

# Appendix

## BEST PRACTICES: How to assess circularity in the urban built environment

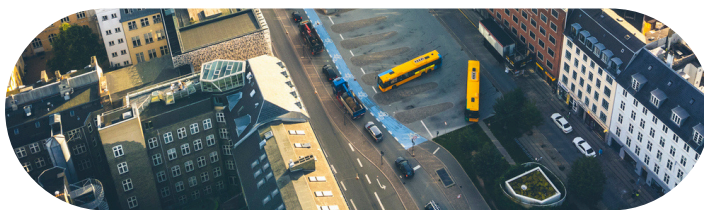
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# Examples of how the recommendation can work in practice, based on DUT projects

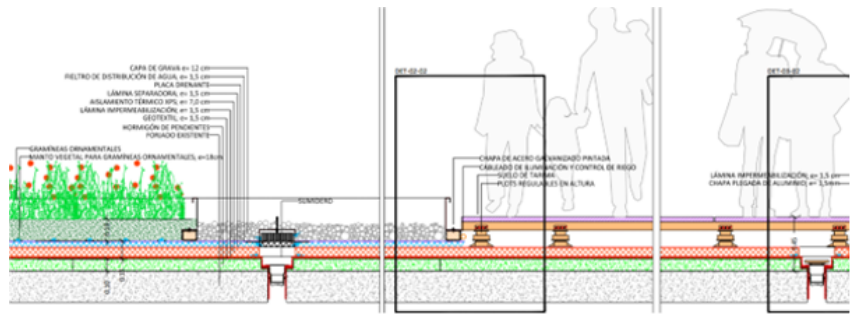
## Example 1: aRTes: Circularity as a result and not as a target

aRTes Consortium main goal is to improve the use of urban rooftops, opening new possibilities to an unused urban built space, primary oriented to boost health, comfort, wellbeing, inclusion, and community participation, while increasing and spreading green areas and generate clean energy, including drone logistic approach with rooftops as potential actor in short time.

This is achieved from various types of tasks and work packages that work together on an ambitious south Europe project including 6 Mediterranean countries. There is a construction-oriented work package to develop physical solutions to ensure security, comfort, access, nature based, while ensuring PV integration. Digitalisation of solutions is a key part of the project. The project visualizes the role of rooftops in drone-based future urban logistics. Also, have a green rooftop initiative. And on top of all the project there is a regulation relevant task that with the consultancy toolkit develop a coherent and shareable understanding about current legislation, barriers, expectations hindering or supporting the rooftops valorisation as establish the state of the art of rooftop potential and sets a methodology and a tool that supports the assessment of rooftop potential and secure the engagement of citizens and other stakeholders in the co-design process.

The culmination of aRTes will produce a Pilot Project in Madrid in collaboration with the Municipality and CIEC (ciecmadrid.es), the Economic Circularity Innovation Center, with all the developments, results, tools, solutions, working together. Consortium circularity assessment frameworks address naturally in a wide range all the 5 dimensions explained in this study: (1) environmental; (2) economic; (3) social; (4) technical; and (5) managerial. We really have a lot of potential to produce and bring circularity to cities and citizens and need in this second year of the project bring circularity to the centre of the project, to ensure robust indicators and policies.





Physical Pilot Project in Madrid. Hosted in a Community of Madrid public building in Braganza 3

## Example 2: B\_Green: Recognise and value circularity and biodiversity richness, example from B\_Green

All over Europe, historic urban centres are dense built-up areas that face many challenges associated with retaining residents and preserving their buildings. Built over time in a continuous and mostly circular and sustainable way, they were built as an example of how to repair, reuse, and adapt sparingly and with local resources. Furthermore, the building process, using local resources and culture-based, is part of the local identity and thus a heritage to be preserved. Densification and recent construction processes affect the climate vulnerability of these areas and the loss of biodiversity.

