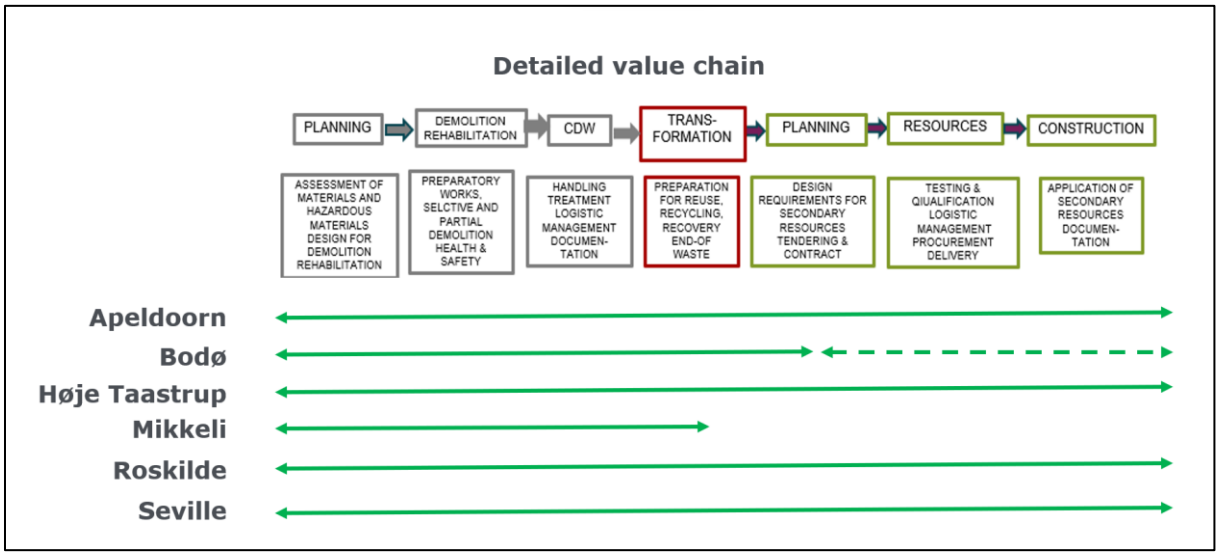


Figure 3: Detailed value chain with indication of which parts are covered by the demonstration actions in the six cities.

Most cities cover the whole value chain from demolition and transformation of e.g. concrete to the use in new construction. Mikkeli focused on screening and selective demolition and handling of the materials, while Bodø covered the first part of the value chain and some of the planning of the construction of the new city within CityLoops, and will continue afterwards.

Below is a short description of the cities work with the demonstration actions.

3.1.1. Apeldoorn

All Apeldoorn's CDW demonstration actions took place in close collaboration with Saxion, a Dutch university of applied sciences. The demonstration actions were all related to a residential road renovation project at Griffiersveld. As road renovations are common practice in many

municipalities, the tools developed and lessons learned in this specific case will allow copying and scaling up in other projects.

Figure 9: An impression of the residential road Griffiersveld before renovation

Figure 10: Parking space after renovating Griffiersveld where old concrete pavers were reused

In our analysis, Apeldoorn and Saxion build on theories of transition management. Specific attention is paid to the way Apeldoorn builds its internal and external coalitions, as this has proven to be difficult and essential. The demonstration actions of the Municipality of Apeldoorn concerning and concentrating in Griffiersveld involved three perspectives:

- societal perspective: a co-design process to align stakeholders and a participation trajectory with residents;
- technical perspective: developing material depots, adopting material passports, collecting road data and visualizing data;
- economic perspective: developing a CO_2 transport indicator, business models and online matching platforms.

All resulted in a particular physical appearance of the renovated residential road, accompanied by digital models and many lessons learned in line with the intentions of the CityLoops Optimized Implementation Plan (OIP).

New approaches and instruments

In the H2020 CityLoops project the municipality adopted multiple new approaches and applied different new instruments, as is explained in this demonstration report. Information about these experiences is laid down in five separate factsheets, conference papers, student reports, study reports and in the demonstration report.

- *Co-design process:* A new approach for the municipality was to align stakeholders in a co-design process with a focus on closing material loops. Traditionally, these residential road renovation design processes are done internally. By letting external stakeholders participate early in the design process, in a so called process journey facilitated by Koos Service Design, Apeldoorn and Saxion noticed an increased awareness and knowledge

amongst the different stakeholders on roles, tasks and perspectives. By bringing these stakeholders together in one group, awareness was increased on the cross-connections in the project. Ideas to improve circularity were generated and many were implemented.

- *Street scans with cameras on vans:* A new approach to acquire knowledge about material qualities and quantities involved automated scanning. Traditionally, a non-automated visual inspection was conducted by an inspector walking around on site. Various new scanning equipment and procedures were used to automatically collect data on the status of road materials in Griffiersveld. It was experienced that it requires quite some steps to store this automatically retrieved data in the asset management software of the municipality.
- *Drone scan:* After the project was executed also a camera equipped drone navigating on basis of GPS set points was used to scan the materials in place.
- *Circular procurement:* A new approach was to make circularity part of the procurement process. A small financial incentive was provided, improving the chance for a contractor to get the renovation project, when circularity was taken into account. In one A4 page the contractors were allowed to set out their own ideas to close material loops and to reduce the environmental impact of the project.
- *Calculating CO2 emissions:* During the project, the contractor helped in collecting data on distances driven enabling Saxion and the Municipality of Apeldoorn to assess CO_2 emissions.
- *Establishing and running material depots:* The implementation of physical and virtual material depots was also a new approach. Just like in many municipalities in the Netherlands, a soil and sand site were already available for many decades, but new physical material depots with different used products for Apeldoorn's public space were opened. These are at the disposal of contractors working for the municipalities and her own departments. Virtual relates to miscellaneous online material platforms, sites and applications.
- *Digital marketplace:* The Municipality of Apeldoorn now works with the matching tool DuSpot to match the used material supply and demand.
- *Citizen involvement:* When the new preliminary circular road designs were available, the municipality started to inform residents using a new approach. Due to covid regulations, it was not possible to get the residents involved more actively in an earlier stage of the project or in the process journey. By organising an event called 'sustainable doing day' for the residents and providing them information through letters, a brochure and a poster presentation, it is expected that the residents of Griffiersveld were more engaged with the circular aspect of the reconstruction of the road. The local social housing association, energy coaches and the contractor were participating in the event.

Implementation

The result of the circular demonstration project is clearly present in the appearance of the street today. The ambition was to renovate a street or section of at least 3000 m^2. In total a paved surface of 4.785 m^2 was renovated, without taking the surface of the kerb stones into account. For the road's foundation much sand stayed onsite, instead of bringing in debris from elsewhere, and 500 m^2 of onsite concrete pavers were reused in this residential road renovation project.

The road Griffiersveld was renovated with 49 tonnes less CO_2 equivalent emissions than normally would be the case. Old concrete pavers, concrete tile slabs and some kerb stones

were reused within the municipality and only two containers left the site with concrete waste materials to be recycled to aggregates for new concrete mixes.

H2020 CityLoops brought us an increased knowledge and awareness within the municipal organisation of Apeldoorn, by means of circularity now being part of design and procurement processes. The municipality is now facilitating multiple material depots, using asset management software as a project passport, and has adopted an online matching application.

External to the municipal organization, multiple residents and companies now have experienced that closing material loops is clearly a new focal point. Taking circularity into account offers new opportunities to reduce your environmental impact, to reduce costs or to increase turnover. The Municipality of Apeldoorn and Saxion UAS organised multiple events and participated in local, national and international events to actively disseminate the derived experiences and insights.

On the other hand, also some obstacles were experienced during the demonstration project. The municipal department were not able to turn the decision to use a new brown concrete paver in parts of the street instead of reusing the old pavers because of the requirements set by the welfare committee. If they had agreed to reuse all pavers Apeldoorn could have reduced the project's environmental impact by 174 tonnes of CO_2 equivalent emissions. This new paver chosen for aesthetic reasons by the urban planner to replace for approximately 90% the old worn out pavers did not encompass any recycled concrete aggregates; only virgin materials were used. Furthermore, used concrete products are generally low valued, while their handling and transport are quite labour intensive and costly. Old usable concrete pavers and curb stones needed to be provided to local agricultural organisations for free or else downcycling by means of crushing it into a concrete aggregate would be the only option.

Summary of lessons learned

A few important lessons are shared in this section.

Adapt existing structure for (automatically collected) project and material data: The Municipality of Apeldoorn had by means of her asset management system, a structure in place to store relevant quantitively and qualitative information on road materials for a specific road or road section. It is this data that makes up the project passport for Griffiersveld after automated data collection had taken place. It could speed up the circular transition, if other (municipal) organisations know that such an existing system can be used to facilitate them in the transition; it might not be necessary to develop completely new information systems.

Use road scans and 3D-GIS to collect data on materials and amounts: Road scans can provide additional insights in the status of road materials and 3D-GIS-data can be used to assess the volumes of material to be moved, indicating the workload and simplifying the planning process. However, developments are still needed to interpret data and to further automate data storage.

Dialogue with the contractor about possible circular measures: In the procurement process, the municipality, as the construction client, asked for circular ideas and measures. The bidding contractors were willing to make an effort to explain what vision they had regarding the renovation process, time management and circularity in the renovation of Griffiersveld. The winning contractor offered in total nine measures to improve circularity. For example keep the sand from under the pavement, because the quality is still good for the use of the street; use the bricks: crush them and use them for water collection. By actively implementing three out of nine measures the environmental impact was significantly reduced. Three measures were not adopted due to the extra costs. One measure regarding an online material matching tool was implemented by the end of the project. One measure out ruled another one, and about one measure communication was lacking. When a project is being executed, it is important that the construction client stays in close contact with the contractor to make sure that all measures are being implemented.

