CIRCUIT

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Extending the lives of buildings through transformation and refurbishment

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Contents

Acknowledgments

The *Circular Construction in Regenerative Cities* report presents the key learnings, tools, methodologies and recommendations generated by the Circular Construction in Regenerative Cities (CIRCuIT) project from 2019 to 2023 across the cities of Copenhagen, Hamburg, London and Vantaa/ Helsinki region.

This report was produced by members of the 31 partner organisations that were involved throughout. It shares a body of work that was made possible thanks to the time and expertise provided by numerous individuals who helped to support the project across its lifespan. This includes local decision makers and built environment stakeholders from each of the CIRCuIT cities, as well as the European Commission's Horizon 2020 programme.

All of the resources presented in this report, along with the accompanying technical report, are available at circuit-project.eu/post/latest-circuit-reports-and-publications.

Glossary of terms

Adaptive Reuse
The process of reusing a structure or building for a purpose other than the original purpose for which it was built or designed.

Business as Usual (BAU)
Shorthand for the continuation of current conventional construction process practices as if the intervention under consideration were not to happen. Usually used as a benchmark to compare interventions.

Circularity Indicator
A piece of information that can be used to measure performance within the built environment to guide decision making and enable the industry to communicate their circular economy actions in a consistent way.

Design for Adaptability (DfA)
An approach to planning, designing, and constructing a building so it can be easily maintained, modified and used in different ways or for multiple purposes throughout its lifetime, extending its practical and economic life cycle.

Design for Disassembly (DfD)
Approach to the design of a product or constructed asset that facilitates disassembly at the end of its useful life in such a way that enables components, materials, and parts to be reused, recycled or, in some other way, diverted from the waste stream.

Downcycling
A form of recycling that repurposes materials into a substance of lower value than the original.

Life Cycle Assessment (LCA)
A methodology developed to assess the environmental impacts of a building, component or material. The assessment compiles and evaluates the inputs and outputs of the material system throughout its life cycle and assesses the relevant environmental impact.

Life Cycle Cost Analysis (LCC)
An analysis of all the costs that will be incurred during the lifetime of the product, work or service. LCC may also include the cost of externalities such as environmental degradation or greenhouse gas emissions.

Meanwhile Use
A range of strategies to make under-utilised spaces and places productive, both economically and socially, often for a shorter length of time until a long-term use for the space is determined.

Pre-demolition Audits (PDAs)
A systematic and comprehensive assessment conducted before the demolition or deconstruction of a building or structure which results in the inventory of materials and components arising from the building. The reusability and recyclability of the materials can also be assessed during this process.

Pre-redevelopment Audits (PRAs)

A systematic evaluation conducted before the redevelopment or repurposing of a property or site, typically with the aim of assessing and addressing potential environmental contamination and regulatory compliance issues. The potential to reuse or incorporate existing structures on site into the new plans can also be assessed during this process.

Recovery

The process of systematically and intentionally collecting, salvaging and reusing materials from a building or construction site to extend their life cycle and reduce waste.

Recycling

Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes.

Return on Investment (ROI)

The quantifiable returns and advantages derived from embracing specific construction methods. This encompasses financial gains, environmental benefits and enhanced social value resulting from the project's design choices.

Reuse

The repeated use of a product or component for its intended purpose without significant modification.

Transformation

In architecture transformation is used as an umbrella term to refer to a wide range of potential changes to a building from a subtle change of appearance to a complete change of use.

Upcycling

A form of recycling that repurposes waste, products or materials into a substance of higher value than the original.

Urban Mining

The process of recovering and reusing the raw materials that are already in the environment, cities or everyday products, in the resource cycle.

Introducing the CIRCuIT project

The way we currently build our cities is wasteful and inefficient with resources extracted, manufactured into components, and constructed into buildings only to be demolished and discarded as waste well before the end of their useful life.

Estimates suggest that 11% of global emissions are linked to manufacturing construction materials such as steel, cement and glass[1]. In the EU alone, the built environment accounts for 36% of carbon emissions, 40% of material use and 50% of landfill waste[2].

Accommodating for the expected population growth within cities will mean constructing additional buildings and infrastructure equivalent to a city the size of Milan (1.5 million people) every week until 2050[3]. There is, therefore, an urgent need to transition from a linear construction model to a more sustainable and regenerative one based on circular economy principles.

In a circular model, rather than continuing the traditional take-make-consume-dispose process, building material loops are closed through reuse, sharing, leasing, repair, refurbishment, upcycling or recycling. This radical reimagining of construction considers how the lifespan and reusability of entire buildings can be maximised at the very start of the design process and thereby ensures that usable materials are not discarded as waste.

Cities hold the keys to this transition. Working collaboratively with industry, they can find new ways of confronting the climate impact of construction and develop a new urban agenda. This also gives rise to co-benefits as embedding circular principles also supports wider policy goals such as net zero targets, climate resilience and adaptation in cities.

Further, this regenerative approach has economic and social benefits as more adaptable and flexible cities are better able to serve the changing needs and interests of residents and circular solutions often also bring cost savings over a building's life cycle.

It is, therefore, crucial that cities and their stakeholders have the support, resources and tools needed to create change and drive circular construction practices locally.

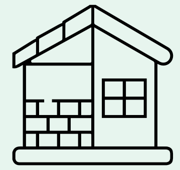
Turning theory into practice

Many circular construction techniques, tools and approaches have been developed and tested around Europe, but circular practices are yet to be scaled up effectively to a city or regional level. To explore how the circular economy can be effectively embedded in cities across Europe, and bridge the gap between theory, practice and policy, CIRCuIT – Circular Construction in Regenerative Cities – was established.

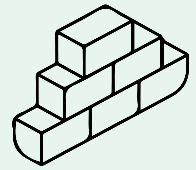
CIRCuIT was a collaborative project funded by the European Commission's Horizon 2020 programme. The project involved 31 partners across the entire built environment supply chain in Copenhagen, Hamburg, Helsinki Region and London.

1 Global Status Report for Buildings and Construction 2019 | IEA
2 Internal Market, Industry, Entrepreneurship and SMEs | European Commission
3 Circular economy in cities: Opportunity & benefit factsheets | Ellen Macarthur Foundation

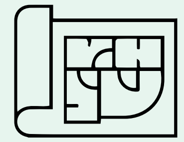
The project's goal was to support the mainstreaming of circular construction practices in the built environment focusing on three key thematic areas:



Transformation and building life cycle extension



Urban mining and material reuse



Design for disassembly and adaptability

Over the course of the project three key results emerged:

1. It is beneficial: Circular practices can improve both the financial and environmental outcomes of construction projects. As part of the project, 36 demonstrators were developed that provide evidence of the carbon and economic implications of adapting conventional construction methods to more circular approaches. The results show that the environmental benefits are great: in all three thematic areas there can be significant carbon emissions reductions and resource savings. Cost benefits are also evident within the context of a circular approach and have been explored in the business cases within chapters 1, 2 and 3. Shifting to circular practices requires use of long-term thinking and seeing buildings as investments to be examined by legislation, integrated collaborations, and new financial models.

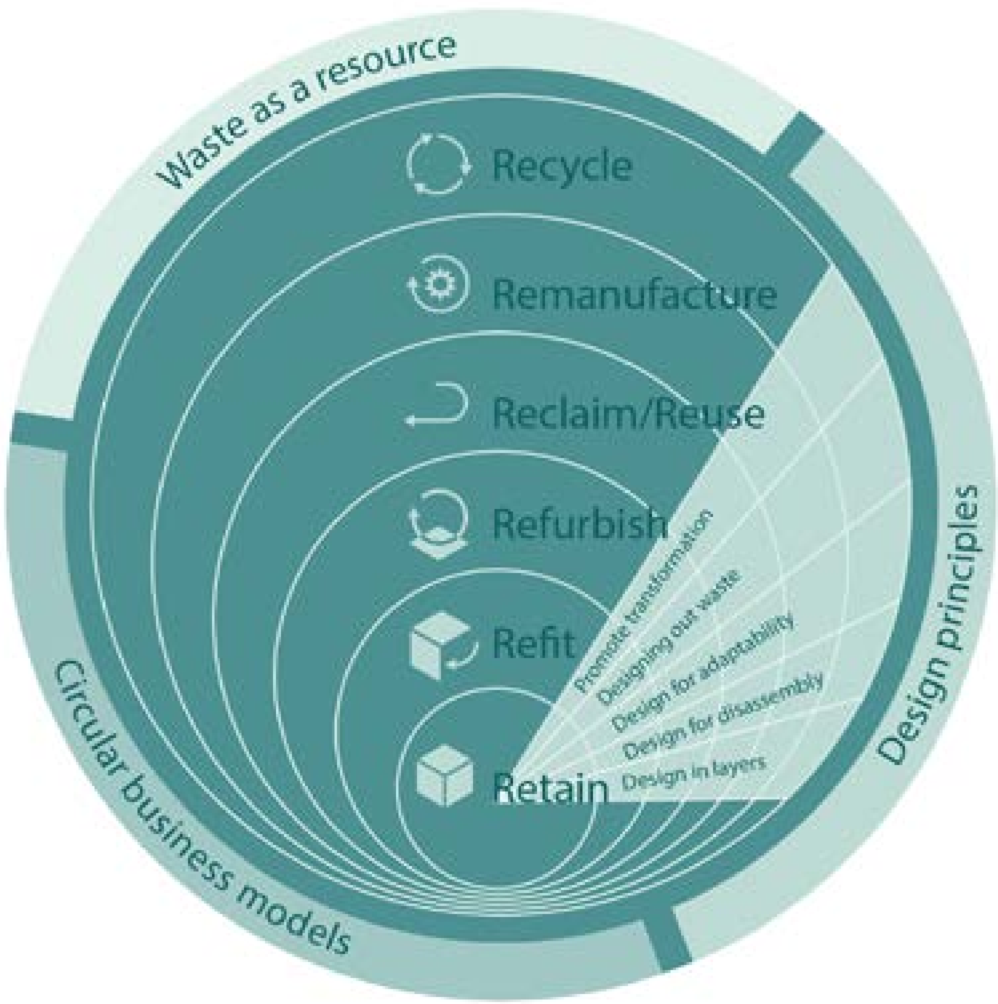
2. It can be done: Real changes are possible by defining a common agenda and applying tools that enable cities to work smarter given the same resources. CIRCuIT has developed tools that can help cities and their stakeholders embed circular economy practices, such as the transformation tool which supports the identification of buildings at risk of demolition, or the dialogue tool which ensures that conversations about circularity start early in the planning process. The CIRCuIT project also developed adaptable procurement requirements in collaboration with the construction industry (see chapter 5). Each of these tools will help to create changes within the landscape, processes, and behaviours.

