CIRCUIT

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Data and indicators for a circular built environment

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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.

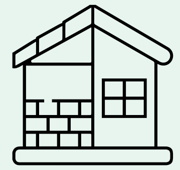
Turning theory into practice

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.

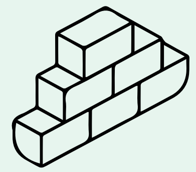
CIRCuIT was a collaborative project funded by the European Commission's Horizon 2020 programme. The project involved 31 partners across the entire built environment supply chain in Copenhagen, Hamburg, Helsinki Region and London.

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

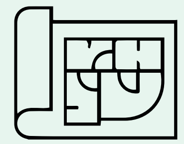
The project's goal was to support the mainstreaming of circular construction practices in the built environment focusing on three key thematic areas:



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.

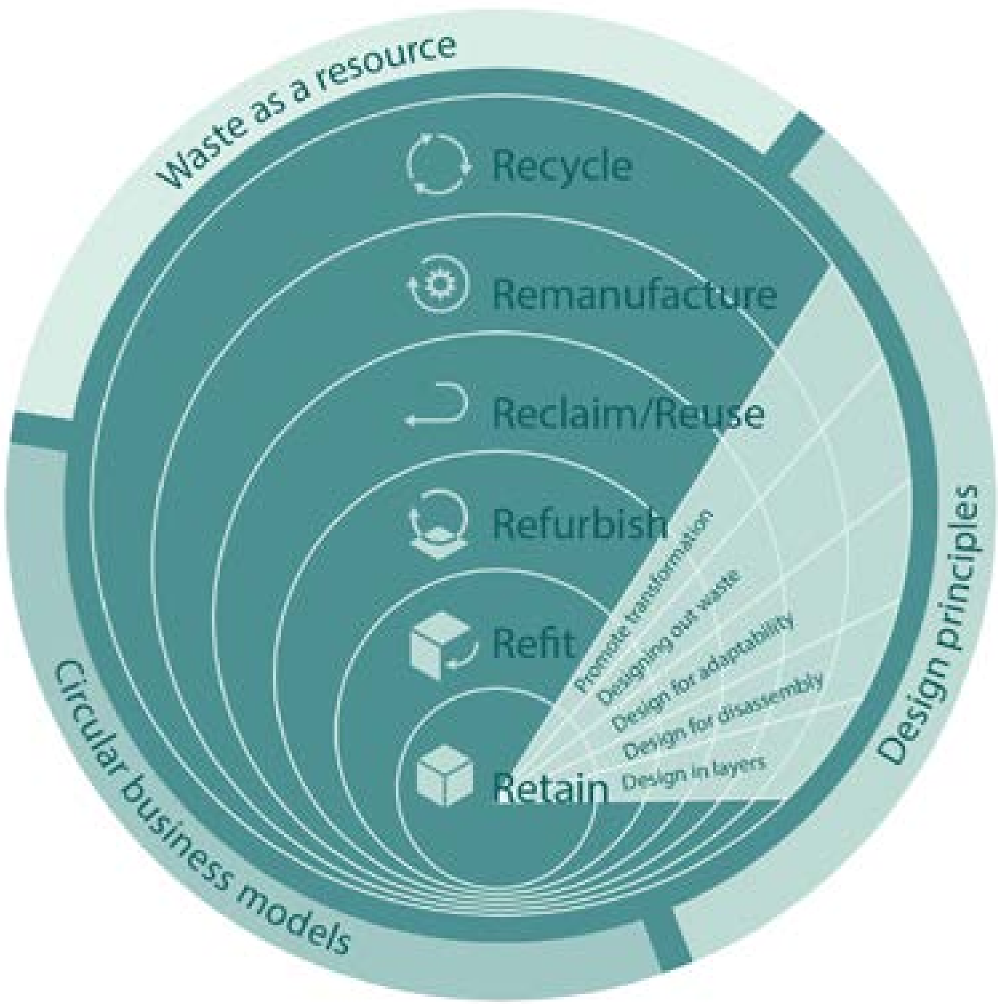
2. It can be done: Real changes are possible by defining a common agenda and applying tools that enable cities to work smarter given the same resources. CIRCuIT has developed tools that can help cities and their stakeholders embed circular economy practices, such as the transformation tool which supports 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.

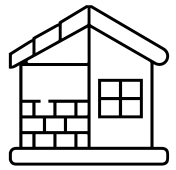
Changing the way that the industry designs, constructs and transforms buildings and infrastructure is critical in the fight against the climate crisis. Thanks to the wide array of tools, case studies and datasets developed by the CIRCuIT project, stakeholders across the value chain are better equipped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



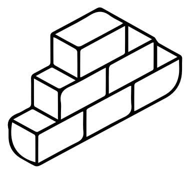
Key findings:

- 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.

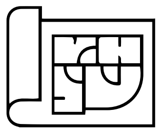


Key findings:

- 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.

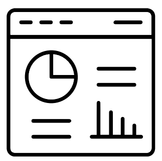


Key findings:

- 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.