The sunny side in this project was that two circular measures were applied very successfully, namely the reuse of concrete paving stones nearby and the reuse of sand as a foundation. During the execution of the renovation, it was experienced that the main contractor was able to recognize various practical possibilities within its network to reuse materials instead of considering them as waste. For example the bricks could be reused for a local farmer. These possibilities were recognized at short distances from the project location and were arranged within a short time. It was estimated that more than 90% of all 3.785 m^2 concrete pavers have been reduced within the municipal boundaries. The lesson learned here is for the construction client to be open to the practical ideas of the contractor and maybe even other organisations in the field.

Know what's in store and what can be put in store: The online matching tool DuSpot had some advantages compared to other platforms. Thus the matching tool was made available to enable material loops in municipal projects to be closed. The material depots of the municipality are also spots in DuSpot, so that one can see what's currently in store.

3.1.2. Bodø

In Bodø, three demonstration actions have been carried out. These demonstration actions aim to:

- Embed circular material management processes of in the demolition of Bodø military airport.
- Establish a practise of stakeholder and citizen involvement in city development.
- Embed circular strategies in the planning of the new city district.

Picture: Demonstration area

The background for these actions is the huge city development projects going on in Bodø, with focus on one, namely the project where a military airport is relocated, a new part of the city and a new airport is to be constructed. Additionally CityLoops instruments are demonstrated in other projects, like the road renovation project Sjøgata and the demolition of a school.

New approaches and instruments

To carry out the demonstration actions, a set of new instruments, methods and actions have been practised, including:

- *3D GIS-based visualisation tools for monitoring and planning (Digital Twin):* Using 3D technology to visualise data related to materials, emission, soil, traffic, BIM-models and reusable buildings on demonstration site. The rationale for this is that complex data is easier to understand if it is visualised, and correlations between different factors are easier identifiable. This enables decision makers to do informed decisions for a sustainable development of the city.
- *CO2-calculator:* Used to assess CO2 savings from reuse/recycling – it has been added to the 3D visualisation.
- *Mapping masses and materials:* Mapping the masses, materials and structures in the city and feeding the information into a databank.
- *Marketplace:* The city established collaboration with a local waste company to develop a marketplace for reused materials.
- *Screening procedures and tool for selective demolition:* these guidelines were used in demolition of a school.
- *Circular soil handling:* The instrument for creating a Soil Roadmap as well as the Instrument for Predicting Future Excavated Soil Production has been applied in Bodø.
- *Stakeholder involvement:* Using CityLab (ByLap) stakeholder engagement platform at Bodø town hall, developing networks with relevant stakeholders on circular construction as well as involving citizens in the circular design of the new city. Bodø has held arrangements aimed at businesses, academia, public sector and inhabitants. They designed some very creative events, like the Minecraft challenge.

- Wellbeing monitoring tool: Exchange with Seville about this tool and the indicators for measuring the wellbeing of citizens. Used as input for Bodø activities.
- *Circular procurement:* Implementation of sustainable and circular procurement, including data gathering on tenders, workshops, establishment of new procurement strategy.
- *Innovative technology for sustainability:* Developing, using and implementing the use of innovative technology for sustainability, like development of a contaminated soil-dashboard, the use of the Material Mapper, and other data management programs to help the municipality get insight on materials & masses and its reusability.
- *Mass handling strategy:* Establishing a mass handling strategy in an overall environmental program for the city development projects, committing the municipality to treat masses and materials to the highest circular degree possible.
- *Requirements on circularity for all building applications:* Preparation of proposals that sets requirements to circularity on all building applications that is treated by the municipality.
- *Circular requirements for architects and city developers:* Defining circular requirements for architects and city developers as criteria in a mission competition on the development of the new city.
- *Circularity assessments:* New knowledge was generated by creating a sector-wide and urban circularity assessment in Bodø.
- *Business cases:* The municipality created business cases on treatment of soil and materials that takes into account not only financial values but also environmental and social factors.

Implementation

In the project, employees in Bodø municipality from different departments have been involved, mainly from business & society, building & property, technical sector and IT. Furthermore, contributions from external actors like Avinor (airport owner), NorConsult (consultant), Augment City (software developers), Nord (University), Circulus (research project) have been crucial in the project.

The CityLoops project's demonstration site is located at the airport area where the new airport and the new part of the city will be constructed.

The structures and materials of the area has been mapped and entered in a 3D visualization tool, helping design the new city with existing masses and structures, and support decisions about the best solution to save CO2, minimise traffic etc. The physical construction and demolishing work on the demonstration site was delayed due to covid, financing and political uncertainty. However Bodø made sure that the CityLoops activities in the optimized implementation plan was still performed. CityLoops has been involved in planning the execution of the project and has been crucial in preparing and manifesting strategies that commits the city development project to a sustainable and circular handling of construction and demolition waste (CDW).

Physical testing of CityLoops tools have taken place in pilot projects in Bodø, including a road renovation project in Sjøgata where 10 000 – 15 000 tonnes of masses of different quality needs to be treated. The different mass treatment options are what the project's business case is based on. Furthermore, tools for registering reusable materials and preparing selective

demolition, have been used on a school in Bodø that is to be demolished. Such pilot actions enable us to demonstrate and test CityLoops tools before they are used in the New Airport New City project.

In addition to influencing how these projects are carried out, CityLoops in Bodø has also had a city-wide focus in terms of influencing how masses are treated, procurements are carried out, emission is reduced, and stakeholders are in involved in city development projects. To evaluate the effect of CityLoops activities, indicator data is gathered to measure whether or not Bodø's circular and sustainable practise is increased.

In the process of increasing circular treatment of materials in the city, social and financial factors are also taken into consideration meaning that data related to these is also gathered and interpreted.

Summary of lessons learned

The CityLoops project has facilitated collaboration among cities in their pursuit of transformative and innovative processes. In the specific context of adopting circular practices related to CDW, it becomes apparent that such adoption necessitates a distinct utilization of resources.

Drawing insights from the experiences of others has proven to be a catalyst and a driving force behind participatory methodologies aimed at generating knowledge and facilitating the exchange of information.

The development of various tools, including the two tools, 3D Visualization (Digital Twin) and Stakeholder engagement, has been a crucial factor in enhancing the efficiency and effectiveness of processes. These advancements have resulted in the creation of multiple tools that aid decision makers in making well-informed decisions grounded in high-quality data.

The utilization of digital twin technology has facilitated the creation of data visualizations, enabling the development of various scenarios. These data-driven scenarios serve to either validate or dismiss certain decisions.

The stakeholder engagement platform has strengthened the collaboration and mutual understanding of circular economic strategies of stakeholders in all processes in the value chain.

The implementation of a circular economy can contribute to the achievement of the climate and environmental objectives outlined in the city or municipal plans. This approach can effectively reduce emissions, facilitate targeted interventions in areas with the greatest environmental impact, and implement necessary corrective measures as required.

Engaging in *rigorous testing, diligent study, and meticulous replication* of actions establishes a robust framework for learning from past errors and sustaining long-term solutions that effectively address the unique needs and circumstances of a given society.

The utilization of *material stream analysis and material mapping* has facilitated the identification of potential applications for secondary materials, taking into consideration their

quality and the opportunities for upcycling, reuse, repurposing, or rethinking. This approach aims to prevent landfill disposal and mitigate environmental contamination and degradation.

Selective demolition and effective construction project planning, which can be facilitated by tools such as the Life Cycle Assessment, are commendable practices that enable organizations to quantify the cumulative benefits or cost savings associated with adopting a more environmentally friendly approach.

The actions and studies conducted have clearly demonstrated the necessity for the *establishment of intermediate storage facilities* to facilitate the reuse of masses. Additionally, it has become apparent that distances and collaboration are crucial factors that significantly impact all stakeholders involved in this process.

The topic of *procurement* has garnered significant attention throughout the project, as it possesses considerable potential to influence the acquisition of products and services, particularly with regard to circular criteria or criteria that facilitate circularity practices.

To enhance the likelihood of *favorable outcomes* in planned projects and goals, it is crucial to thoroughly examine various materials, costs, scenarios, and comparable cases. Additionally, careful consideration of environmental, social, and economic factors is essential.

Simultaneously, it is imperative that *goals are attainable,* and that indicators for monitoring and evaluating specific actions are developed and regularly assessed. The successful implementation of circularity in decision making within a specific city necessitates the active involvement of dedicated and proactive leadership, decision makers, and engaged colleagues.

3.1.3. Høje Taastrup

Høje Taastrup had 5 demonstration actions spanning both private and public projects. The municipality strived to act as match-maker between the material flows in different projects and facilitate the establishing of partnerships between them. The demonstration projects were:

- Demolition of Taastrupgård, extracting concrete for recycling
- Construction of the new City Hall with recycled concrete from Taastrupgaard
- Circular management of excavated soil from construction of new City Hall
- Development and test of recycled sidewalk tiles
- Transformation of the old city hall and the surrounding area
- Implementing circularity when selling old City Hall for demolition

Figure 4: Making the foundation for Høje Taastrups new City Hall with recycled concrete (Photo: Unicon)

Several of these demonstrations were strongly interlaced, with Taastrupgård providing the concrete for the recycled foundation of the new city hall, and circular soil management taking place between these two projects as well.

Through these demonstration projects, the municipality achieved implementing circular criteria in the tendering material for the sale of the old city hall; succeeded in diverting over 1000 tons of concrete from the demolition of Taastrupgård for use as recycled aggregate for the new city hall; experienced that it is never too late to integrate circularity into a project after getting circularity described in the tendering material of the new city hall - which resulted in a recycled concrete foundation being used; found out that it is essential to identify key stakeholders and key risks and who has responsibility for what; and saw a shift in mindset in terms of sustainable soil management.