3. It has scale-up potential: Circular practices are achievable at a building, neighbourhood, city or even country level. To generate the maximum impact of circular construction practices, each of the cities in the CIRCuIT project developed roadmaps that illustrated how best practices could be effectively embedded into city policy (chapters 3 and 5). The project also created working proof of concepts for digital tools such as the Material Reuse Portal that support the delivery of material exchange work and thereby enable increased uptake and the scaling of benefits (see chapter 6).

A call to action

Cities now have the opportunity to connect an ambitious circular economy transition to their sustainability goals. However, to achieve success, cities must also work with professionals from across the entire built environment value chain, from urban planners to material manufacturers, from demolition specialists to residents, and urge them to come together and transform the sector using circular economy principles.

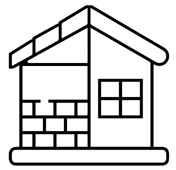
Changing the way that the industry designs, constructs and transforms buildings and infrastructure is critical in the fight against the climate crisis. Thanks to the wide array of tools, case studies and datasets developed by the CIRCuIT project, stakeholders across the value chain are better equipped to turn ideas into reality.



Principles of circular construction
The Handbook to Building a Circular Economy, David Cheshire, AECOM, 2021

Chapter 1: Extending the lives of buildings through transformation and refurbishment

Transformation and refurbishment of existing buildings is the first principle of circular construction. Applying a transformation-first approach will be key to meeting climate targets. Reducing the instances of demolition can keep resources that have already been refined in use for longer, reducing the need for new materials.



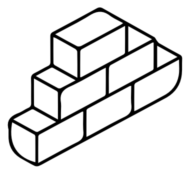
Key findings:

- Methodologies to identify buildings at risk of demolition
- Policy drivers to encourage decision makers and built environment professionals to extend the lives of existing buildings
- 12 demonstrator projects showcasing design transformation strategies.
- 10 business cases for building transformation.

Chapter 2: Increasing the reuse and recycling of building materials

Reusing and recycling building materials is a highly effective way to reduce the resource use and carbon intensity of the built environment by closing material loops. But many challenges are preventing cities from adopting this circular construction approach including issues with cost, adoption and the demolition process.

The CIRCuIT project explored these challenges and suggested ways to embed practical solutions on how cities and the building sector both build and demolish, from policies to Pre-Demolition Audits.

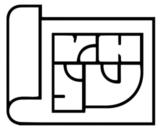


Key findings:

- Recommendations to increase the reuse and recycling of building materials
- Recommendations for embedding pre-demolition audits (PDA) in city policy
- Methodology for developing an optimised PDA
- 12 demonstrators illustrating material reuse and recycling techniques
- 9 business cases for driving the reuse and recycling of building materials.

Chapter 3: Futureproofing cities: designing for disassembly and adaptability

Design for disassembly (DfD) and design for adaptability (DfA) are two construction approaches that can help cities meet their future housing and infrastructure needs while ensuring circular economy principles are adopted. Currently, the technical solutions needed to adopt these approaches exist but take up throughout the construction industry is low. The CIRCuIT project explored what DfD and DfA looks like in practice, how these approaches can be embedded in cities, and how the environmental and economic benefits of DfD and DfA can be calculated to help increase adoption.

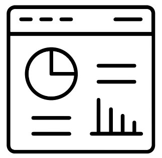


Key findings:

- Methodology for assessing the return on investment (ROI) for DfD and DfA across three areas: monetary cost, carbon use and material use
- Methodology to assess whether a DfD or DfA concept is likely to be scaled up across a city
- Roadmaps for DfD and DfA for Copenhagen, Hamburg, London and Vantaa
- 12 DfD and DfA demonstrator projects
- 7 business cases for DfD and DfA approaches.

Chapter 4: Data and indicators for a circular built environment

A consistent and comprehensive approach to data collection, analysis and management is fundamental for a city to accelerate circularity in its built environment. As part of the CIRCuIT project, partners explored the data available in cities, how data capture can be improved and which indicators are key to supporting circularity.

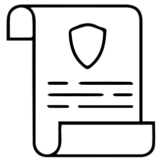


Key findings:

- Two methodologies and template for carrying out a circularity data mapping exercise and assessment of accessible data in a city
- Set of data templates to improve the capture and sharing of data relating to components, spaces, buildings and areas
- Recommendations to help a city address gaps or weaknesses in their data
- Set of 37 indicators that focus on circularity at a city, building and materials level.

Chapter 5: Using policy to power circular construction

Two significant areas where cities can support a transition towards circular construction is through their planning and procurement policies. To help decision makers take effective action in these areas, the CIRCuIT project developed practical guidance on policy interventions, working with developers, criteria for public tenders and city-level circular economy strategies.

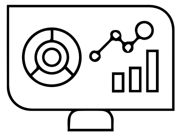


Key findings:

- Policy interventions to embed circular approaches in cities
- Checklist to support circular construction dialogue with developers on city projects
- Recommended circular economy criteria for public sector tenders
- Circularity policy roadmaps for Copenhagen, Hamburg, London and Vantaa

Chapter 6: Supporting circular construction with online tools

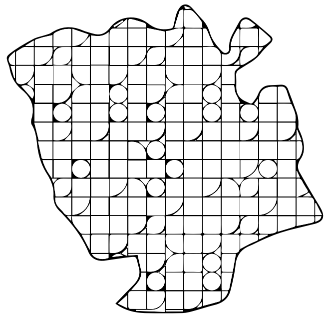
If cities are to increasingly transition to circular construction, it's critical that decision makers and built environment professionals have access to tools that can help them turn circular construction theory into practice. As a result, CIRCuIT's project partners developed five online tools to improve professional knowledge, increase acceptance of this way of building and ultimately, accelerate adoption of circular construction.



Key findings:

- Material Reuse Portal
- Circularity Dashboard
- Circularity Atlas
- Citizen Engagement Portal
- Circular Economy Wiki.

Overview of the four CIRCuIT cities

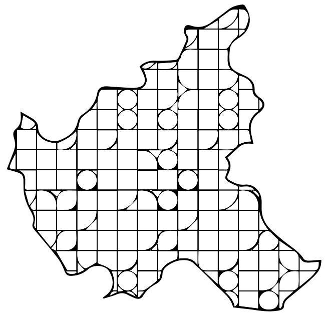


Copenhagen

Copenhagen is internationally renowned for its innovative approach to the climate and the environment. It has a reputation as the world's best city for cyclists. It is a living showcase for Danish architecture. But, most important of all, Copenhagen is a good place to live.

None of this came about by chance. It is the result of years of planning and development based on the needs of Copenhageners – everybody who lives in, uses, visits, works with or runs a business in the city. It is based on the life between the buildings.

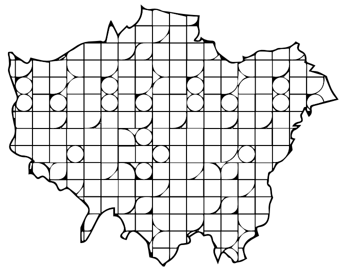
Copenhagen sets ambitious climate goals, aiming to be the world's first carbon neutral capital. It will achieve this through a city-wide transition toward sustainable energy supply, building retrofits, circular waste management, sustainable public infrastructure and mobility, as well as other key initiatives to support the transition.



Hamburg

The Free and Hanseatic City of Hamburg is one of the 16 states of the German federation and the second largest city in Germany. As a member of Eurocities and the City Science Initiative, Hamburg supports European cities and regions, facilitating knowledge sharing across networks, forums and workshops.

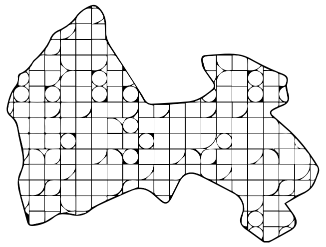
It is currently delivering several EU-funded Interreg and Horizon 2020 projects on urban development, circular economy and smart city elements, harnessing the power of innovation to progress towards its circular goal. In addition, in recent years Hamburg has set up ambitious climate transition targets in line with its industrial composition and socio-economic prospects, and it has introduced sectorial targets, including carbon reduction targets for each sector.



London

London is the engine of the UK economy, accounting for more than a fifth of the country's economic output. Over many centuries London has evolved, resulting in an extraordinary web of distinctive residential streets, squares, markets, parks, offices and industrial and creative spaces.

London aspires to be a zero carbon, zero waste city, and to transition to a low carbon circular economy. This is part of a wider strategy promoting 'Good Growth', which is about working to rebalance development in London towards more genuinely affordable homes, to deliver a more socially integrated and sustainable city.



Vantaa/Helsinki Region

One of three cities in Helsinki metropolitan area, the city of Vantaa is the fourth biggest city in Finland. It has a total area of 240.35 km^2 and a population of 223,000, rising by 2,400 citizens every year. The population is expected to reach over 300,000 by 2050.

Vantaa has a new comprehensive environmental programme called the Roadmap to Resource Wisdom 2030. It focuses on the circular economy and Vantaa's ambition to be carbon neutral by 2030. The circular economy goals consist of reusing materials (including during a demolition), establishing circular economy as part of planning and execution and improving the model for circular economy areas.

Why buildings need to last longer

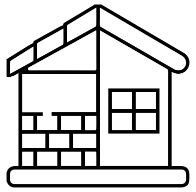
Extending a building's life is the first and foremost principle of circularity in the built environment due to the carbon savings it can deliver.

It's a common perception that building new, highly energy efficient buildings will reduce a city's carbon emissions. However, while increased energy efficiency will help deliver carbon savings in the future, we urgently need strategies that can reduce emissions today.