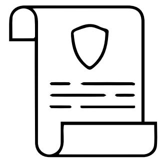


Key findings:

- 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

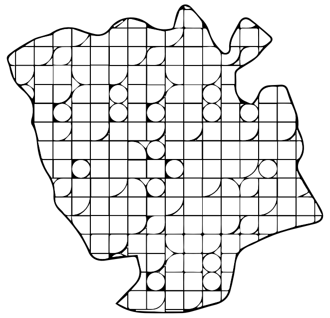
Chapter 6: Supporting circular construction with online tools

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

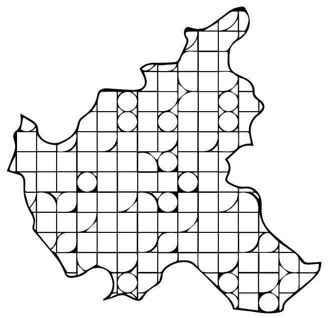


Copenhagen

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.

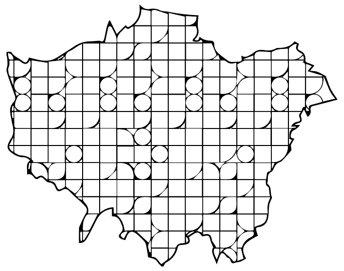
Copenhagen sets ambitious climate goals, aiming to be the world's first carbon neutral capital. It will achieve this through a city-wide transition toward sustainable energy supply, building retrofits, circular waste management, sustainable public infrastructure and mobility, as well as other key initiatives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

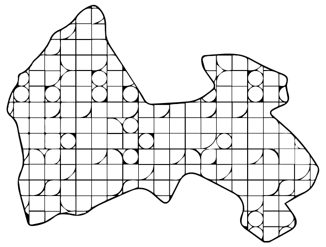
It is currently delivering several EU-funded Interreg and Horizon 2020 projects on urban development, circular economy and smart city elements, harnessing the power of innovation to progress towards its circular goal. In addition, in recent years Hamburg has set up ambitious climate transition targets 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.

Data and indicators for a circular built environment – why they matter

Cities need to take action in many areas to enable a transition to circularity within the built environment. This includes introducing new policies, supporting the development of novel business cases, and advancing material exchange infrastructure. However, if these actions are to be successful, they must be underpinned with robust, quality and accessible data.

Successfully building using circular eocnomy principles requires access to additional information about the local building stock and building industry that is not required in BAU take-make-use-dispose models. The specific characteristics of a building or material need to be defined, recorded, and shared freely, and at the right time during the construction process. This need for additional data was clearly highlighted by key findings from the CIRCuIT project:

Limited data leads to limited results – It is not possible for decision makers at any level to identify key challenges and opportunities relating to the circular economy without robust, quality data.

Accurate, reliable and complete data is needed – Modifying the circularity of a city requires the availability of as much detailed data on as many relevant systems as possible.

Data enables circularity of material flows – The flow of resources is influenced by decision makers who could use data to create circular material flows.

Standardisation is key to the exchange of data – The standardisation of units and formats of datasets is key to facilitating and promoting the exchange of quality data amongst different built environment stakeholders.

To successfully analyse large amounts of data at the city-level, cities need high-quality circular indicators. A circularity indicator is a piece of information that can be used to measure performance within the built environment to guide decision making and enable stakeholders to communicate their circular economy actions in a consistent way. Indicators can help cities benchmark their current activities, set clear goals, communicate about benefits, and assess their performance against targets.

Measuring circularity in the built environment is still a relatively unexplored area. Even though there is often a large volume of data captured, the CIRCuIT project found there are still many gaps in data and other data challenges for circularity to be successfully adopted in cities. These challenges include limited accessibility to existing data, as well as the data often having poor accuracy, granularity and interoperability.

In addition, cities do not fully understand what data they need to measure to get a better picture of circularity in their city. The infrastructure to capture, analyse and store the data that's needed is also not always set up to a necessary standard.

This chapter showcases the tools, methodologies and recommendations developed by CIRCuIT to standardise and improve the capture of circular data relating to the built environment. This includes templates that standardise data capture, as well as 37 key indicators that built environment stakeholders can use to guide decision making and measure circularity performance so they can drive forward circularity in their city.

Figure 4.1: Icon illustrating material passport use

Data to measure circularity – the current state of play

To explore what data cities typically have access to, as well as identify what data is needed to measure circularity within the built environment, the four cities involved in the CIRCuIT project carried out two key activities:

Activity 1 – Mapping data in a city – This was a data mapping exercise that aimed to identify the data accessible to each CIRCuIT city in relation to historical, current and future building material stocks and flows.

Activity 2 – Assessing the usefulness of available data – This exercise assessed whether the data identified as 'accessible' during activity 1 can deliver the insights needed to help cities transition to circularity in the built environment.

Undergoing these activities are key steps in the transition towards a circular built environment, as they can highlight data gaps and other challenges relating to data.

When the four cities involved in the CIRCuIT project carried out these two activities, they identified the following key findings:

- **Accessibility of data** – Large volumes of data were often present but held privately and not open for access. This significantly hindered material flow related work that requires an overview of all construction in the city.
- **Spatial and temporal granularity** – Datasets did not align in terms of the geographical area they covered or the frequency of their updates. This meant the conclusions that could be drawn were very general or out of date.
- **Inaccuracy and unreliability** – Datasets were not always accurate, due to human error, double counting, extrapolations, etc.
- **Standardisation and interoperability** – Datasets were not standardised, which meant they could not be aggregated and used together.

The steps the CIRCuIT cities followed to undertake these activities are outlined in this chapter, as are key learnings that can help to inform similar initiatives in other cities.

Following Activities 1 and 2, CIRCuIT's project partners also developed a set of data templates and recommendations that can be used to help capture the data needed to integrate circularity, build consistency across the industry and address gaps and weaknesses typically found in the data.