New approaches and instruments

- *Decision-making and planning guidelines:* The decision and planning process was mapped out for Høje Taastrup and workshops held with the relevant stakeholders in the municipality. Together with an analysis of the process in Roskilde this shaped the development of the Decision-making and Planning instrument. The experiences from CityLoops will now be implemented in the municipality´s Sustainability Action Plan.
- *Procurement:* Høje Taastrup tested different aspects of circular procurement in several demonstration actions: Buying recycled concrete from Taastrupgaard for the new City Hall, trying to develop and find a test site for recycled sidewalk tiles and in the circular

tendering of the sale of the old City Hall. Several challenges were faced and most handled with success.

- *Business Cases* were made for Circular Soil Handling and recycling of concrete, which had not been done in Denmark before, and they were positive.
- *The Stakeholder Engagement Plan* was made and the stakeholder engagement and dialogue proved to be central to the success of the projects and to create change.
- The Pre-demolition Audit Guide and Guide for Selective Demolition were used in the tendering of the sale of the Old City Hall .
- *Recycling of concrete* for the foundation of the new City Hall was a pilot project which will hopefully lead to permanent change of practices.
- *CO2e calculators* for circular soil handling and recycling of concrete was used and showed large CO2 savings.
- *The three soil tools:* Roadmap for circular soil handling, Instrument for predicting future excavated soil and Methodology for on-site soil reuse was developed alongside with the experiences from the demonstration actions and will form a backbone in future circular soil handling.

Implementation

Høje-Taastrup's demonstration cases are all related to the current urban development taking place in the municipality. The demonstration cases are to certain degrees related to each other. Concrete from the demolition of Taastrupgård was used as recycled aggregate in the foundation of the new city hall – and considered as aggregate for the recycled sidewalk tile. The demolition of the old city hall could not take place before the construction of the new city hall. Sustainable soil management is an important factor in all urban development, including the development of the old city hall area and the construction of the new city hall.

Høje-Taastrup build a new city hall. The foundation of the new city hall was made with 100% of the stones in the concrete being replaced with aggregates of crushed concrete from the demolition of Taastrupgaard. Thus demonstrating a complete recycled concrete loop. The process faced some challenges due to risk aversiveness in the consultant company, but the concrete specialist supervising the process decided to take the responsibility in order for the project to move forward.

Høje Taastrup also managed to demonstrate circular soil handling. The soil from the construction site was used locally in Taastrupgaard. Høje Taastrup also followed the process of circular soil management in the urban development area Nærheden, which managed to keep 90% of the excess soil on-site, saving both CO2 and money for transport.

The municipality looked into recycling concrete from Taastrupgaard or other sources as pavement tiles. They found a company willing to produce recycled tiles, but they could not find a test area - again due to risk aversiveness: The construction owners behind the urban development in Høje-Taastrup C showed interest in the tiles but the lack of guarantee of the quality and durability of the tiles eventually resulted in the development company refusing to use the tiles – and this has been the case with all developers approached by the municipality. However, the municipality is again in dialogue with private developers who may be interested

in testing the recycled pavement tiles – and they also push for the municipality itself to do so in the future.

The last demonstration action took an interesting and very circular turn. The demonstration action was the sale of the Old City Hall for demolition with circular criteria in the tendering material. The municipality sold the old city hall due to the need for extensive renovations. The urban development plan states that it should be developed into a residential area resembling the nearby old village of Høje-Taastrup. The old city hall and surrounding property was therefore sold for demolition with circular criteria for reuse and recycling of CDW and circular soil handling. According to the original plan, the demolition was planned to start in the beginning of 2023. However the quality of the building as well as price inflation and decreasing sale prices led the developer to reconsider demolition, and they are now working towards adaptive reuse for (part of) the old town hall as apartments. Circular soil handling, soft-stripping and partial demolition will still take place following the CityLoops criteria and being documented for the municipality, but not within the CityLoops timeline.

Summary of lessons learned

Looking at the demonstration actions all together, certain themes stand out that from the lessons learned:

- Adaptive reuse of buildings compared to demolition and new construction gives by far the biggest resource and CO2-savings as illustrated by in the demonstration action concerning the Old City Hall.
- Plan for sustainability and circularity right from the start of any project - or as early as possible if a project has already started. While it is easiest to implement circular actions as early as possible, it is never too late – as illustrated in the last minute change to use recycled concrete in the new City Hall.
- Aim for a high ambition level in actions and tenders. The market is ready to respond if there is a demand. Plans can always be adjusted, but starting with a high level of ambition contributes to setting the intention.
- At the same time, celebrate the small successes - Rome wasn't built in a day. Being inspired by the small successes can give traction to the bigger initiatives.
- Involve all relevant stakeholders/departments/people of the value chain to ensure meaningful cooperation.
- Identify key decision makers to ensure that the project in question can actually commit to sustainable initiatives.
- Assess key risks and how to address them, as well as which party is legally responsible for these risks. Confirm that they are willing to take on the risk, ease this process by identifying how to mitigate risk and how to remedy the situation if it occurs.
- Lobby for political change and action in favor of sustainability, both within the municipality and at higher political levels - regionally, nationally or on an EU-level, depending on which political body is responsible for the change in question. This helps make it a standard rather than an exception to operate sustainably.

- Until regulations or laws are established regarding circularity, the success of initiatives is highly dependent on individuals who are dedicated to the initiative.

3.1.4. Mikkeli

The Mikkeli demo case consisted of two phases:

- Case studies of the demolition of two public buildings: the Pankalampi Health Care Centre and the Tuukkala hospital and
- action research of the decision-making processes and policy interventions related to systemic changes needed in the setting of circular economy policies, planning, market engagement, procurement, contracting, permitting and enforcement of public owned demolition projects and waste management and reuse of building parts and wastes.

Figure 5: Pankalampi Health Care Centre

Figure 6: Tuukkala Hospital

New approaches and instruments

The following new CityLoops instruments and approaches were developed and applied in the demonstration cases:

- Digital marketplace for buying or selling reusable building parts or materials was developed
- 3D modelling to track onsite CDW flows with drones used in the demolition projects
- Databank for Recovered Construction Materials receiving the data from the drone scan
- Monitoring environmental and health effects of demolition as well as hazardous materials and contamination of buildings
- CityLoops guide for pre-demolition audits was co-developed in parallel with the demo cases, using the Finnish pre-demolition audit guide as a model. The guide was tested by commissioning a pre-demolition audit of a part of the Pankalampi case
- CityLoops guide for selective demolition was co-developed in parallel with the demo cases

- Lifecycle CO_2 calculators for concrete, soil and mixed CDW developed by Roskilde Municipality were tested in Mikkeli demonstrations to compare waste management options

Implementation

Before and during the demolition of the demonstration buildings, screening procedures were carried out to find out the recycling and reuse possibilities of the demolition materials, to test 3D drone modelling to track material flows, and to monitor the health and environmental effects of the demolition.

Mikkeli found that the pre-demolition audit guide is an important tool that is suitable for replication in all demolition sites, but effective implementation still requires more experience. Also 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.

Drone monitoring was carried out at the Tuukkala and Pankalampi demolition sites during 2021. The imaging was performed mainly 1-2 times a week during demolition phase. The aim of the drone monitoring was to demonstrate mainly CDW volume calculations using the 3D modelling tool.

Mikkeli found that the use of 3D modelling tool to monitor demolition waste flows was a cost-effective alternative in evaluating the amounts of material flows on-site when compared to traditional methods, e.g. tachymeter. The method can also produce useful data e.g., for the pre-demolition audit and planning of the demolition work. Volumetric measurements based on 3D imaging could be a useful tool for contractors, building owners, consultants, and designers especially in the future, when the reuse of building parts and materials are expected to increase. Camera techniques should be further investigated for automatic material recognition as the multispectral camera used (Micasense RedEdge-MX) was not able to recognize different CDW materials.

Selective demolition was implemented well in the demonstration projects and the sorting rate in the demonstration sites was over 99 %. The city-level recycling rate of CDW increased by 11 % from 2019 to 2021. At the same time incineration rate decreased 11 % and landfilling rate 1 %. However, there is lot or yearly variation in recycling, incineration and landfilling rates depending on total amounts and types of demolition projects and CDW. Now most of CDW materials are utilized in the Metsäsairila sorting and recycling centre area in earthworks. New local procedures and companies on circular economy are needed to increase the upcycling of materials.

In the planning phase of the project, the aim was that 5% of the materials would be reused on the demonstration sites. This goal was not achieved because there were no new building plans for the demonstration sites where the materials could have been reused.

In the planning phase of the project, there was also goal that cost effectiveness in the demolition of buildings would increase 10% compared to baseline values. This outcome was only partially reached. Total demolition costs were 30% lower than baseline, but there may be also other reasons for the decrease in costs than increased circularity (like type of the building, number of floors). The average waste costs were not decreased.

Circular economy was recognized as an important element in the Climate Program for Mikkeli City. A separate section on “Recycling of materials in construction” was included in the program.

Mikkeli has set a target in its City Strategy that states that by 2025 25 % of relevant tenders issued by Mikkeli should include criteria related to sustainable development and circular economy. The monitoring and reporting system for the implementation of this outcome is under preparation.

The current procurement practice prevents the demolition contractor from offering recycling services of its own: the only acceptable option is to deliver all demolition waste to the city owned waste company. Miksei CityLoops team has pointed out that an alternative approach is an open call for tenders for a long-term contract of managing specific CDW streams.

As a result of the CityLoops project, a new procurement guide has been drawn up to promote the circular economy in demolition projects. The guide proposes new qualitative requirements, benchmarks, or contractual incentives. Even reversed tendering could be used in demolition contracts: there the price is fixed, and awarding would be based on the quality of circular solutions proposed by the tenderers.

Summary of lessons learned

Procurement practices focusing only on lowest price cannot be used to promote CE. At the same time using in-house waste management as the only model can be seen as conflicting with the business promotion goals set in the Growth Strategy of Mikkeli.

In parallel with the CityLoops project Mikkeli has now adopted circular economy in its Climate Program and its City Strategy. The policy goals need to be translated into institutional change and adopted as new practices in all relevant departments.