New building construction is responsible for a great deal of emissions due to the extraction of raw materials, processing into products, transport, and construction. Transforming or refurbishing an existing building prevents demolition and can keep resources that have already been processed in use for longer. This reduces the need to extract and process additional virgin materials reducing carbon emissions as well as minimising waste.

One of CIRCuIT's findings is that building preservation generally results in lower emissions compared to new construction. This is exemplified by results from demonstrator 19, the Korso school in Helsinki illustrating that even an extensive refurbishment without the addition of façade insulation showed a 26% better carbon performance over 50 years compared to conventional demolition and rebuild.

Where possible, extending the life of existing buildings must always be considered before demolishing a building and reusing components or recycling materials as it results in greater environmental benefits.



Where possible, extending the life of existing buildings must always be considered before demolishing a building and reusing components or recycling materials as it results in greater environmental benefits.

To help make the practice mainstream, decision makers and built environment stakeholders need to be able to easily identify buildings at risk of demolition with the potential to be transformed. They also need to understand how and why they should drive greater transformation and refurbishment .

This chapter outlines practical ways cities can identify buildings at risk of demolition by highlighting learnings informed by the CIRCuIT project's process. This includes showcasing a variety of examples that demonstrate what successful transformation looks like in practice. The resulting strategies enable and encourage more refurbishment and transformation in cities around the world.

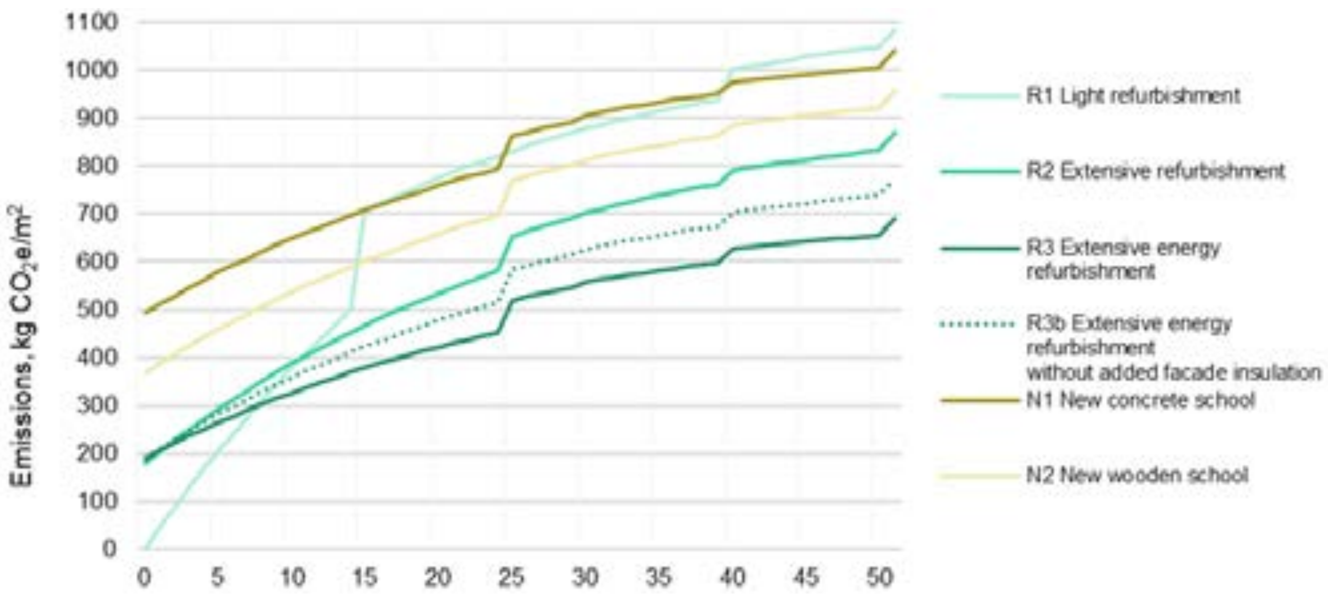


Figure 1.1: Accumulation of emissions in the different refurbishment and replacement scenarios, showing how building preservation results in lower emissions than new construction in most cases in demonstrator 19, Korso school.

How to identify buildings at risk of demolition

It is crucial that the construction sector makes significant changes to conventional practices and begins to prioritise resource conservation.

Presently, when the needs of a city change, built environment professionals – in particular building owners and asset managers – often choose to demolish rather than rethink existing buildings. In some cases, this is due to a lack of integration of refurbishment principles in city development practices, or a perception that it is a more expensive option.

Driving change starts with ensuring stakeholders can easily identify buildings that can be refurbished rather than demolished.

CIRCuIT project partners worked with local built environment stakeholders to develop three 'big picture' strategies for identifying endangered buildings. The strategies apply across different building types and can be adapted or developed to fit local data, allowing circular economy practices to become an integral part of a city's sustainable urban planning and policymaking.

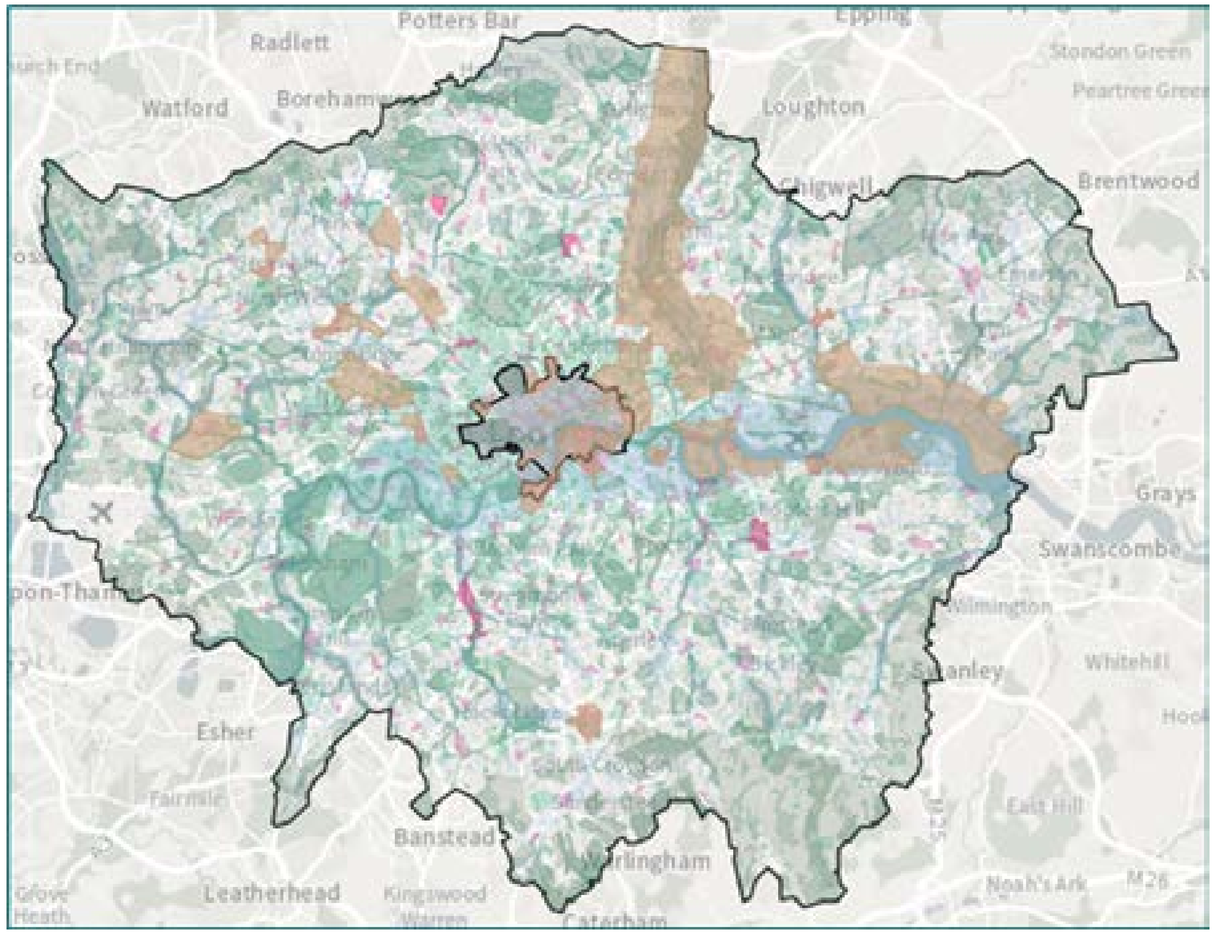


Figure 1.2: Map of London outlining planning areas of interest that could inform demolition trends. Key: opportunity areas (brown); intensification areas (pink); town centres (pale pink); central activities zone (pale pink);conservation/ designated open space (greens); flood risk (blue)

1. Analyse building stock patterns

Building stock data helps identify the kind of buildings typically demolished along with their replacements. This can help decision makers understand what buildings are at risk of demolition.

Data can be analysed by: using maps to extract geographical demolition data, using a building registrar to analyse replacement patterns or using text databases to identify demolition and replacement.

a) Use maps to extract geographical demolition data

This can work for cities that don't have a building register. It uses maps from different points in time to identify demolished buildings by analysing their footprints. Maps can provide an overview of upcoming demolition and allow targeted demand for transformation through urban planning.

Key steps

1. Acquire at least two maps of the city that showcase the location from different points in time, with at least a five-year difference.
2. Overlay the maps in a geographical information system (GIS) or by other means.
3. Compare building footprints manually or using computer software to detect changes.
4. Analyse the changed footprints to identify whether they indicate demolition or something else (like building extension).
5. Use additional data (for example Google Street View) to identify the key characteristics of demolished buildings, such as function and height/number of storeys.
6. Compare the key characteristics, including location, to new builds to identify opportunities for retention. This can include where similar buildings are demolished and built, or where buildings with potential for adaptive reuse are demolished.
7. Analyse existing buildings for key characteristics of demolished buildings to identify those at risk of future demolition.

b) Use a building register to analyse replacement patterns

This is recommended for cities with a building register that retains information about demolished buildings. In addition to a simple register analysis, cities with registers containing information about building location (e.g. coordinates) can supplement the analysis on demolitions and other building stock patterns with a geographical analysis similar to the first approach. A geocodable building register can substantially speed up the analysis as it can contain key characteristics of buildings, such as function, floor area, height, number of floors or building year.