Activity 1: Mapping data in a city

Members of the CIRCuIT project and their built environment stakeholders worked together to map the building material stocks and flows ecosystem in each CIRCuIT city with the aim of building understanding and enabling circularity. To do this, the following data types were investigated:

- **Inflows** of materials or products to the building and infrastructure stock, such as data on installations or material sales
- **Building and infrastructure stock figures** such as number of buildings, total floorspace, kilometres of track, split of building and infrastructure types
- **Current material stocks** in use across existing building and infrastructure
- **Circular flows** of materials or products at end-of-service life to a new-use cycle, i.e. reuse, remanufacture and recycling of building components, products and materials
- **Outflows/waste flows** of materials or products at end-of-service life in buildings and infrastructure stock to landfill, incineration, energy recovery or fly-tipping
- **Past, current and future demand** for buildings and infrastructure, and for the materials and products they contain
- **Future arisings of materials or products** at end-of-use within a city
- **Externalities** – the environmental, social and economic impacts arising from the extraction, operation, transport and disposal of products and materials
- **Contextual data** including data on factors that influence or are related to material stocks and flows, such as demand for new housing
- **Geographical and land-use data** that could provide a basis for mapping and visualisation

Undergoing these activities are key steps in the transition towards a circular built environment, as they can highlight data gaps and other challenges relating to data.

Assessment of mapped data

Variable accessibility of data

Open data is data that can be freely used, modified and shared by anyone for any purpose. This data is usually collated into centralised datasets and shared by local authorities or government bodies. The mapping exercise revealed that a significant amount of open data about a city's building material stocks and flows is typically available. However, most open data is top-down data, which tends to be broad and lacking granularity.

Public non-open data is data that is usually available to all but has a set of requirements to satisfy prior to access, such as registration fees or a licence. The mapping exercise identified that this is the most common type of data available about a city's building material stocks and flows.

CIRCuIT partners concluded that making non-open data more freely available would significantly help built environment stakeholders capture a fuller picture of the material stocks and flows in a city, and especially upstream (material supply) and downstream (demolition/waste management) material flows.

Private data is collected by a private entity for their own purpose and is not viewable to the public. The mapping exercise identified that there is a large amount of data held privately about materials stocks and flows. If this was centralised and released as open data (aggregated and anonymised, as appropriate), this data would support and enhance commercial and political decision making relating to the circularity in the built environment.

Data quality issues

Granularity of data – The mapping exercise identified a wide range of granularity across datasets, from single statistics on recycling rates at a national level to real-time data uploaded to centralised planning systems. Overall, the granularity of the surveyed data tended to be low, with many datasets only being updated annually and covering a broad subject area.

Accuracy and reliability of data – The accuracy and reliability of data tends to be difficult to ascertain, largely owing to poor transparency in terms of the data collection methodology, analysis and verification. Often, there is only one dataset relevant to a particular subject available within a city, which means there are often no benchmarks for comparison.

Standardisation of data – There are a large number of datasets from varying sources which use different units and formats. In some cases, even different datasets dealing with the same subject do not use standardised units and formats. Another challenge is the discontinuity of some material and product classifications.

Updating of data – Large variability was observed in terms of how up-to-date datasets are and whether they are actively monitored. In many cases, there was a gap between the data's timeframe and the date of its publication, which could stretch to a number of years. Additionally, many datasets were identified that were relevant in terms of subject but no longer updated.

Data differences at different points of the construction pipeline

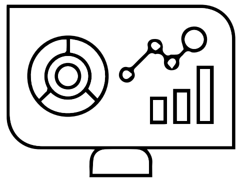
Supply chain – There was little data openly available related to the supply of construction materials. However, there is likely to be substantial data collected privately by supply chain organisations on the volumes of materials being handled and exchanged with upstream or downstream actors in the supply chain. If this data was centralised, aggregated, made openly accessible and, where necessary, anonymised, it could help to plug significant gaps in understandings of material flows. See chapter 6 for more information on our work on material flows.

Building typology – Data on residential building stock was found to be widely available. Building-level datasets were also accessible within the four cities. Both provide a good degree of granularity and a more precise indication of the characteristics of a building, which may be aggregated.

In some cases, however, there was found to be less systematic data collection on non-residential building stock, such as commercial, industrial and retail buildings, despite these being estimated to represent large proportions of stock.

Material stock data refers to materials that are currently in use within buildings and infrastructure. Data that focused on material stock quantities per building or per infrastructure was not available within the CIRCuIT cities. However, there is data available in all cities that could enable a material flow analysis to calculate material stocks.

Waste management and circular material flow data is typically more complete and extensive than other segments of material flow chains. In all the CIRCuIT cities, data was readily available on the tonnage/volume and origin of construction and demolition waste. This data is generally split by material/waste class, partly due to reporting requirements under the European Commission's Waste Framework Directive. In some cases, data on the destination of waste is also captured.



Activity 2: Assessing the usefulness of available data

After identifying what building material stock and flow data is accessible across each CIRCuIT city, project partners then created 29 potential use cases for how this data could be used to provide insights relevant to the circular economy.

These use cases cover the entire materials stocks and flows ecosystem and include a range of built environment stakeholders, including product manufacturers, contractors, waste management organisations, policymakers, planning authorities and researchers.