Reuse of building parts cannot be promoted without a pre-demolition audit. The soft stripping procedure must be formalized with clear roles and duties for each participant. At least the soft stripping phase must be executed promptly after the last user of the premises has moved out. Soft stripping and organizing the reuse of items should occur before moisture and vandalism ruins the items.

Organisational change and changes in procurement practices must start from the strategic level. The policy level actors must set clearly defined circularity goals and indicators to monitor the implementation. This work has now started in Mikkeli with significant contribution from the CityLoops project.

Better coordination is needed between environmental authorities and building permit authorities and the units implementing public procurement. The minimum requirements on a case-by-case basis could be defined in the demolition permit or in the tender documents or both.

Land use planning, which in Mikkeli is lagging the demolition boom should be engaged so that the mass balance of digging soil and using of natural and recycled aggregates or building parts could be coordinated with infrastructure planning and operations.

CityLoops Mikkeli team proposes that the Mikkeli City Consortium would adopt a practice that a pre-demolition audit is performed for all demolition cases exceeding 250 m^2. In addition, the City Consortium organizations should consider creating a “pipeline” of future demolition cases within 5-10 years scope by creating a database of basic data of the material masses and reusable construction parts.

Drone monitoring and 3D modelling could be developed to aid the flow of building parts and recyclable waste to be used in a parallel building site. Using a drone can also be a useful tool during the pre-demolition audit before the demolition work begins. Drone imaging can be used in the planning of the demolition work. The overall progress of the demolition work can be monitored using a drone.

Recommendations

The systemic transformation in a city organisation requires time. It needs ambitious leadership decisions to initiate the change and to set realistic step-by-step goals and measurable indicators. It requires back and forth processes to engage the substance experts in the process of setting the goals.

Public-private partnership must be forged through the procurement activities to identify new ways of planning and implementing construction projects and linking demolition to new uses of demolition materials and building parts.

Circular economy is a necessity and an important part of climate action and sustainable development. Adopting circular practices may cause extra costs in the development phase, but neglecting such changes constitutes a major risk of losing vitality and a positive image as a city and failing to promote the competitiveness of local businesses.

3.1.5. Roskilde

In CityLoops the municipality of Roskilde has developed procedures, methods, instruments and generated knowledge to promote a circular transition, through a series of demonstration projects. These demonstrations took place in the urban development area Musicon, a transformation of an old concrete factory and former waste deposit. The area contains a series of production halls and the development of the area focuses on preserving the industrial aesthetic as well as the existing buildings, to be a hub for creativity, music and cultural activities.

The demonstration projects are:

- Transformation and partial demolition of old factory halls
- Circular construction of two Car Parks
- Circular soil management in the area.

New approaches/instruments

To support the promotion of circular construction, demolition and urban development, a series of methods, instruments and tools was developed and tested in the demonstration projects. In Roskilde the following were developed and/or tested:

- *Procedure for CDW to obtain a Material Passport: The* procedure consists of first, an environmental and resource screening to identify materials or elements for reuse and recycling. The information is typed into an Excel sheet, which forms the Material Passport. Information includes procedures for handling and application a structural assessment of the materials and recommendations for application. If the materials are planned for reuse or recycling, information about location of storage and expected future use (time, place and building) is also included. If this is the case, the elements or materials will be added to the tendering of the selective demolition. When the demolition is completed, the elements and materials are assessed for further tests required for reuse/recycling Based on a colour coding. Green means they are fit for direct reuse/recycling, yellow means they need further testing, red means they should

not be reused/recycled. The local construction authority can then authorize use of the materials in a new construction if they fulfil the requirements for application.

- *Lifecycle CO2 calculator for soil:* Based on an LCA methodology, the tool calculates the CO2 impact of excavating and moving soil from a site. In the demonstration phase, the methodology has been applied in planned soil movements in Musicon, including the demolition and reconstruction works of hall 11/12, and is also considered in the procurement process for the demolition works, to encourage site soil balance.
- *Lifecycle CO2 calculator for Concrete:* The tool calculates the lifecycle CO2 impact of using and demolishing concrete. The tool was used in the pre-demolition screening of Hall 11/12 to encourage preservation and recycling of concrete. The tool will also be applied to other projects in the Musicon area.
- *Lifecycle CO2 calculator for 11 fractions of CDW incl concrete:* Building on the CO2 calculators for soil and concrete, the calculator for CDW, was expanded to 11 fractions and developed to specifically support planning and decision inthe demolition process, on whether to keep and refurbish, deeply renovate, or demolish a building by comparing a multi-material composite calculation taking into account the pre-demolition state, and post-demolition state of the CDW. The tool has been tested at Hall 11/12 and the methodology will be applied in other projects in Musicon.
- *Framework for circular soil management: Roskilde* is incorporating a circular soil strategy in urban development strategies as well as real estate management strategies. A builders guidance has been developed as the project planning went on for the demonstration project at the parking house area in Musicon. In the process the builders guidance has been designed to address each identified barrier. For tendering, prices and CO2 calculations have been lifted to the same strategic decision level in order to highlight the economic potential of circular soil management in the future. The effect of the circular soil strategy has been evaluated on project level by comparing predicted soil volumes with soil volumes which has proved to be suitable for use inside the project area. Current builders guidance concentrates on the description of the procedure regarding necessary steps in the initial work prior to the project planning, and simultaneously with the construction process. The framework is applied to identify levers, plans, procedures or tools promoting circular soil management in Roskilde Municipality to support the development of a circular soil strategy. Key actions are identified at the strategic, tactic and operational level including main actors to be involved, thus supporting the alignment of strategies, plans and operational procedures. The effect of the circular soil strategy will be evaluated on an annual basis by comparing predicted soil volumes with soil volumes actually produced in corresponding years.
- *Instrument for predicting future excavated soil production:* Roskilde has used this tool to predict annual volumes of future excavated soil within a period of 12 years (2020-2031). It will be evaluated by comparing predicted soil volumes with annual soil volumes reported. Drawing on data from planned future construction works, the prediction is based on a “business as usual” scenario, considering a situation where municipal planning and construction activities are performed without paying special attention to excavation and production of excavated soil, to mobilize planning efforts to avoid soil excavation, contamination and movement – creating both economic and CO2 savings.

Implementation

Transformation of Hall 11 & 12

Hall 11 and 12 are secondary buildings situated in the demonstration area. Hall 11 has been screened and partly selectively demolished, and materials from the demolition incorporated into other construction projects. Hall 12 was preserved and renovated keeping its current function as a skaterpark. Some of the high quality aggregates such as steel structures are dismantled and preserved. Hall 12 will be connected to car park “Pulsen”.

To secure the quality of the materials, the following actions was applied:

- A pre-demolition audit and selective demolition was performed to preserve and document the materials
- A material passport afterwards documented the quality of materials and possible application.
- A virtual material bank was developed using Building Information Modelling (BIM) for information on regulations, quantities, material types, etc.
- Life cycle assessment (LCA) on selected materials was performed to support decision making by revealing the carbon emissions impacts of different handling options.

Car Park “Indfaldet”

Based on experiences from minor construction projects, the Car Park Indfaldet was developed as flagship to apply circular actions in larger commercial projects. Thus circular tender criterion was included to engage market dialogue focusing on recycling of materials, design for disassembly, multifunctionality, and reduced CO2 emissions. When preparatory digging for the car park was initiated, a large amount of concrete obstacles was discovered, originating from concrete production activities from the past. The concrete was stored and crushed on site, to be integrated in the construction of the car park as filling under the foundation and as aggregate in the new concrete. This resulted in a positive business case saving almost 53,000 € and 6-tons CO2 on demolition, loading and disposal of concrete residues, as well as on the price for new gravel and aggregates.

Car Park “Pulsen”

The construction of the second multi-storey car park was delayed due to rapidly rising costs of construction. The delay was used to investigate further options to build with reused materials. Besides using recycled concrete aggregate in the foundation, application of reused hollow core concrete elements, is tested, moving concrete elements up in the waste hierarchy from recycling to reuse. As this requires a very different risk assessment method, it involves close cooperation between advisor, contractor and building authority. In the new car park a physical material bank in the ground floor will be created and a roofed passageway between the car park and hall 12 will connect the projects. The project is now on its way, but the new car park will be finished outside the CityLoops timeframe.

To secure the quality of the materials, the following actions was applied:

- A Sustainability plan was developed for the projects and quality criteria was formulated to secure circular decision-making in procurement

- A Design for disassembly manual was created and demountable joints applied to preserve materials for future use
- An LCA was performed to document environmental benefits of reuse and recycling
- Multifunctionality involving local stakeholders provided the car park higher value to the community and more efficient use of m2
- Reuse and Recycling of materials reduced CO2 emissions and consumption of virgin resources

Circular soil management

To secure circular soil management, thus minimising excavation and transportation of soil by using excess soil locally, a series of instruments were tested in Roskilde. To support planning and decision-making in the Hall 11/12 area, LCA calculations were performed to assess the CO2 impact of minimising excavation and transport of soil. Moreover, barriers in reusing soil was uncovered by interviewing authorities, clients, advisors and contractors with experience in projects involving circular soil management. The result was that all soil was reused locally.

At the strategic level activities supporting the development of a circular soil strategy was conducted. Feeding into such strategy a framework for circular soil handling was tested, and a prediction of potential generation of soil to be excavated in the coming years was performed.