Key steps

1. Get access to, or an extract from, the building register.
2. Make a simple descriptive statistical analysis of the demolished and built buildings, highlighting their quantities and key characteristics.
3. Compare the key characteristics of the two stocks to identify similarities and differences in (for example) functions or sizes of demolished and new buildings.
4. If the register is geocodable, transfer the register information to GIS to analyse locations of demolished and new buildings to identify simultaneous occurrence in the same neighbourhoods or plots (like replacement).
5. Using the same approach, analyse the existing building stock for key characteristics of demolished buildings to identify buildings at risk of future demolition.

c) Use text databases to identify demolition and replacement

This approach is suitable for cities that don't keep track of demolished buildings in a building register and are too vast to analyse with maps. If the city has a non-indexed text database on building and/or planning permits, search the database text for 'demolition'.

Key steps

1. Get access to, or an extract from, the city's database on permits.
2. Search the database for the terms of interest (for example 'demolition', 'deconstruction', 'replacement' etc).
3. Analyse the identified permits for key characteristics of demolished buildings, such as location, function, floor area, building year etc.

2. Identify external factors

Many factors can play a decisive role in determining whether a building becomes obsolete, and so influence the risk of being demolished. These can include the surrounding neighbourhood, the owner's aims and expectations and whether the construction sector leans towards transforming existing buildings or building new ones.

To identify what external factors may play a role in determining whether a building is at risk of demolition, cities can a) analyse locational factors and b) analyse key stakeholder perspectives.

Analysing locational factors

Supplementing method one with a closer look at neighbourhood-level factors, like access to transport, facilities and services, can help identify urban characteristics that contribute to demolition.

Key steps

1. Establish where demolition has taken place in the city over a set period (outlined in method one above).
2. Collate data on locational factors that could play a role in increasing or decreasing a building's risk of being demolished. These could include:
   - transport access (proximity to motorways, public transport, airports etc)
   - distance and quality of facilities and services
   - historical and architectural characteristics
   - safety
   - land use
   - land and property value
   - planning zones and rezoning potential
   - density of occupation

Geographically compare your demolition activity data with locational data to identify common trends. For example, that a high percentage of demolitions over the past five years took place in areas with poor transport links, or particular issues in a neighbourhood.

Analysing key stakeholder perspectives

Understanding how the real estate and construction sector operates, how key stakeholders view building retention, and which factors are important to them in making demolition decisions, can be useful. It can also complement any available building and/or urban data.

Key steps

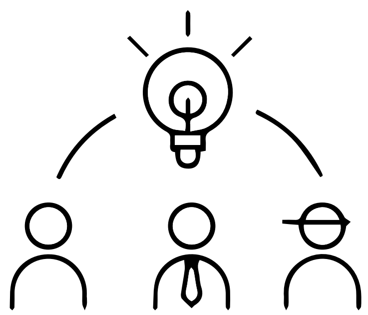
1. Speak to colleagues or other planning professionals to understand how planning decisions around redevelopment and demolition are made. Decisions made by built environment stakeholders can greatly influence whether a building is transformed or demolished.

2. Conduct interviews and workshops with stakeholders to discuss the most influential factors.

Questions could include:

- What are the key factors that guide decisions to demolish or refurbish?
- What do your short-term and long-term cost analyses include as assumptions?
- Is the impact on social value and communities included in your analyses?
- What (or who) might change a decision to demolish or retrofit? For example, tax incentives, legislative requirements, improved guidance, technological development, site context (location, building type).
- Do you have any insights on how the decision to refurbish or demolish has come up in existing projects? Are there case studies?

3. Market research into current and future built environment trends could help identify types of buildings or areas at risk of becoming obsolete now and in the future. Discussions with built environment stakeholders may shed light on these. Additionally, review reports and articles on relevant topics.



3. Adopt a multi-method approach

This approach is recommended if there is access to the right data and stakeholders to provide a broader perspective.

Key steps

1. Use building stock data to identify what kind of buildings are typically demolished in a city and what they are replaced with. See method one on page 1-7.

2. Geographically compare demolition data with data on key external factors that may influence whether a building becomes obsolete and at risk of demolition. Identify common trends that may help predict where at-risk buildings are likely to be located in the future and the amount of floorspace that may be demolished. See method two on 1-8 and 1-9.

3. Hold discussions with built environment stakeholders to gain valuable insights about planning decisions, redevelopment and demolition that may not be publicly available. See method two on page 1-10.

Recommendations

Urban planners and policy makers should use a circular perspective on all city development

Consider transformation possibilities when identifying land for development in the city. Overprovision of new space will vacate and drive premature demolition of already existing buildings with life cycle extension potential. For example, the list of 'at-risk' buildings could figure in these decisions.

- Tax empty buildings to prevent them becoming underused, vacant and falling into disrepair.
- Establish a lighter and quicker route to change the urban plan or deviate from a building's stated function to help transform buildings temporarily, before the long-term plan is implemented.
- Design transformation projects for circularity ensuring transformed spaces can be adapted for another future use, or structures can be easily disassembled.
- Try to engage early on to create a common understanding between building permit and heritage protection departments and developers.
- Reserve funds for systematically developing life cycle extension in all branches of city administration.

Practical ways to extend a building's life

This section outlines transformation strategies and drivers that encourage decision makers and built environment stakeholders to extend the lives of buildings as opposed to demolishing and building new.

Renovation projects usually save between 50–75% of embodied carbon emissions compared to constructing a new building[4]. As we must reduce emissions quickly and sharply, ensuring we extend the life of existing buildings and do not need a large influx of new materials is critical.

Cities often focus on preserving or transforming buildings with heritage value. Transitioning to a circular economy means shifting this focus to include more everyday buildings like workplaces and housing, such as post-war era stock, where preservation is typically not mandatory or even encouraged by public policy.

Assess transformation potential

CIRCuIT recommends municipalities focus on identifying which buildings are suitable for transformation. It is important that cities are proactive in being informed and informing others on the potential for preservation through transformation a long time before any demolition is scheduled. Depending on the case, this could mean identifying harmful substances, investigating possibilities for extensions, or finding the best transformation strategy based on a building's existing layout.

When rezoning already developed areas with existing building stock, cities should consider the transformation potential of the area's buildings. They should also consider the positive environmental impacts and devise city plans that enable maximum retention of buildings with preservation potential. Cities must also proactively inform and negotiate with current and future building owners about preservation potential through circular design principles.

Review financial and environmental factors

Most CIRCuIT transformation demonstrators showed there are financial savings from transforming buildings rather than demolishing and building new. However, there are still other conditions or considerations, such as risk management. They can make the transformation more expensive, less profitable, or less attractive to business decision makers.

CIRCuIT recommends reviewing processes in municipalities or applicable locally around how transformation projects are taxed compared to new construction. Legislation should be streamlined so that transformation projects are equalised or prioritised financially compared to new construction.

Removing financial barriers to transformation projects can make it cheaper or more profitable to preserve rather than tear down and build new. This can also help remove some of the risks in transformation projects. These include uncertainty on an existing building's technical condition – which investors say is the main reason why many buildings are demolished rather than preserved.

4. Embodied carbon: What it is and how to tackle it | RPS Group

Factor in resource savings

CIRCuIT's demonstrator projects show large material savings thanks to the circular retention strategy, particularly where the structure and foundation are preserved. Transformation is less material intensive than new construction because most of the existing building parts are preserved. This means there are potentially big carbon savings from the reduced need to produce new building materials.

CIRCuIT recommends current or future environmental preservation value should be implemented in the municipalities' work with urban development and handling applications for demolition.

Embed transformation priorities in procurement policies

Procurement processes and public tenders are an impactful way for cities to drive their circularity priorities. For transformation, procurement recommendations are particularly relevant in the design stages of the project. To that end, draft designs should be procured for both alternatives– renovation and replacement, and both alternatives should be supplemented with LCA and LCC calculations to facilitate informed decision-making. Subsequently, detailed design and construction can be procured based on the selected alternative, where further environmentalcriteria can be requested (e.g. related to energy efficiency).

To read more about procurement see Chapter 5: Using policy to power circular construction.

Construction strategies to promote life extension

These different strategies can be used by cities to encourage extending buildings' lives.

Refurbishment and renovation

The most direct way to promote life cycle extension is simply taking care of built structures by regular and timely refurbishment and renovation. This includes upgrading buildings' technical aspects, such as energy consumption and insulation.

Transformation and adaptive reuse

Transformation can include everything from changing structural and spatial properties or expression to changing functions (sometimes both). 'Adaptive reuse' refers specifically to change of function.

Densification or infill

This means adding more built square metres into an already built-up area with new construction. It may seem contradictory that new construction is a strategy for life cycle extension. Yet construction comes with additional income which may fund renovation or transformation. Making the space viable with a small addition saves the need for total demolition and rebuild.

Listing

Heritage listing is an effective way to save buildings from demolition. More inclusive listing strategies could consider wider building categories that value existing buildings for their embodied carbon intensity.

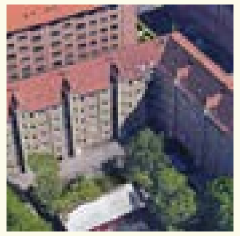
What successful building transformation looks like

Working with each other and local built environment stakeholders, partner organisations in the four CIRCuIT cities developed and evaluated and the benefits they can deliver, four are highlighted here.

Each of the demonstrators illustrated a range of buildings often at risk of demolition in the CIRCuIT cities and beyond and the typical challenges when trying to transform these buildings. These examples bridge the gap between theory, practice and policy. They don't just prove that cities can embed circular construction techniques – but that these activities are scalable and replicable.

> **Full overviews including detailed carbon and cost assessments of all demonstrators can be found at circuit-project.eu/post/latest-circuitreports-and-publications**

Copenhagen



Transforming a 1930s commercial site into student housing

Virtual Demonstrator

Overview

Buildings on the commercial plot were originally developed for manufacturing, including production of timber, soda water and cast metal products.

Currently, the site houses businesses including auto repair shops, a night club, musicians' studios, start-up companies and education services.