To develop these cases, partners first assessed what specific data was needed for each use case, and then looked to determine:

- whether the required data existed in each CIRCuIT city and was available to the relevant stakeholders
- whether there was any indication of the quality and reliability of data sources that did exist

> **All 29 use cases can be found in the CIRCuIT report D3.2 Recommendations for improving the capture of material flow data in the built environment. This is available to download at circuit-project.eu/post/latest-circuit-reports-and-publications**

Two examples of how data could potentially be used to provide circular economy insights

Use case 1 – Using building typology data to calculate a city's material stock

If it's not possible to calculate the amount of materials in individual buildings, it may be possible to follow a building typology-based approach. This involves obtaining or calculating the typical quantities of materials in a range of common building types, which are distinguished from each other according to factors such as age, use class, construction type, and so on.

Using this information, the material totals for the area under study may be calculated based on the number of instances of each building type within it, multiplied by their respective typical material quantities.

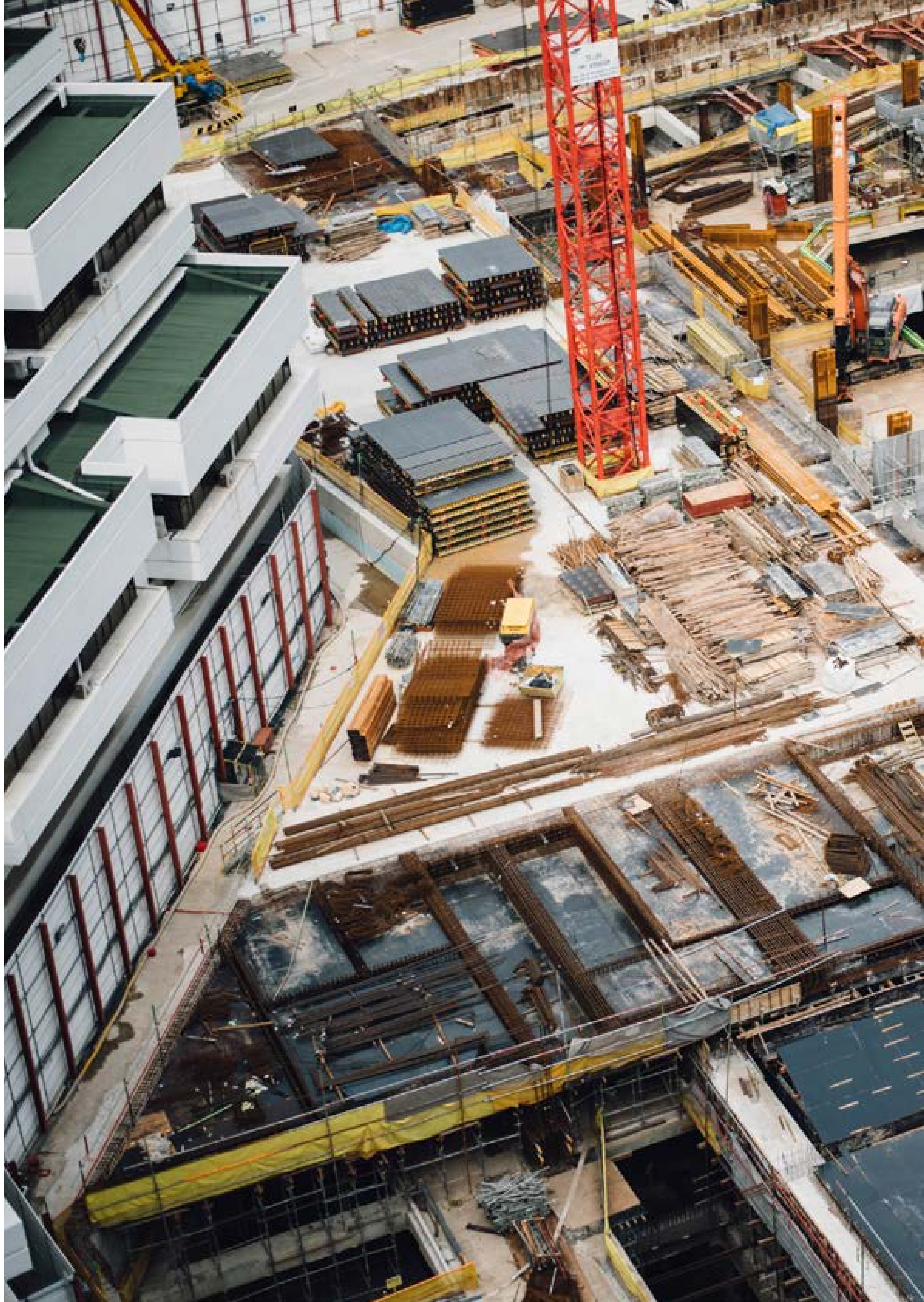
Use case 2 – Using historical data to predict demolition rates in a city

One way to estimate the future rate of demolitions in a city is to carry out a survival analysis of building stock.

Historical demolitions data can be used to ascertain patterns related to the typical age that different building types are demolished and the circumstances preceding demolition.

By evaluating information related to a building's attributes (such as age and use class) and the contextual factors influencing their survival or demolition, it's possible to identify patterns in mortality and survival of certain building types.

In turn, this may be applied to a city's current building stock to predict future rates of demolition. See the report Extending the lives of buildings through transformation and refurbishment for more information about identifying buildings at risk of demolition.



Improving data capture across the built environment

In Copenhagen, Hamburg, Vantaa/Helsinki Region and London, CIRCuIT partners identified that data issues are preventing decision makers and built environment stakeholders from increasing circularity in the built environment.

To help address these data gaps and weaknesses, a set of templates were created to improve and standardise the capture of data across the building ecosystem.