Summary of lessons learned

The overall approach taken within the circular demonstration actions in Roskilde Municipality has several key aspects:

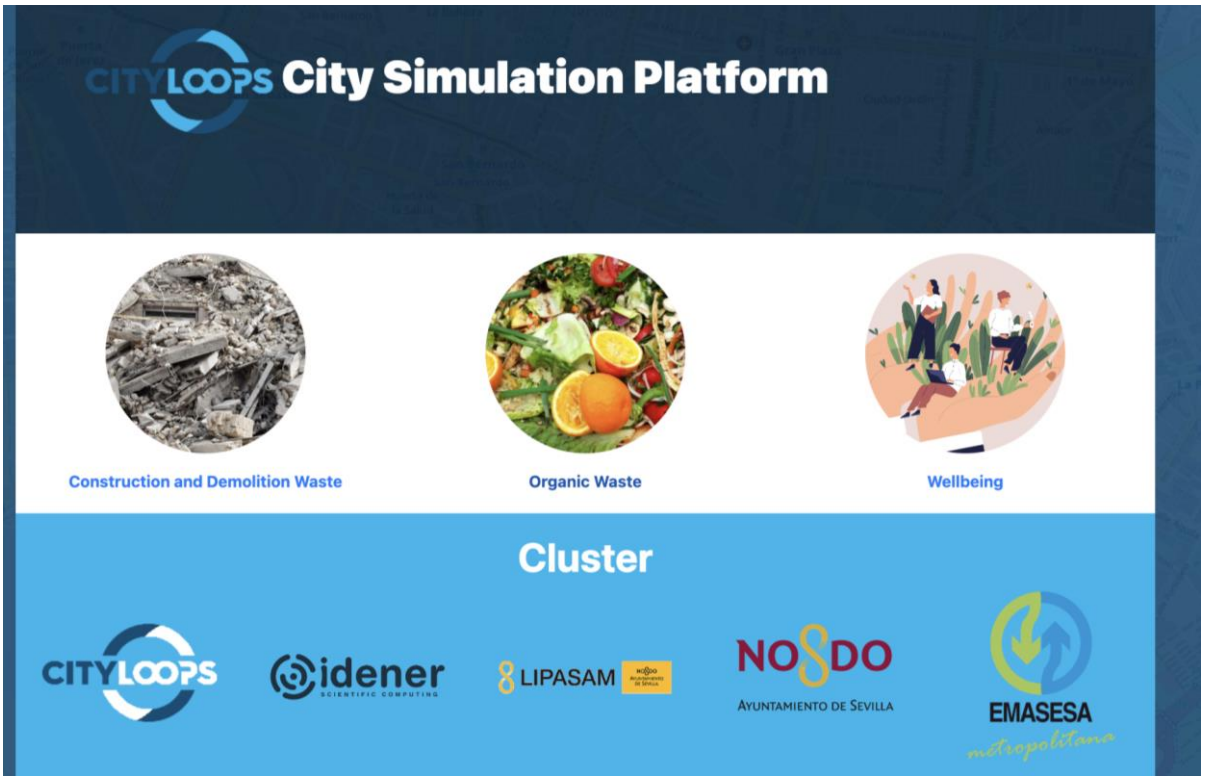
Local Context and Collaboration: The success of the circular demonstration action in Roskilde is closely tied to the understanding of the local context and the collaboration between various stakeholders. To replicate the approach, it is crucial to assess the specific conditions and challenges of the target region. This includes factors such as waste management infrastructure, regulatory frameworks, available resources, and the willingness of local stakeholders to participate and support circular initiatives.

Circular Economy Strategies and Policies: The circular demonstration action in Roskilde is underpinned by a strong commitment to circular economy principles, which are reflected in the municipality's strategies and policies. These include setting clear goals and targets for resource efficiency, waste reduction, and sustainable practices.

Integrated Approach and Innovation: The circular demonstration action in Roskilde takes an integrated approach, addressing various sectors and value chains to maximise resource efficiency and minimise waste. It also emphasises innovation and the adoption of new technologies and practices to enable circular solutions.

Knowledge Exchange and Learning: The circular demonstration action in Roskilde places importance on knowledge exchange and learning from other regions and stakeholders. This includes sharing best practices, participating in networks and initiatives, and actively seeking collaboration opportunities.

3.1.6. Seville



In order to comply with the current European objectives in the field of the municipal waste management, the City of Seville is seeking to implement various tools and actions, to advance the circular management of CDW, its ulterior treatment and valorisation as well as the optimisation of its logistics, awareness of citizens and small generators of CDW as well as municipal companies and large constructors.

Three demonstration actions were carried out in Seville:

- Renovation of water pipelines with circular material management
- Optimising clean points (municipal facilities to specific waste management such as CDW)
- Development of IT tool to the data driven decision making and Best Practice Guidelines for CDW Management in Sevilla.

All demonstrations were conducted in collaboration with stakeholder groups. The main stakeholders Lipasam, Emasesa, Idener, City Council of Seville, Fermovert (CDW management company), citizens and constructors.

New approaches/instruments

In the demonstration action on renovation of water pipelines with circular material management the new approaches and instruments have been:

- Development of an instrument for Quality Assessment of CDW
- *Strengthened alliances* with relevant local and regional actors in the field of CDW circularity.
- The *increased amount of material that is recovered/recycled*, and therefore reduced amount of material that is deposited in landfills
- 2 sites in which underground pipe replacement was carried out with *recycling of unearthed CDW*
- The usage of material from public construction projects, local re-use of CDW and/or soil for combined climate-adaptation and recreational purposes by Fermovert
- A *circular procurement criterion* will be standard in all Emasesa's projects, demanding for reuse and recycling of CDW
- Development of a *Best practices guidelines* on CDW management

In the demonstration action on Optimising clean points the new approaches and instruments have been:

- Advance in the fulfilment of the European, national, and regional objectives, in the *selective collection, recycling and not disposal in a landfill,* marked by Directive 851/2018 and 850/2018.
- Strengthen the *education, awareness and knowledge of citizens* and other socio-economic agents related to the basis of the circular economy about the improvement of CDW management.
- *Reduced illegal dumping* and abandonment of CDW and increased reused and recycled CDW due to the awareness campaign and improved management and clean points.

In the demonstration action on data-driven decision-making and Best Practice Guidelines for CDW Management in Sevilla the new approaches and instruments have been:

- *Increase the amount of material that can be recovered/recycled,* and therefore, reduce the amount of material that is deposited in landfills.
- Contribute to the *decision-making process* of the municipality managers to develop circularity plans and prioritize actions in the city to increase Well-Being.

Implementation

Renovation of water pipelines: Seville is replacing the old water and sewage pipelines in large areas of the city. In this demonstration action, Emasesa undertook the circular renovation of old water and sewage pipelines by recycling concrete, road surface, filling, and soil in the placement of new pipelines.

A Quality assessment tool was developed to ensure the environmental quality of the concrete that was crushed and used around the new pipelines.

Tendering criteria for recycling concrete, road surface, filling, and soil in the placement of new pipelines was used. During CityLoops it has gone from including the circular criterion in 25% of the procurements to 100% in the procurements currently. Offers submitted in the tendering processes during CityLoops implementation have gone from 98% to 100%.

Considering framework conditions, a standardisation of the methodology to circular CDW management has now been identified as a requirement. Also Emasesa has developed Best Practices Guidelines.

The positive interest shown by the local stakeholders in the engagement strategy has been critical to the performance of the demonstration action.

City Simulation platform: Seville has created a centralised virtual hub for software tools and datasets to support its sustainability goals. It includes:

- *CDW Flow optimisation instrument* that supports managers on deciding new locations for future clean points, while giving citizens access to a map with the location of the optimal clean points. The CDW flow optimisation for citizens is available here
- *Wellbeing monitoring tool that* determines the relationship between wellbeing and the demonstration actions. The tool is focused on circularity, giving mangers access to a simulation framework that quantifies the influences of circular actions on well-being, while providing citizens with data about the well-being circularity indicator, demonstration actions, and impact estimations on the city´s well-being. The well-being simulation for citizens is available here

Combining these tools in a platform supports cross-sectoral dialogue and facilitates data exchange between municipal departments, research institutions, and relevant business partners. The platform can be used during stakeholder engagement events to forment an informed, flexible, and balanced transition to circularity.

Optimising clean points: In this demonstration action, Idener developed a digital tool to help optimise the use of Seville's five clean points (local recycling stations) for the collection of CDW from citizens and small producers. Additionally, Lipasam arranged an awareness campaign to increase the users' commitment, increase the use of the clean point and prevent illegal dumping of CDW.

The digital tool visualises the presence of clean points around the city and the proximity of the sites to citizens (e.g., easily accessible with a car and nearby to residential areas). It is created to maximise the divulgation of CDW collection service and facilitate users' actual information of the clean points. The managers of the clean points can use it to optimise the infrastructure and facilities according to actual requirements (including machine learning methodology to analyse available data). The platform has had 6,824 visits to the tool in the last 12 months.

To enhance the performance of the Clean Points the managers have created separate collection of as many fractions as possible and the possibility to drop off professional CDW, under the limits established. The staff of clean points has been trained to maximize CDW recycling and appropriate management. Also long opening hours to enhance convenience for citizens.

To stop illegal dumping of CDW regular inspections of "frequent" areas where waste is abandoned has been performed. The local neighbourhood of the surrounding areas has been engaged. And there has been an awareness campaign about possible sanctions for CDW abandonment.

Data-driven decision-making and Best Practice Guidelines for CDW Management in Seville: In this demonstration action, Idener developed a digital tool to analyse the Well-Being of the districts in Seville city.

There are a lot of socio-economic and environmental indicators related to the wellbeing of a city. A good understanding of the impact of those indicators on well-being can facilitate the transition to a circular economy.

The development of IT wellbeing monitoring tools help the municipal managers make decisions, since they analyse a large amount of data and can advance data analysis and create different future scenarios, thanks to the methodologies of Machine Learning.

The wellbeing platform highlights that the municipal waste management as well as the house renting pressure in the city have a critical impact on the wellbeing of citizens. For this reason, in September of 2023 Lipasam will establish specific meetings with different associations a municipal stakeholders in order to adapt the municipal waste collection service in those districts with higher house rent pressure.

There is a growing need to use different means of dissemination to reach the widest range of people with information that helps make the transition to a circular economy as successful as possible. The deployment of these tools with public information for citizens and users of public services not only helps maximize the dissemination of the actions carried out by the municipality in the circular economy but also contributes to increasing the social commitment of citizens and the increase in the use of services at their disposal.