Threat of demolition

Industrial buildings account for the vast majority of demolished area in Denmark. Typically, a site like this is sold to a developer that will demolish it as far as possible so new housing can be built. The huge demand for housing in Denmark and soaring residential prices means the developer is likely to build at high density.

Transformation project

CIRCuIT partners in Copenhagen and local built environment stakeholders investigated how the site could be transformed into affordable student housing. Overall, the circular intervention's lower material consumption resulted in a potential CO_2 saving of 23%.

Key findings

Public data has an important role in assessing transformation potential. A publicly available database made it possible to create static calculations and a 3D model of the building's construction and layout to support the design process.

Hamburg

Gröninger Höf Parkhaus – Giving new life to a heritage-listed building

Physical Demonstrator

Overview

This building is in a popular resort on the Baltic coast of Schleswig-Holstein, about 85km north-east of Hamburg city centre.

It was built as a one-storey car dealership in the mid-1950s and extended several times in the following years. In the early 2000s parts of the structure (sales areas) were heritage-listed because of the curved glass façade. In the last years before conversion, the building was briefly vacant during planning and project development. .

Threat of demolition

Gaining heritage-listed status meant the building could never be demolished. However, analysis of demolished buildings in Hamburg showed it exhibits many characteristics typical of demolished buildings. This includes the commercial-industrial function, distant location and small, low-rise character. These buildings are often demolished without second thought to give way for denser and higher development – especially buildings without a heritage listing. A significant problem with buildings like this is how to use them and the land they stand on effectively while retaining spaces and components with preservation potential.

Transformation project

Transformation and extension of the existing heritage-listed building into a gym and vacation apartments was completed in 2020.

By strengthening the structure's load-bearing capacity three extra levels for vacation apartments were made possible. This resulted in savings of 321 tonnes of materials, 186 tonnes of waste and 74 tonnes of CO_2 emissions. The cost of the circular intervention was 4.2% less than demolishing and building new.

Key findings

Early collaboration with heritage protection authorities was key for success. It helped precisely identify areas for preservation, alongside those that could be modified and by how much.

Increased density and a new future-oriented use was achieved through revised room layouts and structural strengthening to enable three new floors above the original building. Close collaboration with architects helped harmoniously integrate modern, high-quality features people would expect with the original heritage look.

Figure 1.3: Illustration of suggested redevelopment of Groninger Höf Parkhaus

Vantaa/Helsinki Region

Transforming 1970’s public rental housing to accommodate more people

Virtual Demonstrator

Overview

This transformation covers two blocks of flats (one with three floors and one with five floors) in the Hakunila district of Vantaa. Both buildings were completed in similar Modernist style with precast concrete panels in 1979. The buildings have always been social rental housing.

Threat of demolition

There is no particular threat of demolition for the flats. However, there is pressure to demolish existing housing in the area as the urban population rises.

Social rental housing is particularly prone to demolition due to factors like:

- typically having only one institutional owner, which eases decision-making on demolition
- physical degradation of buildings or lacking necessary flat properties, e.g. in accessibility or demand on flat size
- socio-economic environment with precarious groups, neighbourhood image issues
- vacancy issues, mismatch of flat size with demand
- city’s policy targets for urban densification and social mix/gentrification and the potential value of the plot with a renewed urban plan featuring substantially increased building rights (in m2)

Transformation project

Instead of demolition and replacement, urban densification targets were pursued through a retention and extension approach, with additional floors added on top of the existing buildings. Through consultation with the owner, it was decided there was no need to change the flat or room layouts. They serve the needs of renters well, as evidenced by the low vacancy rate. Instead, it was decided to balance out the flat-size offerings in the buildings with the help of additional floors to house smaller flats. The facades, building services and interiors of existing floors (including flats and shared facilities) were renovated as part of the overall transformation.

Additional floors were designed to be added on top of the existing buildings with the help of steel beams, running from cross-wall to cross-wall. This provides freedom for the placement and sizes of the new flats, as the new walls will not need to coincide with the underlying load-bearing walls.

The wooden load-bearing frame of the additional floors is lighter than concrete and helps to avoid the need to reinforce foundations, but also results in shorter spans. This fact, together with creating smaller flats, means that layouts may not be particularly adaptable in future.

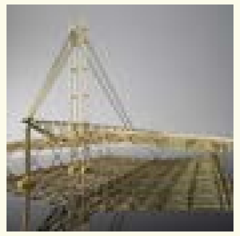
Key findings

If a city has a densification target, extending housing blocks with additional floors can be a technically, economically and environmentally viable alternative to demolition and new build.

The approach is particularly viable in social housing, as there is only one owner who can easily make the decision to transform. Because the building is non-profit, the project’s demonstrated cost saving is more relevant than the potential profit from demolition (a factor that can limit the interest of for-profit housing providers). As public actors, social housing companies could set an example for other types of housing providers.

Depending on the size and shape of the site and its location, a densification target may only be achievable if new buildings are constructed on the site as well as adding additional floors to existing buildings. The terrain and soil of the site may influence whether this is possible and what the cost implications will be.

London



Extending the life of a 1980s commercial shopping outlet

Virtual Demonstrator

Overview

The subject of the transformation is a large commercial shopping outlet, which was completed in 1987 and functioned as a Do-It-Yourself store.

The structural scheme was created to be column-free through a structural steel spine truss along the length of the building. This is supported at an intermediate point by steel tension cables. The building is clad with sheet metal and sits on a concrete podium deck.

Threat of demolition

A developer recently acquired the outlet and surrounding land. The plan for the site is to build high-rise residential properties and retail outlets on it. This is because of the huge demand for residential properties in London. As a result, the large shopping outlet is at high risk of demolition.

Transformation project

In an attempt to save it, CIRCuIT partners in London explored options for retaining and transforming the whole building. The sectors these options covered included retail, multifunctional/cultural, healthcare, transport, industrial/manufacturing, agricultural, sport and research/educational.

After considering the different options and the potential environmental and economic benefits, the developer decided none of the transformation options were suitable.

However, dismantling and re-erecting the entire structural frame on another site was chosen as an alternative option.

This circular intervention (retaining the substructure, steel frame and roof) would save up to 1.2 million kg of CO_2 compared to a new building alternative.

Key findings

This kind of project could potentially be replicated across other out-of-town retail units. This could result in a reduction in whole life carbon emissions of 400,000 tonnes of CO_2 across Greater London.

Making the case for building transformation

A 'business case' makes the case for change. It is directed at a specific audience who can make the proposed change and describes actions to be taken outside of BAU and expected outcomes.

Each business case includes five perspectives presented under the headings: strategic, financial, feasibility, risk and scalability. Together these commentaries and the demonstrator templates provide evidence on the benefit of investment in the proposed changes for both the decision maker and the community.

> **A full list of all business cases developed from demonstrator results can be found in appendix A1.2**

B. Public and private asset owners can identify the optimum cost and carbon approach to projects by commissioning assessments of different degrees of retaining and transforming existing assets.

Strategic: Public and private asset owners can improve projects' costs and carbon profiles by commissioning early-stage assessments of different degrees of retention and transformation to meet future needs. This is rather than just comparing default demolition or a façade retention-only approach against minimal refurbishment of existing buildings.

Financial: In the demonstrator projects on which this case is based, life cycle costing found the total costs of optimal approaches to existing buildings result in savings of 7% and 26-41% compared to default new build or façade retention only. The savings range from €1m to €5.5m, indicating a strong case for investment in assessments.

Feasibility: Skills exist to implement assessments of various approaches to building retention. The benefits should be considered at the start of projects and consultants appointed on the basis of proven abilities and their willingness to interrogate the best use of existing assets.

Risk: Regulations might change during a development project. Setting out early on with evidence of the optimal approach to existing assets minimises the risk of developing a BAU approach and creating abortive work that's non-compliant under new regulations.

Scalability: This approach would not work on sites where city planning allows significantly taller new buildings than can be achieved through retention and extension of existing buildings. Nevertheless, the demonstrator cases are widely applicable across many other sites and building types. While the Korso School project showed significant economic advantage in carrying out various levels of refurbishment, North Row was more marginal. In marginal projects, making the economic case for building retention may require new financial incentives such as (in a UK context) charging VAT equally on new build and refurbishment.

Related demonstrators: Demonstrator 19 – Korso School, Demonstrator 24 – North Row

D. Public and private asset owners can activate a neighbourhood and support new businesses by retaining existing assets for temporary use during long-term, phased regeneration projects.

Strategic: Public and private asset owners can activate a neighbourhood and support new businesses and job creation by assessing masterplans to identify existing assets to retain for temporary use during long-term, phased regeneration projects.

Financial: In the demonstrator project on which this case is based, construction costs for adapting and upgrading an existing building were 6% less than providing an equivalent new building. The projected return on investment over a fifteen-year temporary use period was enhanced by 8% compared to the new build alternative. Compared to a scenario in which the existing building is demolished, not replaced, and the land is rented out, the building retention option creates significantly higher net revenue, more jobs and a greater net total Gross Value Added.

Feasibility: Building retention to support temporary use is a familiar concept and skills exist to achieve it. The challenge is to recognise opportunities early on, assess their merit in terms of placemaking and social as well as economic value, and place sufficient weight on these benefits when briefing for design and phasing. Triple bottom line assessments should inform the approaches taken towards existing buildings.

Risk: Temporary uses can be seen as a risk for landowners in terms of safety and logistical reasons or delays in getting vacant possession when the site is due to be developed. A building or site will not always be suitable for temporary uses – for example if access blocks construction vehicles – but this can be considered in the early planning stages. Vacant possession can be ensured by establishing lease arrangements and maintaining clarity about the temporary use period.

Scalability: Large-scale redevelopment of industrial areas, such as the project that provided this demonstrator, are common in expanding urban areas where there is high demand for housing. With long redevelopment timeframes, there is good scope to treat existing buildings as assets that can provide income and social benefits through temporary use.

Related demonstrators: Demonstrator 23 – Block F

N. Private asset owners, investors and developers can gain recognition and achieve market differentiation by assessing whole life carbon when deciding between retrofit and demolition.

Strategic: Private asset owners, investors and developers should include results of whole life carbon assessments in strategic decision-making over retention and retrofit versus demolition and new build. This will help them meet changing legislation and public perception.