Additionally, 17 overarching recommendations were developed for stakeholders across the value chain, from planning officers and policy makers to industry practitioners. These aim to help address gaps and weaknesses in circular data.

Circular economy data templates

Templates help to define the data required at all levels of a city's built environment ecosystem. These levels relate to the following dimensins: A) components, B) spaces, C) buildings, and D) areas

The templates developed during CIRCuIT are organised as 'data dictionaries', where information about an object is listed as 'properties'. For each property, a description and the recommended unit of measurement are provided, as well as predefined response options, where relevant. Wherever possible, these have been standardised across all levels.

The data templates serve as a complete framework for the consistent capture of data and cohesive sharing of data between professionals. Ultimately, this will improve the collection process of data and help stakeholders to take actions promoting circular use and the management of built environment resources.

Recommendations for addressing gaps or weakness in data

Based on the availability and quality of data found in the mapping exercise outlined in Activity 1, CIRCuIT partners and built environment stakeholders developed a list of recommendations for how data could be improved or applied more effectively to increase circularity in a city's built environment.

Recommendations on data creation through primary research

Develop a methodology for calculating the reuse potential of a building component or element based on available data

It's not easy for stakeholders such as building owners or prospective reused material procurers to understand the reuse potential of a building once demolished or disassembled. Research is required to create an approach to fill this gap.

Relevant stakeholder(s)

Researchers

Develop a methodology for automatically calculating building and spatial transformation capacity based on available data

Stakeholders cannot easily quantify how transformable a building is. More information is needed to support decision making about whether to attempt to transform a building, replace it, or leave it as it is. Research is required to create an approach to fill this gap.

Relevant stakeholder(s)

Researchers

Develop lifecycle assessment (LCA), lifecycle costing (LCC) and social impact factors

Developing these factors at product and building level can incorporate the whole lifecycle impacts related to the transformation, reuse and recycling of materials from existing buildings (urban mining), and design for disassembly and adaptability.

This could be used to model and compare the lifecycle impacts of different approaches or specifications, or to inform decisions on whether to refurbish a building, demolish it or leave it as it is. This could also help to inform retrofit strategies at a city-scale, based on costs and benefits variable by building type and context.

Relevant stakeholder(s)

Researchers

Develop methodologies for quantifying the reuse potential/transformation capacity of materials, components, elements and buildings

Once recommendations 1 to 4 have been achieved, and given appropriate data on the building stock, it could be possible to quantify the reuse potentials/residual values of materials, components and elements currently embedded in the building stock, and the transformation capacity of buildings.

Combined with LCA/LCC/social value modelling, this could assist with decision making over how to manage different segments of the building stock to achieve optimal environmental, social and economic outcomes.

Relevant stakeholder(s)

Researchers

Recommendations on capture of data by practitioners

Capture data relevant to circular economy according to circularity data templates

As identified by research carried out by CIRCuIT partners, there are issues with the granularity, accuracy and reliability of building materials stocks and flows data, which is preventing cities and built environment stakeholders from increasing circularity in buildings and infrastructure.

Getting cities and stakeholders to capture the data outlined in the data templates developed by CIRCuIT partners could help overcome this issue. See page 4-10 for more information about the templates.

Relevant stakeholder(s)

Construction industry

Recommendations on data standardisation and interoperability

Develop and mainstream the use of circularity indicators

Strong circularity indicators will enable cities and stakeholders to consistently measure circular economy approaches. This will help with the setting of targets and improve the sharing of information between stakeholders.

Please go to page 4-19 to see the set of key circularity indicators developed and recommended by CIRCuIT partners for cities. You can also see how CIRCuIT cities used circularity indicators in practice by visiting the Circularity Dashboard at circuit-project.eu/circularity-dashboard

Relevant stakeholder(s)

Researchers Policy makers

Construction industry

Develop and mainstream the use of circularity data templates at multiple levels

Data templates that identify what data is necessary to support circular action in the built environment should be developed. Standardisation is absolutely essential, as is the ability to integrate the data captured by the templates.

This supports the better exchange of data between stakeholders at different levels of organisations and at different points in material lifecycles.

Relevant stakeholder(s)

Researchers Policy makers

Construction industry

Develop and mainstream data exchange methodologies for integration of material and product data with building data

Currently, there is little ability to carry through material/product data to building information models (BIM) upon installation, and from BIM models to subsequent data management systems upon the material or product's deinstallation from the building.

Without this 'golden thread' of data from cradle-to-cradle or cradle-to-grave of a material, it is less easy for subsequent material/product handlers to understand the origin and circular economy-related attributes, and to make decisions that promote circularity.

Relevant stakeholder(s)

Standards organisations Researchers

Recommendations on exchange of data between stakeholder groups

Capture data on each unit of material, component or element throughout its lifecycle, and store it in a transferable digital record

This would enable accurate and transparent measurement and modelling of circularity and lifecycle impacts at any point across the value chain. As a result, a procurement manager, for example, could calculate exactly how the use of a particular product may impact the footprint of their project. Relevant data may include material passport data, as well as composition, circularity indicators, and any other circular economy-related information.

Relevant stakeholder(s)

Construction industry

Create, update and handover building information models (BIM) to relevant stakeholders, depending on building lifecycle stage

BIM models will be essential in circular economy since they allow the storage and sharing of data useful for circular decision making between relevant stakeholders. Additionally, given appropriate data on the impacts of a product, design or logistical method, they may be used to model the whole life impacts different project approaches through integration of LCC/LCA and social impact assessment approaches.