The B\_Green: Biodiversity & Green in Mediterranean Historic Cities project is addressing these shortcomings through a series of training and awareness-raising activities for residents and local stakeholders, which will lead to the co-creation of NBS solutions to introduce greenery, enhance biodiversity in the historic centre, and improve heat regulation, aligned with the above recommendations. These actions involve the collaboration of experts in nature and heritage protection and are based on an initial phase of transparent and effective diagnosis and analysis, through a bird census and a monitoring process of the local environment (assessing temperatures and humidity). The collaborative workshops will be supported by educational material that will foster the dissemination and exploitation of results for other cities. This workshop will involve activities to co-create small interventions in the historical urban spaces, enhancing biodiversity and well-being in the urban areas.

B\_Green acts in urban areas that are covered by other projects (Horizon, Interreg, and national) and, to optimise efforts, has created synergies and collaborations with other local projects in the four cities that favour implementation and awareness.

In the second phase, and with the collaboration of the municipalities of the four cities, these collaborative activities will define a set of actions to compose an action plan for each city. This action plan will be put into practice by each local administration in the coming years, contributing to the improvement of biodiversity and reducing climate vulnerability in a local and culture-based way.

## Example 3 CAGE: Building the Foundations for Tomorrow: Enhancing Circular Literacy among Future Construction Professionals

Activity Overview: Workshops at the Technical High School in Wrocław

As part of the international project Circular Approaches for the Built Environment (CAGE), funded by the National Centre for Research and Development (NCBR) under the Driving Urban Transitions (DUT) Partnership, a dedicated educational initiative was launched to bridge the gap between academic research and practical training for students with a civil engineering profile. In January 2026, a workshop on circular systems in construction was held at the Technical High School (Zespół Szkół Budowlanych) in Wrocław. Led by experts, the session engaged students, the future workforce of the construction sector, in a critical dialogue about the industry's ecological transition.

The workshops were structured to combine conceptual knowledge with practical experience, ensuring a comprehensive learning outcome. The session began with a specialised presentation based on dedicated educational materials specifically developed within the CAGE project for technical school students. These resources were designed not only for this single event but as a versatile pedagogical toolkit that can be readily adopted by teachers in future training activities, supporting the long-term integration of circular economy principles in education. This theoretical component was followed by an interactive hands-on workshop. Working in collaborative groups, students engaged with physically reclaimed materials. Their task was twofold: first, to reverse-engineer the material's life cycle by identifying its source and previous application, and second, to propose innovative ways in which these "secondary resources" could be reintegrated into new construction projects. This practical exercise transformed abstract sustainability concepts into tangible technical challenges, highlighting the latent value embedded in materials traditionally considered as construction waste.

The workshops in Wrocław focused on three key areas of circularity:

1. **Resource Efficiency:** Understanding that waste in construction is often a result of suboptimal design and insufficient planning for material recovery.
2. **Circular Systems:** Moving beyond simple recycling toward high-value reuse and closed-loop material cycles.
3. **Innovation and Technology:** Exploring how digital tools and modern management approaches can facilitate more sustainable and circular construction practices.