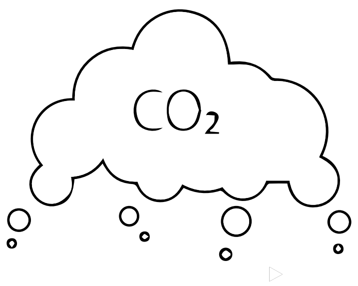
Financial: In the demonstrator projects on which this case is based, life cycle costing over a 50-year period found the total costs of retrofit scenarios to be 37%, 36%, 25% and 4% lower than new build.

Feasibility: There is growing capacity among consultants including access to software to enable whole life carbon assessments. In the demonstrator projects, the whole life carbon of retrofit scenarios was found to be 23%, 19% and 6% lower than those of new build. Giving the results of assessments sufficient weight in strategic decision-making, beyond meeting statutory minimum requirements, will be a matter of developers' setting their own policies and targets.

Risk: Gaining recognition for transforming underused buildings and exploiting opportunities for creating new housing in existing assets minimises businesses' exposure to the risk of demolition becoming an unacceptable approach in many contexts. Developing the capacity to work efficiently with existing assets builds businesses' resilience to shifts in policy and taxation that incentivise retrofit over demolition and limit whole life carbon.

Scalability: There are few barriers to introducing whole life carbon assessments and taking them into account when deciding between demolition and new build. The demonstrator projects indicate economic and environmental benefits as well as reputational benefits in doing so. The ability to scale retrofit as a solution requires greater familiarity working with existing buildings across the construction value chain and innovation in surveying methods to de-risk and generate better information about existing buildings.

Related demonstrators: Demonstrator 13 – Godewind Park, Demonstrator 18 – 1930s commercial plot, Demonstrator 21 – Vantaa office building



In the demonstrator projects, the whole life carbon of retrofit scenarios was found to be 23%, 19% and 6% lower than those of new builds.

Y. Citizens can form cooperatives and create new affordable homes and workspaces by identifying and transforming underused assets.

Strategic: Citizens can form cooperatives to work with municipalities to identify underused assets that are otherwise a blight on the urban landscape and at risk of demolition, and transform them into productive buildings.

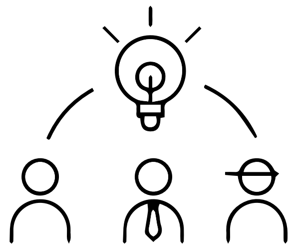
Financial: In the demonstrator project on which this case is based, transformation of an underused multi-storey car park into housing resulted in a saving in demolition costs of around 15%. It also led to a total construction cost reduction of around 5%, compared to demolition and new build.

Feasibility: A key step for citizen-led cooperatives is to form relationships with city planners and collaborate in identifying underused assets suitable for transformation. The demonstrator project found that there is increasing appetite among cooperatives to invest in alternative residential-led mixed use developments.

Risk: Early investigation of existing structures is critical to ensure any hazardous materials or historic contamination can be remedied and the associated costs and risks are understood.

Scalability: The demonstrator focused on a multi-storey car park. Many cities are aiming to reduce car use and keep cars out of inner-city areas. This means reuse and transformation of car parks is one opportunity to scale creation of valuable living, social and commercial spaces in inner cities. In Hamburg, nearly 10,000 parking spaces in multi-storey car parks are expected to be suitable for transformation in the next twenty years. Municipalities can support cooperatives by systematically identifying these and other assets at risk of demolition to maximise the likelihood of their transformation and the social, environmental and economic benefits shown in this demonstrator.

Related demonstrator: Demonstrator 15 – Gröninger Hof Parkhaus



Citizens can form cooperatives to work with municipalities to identify underused assets that are otherwise a blight on the urban landscape and at risk of demolition, and transform them into productive buildings.

Further reading

For further information about these outputs and the work behind them, please read the following reports, which were published by members of CIRCuIT partner organisations during the lifetime of the project.

- D5.1 How to identify buildings for life-cycle extension? Guide for case selection via the mapping of transformable neighbourhoods and buildings
- D5.2 Developing and applying replicable strategies and design principles for keeping buildings and neighbourhoods in circular use
- D5.3 Policy brief and business case of building transformation

> **All these reports can be downloaded at circuit-project.eu/post/latest-circuit-reports-and-publications**

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CIRCUIT

A Appendices

A1.1: CIRCuIT demonstrators

	Theme	City	Demonstrator name
1	Urban Mining	Hamburg	Luruper Hauptstraße
2	Urban Mining	Hamburg	Offakamp
3	Urban Mining	Hamburg	Musterbude
4	Urban Mining	Copenhagen	Circulation of materials from Gladsaxe school / The Swan
5	Urban Mining	Copenhagen	Stablen / The Stack
6	Urban Mining	Copenhagen	Hyltebjerg school
7	Urban Mining	Vantaa/Helsinki Region	Hevoshaka school
8	Urban Mining	Vantaa/Helsinki Region	Vantaankoski school
9	Urban Mining	Vantaa/Helsinki Region	Tikkurila school warehouse
10	Urban Mining	London	Component reuse of retail unit
11	Urban Mining	London	Demolition of One Leadenhall Street
12	Urban Mining	London	Glulam from secondary timber
13	Transformation	Hamburg	Godewind Park
14	Transformation	Hamburg	Horner Geest
15	Transformation	Hamburg	Gröninger Hof Parkhaus
16	Transformation	Copenhagen	1900s housing urban densification
17	Transformation	Copenhagen	1970s housing estate – Taastrupgård
18	Transformation	Copenhagen	1930s commercial plot
19	Transformation	Vantaa/Helsinki Region	Korso school
20	Transformation	Vantaa/Helsinki Region	Transforming 1970s public rental housing
21	Transformation	Vantaa/Helsinki Region	Adaptive reuse of office buildings for housing in Vantaa
22	Transformation	London	Extending the life of a large 1980s commercial shopping outlet
23	Transformation	London	Transformation of Meridian Water Block F
24	Transformation	London	Transformation of 31-34 North Row
25	Dfd and Dfa	Hamburg	Hamburger Klassenhäuser – Slab construction
26	Dfd and Dfa	Hamburg	Hamburger Klassenhäuser – Façade comparison
27	Dfd and Dfa	Hamburg	Neustadt – Partition walls
28	Dfd and Dfa	Copenhagen	Copenhagen Adaptable housing
29	Dfd and Dfa	Copenhagen	DfD modular façade – Taastrupgård
30	Dfd and Dfa	Copenhagen	Living places Copenhagen
31	Dfd and Dfa	Vantaa/Helsinki Region	Vantaa Hybrid school
32	Dfd and Dfa	Vantaa/Helsinki Region	DfD Warehouse
33	Dfd and Dfa	Vantaa/Helsinki Region	Helsinki Adaptable flats
34	Dfd and Dfa	London	Albion Street / The Hithe
35	Dfd and Dfa	London	Meridian Water: RightSizer
36	Dfd and Dfa	London	Green Street Workspace, Newham

A1.2: Business cases emerging from the CIRCuIT demonstrators

A 'business case template' was prepared based on data attributes and analytics developed during the CIRCuIT project to support, monitor, measure and assess CIRCuIT demonstrator projects.

This template has been used as the framework to gather data and present findings from demonstrators across the three core themes of the project: urban mining and material reuse, building transformation and life cycle extension, design for disassembly and adaptability. The completed templates for all demonstrators can be found at circuit-project.eu/post/latest-circuit-reports-and-publications.

In this section, cases emerging from all demonstrators are aggregated to provide a selection of concise, evidenced, and actionable business cases. A 'business case' is understood as making a case for changing something. It is directed at a specific audience who can enact the proposed change. It describes actions to be taken outside of BAU and the outcomes that are expected. These commentaries and the demonstrator templates provide evidence on the benefit of investment in the proposed changes for both the decision maker and the community.

Public and private asset owners, investors, and developers

A. Public and private asset owners can assess cost and carbon saving opportunities from reuse across projects and asset portfolio by commissioning and acting upon pre-demolition audits

Related demonstrators: 2 – Offakamp, 4 – Circulation of materials from Gladsaxe School / The Swan, 6 – Hyltebjerg School, 7 – Hevoshaka School, 8 – Vantaankoski school, 10 – Component reuse of retail unit, 11 – Demolition of One Leadenhall Street

Public and private asset owners can reduce costs and carbon emissions by implementing PDAs proactively or in early project stages. By understanding the materials available for reuse and establishing a potential material reuse pipeline, materials more likely to be exchange within the asset portfolio. Financially, conducting PDAs early can offer a cost- material solution. One demonstrator found a 12% construction cost reduction by implementing onsite use of recycled aggregates. While PDAs are gaining industry familiarity, some secondary material supply chains do not have the financial capacity yet to widely and strategically implement them. Policy recommendations suggest mandating PDAs for all projects, upscaling PDAs and in turn reducing the costs of deconstruction, processing and testing.

B. Public and private asset owners can identify the optimum cost and carbon approach to projects by commissioning assessments of different degrees of retaining and transforming existing assets

Related demonstrators: 19 – Korso School, 24 – Transformation of 31-34 North Row

Owners of public and private assets can identify optimum cost and carbon approaches to projects by commissioning early-stage assessments of the different ways to use buildings (I.e transformation and retention). The demonstrator projects have shown that optimal retention approaches (achieved through early assessments) can save 7% - 41% of total project costs, amounting to €1 million - €5.5 million saved making a strong case for investing in these assessments. The skills and knowledge do exist to implement assessments to retain buildings and in turn reduce costs and associated carbon. It is vital to consider the cost and carbon saving benefits with evidence at the beginning of projects and appoint experienced consultants. For less economically viable projects, financial incentives such as (in a UK context) charging VAT equally on new build and refurbishment might be necessary.

C. Public and private asset owners can assess existing housing roof and loft spaces and other opportunities for densification

Related demonstrators: 16 – 1900s housing urban densification, 20 – Transforming 1970s public rental housing

Public and private asset owners can assess existing housing roof and loft spaces and other opportunities for densification to cope with increasing housing demand. This essentially means accessing the benefits of transforming roof spaces into residential space. For example, demonstrator project 16 assessed several roof transformation projects in Copenhagen to conclude that roof transformations for residential space can enhance environmental performance, in turn supporting the case for transformation. Roof conversions for housing is technically straightforward but they have legislative and financial obstacles which limits the upscaling potentially, however more assessments of the benefits could help to build a case for more lenient roof conversion regulations.