Relevant stakeholder(s)

Construction industry

Recommendations on integration of data into databases

Create a database of services and facilities assisting with circular economy of the built environment

This could follow the example of the London Waste Map and its underlying database, expanded to include all services and facilities of use to the circular economy, with live or regularly updated data that is readily integrated into the management systems of stakeholder groups.

Relevant stakeholder(s)

Policy makers

Create a live database of material stocks and flows

A city level database that records where materials are stocked and how they flow throughout the city system, including data of relevance to circular economy such as whether materials are reused or what their typical sale prices are.

If aggregated and analysed, this would be a valuable resource for planning and policymaking to enable city-level material flow management (including waste management), as well as for other applications, for example, prospective material sellers being able to understand the likely market value of their assets post-demolition.

Relevant stakeholder(s)

Construction industry | Policy makers

Create a live building stock database

This database could include data on existing building stock, as well as predictive or modelling capabilities regarding the future of building stock. This could inform decision making and strategy by planning officers and policymakers as to how to modify patterns of construction, refurbishment and demolition to achieve the best social, economic and environmental outcomes.

Relevant stakeholder(s)

Construction industry

Recommendations on analysis of databases

Quantify and predict rates of circular economy-related building stock dynamics

Understanding the existing rates of building stock dynamics (e.g. new construction on greenfield sites, demolition and replacement, transformation, design for disassembly and adaptability in new construction, the reuse and recycling of materials, etc), as well as more detailed information such as the typical efficiencies, financials and impacts associated with different approaches, is useful for developing strategies, benchmarks and policies that decision makers in cities' construction and buildings sectors can use to guide their actions.

Relevant stakeholder(s)

Researchers

Quantify and predict stocks and flows of (reusable / recyclable) materials, components and elements from building stock

Understanding the profile and quantities of different building materials, components and elements within building stock, and those that are projected to emerge from the stock, can inform strategies and policies around recycling, reuse and building stock management.

Relevant stakeholder(s)

Researchers

Quantify and predict demand for reused and recycled products

Understanding the demand for reused and recycled products can allow prioritisation of which building stock segments may be demolished and those for which demolition should be avoided, based on both the proportions of recyclable and reusable parts within them, as well as the level of demand for those parts.

Relevant stakeholder(s)

Researchers

Indicators for measuring circularity

For the CIRCuIT project, a 'circularity indicator' is a piece of information that any stakeholder in the built environment sector can use to measure performance and guide their decision making to enable a circular economy.

Numerous circular indicators have already been developed around the world. However, these indicators vary significantly, with most using different methodologies, structures, terminologies and measures.

This lack of standardisation is currently a significant barrier to built environment stakeholders who wish to accelerate circularity in their city and beyond. To address this issue, CIRCuIT partners used the findings from their city data mapping exercises and a comprehensive research programme to identify a list of key circularity indicators for cities.

The indicators provide an overview of circularity at city, building and materials levels and use a mix of impact metrics (such as recycled content, material use), productivity metrics (e.g. per value, area) and enabler metrics (the number of projects with circularity economy requirements).

Each of the 37 indicators is listed with supporting information, including which built environment stakeholder it is relevant to.

Built environment stakeholders can look through the indicators to understand what they should measure to support circularity in their city. The indicators can also be used to measure the environmental, economic and social impact of circular economy decisions and set circular targets for stakeholders, from product designers to local authorities.

At a city-level, the indicators can help to support evidence-based policy and planning development, as well as decision making to support the circularity of material flows within buildings and throughout material lifecycles.

How local government can use policies to drive circularity in their city is explored further in the report titled Using policy to power circular construction.

Using indicators in the real world

CIRCuIT partners identified five key circularity indicators for their cities. These are presented visually on a Circularity Dashboard at circuit-project.eu/circularity-dashboard

> **Read more about the Circularity Dashboard and other online tools developed as part of the CIRCuIT project in Chapter 6.**

Recommended city level indicators

Indicator name	Description	Unit	Stakeholder benefits
Material inputs to building stock			
Total material inputs to building stock (UM)	Indicates the quantity of material inputs (virgin and secondary) to the city's built environment. Calculated as an absolute quantity of materials used.	Tonnes of materials	Urban planners will be able to set targets on how much materials is needed and what type.
Secondary inputs to building stock – recycled materials (UM)	Indicates the proportion of raw material inputs to the city's built environment that are recycled (excluding downcycling) following a previous use cycle.	% by mass of recycled materials versus virgin materials	Planning officers will be able to set targets for amount of recycled materials to be used in future buildings.
Secondary inputs to building stock – reused materials (UM)	Indicates the proportion of raw material inputs to the city's built environment that are reused) following a previous use cycle.	% by mass of reused materials versus virgin materials	Planning officers will be able to set targets for amount of reused materials to be used in future buildings.
Lifespan and in-use performance			
Transformation market penetration (L)	This indicator is intended to demonstrate the extent to which transformation activities is being pursued within the city relative to new construction. If the ratio increases over time this would suggest that space is being utilised more efficiently/ intensively (where the ratio is increased through an increase in transformations) or that transformation is displacing new construction demand (where the ratio is increased due to a drop in new construction accompanied by a stable or increasing number of transformations).	% by value (transformation as a proportion of all works including new construction)	Urban planners will be able to assess how much demolition they are avoiding and more easily set benchmarks, targets and requirements for transformation.
Average transformation capacity of building stock (L)	A transformation capacity score given to each existing building within the building stock, which is then aggregated and averaged for the whole city.	Monofunctional (score 3-6) Transfunctional (score 6-8) Fully transformable (score >8)	Policymakers and planners can set benchmarks and targets for the amount of transformation activity in the city based on the building stock's propensity to be transformed.
Intensiveness of use (L)	The average intensiveness of use of the building stock relative to the average potential intensiveness of use. This indicator is only suitable for buildings such as schools, offices or community centres.	% hours actually occupied versus potential	Planning officers will be able to validate the need for new buildings to be added or if they could more efficiently use existing ones.
Circular potential of existing building stock			
Reuse/recycling potential of existing building stock (UM)	The amount of materials which are available for reuse/recycling in the building stock.	Tonnes of materials that has the potential for reuse/recycling	Policy makers will be able to set targets for recycling and reuse.