## **Example 4: MAINCODE: Demonstrating Circular Economy through Schoolyard Transformation into Urban Climate Shelters**

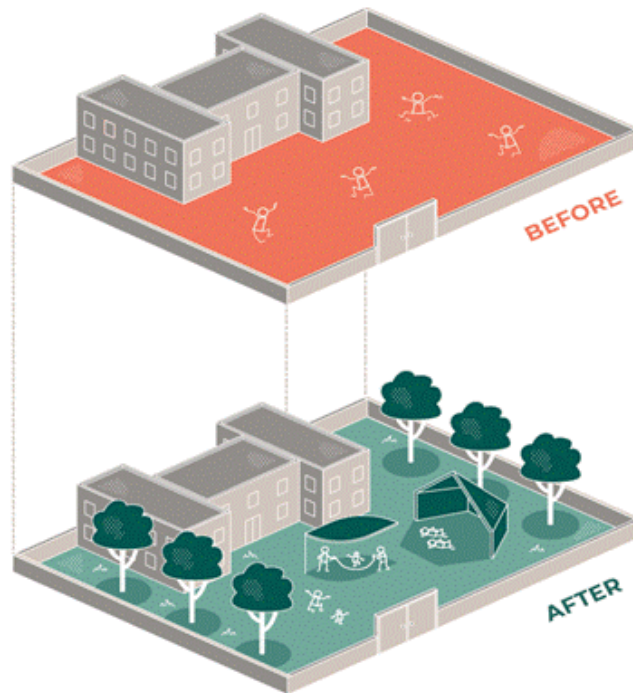
European cities are increasingly affected by climate change, particularly heat waves and related impacts. MAINCODE is committed to integrating nature to promote adaptation actions that cope with extreme heat, fostering urban regeneration, and generating co-benefits for communities and ecosystems. MAINCODE frames Urban Climate Shelters (UCS) as cooling demonstration projects to transform schoolyards into refuges for urban populations, using Nature-based Solutions (NbS) and co-designing processes involving children, local communities, policymakers, and practitioners (Caldarice et al., 2025). By providing a tested and validated methodology in two pilot schoolyards in Turin (Italy) and Halandri (Greece), MAINCODE expands theoretical knowledge on climate shelters, enhances community consciousness, and facilitates upscaling and replication in other European cities. By reinterpreting underutilised and predominantly impervious school spaces as multifunctional and community-accessible climate infrastructures, MAINCODE directly contributes to circular economy objectives.

A central element of the project is the integration of NbS as a structural component of schoolyard redesign. Through the introduction of permeable surfaces, vegetation, shading systems, and biodiversity-enhancing elements, the project prioritises heat regulation, water retention, and climate resilience, while strengthening ecosystem service provision. Rather than treating NbS as an add-on, MAINCODE embeds them into the spatial and functional reconfiguration of schoolyards as climate shelters.

Beyond physical transformation, MAINCODE adopts a multi-dimensional assessment framework that reflects the need to institutionalise environmental, spatial, social, and governance dimensions within circularity evaluations. The project fosters reduction of urban heat island effects, soil restoration, and ecological performance, while simultaneously considering health, well-being, recreation, and social cohesion outcomes. MAINCODE also explicitly identifies trade-offs and synergies between environmental and socio-economic objectives, using multi-criteria approaches rather than relying on single indicators.

Building on this perspective, MAINCODE moves beyond purely environmental performance indicators and incorporates qualitative and participatory dimensions, acknowledging that circularity in schoolyard transformation cannot be reduced to technical efficiency alone. The project seeks to link assessment results to planning and design decisions, although the full institutional integration of indicators into procurement and investment procedures remains beyond the project's direct mandate.

Grounding circularity in local contexts is another core aspect of MAINCODE. Pre-intervention analyses and baseline assessments ensure that ecological and socio-spatial conditions are understood before transformation. The emphasis on community participation, civic empowerment, and long-term engagement positions stakeholder involvement as an ongoing component of planning, co-designing, and monitoring.



As a real-world demonstration of circular schoolyard transformation, this promotes testing and validating circularity indicators through practical implementation. By documenting co-benefits, trade-offs, enabling conditions, and barriers, the project generates transferable knowledge that supports replication and upscaling. In this sense, the transformation of schoolyards into climate shelters acts as a learning laboratory of the circular economy, helping anticipate and prevent unintended social or environmental trade-offs.

### Example 5: Urban-CoLLaR: MIND - Milano Innovation District, Italy

MIND - Milano Innovation District is a 1 million sqm brownfield regeneration project developed on the former Expo 2015 site. Launched in 2017 by Lendlease and Arexpo - with strategic advisory support from PlusValue during the start-up phase - MIND is now an operational life-science and smart-city innovation hub. It hosts major research facilities and a growing ecosystem of universities, corporates, and start-ups, with a target of 70,000 daily users once fully completed in the coming years.