D. Public and private asset owners can activate a neighbourhood and support new businesses by retaining existing assets for meanwhile use during long-term, phased regeneration projects.

Related demonstrators: 23 – Transformation of Meridian Water Block F

Public and private asset owners can activate a neighbourhood and support new businesses and job creation by assessing masterplans to identify existing assets to retain for temporary use during long-term, phased regeneration projects. In the demonstrator project, construction costs for adapting an existing building were 6% less than providing an equivalent new building. The projected return on investment over a fifteen-year temporary use period was enhanced by 8% compared to the new build alternative. Building retention option creates significantly higher net revenue, more jobs and a greater net total Gross Value Added when compared to when an existing building is demolished, not replaced, and the land is rented out. Building retention for temporary use is technologically feasible, but the challenge lies in recognising opportunities early and prioritising benefits in planning. With long redevelopment timeframes, there is good scope to treat existing buildings as assets that can provide income and social benefits through temporary use.

E. Public and private developers can create more valuable homes, improve resident satisfaction and reduce life cycle cost by developing adaptable housing

Related demonstrators: 28 – Copenhagen adaptable housing, 30 – Living places Copenhagen 33 – Helsinki adaptable flats, 35 – Meridian Water: Rightsizer

Public and private developers can create more valuable homes, improve resident satisfaction, and reduce lifecycle cost by creating adaptable housing. In the CIRCuIT demonstrators the upfront costs for adaptable housing were 21% - 24% higher. However, in one case life cycle cost savings of 28% were achieved if the spaces was adapted compared to demolishing and rebuilding after one use cycle. Adaptability of the spaces was made possible through simple design changes using available construction methods. Resident surveys show demand for adaptable flats, with a willingness to pay a premium (2–10%) for the communicated benefits. In homes owned by residents, a noted challenge was making owners aware of potential savings to motivate them to invest in adaptability. For public developers and housing associations, it's crucial to use life cycle costing over multiple life cycles to evaluate the benefits of designing for adaptability when they retain ownership.

F. Public and private landowners and asset owners can achieve increased rental income by facilitating meanwhile use of underused land and assets.
Related demonstrators: 34 – Albion Street / The Hithe

The term 'meanwhile use' represents a range of strategies that can be put into place to make under-utilised spaces and places become productive, both in an economic and social sense. Sites set for redevelopment often remain unused for a long time before construction begins, leading to unnecessary expenses for security and hoarding. Some businesses have evolved to offer meanwhile use construction for these underused plots, but finding a willing site can sometimes be difficult. Landowners can achieve increased rental income by identifying opportunities for 'meanwhile use' prior to longer-term redevelopment and actively working with the organisations offering meanwhile use construction. In London, there are 466 suitable plots, totalling nearly 500,000 sqm, showcasing the significant opportunity for meanwhile use, and thus increased rental income for public and private landowners in the UK.

G. Local authorities can help to create circular supply chains by driving demand for novel remanufactured secondary materials by adopting their use in public projects.
Related demonstrators: 12 – Glulam from secondary timber

Local authorities can support circular supply chains by instructing procurement teams to specify secondary materials in public projects. This will help local authorities to meet their carbon reduction objectives, while increasing the market for novel remanufactured secondary materials. The demonstrator project showed that deconstructing timber framing was estimated to add 15% to the demolition contractors' costs, however there is a holistic economic benefit to the area if more construction spend is retained in the local economy. This spend also helps new businesses to expand and reduces their costs, increasing the competitiveness of circular supply chains in the longer term. In the demonstrator, using secondary timber in glulam manufacture can achieve a 40% reduction in embodied carbon compared to conventional production. Understanding and communicating these environmental benefits of using novel secondary materials in projects will be key to resisting the pressure to revert to business as usual. The success of this business model relies on having enough secondary materials for big projects to enable consistent demand.

H. Public asset owners and housing associations should include assessments of whole life carbon, resource consumption and waste generation in strategic decision-making over retention and retrofit versus demolition and redevelopment
Related demonstrators: 17 – 1970s housing estate – Taastrupgard, 14 – Horner Geest

Public asset owners and housing associations should include assessments of whole life carbon, resource consumption and waste generation in strategic decision-making over retention and retrofit versus demolition and redevelopment. Assessments have shown that the transformation of socially challenged developments can be considered a win-win, aligning with both social and climate concerns, particularly when coupled with ambitious climate impact reduction initiatives and sustainable practices like repurposing and reuse. Through such assessments, demonstrator 14 showed that by updating and modernising apartment buildings, we can reduce carbon emissions by 4.5 kg per square meter of living space. Economic analysis shows a 20.9% cost reduction per square meter for demolition and construction/modernisation, building a case for retention and retrofit versus demolition and redevelopment.

I. Local authorities can help to create circular supply chains by driving demand for novel DfD construction by adopting its use in public projects.
Related demonstrators: 25 – Hamburger Klassenhäuser – Slab construction,
26 – Hamburger Klassenhäuser – Façade comparison

Local authorities can play a pivotal role in reducing future embodied carbon emissions and promoting circular construction by leading procurement teams to specify DfD in public projects. While resource savings are a large driver for implementing DfD techniques, the CIRCuIT demonstrators also found financial benefits. Demonstrator 26 found that in comparison to the basecase, the circular construction intervention adopting DfD facades resulted in an overall cost reduction of 61 % over the building's life cycle. Implementing novel construction techniques requires commitment and understanding from development and regeneration officers who must champion the policy through project briefs and challenges. Collaborating with innovative, circular businesses can enhance a local authority's reputation. The scalability of this business case depends on the availability of ready-to-use products and increased market demand driven by progressive purchasing and tighter regulations.

J. Local authorities can achieve faster, cheaper school construction and the ability to adapt sites to rising and falling school-age populations by procuring DfD construction
Related demonstrators: 25 – Hamburger Klassenhäuser – Slab construction, 31 – Vantaa Hybrid school

Local authorities can achieve faster, cheaper school construction and the ability to adapt sites to rising and falling school-age populations by procuring DfD constructions for schools. Demonstrator 31 showed that enabling larger degrees of flexibility in school design would allow the buildings to adapt to changing future needs without requiring major construction works, bringing carbon, material and cost savings. This business case could potentially be replicated to all future school projects in which could potentially result in significant environmental savings and increased efficiency of school space for the city at large.

K. Private asset owners, investors and developers can gain recognition and market differentiation by adopting novel, remanufactured secondary materials
Related demonstrators: 5 – Stablen / The Stack, 10 – Component reuse of retail unit,
12 – Glulam from secondary timber

Embedding circular strategies into construction can allow private asset owners, investors and developers to gain recognition and market differentiation. Effective use of remanufactured materials can highlight the private asset owner, investor, or developer as a sustainable lead in the industry. Strong carbon benefits can be found by embedding this approach as well. Demonstrator 5 showed that by using 58% reused and 42% new glulam beams, there was a 47% reduction in overall carbon impact of the project. This approach was also shown to reduce costs 12% compared to using only new beams. This specific approach could be applied in other types of buildings that have a beam structures.

L. Private asset owners, investors and developers can develop expertise in identifying and transforming underused assets
Related demonstrators: 15 – Gröninger Hof Parkhaus, 24 – Transformation of 31-34 North Row

Private asset owners, investors and developers can develop expertise in identifying and transforming underused assets to reduce construction costs and increase social value. For example, demonstrator 15 highlighted that there is a large market for the transformation of unused car parks, especially in cities like Hamburg that are transitioning away from cars to more sustainable travel. This transformation of underused spaces can contribute to the creation of valuable living and social and commercial spaces in inner cities. The total construction costs were also found to be 5% lower in the transformation model.

M. Private asset owners, investors and developers can relocate entire structural steel frames by connecting to others' project needs

Related demonstrators: 22 – Extending the life of a large 1980s commercial shopping outlet

Certain assets such as steel frame builds are technically simple to take apart and relocate. Private asset owners, investors and developers have the opportunity to capitalise on this by facilitating the relocation and transformation or selling their assets for the purpose of relocation. Demonstrator 22 illustrated that whole life carbon was improved 47% by applying the relocation and transformation approach as opposed to demolishing and building new. This approach was also more cost effective with a 15% saving in the capital construction cost, and reduced the Whole Life costs by 2%. This points to the value in pursuing the sale of a steel frame asset as a relocatable building.

N. Private asset owners, investors and developers can gain recognition and achieve market differentiation by assessing whole life carbon when deciding between retrofit and demolition

Related demonstrators: 13 – Godewind Park, 18 – 1930s commercial plot, 21 – Adaptive reuse of office buildings for housing in Vantaa

Private asset owners, investors, and developers can gain recognition and should consider whole-life carbon assessments when deciding between retaining and retrofitting versus demolishing and building new on new developments. This approach has strong financial benefits, with the CIRCuIT demonstrator projects illustrating that retrofit scenarios can result in total costs up to 37% lower than new builds over a 50-year period. There were also strong carbon benefits with retrofit scenarios illustrating an up to 23% lower whole-life carbon than new builds. This approach can be scaled with increasing software access, consultants can efficiently conduct whole-life carbon assessments of retention or demolition and rebuild scenarios. To integrate assessments into strategic decisions, developers should go beyond the legal requirements and set ambitious policies. Consistently taking on this approach will also allow the companies to benefit from beneficial market differentiation. Specialising in this approach also enhances resilience against policy/tax shifts that incentivise retrofit over demolition. Scaling retrofit solutions requires familiarity with existing buildings and innovative surveying methods for better data as to existing structures.