Indicator name	Description	Unit	Stakeholder benefits
Material outflows and recirculation – based on actual current activities			
Total materials/ wastes arising from construction and buildings sector and end of life reporting (UM)	The total amount of materials and wastes emerging from the construction and buildings sector.	Tonnes of wastes generated	Policy makers will be able to understand quantities of wastes generated.
Recirculated materials (UM)	The proportion of total materials arisings at end-of-use in buildings within the city/ region (see above), that enter new use cycles within the city/region (reuse/recycle).	% per tonnes of the city's construction and demolition waste that is recycled or reused % per tonne of the city's solid waste that is recycled or reused	Policy makers will be able to validate their targets for recycling and reuse against those numbers.
Quantity of materials that is reused/recycled through dedicated centres (UM)	Quantity of materials that is reused/recycled through as a material outflow.	Tonnes of materials reused/recycled	Policy makers will be able to understand the efficiency of reuse/ recycling ability at city level.
New buildings			
New buildings designed to circular policies and principles/ standards (CD)	This indicator measures the extent to which new projects are being designed according to circular policies and principles, demonstrating whether practitioners are considering how they can ensure that the buildings they create support circular economy throughout their life cycle.	% of new building stock by floor area % of new building stock by value	This would help policymakers and planners to understand the extent to which new buildings are being designed and built using circular principles, providing an evidence base for policy development.
Average transformation capacity (new buildings) (CD)	Measures how adaptable are the new buildings constructed within the city. Higher average transformation capacity in new build means that there is a possibility for a higher rate of transformation versus building replacement in future.	Monofunctional (score 3-6) Transfunctional (score 6-8) Fully transformable (score >8)	As above.
Average reuse potential of materials and components at end of life (of new construction) (CD)	The average portion of new buildings which can be reused at the end of the life of the building.	% by mass of materials within new building stock that can be reused or recycled at their end-of-use	As above.

Recommended building level indicators

Indicator name	Description	Unit	Stakeholder benefits
Building design			
Dematerialisation (linked to total material inputs to building stock) (CD)	Building has been designed so that the minimum material inputs are required to achieve the same whole life functionality, without compromising on durability, resilience, other technical performance requirements or health and safety.	% by mass of material not used	Designers demonstrate that they have designed the asset with material optimisation. This will support building level assessments, such as BREEAM. This information will also inform LCA and LCC studies.
Design for disassembly (CD)	Proportion of building components that are reversible from the wider building without significant damage to either the removed component or its wider assembly. This indicator should be linked to BIM and guidelines to ensure stakeholder down the supply chain can optimise the building end of life. This indicator is measured using ISO20887.	% by mass of the building that can be disassembled at the end of life	Designers can demonstrate to urban planners that the building can be disassembled at the end of its life. This will support building level assessments, such as DGNB. This information will also inform LCA and LCC studies.
Design for adaptability (transformation capacity) (CD)	The spatial and technical aspects of building design allow for adaptation to another function (as designed). This indicator is measured using ISO20887.	% by mass of the building that can be adapted at end of life	Designers can demonstrate to urban planners that the building can be disassembled at the end of its life. This will support building level assessments, such as DGNB. This information will also inform LCA and LCC studies.
Material inputs to building			
Reused content (UM)	Proportion of the building that is formed of reused products and product components.	% by mass reused content	These will enable contractors to demonstrate compliance with local requirements, such as the GLA circular economy statement. This indicator will also inform policy makers to set future targets. This information will also inform LCA studies.
Recycled content (UM)	Proportion of the building that is formed of recycled/upcycled products and product components (exclude downcycling).	% by mass recycled content	
Circular potential (as built)			
Transformation capacity (L)	The spatial and technical aspects of building design allow for adaptation to another function (for existing buildings).	Monofunctional (score 3-6) Transfunctional (score 6-8) Fully transformable (score >8)	This enables building owners/ managers or developers to understand the potential to transform their building to deliver greater value and function with lower resource inputs.
Reuse potential (UM)	The percentage (by mass) of products which can be reused at the end of the life of the building.	% by mass of products that can be reused	These will enable contractors to demonstrate compliance with local requirements, such as the GLA circular economy statement.
Recycling potential (UM)	The percentage (by mass) of products which can be recycled at the end of the life of the building.	% by mass of products that can be recycled	Core.