At MIND, circularity is embedded in the district strategy through a combination of qualitative principles and quantified performance requirements. From the outset, Lendlease adopted a “regeneration-as-circularity” approach, treating the Expo legacy as a stock of materials to be preserved, reused, or recycled wherever feasible.

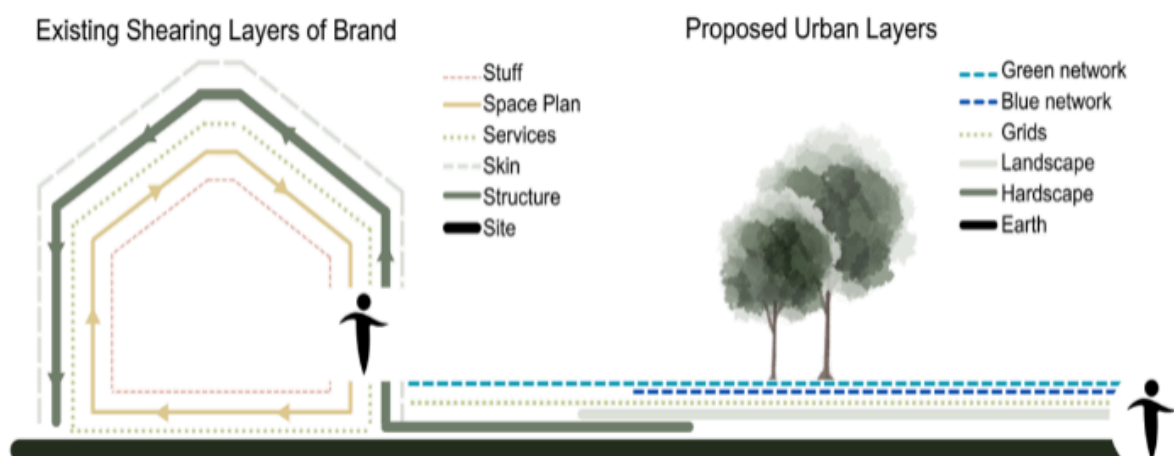
This approach is translated into measurable KPIs. For example, in construction waste management, MIND targets 98% of construction-site waste to be reused or recycled. Lendlease has also set ambitious net-zero goals for MIND, aiming to reach absolute net

zero across Scope 1, 2, and 3 emissions by 2040. MIND's carbon roadmap is among the first large-scale examples of a carbon budget applied to an existing urban redevelopment. Environmental performance is assessed through cradle-to-grave LCA, enabling consistent monitoring over time.

Circularity is further enabled through construction strategies designed to keep materials in use longer and maximise future reuse - particularly prefabrication, modularity, and design for disassembly. These approaches reduce waste and rework while preserving component value across the asset lifecycle. Lendlease applies Design for Manufacturing, Assembly and Disassembly (DFMAD) to improve efficiency from design through construction, shorten delivery timelines (with potential cost benefits), and support end-of-life recoverability.

Today, MIND also serves as an Urban-Collar demonstration site, hosting urban living labs (ULL) with local stakeholders to co-design, validate, and test project outputs, and to explore alternative development scenarios by applying Urban-Collar circularity criteria to selected buildings across the district. The aim is to integrate validated circularity indicators localized to MIND into environmental LCA and circularity assessment. This is to support formal decision-making processes of Rho Municipality, ensuring they influence outcomes rather than serve as reporting tools. Later on, this application will be an exemplary study for the other ULLs in Türkiye and Belgium.

The district also promotes collaboration and shared sustainability practices through stakeholder platforms and district-wide initiatives, including participation in EU-supported programmes (e.g., Horizon projects) and the New European Bauhaus. As an example, between 2022 and 2024, MIND served as a demonstration site for the DESIRE project ("Designing the Irresistible Circular Society"), which ran an extensive stakeholder engagement programme - surveys, workshops, focus groups, and ULLs - to identify opportunities, gather perspectives, and test circular, aesthetic, and inclusion principles in practice.