CityLoops influences future plans and practices:

CityLoops results contribute to the development of the Local waste prevention and management Plan of Seville (currently in draft status).

The gained knowledge throughout demonstration actions made under the CityLoops implementation period has produced the development of best practices guidelines which will be implemented into the internal practices both in Emasesa and Lipasam. The assessment of the potential changes from a linear economy to a circular economy approach is under discussion in the municipality. So, the best practices guidelines, as well as the gained knowledge thanks to the demonstration actions made under the CityLoops project implementation, should help to identify the potential improvement of the CDW valorisation as a common goal for all the municipal companies.

Summary of lessons learned

Time and commitment: A significant change in a city like Seville i.e., a municipality that manages around 700,000 inhabitants takes a long time, needs the commitment of all the municipal companies and has to be backed up by political leaders and leading civil servants.

Organizational change has to be designed at the strategic level. Policy decision-makers have the position to set clearly defined circularity criteria and monitor their implementation. The work

started with CityLoops will contribute to enhancing collaborative connexions and support circular approach in all the municipal companies.

A common strategy is needed in order to optimize the local resources which could increase and strengthen the private engagement in a holistic approach emphasizing the critical role that the private sector held in the circular CDW management.

Dialogue, collaboration and standardisation of requirements: Fluent communication and coordination are required between the municipal companies and the municipality. Standardisation of the minimum requirements in procurement with an evaluation team that studies in-deep case by case could enhance a sound replication and/or scale-up of the demonstration actions carried out during the CityLoops project implementation.

Involving stakeholders make circular criteria in tendering possible: The municipal company on water and wastewater management has gone from including the circular criterion in 25% of the procurements to 100%. This has been possible thanks to the interest shown by the local stakeholders in the engagement strategy carried out among workshops, and Collaborative Learning Networks meetings under the CityLoops project. The interest observed in the engagement activities done in CityLoops as well as the business promotion that Seville shows has attracted enough companies from the private sector that makes it desirable to scale up these practices in other municipal areas.

The rising awareness of the circular economy concept is a major driving force for establishing and operating clean points. This awareness is driven by the limited availability of landfills and the legal ban on landfilling less than 10% of waste collected by 2030.

Actions to reduce uncontrolled CDW abandonment could be strongly supported by the pay-as-you-throw system or incentives for a “strong” environmental awareness due to the use of segregation mechanisms (such as clean points) instead of mixed waste disposal.

Further analysis and a frequent update of the dataset in the City Simulation platform as well as the selected indicators is required in order to help in the decision-making process on circular economy and required mechanisms.

Monitoring supports upscaling: The good monitoring of the implementation actions made during CityLoops implementation as well as keeping fluent communication with the other municipal as well as private stakeholders will allow to scale up the circular economy approach in the city.

3.2. Reflections on the journeys of the cities

In general the journey of the cities fuelled by CityLoops during the last four years has been very impressive to witness. They have all experienced a movement taking them much further down the road towards circularity. The cities report that CityLoops have moved boundaries and

helped build support to both circular construction and circularity in general. This has generated new procedures and new solutions pushing circular construction, feeding into strategic development plans, procurement procedures and construction practices. The development is illustrated by these quotes from the cities – and is further elaborated in the demonstration reports:

"The gained knowledge throughout demonstration actions made under the CityLoops implementation period has produced the development of best practices guidelines which will be implemented into the internal practices both in Emasesa and Lipasam. The assessment of the potential changes from a linear economy to a circular economy approach is under discussion in the municipality. So, the best practices guidelines, as well as the gained knowledge thanks to the demonstration actions made under the CityLoops project implementation, should help to identify the potential improvement of the CDW valorisation as a common goal for all the municipal companies." (Seville)

"Through workshops, data gathering and awareness communication, CityLoops has in Bodø Municipality been an initiator and contributor to the preparation of a new more circular procurement strategy. Qualitative and quantitative data is gathered from accountancy, workshops, interviews, three master theses, and tender assessment. The findings from these have enabled the municipality to identify potential and challenges. Which have been taken into consideration for the new procurement strategy. … Through project work in municipal soil management group, it was decided to create a suggestion for a strategy for soil management in Bodø municipality. The strategy work was started by CityLoops but will not be finished by the end of the project." (Bodø)

"The lessons learned from the demonstration cases will be incorporated into new practices in the procurement of demolition work throughout the Mikkeli Consortium. The driver for this is the requirement for using sustainability criteria in relevant procurement cases, as stated in the City Strategy and the goals in the Climate Program. After CityLoops -project Miksei Ltd. and Xamk are planning to start a new circular project with the Mikkeli social housing company Mikalo Ltd. This project would demonstrate the reuse of dismantled concrete elements on the same site." (Mikkeli)

"In CityLoops a material depot was designed - and two are now open for 'business' for all kinds of paving materials and products for open space projects in the municipality. The demonstration project helped us in the quest for a proper online marketplace for used building materials. Now we will set up a description on 'how to manage a material depot' and a protocol to use the digital market place." (Apeldoorn)

"The results directly support the development of a new political sustainability strategy in our interdisciplinary sustainability group. In addition, the sustainability group raises awareness of circular economy across the organization. The group works as an inspiration forum where members share relevant experiences with each other - and brings the inspiration back to their own departments. … The experiences from the demonstration actions have furthermore contributed to an increased focus on circular procurement in general in Høje-Taastrup. For

instance, Høje-Taastrup is a part of "partnership for green public procurement" (POGI) where ambitious procurement goals are set for a number of different goods and services. In general, CityLoops experiences have raised awareness about circular economy and sustainability across the organization." (Høje Taastrup)

4. Replication

The EU review towards the end of the demonstration phase in CityLoops changed the way we decided to develop the CityLoops legacy. The reviewers suggested that we stopped focusing on reporting what had been done and instead focused on communicating the most important and replicable lessons learned from CityLoops. This led to the design of two types of replication tools:

- The Handbook on Circular construction targeting cities new to the concept who needs an introduction to what circular construction is and how you can implement it.
- The Replication Packages focusing on 9 different topics where CityLoops have developed instruments and experiences that will help other stakheolders in their effort towards circular construction.

4.1. The Handbook on Circular Construction

Based upon the learnings and outcomes of the CityLoops project, the handbook aims to inspire and guide local and regional European public authorities of all sizes to know more about the different steps to follow. It aims 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, this handbook aims 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.

The handbook follows this 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 re-thinked and 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.

Many questions have been asked throughout the handbook development, amongst those: how not to be too redundant and bring added value, since there are already a lot of documents on the topic of circular construction? We took some time to go through the publications on this topic, to define which angles would be the most relevant and useful for our main target. We ended up that this handbook should be an evidenced-based and practical document on how to implement a circular construction strategy for cities who would like to start this journey, packed with concrete tools, methods, and case studies for inspiration. The added value of CityLoops is to have gone beyond theory and concept, and to have different cities with different contexts that have implemented innovative solutions. To make all this knowledge useful for readers, the question that has led us has been “What lessons can we learn from the experimental projects, and what could have been done differently?”. Readers can therefore find throughout the handbook some inspiring “Good example from cities” boxes, with projects that could be followed and/or replicated. As a complement, the “Toolbox – First step towards circularity” boxes give practical tools and instruments which can be used for each step of the project. To demonstrate circular construction is a flourishing topic with more and more projects running all over Europe, it also showcases pioneers’ projects beyond CityLoops,

This handbook works together with the replication packages. Whilst the handbook provides a first level of information, the replication packages delve deeper into specific topics to know more about the tools, instruments and study cases that have been developed all over the four years of CityLoops. Those are mentioned throughout the handbook with a clickable link and are listed at the end of the document. The handbook and the replication packages provide a comprehensive and complete set of documents for beginners and more advanced local authorities.

4.2. Replication Packages: Toolboxes for replicators

The 9 Replication Packages cover topics with strong prospects of uptake and replication from CityLoops demo actions and instruments. The Replication Packages were developed after the last review meeting. The comments from the reviewers on creating the best possible conditions for replication made us invent a new way to communicate and display the instruments and demonstration results: Rather than just adding all the demonstration reports and all the instruments to the website, leaving it up to replicators to find the relevant instruments or demo-experiences, we designed nine Replication Packages on central topics for creating circular construction flows – topics where CityLoops instruments and experiences could support replicators in becoming more circular. The nine Replication Packages comprise the necessary instruments and methods and the demo-experiences from different cities about this topic.

Overview of the Replication Packages with links:

1) Planning and decision-making

2) Stakeholder engagement

3) Circular demolition

4) Data and material passports

5) Material banks and marketplaces

6) Recycling concrete

7) Circular soil handling

8) Circular procurement

9) Business cases

In order to make it easy for replicators to find and use the relevant information, each Replication Package is designed with a front page displaying:

- A short introduction to the topic
- The most important lessons learned
- An overview of CityLoops intruments with a short fold-out description of each instrument and a link to the full instrument
- An overview of the relevant demonstration actions with a short fold-out description of each and a link to a cut-out from the demonstration report about the city´s work with this specific topic

This design seems to work very well and makes it easy for a city that wants to learn how to eg make a tender for selective demolition or assess the possibilities of circular soil handling to find the relevant replication package and choose the instruments and demo experiences most relevant to them.

In order to improve the Replication Packages, each of them was reviewed by CityLoops partners and replicators with knowledge on the topic or who wanted to/had used the instruments.