O. Private investors and developers can rent out affordable workspace by deploying a portfolio of reusable assets on meanwhile use sites

Related demonstrators: 34 – Albion Street / The Hithe, 36 – Green Street Workspace, Newham

Private investors and developers can increase their return on renting affordable workspace by acquiring demountable and reusable buildings and deploying their portfolio on meanwhile use sites. Land and assets earmarked for redevelopment are often underutilised before starting construction. These periods of under-utilisation of assets are often significantly longer than is first anticipated, due to delays in projects coming forward for allocated sites and delays in implementing existing planning permissions, leading to years of outgoings for landowners. Developers should invest in a portfolio of relocatable assets and market them to owners of underused land. The demonstrator The Hithe found that over thirty years and in comparison to a conventional basecase, the circular construction intervention resulted in a 6% increase in construction cost, but an overall reduced operational cost by 5%, reduced maintenance cost by 13%, reduced renewal costs by 60% and reduced the Whole Life costs by 23%.

Municipality as policymaker

P. Local authorities can help to create supply chains for secondary materials by establishing circular economy construction hubs closer to city centres.

Related demonstrators: 1 – Luruper Hauptstraße, 3 – Musterbude, 5 – Stablen / The Stack, 12 – Glulam from secondary timber

Local authorities can help create circular supply chains for secondary materials by allocating sites for circular economy construction hubs and facilitate partnerships to manage them. These hubs enhance material value retention in the local economy, reducing supply chain length, and creating local jobs. Issues such as limited storage space and high transportation costs for materials can impact reuse opportunities. However, as reuse becomes more visible, costs are expected to decrease. Partnering with organisations experienced in site management is crucial. Temporarily using disused brownfield sites for these hubs can revitalise unused spaces and benefit the urban environment. Such initiatives contribute to evolving urban waste management into a circular economy infrastructure, with demonstrator projects illustrating carbon emissions reductions ranging from 2% to 47%. Policy objectives aimed at achieving waste self-sufficiency should support the development of these sites.

Construction industry – deconstruction and secondary materials management

Q. Demolition contractors can maximise revenue from existing materials by assessing cost/benefit of different deconstruction techniques

Related demonstrators: 9 – Tikkurila School Warehouse

In a circular economy, existing materials are valued and there are market systems in place to sell and exchange materials. Demolition contractors are in a great position to leverage this newfound value by establishing a process of valuing existing materials and costing the necessary deconstruction techniques to extract these materials. Demolition contractors usually view buildings up for demolition through the lens of waste, however when materials are seen as resources the contractors detailed knowledge of deconstruction techniques can be applied to create a new income stream. Knowledge of deconstruction techniques are not yet widely known though there have been success stories of demolition companies refashioning themselves into deconstruction companies specialising in value retention. In the demonstrators various techniques for deconstructing bricks - e.g using hand held power tools, using an excavator – were compared for their efficacy and cost. Handheld power tools were more effective in harvesting undamaged bricks but took significantly longer to deconstruct the building and cost more due to increased labour needs – 17% more than other reclaimed bricks and 69% more than virgin bricks. Using the excavator resulted in reclaimed bricks that were 48 % cheaper than other reclaimed bricks and 24% cheaper than virgin bricks. Understanding the most effective way to reclaim materials can keep costs down and secondary materials of interest to consumers. x

R. Demolition contractors can improve cost estimates by comparing PDA predictions to actual materials arising from demolitions

Related demonstrators: 1 – Luruper Hauptstraße, 2 – Offakamp

Seeing demolition materials as resources as opposed to waste can increase the profitability of deconstruction or demolition work. However, as this is a new sector the practice of deconstruction or selective demolition to retain the value of materials still requires a level of data collection and analysis to determine optimal approaches. Demolition contractors looking to shift from waste management to reselling material resources should approach each project as an information collection exercise and compare PDA results to eventual material arisings from demolition. This comparison will help hone the most effective deconstruction techniques. These demonstrators showed that current method to estimate recyclable content are flawed and onsite demolition and reusing of mixed mineral waste results in lower environmental impacts compared to demolition and being processed in a recycling facility.

S. Demolition contractors can maximise higher quality recycling by streamlining mineral wastes

Related demonstrators: 3 – Musterbude

Demolition contractors can maximise high quality recycling by being more effective in the collection and separation of mineral wastes. Clear separation reduces the likelihood of downcycling of aggregates by allowing more control in terms of performance and aesthetics. The Musterbude demonstrator tested seven different concrete mixes with various levels of recycled aggregate. Aggregate with the highest value recycled material was 55% cheaper than virgin aggregate.

T. New and existing businesses can achieve new revenue streams by launching products based on novel recycling and remanufacturing processes

Related demonstrators: 12 – Glulam from secondary timber

There is growing interest across the industry to reduce the carbon impacts of projects by increasing the proportion of material that is reused or recycled. This poses an opportunity for new and existing businesses to achieve new revenue streams by launching products based on novel recycling and remanufacturing processes. For example, the Glulam from secondary timber demonstrator showed that reclaimed timber can easily be worked and transformed, allowing it to serve various functions like structural columns and beams. Challenges include obtaining reliable material sources within a useful timescale, characterisation of the material in terms of material grade, and identifying metallic fasteners in the material as removal is crucial to avoid damaging the tooling used in the formation of the glulam. A significant amount of construction waste is downcycled, so there is significant scope for upscaling this solution.

U. Demolition contractors can achieve new revenue streams by becoming retailers of recovered materials

Related demonstrators: 5 – Stablen / The Stack, 8 – Vantaankoski school, 9 – Tikkurila School Warehouse, 10 – Component reuse of retail unit

Demolition contractors can find new ways to make money by becoming experts in urban mining and reclaiming materials for reuse, remanufacturing, or high-quality recycling. In terms of reselling components demolition contractors traditionally focus on high-value goods for heritage projects, however there is a growing demand for other secondary materials like structural steel. In one demonstrator project, deconstructing a steel frame added £50/tonne to costs, but the resale value is approximately £80/tonne, making it financially viable for demolition contractors to sell. Simplifying deconstruction through improved skills and technology, along with a better understanding of secondary material markets, can reduce costs and enhance feasibility even further. Greater demand for secondary materials, driven by progressive purchasing and carbon regulations, can increase profit margins and expand the range of recoverable materials.

Construction industry – designers and supply chain

V. Designers can become building transformation specialists, capable of rigorously assessing a range of approaches to building retention and adaptation

Related demonstrators: 19 – Korso School, 24 – Transformation of 31-34 North Row

Thriving in the circular economy will require rethinking the entire construction process from design through to demolition. On the design side this means designers must become specialists in transformation – being able to assess a range of approaches to building retention and adaptation. Initially this can support the design organisation differentiating themselves as a leader in the sustainable construction field. As policy requirements for circular approaches and low embodied carbon construction grow, specialising in transformation will futureproof design agencies against future requests and requirements.

W. Manufacturers can generate new revenue streams by developing demountable product-as-a-service business models.

Related demonstrators: 27 – Neustadt – Partition walls, 29 – DfD modular façade – Taastrupgård, 32 – DfD warehouse, 36 – Green Street Workspace, Newham

Manufacturers can make money by leasing building products, like partition systems, and keeping ownership for future savings. In the demonstrator projects, systems designed for disassembly had 11–25% higher upfront costs but saved 13–25% when used a second time. Real savings were seen in the Neustadt example, benefiting manufacturers who can disassemble and re-warrant their products. To make leasing common, there needs to be a mindset shift and considerations for pricing and ownership. While there are financial and organisational risks, keeping ownership of materials protects against future price changes. Leasing works best for shorter-lived components and temporary buildings, raising questions about compatibility among manufacturers. Technology alignment and information retention, like material passports, ensure proper disassembly and reuse, even if the original manufacturer stops trading.

X. Manufacturers can invest in offsite manufacture of slabs and façade elements to enable faster construction

Related demonstrators: 25 – Hamburger Klassenhäuser – Slab construction

Manufacturers can invest in offsite manufacture of slabs and façade elements to enable faster construction and thus make themselves the preferred supplier. Shorter construction times means lower costs for the client, so providing a product that makes this possible while also offering environmental benefits can be a key business strategy. Demonstrator 25 illustrated that byincorporating flexible designs for slabs, a 75% reduction incarbon footprint can be achieved. The economic analysis found that a cost reduction of 37% is possible, when considering two buildings constructed with a 90% reuse potential of the slabs compared to demolition and building new.

Citizens

Y. Citizens can form cooperatives and create new affordable homes and workspace by identifying and transforming underused assets.

Related demonstrators: 15 – Gröninger Hof Parkhaus

Citizens can form cooperatives to collaborate with municipalities to identify and repurpose underused assets around the city transforming them into valuable buildings. In one CIRCuIT demonstrator a citizen cooperative led the transformation of an underused multi-story car park in Hamburg into a mixed use residential development. This approach found a 15% saving in demolition costs and a 5% reduction in total construction costs compared to demolition and new build. Citizen-led cooperatives can enhance feasibility of such projects by building relationships with city planners and investing in alternative residential-led mixed-use developments. Early investigation of existing structures is crucial to understanding and mitigating risks associated with hazardous materials or contamination. Scaling this approach is feasible, particularly in cities aiming to reduce car use, with Hamburg alone expecting nearly 10,000 parking spaces in multi-storey car parks to be suitable for transformation in the next twenty years. Municipalities can support cooperatives by systematically identifying assets at risk of demolition, maximising the potential for their transformation and social, environmental, and economic benefits.

Z. Housing cooperatives and resident associations can assess roof and loft spaces of existing housing for building- or estate-wide densification potential.

Related demonstrators: 16 – 1900s housing urban densification

As cities struggle with housing availability and affordability, expanding existing buildings vertically is a compelling option as it increases density without changing the character of the city area. Assessing this transformation potential for housing cooperatives and resident associations would allow these organisations to create significant additional value for a fraction of the financial and environmental cost of an entirely new development.

CIRCuIT's housing densification demonstrator illustrated that creating new housing via roof conversions is technically uncomplicated but runs into legislative and financial barriers. For this approach to be taken forward successfully, certain apartment requirements such as additional parking spots would need to be lightened or removed. These legislative changes should be possible with close collaboration with the city. A full transformation of the attic space is also too expensive for individual housing owners to consider, even with the rent income from future apartment residents, as construction costs remain high due to the customized nature of building on top of existing structure. Different financial arrangements, such as selling the entire floor to a developer could circumvent this challenge. The environmental benefits of this approach are clear, with the embodied carbon of a rooftop conversion being 48% lower than a comparative new build.

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