# DUT projects contributing to the insights

Existing circularity frameworks, such as MCI, BCI, and Madaster, as well as other sustainability tools such as Level(s), provide valuable support but are typically limited to specific scales (material or building) and primarily focus on environmental performance. This document extends these approaches by promoting a multi-scale assessment framework that integrates environmental, economic, social, technical, and governance aspects across buildings, neighbourhoods, and cities. It further emphasises the need to combine different types of indicators and embed them into decision-making processes, supported by local context adaptation and validation through real-world demonstration projects.

Therefore, DUT best practices aim at finding approaches that can be defined as:

- **Multi-scale:** whenever possible, multiple scales are addressed simultaneously, or at least it is recognised that circular interventions at one scale have implications for other;
- **Integrated:** different circularity dimensions are considered together, preventing trade-offs, and if necessary, mixed methods for assessing circularity are adopted;
- **Systemic:** challenges and objectives are not addressed through siloes, but rather in an open and holistic manner.

Five of the CUE projects contribute to such perspectives on how to assess circularity in the urban built environment:

## B\_Green | Biodiversity & Green in Mediterranean Historic Cities

B\_Green addresses the need for innovative solutions to enhance urban biodiversity, mitigate climate vulnerability, and promote health and wellbeing in historic cities. The project will examine four Mediterranean historical urban areas through transparent, inclusive, multidisciplinary, and reliable assessment methods that will enable the development of data-driven, innovative solutions in Living Labs, for improving urban biodiversity, raising awareness, and fostering community participation.

DUT project page: [B\\_Green | dut](#) | Project website: <https://b-green.cyi.ac.cy/>

## aRTes | Transforming Urban Rooftops into Spaces for Sustainability

Behind aRTes lies a simple yet powerful idea: rooftops can become a new frontier for urban living. They can generate renewable energy, host gardens and urban farms, provide venues for social and cultural activities, and at the same time improve buildings' thermal comfort while reducing urban heat islands. aRTes is not just a technical project, but a cultural transformation experiment: it invites citizens and institutions to reimagine their relationship with urban space making it more open, shared, and sustainable.

DUT project page: [aRTes | dut](#) | Project website: <https://www.artes-dut-rooftop-project.eu/>

## CABE | Circular Approaches for the Built Environment

The CABE project aims to accelerate the transition towards a circular built environment by enabling the systematic reuse of construction and demolition materials as valuable urban resources. It seeks to develop and implement practical digital tools to support planners, developers, investors, and public authorities in integrating circular economy strategies into urban development processes. CABE aims to provide scalable, data-driven solutions that enhance resource efficiency, reduce environmental impact, and strengthen resilience.

DUT project page: [CABE | dut](#) | Project website: <https://cabe.zag.si/whatis>

## MAINCODE | MAINstreaming nature to CO-DEsign urban climate shelters in schoolyards

The MAINCODE project aims to transform schoolyards in Turin (Italy) and Halandri (Greece) into Urban Climate Shelters (UCS), a cooling strategy that employs NbS and co-design processes with local communities, envisioning schoolyards as safe, accessible spaces for all and fostering pathways to heat-resilient and healthy cities.

DUT project page: [MAINCODE | dut](#) | Project website: <https://main-code.eu/>

## Urban-CoLLaR | Co-creating Urban Living Labs for Circular Regenerative Neighbourhoods.

The project aims to accelerate the application of circular solutions in regenerative urban renewal projects at the neighbourhood level, supporting the transition towards a carbon-neutral and circular building stock by 2050 as promoted by the European (EU) Renovation Wave strategy and Circular Economy Action Plan. The project adopts a multilayer approach to frame the availability of environmental resources (e.g., energy, materials, water, etc.) and socio-economic resources (e.g., cultural heritage, local employment, etc.) that characterize a neighbourhood, in turn developing appropriate solutions to increase the recirculation of such resources for urban regeneration.

DUT project page: [Urban-CoLLaR | dut](#) | Project website: <https://urban-collar.snsipa.ro/>



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