4.3. Conclusions and lessons learned for future EU projects

4.3.1. Conclusions and the lessons learned about creating a circular CDW flow

The CityLoops development of instruments, described in section 2.2. and performance of the CityLoops demonstration activities are based on the value chain concept as described above in section 3.1. The development of tools and instruments which are tested in demonstration

activities has proofed the function of the value chain and implementation of circular construction. To summarize and provide an overview of the conclusions and the lessons learned, the tools and instruments, listed in table 1, are arranged in the following categories as illustrated in figure 7:

- Framework conditions for circularity in the building and construction sector from demolition/renovation from to new construction comprising the management instruments: *Planning and decision-making*, *Stakeholder engagement*, *Circular procurement,* and *Business cases*.
- Material flow of waste materials from demolition/renovation and transformation to useful materials in new construction comprising the demolition and logistic instruments: *Circular demolition*, *Data and material passports*, *Material banks and marketplaces.*
- Optimal reuse/recycling the individual materials focusing on selected dominating materials: *Recycling concrete* and *Circular soil handling.*

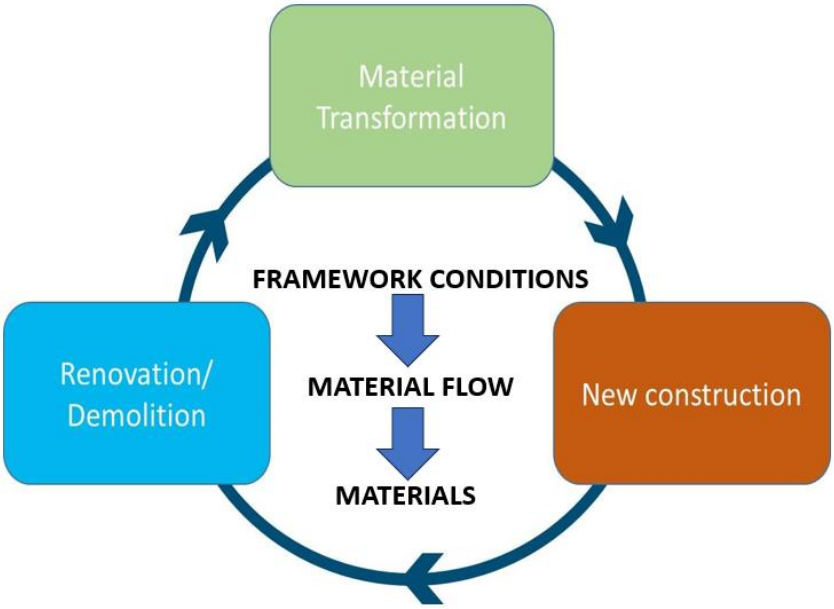


Figure 7. The value chain for circular construction and how it works

Framework conditions

The framework conditions originate from laws and regulations that create the basis for *planning and decision-making*. Planning and decision-making of circular projects follow the principles for traditional construction projects. No serious barriers to circular construction have been identified. However, we have learned that public authorities face different challenges in the pursuit of circularity for the built environment which can be addressed by action on four interconnected fronts:

- Interdisciplinary collaboration
- Knowledge and skills
- Economic measures
- Policy and management

Implementing circular development projects requires active *stakeholder engagement*. It is very important that all stakeholders of elements and processes of the value chain have mutual understanding of the challenges and opportunities of the integrated development processes. They should be involved throughout the project as it increases the ownership and sense of responsibility.

The successful implementation of projects – traditional as well as circular development projects depends on compliance with agreements made. *Circular procurement* follows rules of public procurement to allow competition in the unique market of circular materials and products. The procurement processes and materials require knowledge of the market and understanding of the processes and elements of the value chain.

It is important to start an early market dialogue with potential stakeholders (e.g. partners, suppliers, and consultants) and discuss opportunities, barriers, and solutions. Criteria of selection, clauses in the tender, scop and key specification of the work must be discussed and understood.

Besides the policies on sustainability, green change, CO2 reduction etc. economy is the most important driver of circular projects. As mentioned under framework conditions economy measures must be addressed and challenged. The establishment of *business plans* and evaluation of *business cases* of alternative scenario/solutions is necessary.

The success of business cases depends on the indicators to measure the cost and benefit (economic, but also social and environmental). The economic profit, or at least the balance, remains crucial to achieve the upscaling of these innovative approaches. Even though the contexts, the cases, the step of the value chain and the materials were different, the business case is a product of economic assessment of the framework conditions, stakeholder cooperation, competition, estimated cost of works and materials, and project risks.

The business case must be simple and understandable and based på actual market prices. Compared to traditional materials on the market, prices for recycled materials are problematic due to the origin, material flow and transformation of the different material types. Referring to experiences of demonstration activities prices of local recycling aggregates are competitive with of natural aggregates.

Material flow

The journey of materials from selective demolition through transformation to demanded materials in new constructions passes many barriers and challenges. Today the traceability and documentation of the materials are required. End-of-waste criteria must be fulfilled. The logistic challenges of providing the material in right time, quality, amount and place must be met. Potential customers for recycled materials do not want to have the hassle of delivering the ordered materials. Therefore, CityLoops has developed and tested instruments ensuring optimal and sustainable flow of materials in accordance with til value chain starting with circular demolition followed by transformation, documentation and material passports, and preparing for placing the materials on the market.

Two guides, guide on pre-demolition audit and guide on selective demolition, have been developed to support *circular demolition*. The guides have been tested and evaluated in the CityLoops demonstration actions and recommended for replication in all renovation and demolition projects. A general recommendation is that the screening and selective demolition both need to be planned for well in advance and are incorporated when tendering. Once contracted, contractors will not voluntarily spend time and money on carry out the screening – so any foreseen activities should be clearly intended in the demolition planning phase.

Referring to the list of lessons learned in the Replication Package all EU member states are recommended to introduce pre-demolition audit and selective demolition as mandatory actions. The CityLoops developed guides are suitable for replication and translation to national guides.

Among the cross-cutting lessons learned about *mapping and documenting the reusability/recyclability* of materials it is realised that it is valuable to have a standard procedure in place for mapping and documenting the reusability/recyclability of materials in demolition projects.

The major challenge of the material flow is the fact that there is no coherence between production of CDW and demand on secondary (recycled and reused) materials. To ensure the supply of secondary materials, the logistic challenges of discontinuity of material streams must be met by *material banks and marketplaces*. Some important lessons learned among others about physical material banks and digital marketplaces are following:

- Different types of material banks require different set-ups and are useful in different scenarios. With temporary/pop-up material banks you can have fewer rigid rules, but with permanent/central material banks you need very rigid rules for what materials enter, the documentation (material passport) and who has access.
- Local material banks can create large CO2 and economic savings from reduced transport. However sometimes longer transport is preferable for the best treatment of the resources.
- Preparing the materials for reuse or recycling is a valuable service for a material bank – e.g. decontamination of materials, downsizing and crushing concrete, sorting sand and aggregates and denailing timber etc.
- It is recommended to connect to a well-known digital marketplace instead of creating your own as it will take time and money to develop a new website and to attract users

Materials

The success of circular construction is measured in saving resources, reduction of CO2-emission and energy together with reduction of impact on the environment and community. The dominating materials in the construction sector is concrete and soil. Therefore, Cityloops has put fucus on opportunities for recycling of these two materials.

Recycled concrete can replace stones and sand in new concrete. In 2020 Denmark got the special standard for concrete DS/EN 206 DK NA:2020, allowing up to 100% of stones and sand to be replaced with crushed concrete. In many EU countries the standard is still only 20

% stones/10 sand %. The CityLoops demonstration actions in HøjeTaastrup and Roskilde helped push this development in Denmark and other CityLoops partners.

It is learned that recycled aggregate concrete produced in accordance with the EN 206 concrete standard is competitive with traditional natural aggregate concrete. However, because of the complexity of the material flow and special logistic conditions compared with natural aggregates, the demand of recycled aggregate s very low.

Several lessons learned on recycling concrete is listed in the Replication Package. Education, knowledge, dialogue and mutual understanding of the concrete value will promote recycling of concrete to mainstream action in circular construction.

The environmental and economic impact of excavated soil is massive, as the amounts of soil excavated for construction often surpass the amounts of CDW. However, early soil management and geotechnical investigations can reduce the amount of soil that has to be excavated. Furthermore, if excavated and treated correctly soil may be used for a wide range of purposes of considerable value. *Circular soil handling* can replace other raw materials and substantially reduce cost and CO2-emissions from transporting truckloads of soil.

In the CityLoops-project three soil instruments have been developed:

- Instrument for prediction of soil production
- Roadmap for soil management
- Guidelines for sustainable soil management and assessment of reuse potential of excavated soils

Generally, it is recommended to address soil management with specific requirements in all building and construction project to optimize reuse/recycling and minimize transport, CO2-emission and other impact to the environment and community. Specific lessons learned and recommendations are found in the replication package.

4.3.2. Conclusions and lessons learned about the design and implementation

The implementation of the CDW actions in CityLoops has been a success: We managed to develop the instruments and methods and use them in the demonstration actions, taking the cities on a journey that changed their approach to construction and has long-lasting effects in the municipalities and companies involved. Furthermore the CityLoops WP2 legacy – The Handbook and the Replication Packages – has already been very well received and will hopefully be used by a number of cities and construction clients in the years to come.

Although we managed to implement CityLoops we also struggled with all the tasks and deliverables in the many WPs. The conclusion would be that we did not fully anticipate the workload and complexity of the many CityLoops tasks crosscutting the work packages and the

need for direct support for the cities to carry them out. Also we did not fully anticipate the constant changes in the progress of construction projects, although we had “Plan Bs”. In future projects, a recommendation would be to have fewer tasks and more direct dialogue and support in completing the tasks, making work packages support the actual demo actions to a higher degree. In CityLoops some work packages depended more on extracting knowledge from the demo actions rather than supporting the development of the actions, which strained the cities limited resources.

Instruments and tools

CL chose some general framework instruments to be developed and used by all cities, lead by one of the partner organizations (planning and decision making, stakeholder involvement, procurement and business cases). The cities then prepared for the demonstration phase by developing specific instruments needed to support their own circular demonstration actions. This resulted in a wide range of instruments and tools supporting the different steps along the value chain of circular construction, many touching on the same topic eg gathering data or creating a digital marketplace.