Indicator name	Description	Unit	Stakeholder benefits
Lifespan & in-use performance			
Intensiveness of use (L)	The average intensiveness of use of the building stock relative to the average potential intensiveness of use. This indicator is only suitable for buildings such as schools, offices or community centres. Number of hours the building is occupied versus the number of hours it has the capacity to be occupied in average.	% hours actually occupied versus potential	Clients will be able to understand whether the use of their asset is optimised. Planning officers will also be able to validate the need for new buildings to be added or if they could more efficiently use existing ones.
Material outflows and recirculation			
Residual value (all materials in building) (UM)	The forecasted total value obtained from material recirculation of materials within the building.	£ or € that can be extracted from the reuse of components in the building	Demolition companies and contractors will be able to quantify the benefits of maximising reuse and recycling. Investors will understand the value of their portfolio.
Total material arisings (whole life) (UM)	The amount of waste materials from the building across its lifetime, including during future refurbishment, repair phases.	Tonnes of waste arising	Policy makers will be able to understand quantities of wastes generated. This information will also inform LCA and LCC studies.
% reused, remanufactured, recycled (UM)	The percentage of materials which were reused, remanufactured or recycled at the end of the life of the building.	% by mass reused, remanufactured, recycled	Policy makers will be able to validate their targets for recycling and reuse against those numbers. This information will also inform LCA studies.
End of Life reference scenario (UM)	Mapping of material history and recycling potential, before it reaches a material bank/storing site.	Typical % by mass recycled or reused at end of life	Policy makers will be able to validate their targets for recycling and reuse against those numbers. This information will also inform LCA studies.

Recommended materials, products, and component level indicators

Indicator name	Description	Unit	Stakeholder benefits
Product design			
Dematerialisation (linked to total material inputs to building stock) (CD)	Product has been designed so that the minimum material inputs are required to achieve the same whole life functionality, without compromising on durability, resilience, other technical performance requirements or health and safety. The percentage of material that has not been used as a result of redesigning the product and as a function of the total amount of material used.	% by mass of material not used	Product manufacturers demonstrate that they have designed the product with material optimisation. This will support scheme such as the cradle to cradle certification scheme. This information will also inform LCA and LCC studies.
Design for repairability (CD)	Product has been designed to enable future repair of key components of the product. This is not applicable to all products.	% by mass of components of the product that can be easily removed and repaired or replaced.	Product manufacturers demonstrate that they have designed the product for future repairability. This will support scheme such as the cradle to cradle certification scheme. This information will also inform LCA and LCC studies.
Material inputs (as manufactured)			
Reused content (UM)	Proportion of the product/ component that is formed of reused materials/products.	% by mass reused content	These will enable products manufacturers to demonstrate to contractors' compliance with local requirements, such as the GLA circular economy statement. This indicator will also inform policy makers to set future targets. This will also support product certification schemes like EPD or cradle to cradle. This will support schemes such as the cradle to cradle certification scheme. This information will also inform LCA and LCC studies.
Recycled content (UM)	Proportion of the product/ component that is formed of recycled materials/products (exclude downcycling).	% by mass recycled content	

Indicator name	Description	Unit	Stakeholder benefits
Material inputs (as installed in building)			
Product is reused after it has been used in a building (CD)	The product has previously been used for the same function in another building. The percentage of similar products/ components that are reused at the end of their life based on actual waste analysis.	% by mass reuse	This informs the product manufacturers on the end of life potential of their product/ component.
Product is recycled after it has been used in a building (CD)	The product has previously been used for the same value function in another building and has been through some processing. The percentage of similar products/ components that are recycled at the end of their life based on actual waste analysis. Excludes downcycling.	% by mass recycled	This can also inform policy makers on whether there is a further need for recycling facilities. This will support scheme such as the cradle to cradle certification scheme. This information will also inform LCA and LCC studies.
Circular potential (as installed)			
Reuse potential (UM)	Product is designed and installed so that it can be easily demounted from the wider assembly with no loss of value to itself or the assembly. The percentage of the product/ component that has the potential to be reused.	% by mass potential reuse	This will support scheme such as the cradle to cradle certification scheme. This information will also inform LCA and LCC studies.
Part of an extended producer responsibility scheme (CD)	The product is covered by an Extended Producer Responsibility scheme by the manufacturer (e.g. a take-back scheme). This is a yes/no answer	Yes/no	This will enable policy makers to identify where more EPR schemes may need to be implemented. This will affect product manufacturers & suppliers.
Repairability potential (L)	The amount of components of the product that can be easily removed and replaced (once installed).	% by mass of the essential components of the product that can be repaired	This will enable the replacement of core components of units without the need to replace whole units. This will enable facility managers to manage better the buildings.
Lifespan and in-use performance			
Service life (L)	The number of years the material or product has been used for its intended function.	Number of years	This will enable the demolition industry to understand whether the product/component can be reused. It will also inform contractors on when the product needs to be considered for further testing to ensure it is fit for purpose.
Material outflows and recirculation			
Residual value (L)	Financial value obtained by actor with duty of care of product at building end of life.	£ or € that can be made from the reuse of a product	Demolition companies and contractors will be able to quantify the benefits of maximising reuse and recycling. Investors will understand the value of their portfolio.

Further reading

More information on the tools, methodologies and recommendations developed by CIRCuIT to standardise and improve the capture of circular data for the built environment is available in the reports listed below.

- D3.1 State of the art on material flow data in the built environment
- D3.2 Recommendations for improving the capture of material flow data in the built environment
- D3.3 Recommendations on circularity indicators for WP8
- D3.4 Report on the creation of CIRCuIT circular economy data templates
- D3.5 Business case for database and marketing strategy
- D3.6 Finalised framework of data attributes and analytics for pilots
- D3.7 How to exploit the framework and data at city level

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

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