Retrospectively I think we were a bit naïve thinking that we could both have the cities develop instruments and tools for testing in the large scale demonstration actions, which they were preparing alongside the instrument development – and still have enough time for the other cities to put these tools to use in their demonstration actions, which were being planned at the same time.

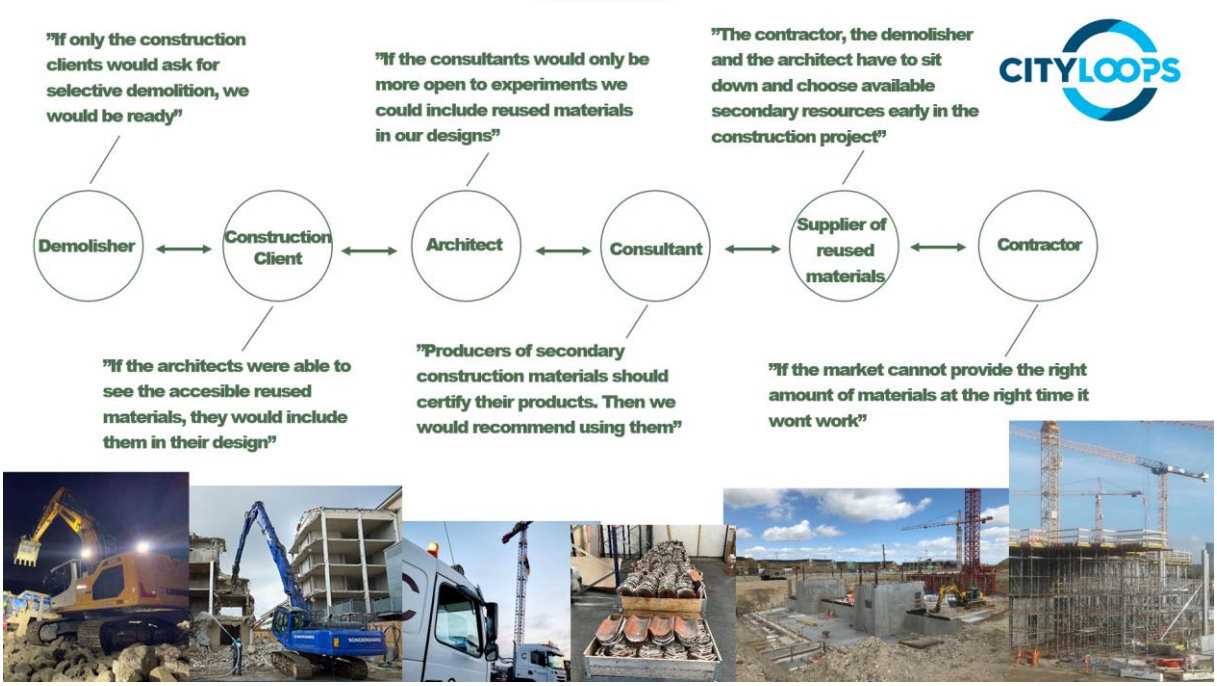
In some cases the tools were easy to apply to other demonstration actions – e.g. CO2 calculations and to some extent screening and selective demolition, so they were used in multiple demonstration actions. But in the case of more complicated instruments and actions you will need to implement them in a construction project at the early planning stages, so it becomes part of the plan, is entered in the tendering and becomes integrated in the project. For example Bodø has developed a digital twin 3D modelling to visualize the materials for reuse and recycling, thus managing flows and design of the new city using these materials. This is a great demonstration action to replicate for other cities, but it was not possible for other CityLoops demonstrations to integrate such an instrument in already planned or ongoing demonstration actions. Here the direct replication or uptake lies in future circular construction projects.

In the case of the more complex instruments or actions, our focus in WP2 has been to create as much knowledge exchange as possible between both demonstrators and replicators with deep dives into topics, instruments and demonstrations at the monthly WP2 cross consortium meetings for both partners and replicators, focused topics at the half-year expert workshops and dialogue at the city-to-city meetings, either between partner cities wanting to learn about a specific experience or topic, or between partner-replicator cities.

A suggestion for future EU projects would be for the partners to focus on fewer instruments, where the same template is developed and tested by all partners.

Demonstration actions

Each step of the value chain poses its own challenges – and all the stakeholders are asking for other stakeholders to change their actions, as shown in figure 8 below.



These are all necessary actions, which means all stakeholders need to act, to change our way of thinking and stop doing business as usual: Then a well-functioning market for adaptive reuse of buildings as well as reuse and recycling of materials into new construction can be established.

Changing the ways of all stakeholders is not an easy task. This explains the complexity behind implementing the demonstration actions: Why a lot more effort is needed than if the cities were just trying to change the ways of one part of the value chain or one stakeholder.

The main finding from the demonstration actions is that this can be done through close dialogue and collaboration with the stakeholders, preferably involving them in designing the solutions, acknowledging and mitigating the risks. The strongest lever for the construction client is in the tendering process. Thus planning a circular process, screening buildings beforehand, engaging in market dialogue about possible circular solutions - and then entering the relevant criteria in the tendering is the best possible way of achieving circular construction. However, a learning is also that you should not give up if the tendering has been done and the contract signed - it is never too late to get some circular measures into a construction project.

Another learning is that the time schedule and progress of large construction projects is very hard to rely on – it will move faster or slower, come to a halt or even change content eg from demolition to transformation of a building. Thus it is necessary with an agile process with room for dialogue about changes and mitigations, preparing a "Plan B" and for the WPlead to follow

up closely on the progress and challenges of the demonstration actions. It was impressive to witness how well the CityLoops cities handled the obstacles, delays or changes in their demonstration actions, finding new demonstrations to test their instruments or using the delay to enhance circularity: When the access to the military airport in Bodø was delayed they tested the CityLoops instruments on a development project in Sjøgate and on the demolition of a school. When the construction of the second P-house in Roskilde came to a halt due to rising construction prices, they spend the time doing research on making the project even more circular by reusing hollow core slabs for part of the floor and rooftiles for the façade. The will of the cities to solve the problems and demonstrate circular demolition and construction has been a huge driver and formed the heart of WP2.

The lessons learned from each demonstration action are many. The general lessons learned from each city is described above in chapter 3, and for the specific topics the lessons learned across the cities are described in the nine Replication Packages at CityLoops.eu.

Management instruments

This framework was created to support the progress and documentation of the demonstration actions:

- The WP2 cross-consortium meetings
- The Optimised Implementation Plans
- The log documenting the progress and actions in each demonstration action
- The interim and a final demonstration report

The WP2 cross-consortium meetings took place from the beginning to the end of the project. At first every two months, but it was quickly realised that monthly meetings were needed in order to keep track of the progress, ensure knowledge exchange and address issues. At each cross meeting the CityLoops status and next steps in WP2 was addressed, so the partners knew what was expected eg upcoming tasks on developing OIPs, on procurement or on business cases. The demo managers were also asked to give a status of their progress, challenges or changes in their project. Finally the meetings often had a deep-dive into either one of the demonstration actions, one of the instruments or a specific topic relevant to all (eg material passports).

The cross-meetings have created a familiarity with each other's demonstration actions and a bond between the cities, supporting dialogue and cross collaboration on applying instruments or addressing similar challenges. They have supported the feeling, that several cities have expressed by the end of the project, which is that we are a "CityLoops family".

The OIPs were developed by M18, describing in detail the steps and expected time schedule of each demonstration action. Due to the changes in time schedules for the construction projects – some moving faster and some slower – M18 was a bit late in the project for some demonstration actions. Apart from that the OIPs worked very well, making the cities decide on the details in their demonstration actions, making it possible for them to consider how to

document the demonstrations and also making it possible for the WPlead to ask specific questions about the progress of the different steps in the demonstration actions.

About half-way into CityLoops a LOG template was developed and introduced. The LOG was an online document based on the OIP where the cities should describe the latest actions and development in their demonstration actions before each cross-consortium meeting. The LOGs worked very well and served two purposes. It made it possible for the WPlead to follow the progress of the demonstration actions and address issues. It kept track of the actions, challenges and considerations during the process of implementing the demonstration action – making it possible for the cities to remember and include this in the demonstration report. The only downside was that the LOG was introduced so late in the project. It would be great to use a LOG from the beginning of the project next time.

The demonstration actions were described by each city in an interim and a final demonstration report. The original idea was that the demonstration reports would be an output to be read by interested stakeholders and replicators. However, as the cities have multiple instruments and demonstration actions, the scope of these reports was huge – as was the length, in general around 100 pages. It became clear that if a replicator wanted to learn from the recycling of concrete in Høje Taastrup or the stakeholder engagement in Bodø, then it would be overwhelming for them to find the relevant passages in the full demonstration reports. Thus the nine Replication Packages were made with cut-outs from the demo reports about the specific topics. The full demo reports serve as a deliverable for the EU documenting the full development and implementation of demonstration actions in the cities. A learning is to consider whether this level of detail is necessary for documentation for the EU – make much shorter demo reports and instead focus on the topics for the Replication Packages.

CITYLOOPS

CityLoops is an EU-funded project focusing on construction and demolition waste (CDW), including soil, and bio-waste, where seven European cities are piloting solutions to be more circular.

Høje-Taastrup and Roskilde (Denmark), Mikkeli (Finland), Apeldoorn (the Netherlands), Bodø (Norway), Porto (Portugal) and Seville (Spain) are the seven cities implementing a series of demonstration actions on CDW and soil, and bio-waste, and developing and testing over 30 new tools and processes.

Alongside these, a sector-wide circularity assessment and an urban circularity assessment are to be carried out in each of the cities. The former, to optimise the demonstration activities, whereas the latter to enable cities to effectively integrate circularity into planning and decision making. Another two key aspects of CityLoops are stakeholder engagement and circular procurement.

CityLoops started in October 2019 and will run until September 2023.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 821033.