Measuring circular buildings – key considerations

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Summary

The circular economy is a key enabler for sustainability, resource efficiency and mitigating climate change.[1] Transparency and alignment on circular metrics are critical to establishing a common language across industries and governments aspiring to develop strategies and measure progress on circularity. Particularly for the built environment, implementing and adopting circular economy principles of designing out waste and pollution, keeping products and materials in use and regenerating natural systems can support the decarbonization of the entire system and improve collaboration within the value chain.[2] The circular economy can therefore be considered a means to support the built environment in shifting toward one that is more sustainable.

Consistent circularity measurement and the adoption of a standardized approach are important, as they can allow stakeholders to understand the level of circularity of their buildings and determine actions toward improving their performance, accelerating the shift toward a sustainable built environment.[3] While considerable efforts are being made to improve the circularity of buildings, a full set of indicators that can comprehensively measure the circularity of buildings is still under development.
This paper summarizes key considerations for measuring the circularity of buildings. Developed through a six-month study in collaboration with WBCSD member companies, the paper aims to align the built environment value chain on what makes a building circular, how to most effectively apply circular principles and how to measure progress toward circularity.

To reduce the complexity of measuring circularity in buildings, one should start by analyzing different building layers, such as stuff, space plan, service, structure, skin, site and social, given the different lifetimes of these layers. Furthermore, it is important to use a consistent terminology, such as ELPMs (Element, Layers, Products, Materials). This allows us to identify a building as an **Element**, then recognize that buildings are composed of **Layers** made of **Products** (doors, windows, walls, etc.) and are built using **Materials** (wood, cement, steel, etc.).

Circular principles like lifetime extension, detachability, adaptability and flexibility should be considered throughout the building design phase. Key considerations in measuring circularity include measuring circular inflow and outflow, which consists of monitoring the type of material, the percentage of reused and recycled materials and end-of-life recovery. For this matter, benchmarks, standards and key performance indicators should be set and improved where existing.

Besides closing the loop on material flows, water and energy inflows and outflows need to be measured, together with closely monitoring the carbon life cycle, to ensure circular evaluations are complementary and not substitutive to the environment. Qualitative and quantitative data is equally important when measuring the circularity of buildings.

The results presented in this paper set out the basis for further work toward developing and adopting a common approach to measuring the circularity of buildings.

1. Introduction

The need for circular buildings
The built environment is the physical part of where we live, work and spend our free time. It is a primary employer representing a significant share of national wealth[4] and is responsible for almost half of all global resource consumption.[2] By 2060, the global area of buildings is expected to double to more than 415 billion m^2, increasing their resource consumption significantly.[5] The sector is responsible for 12% of all freshwater consumption and produces up to 40% of global energy-related carbon emissions and solid waste.[2] With urbanization rapidly increasing, building sustainably is essential to achieving sustainable development. A circular economy addresses these challenges and has the potential to significantly reduce carbon emissions from materials and reduce impacts on nature.[2]

The circular economy is an economic model that is **regenerative by design**. Its goal is to **retain the value** of circulating resources, products, parts and materials by creating a system with innovative business models that allow for **long life, optimal (re)use, refurbishment, remanufacturing and recycling**. By applying these principles, organizations can collaborate to design out waste, increase resource productivity, maintain resource use within planetary boundaries and increase economic benefits.[2]

The World Business Council for Sustainable Development (WBCSD) believes that the circular economy principles are a means to achieving a sustainable built environment system. The study of the use of circular principles within the built environment started in 2018 with the publishing of the report Scaling the circular built environment: pathways for business and government to highlight how the entire value chain can move toward being more circular,[6] and was followed by The business case for circular buildings: Exploring the economic, environmental and social value[2] to showcase how circularity principles can positively impact the three critical dimensions of sustainability and identify possible Key Performance Indicators (KPIs) for each of them.

The definition of what makes a building circular is still evolving based on market research, experiences and needs. This paper adopts the definition provided in The business case for circular buildings: Exploring the economic, environmental and social value,[2] as this represents the most recent and comprehensive definition of a circular building generated though a collaboration between WBCSD, its members and other partners, including the World Green Building Council (WGBC),[8] the Royal Institution of Chartered Surveyors (RICS)[9] and others.

> ***A circular building optimizes the use of resources while minimizing waste throughout its whole life cycle. The building's design, operation and deconstruction maximize value over time using:***
>
> - ***Durable products and services made of secondary, non-toxic, sustainably sourced, or renewable, reusable or recyclable material;***
> - ***Space efficiency over time through shared occupancy, flexibility and adaptability;***
> - ***Disassembly, reuse or recycling of embedded material, components and systems;***
> - ***Life-cycle assessment (LCA), life-cycle costing (LCC) and readily available digital information (such as building material passports).***

This definition constitutes the foundation of the work outlined in this paper. Alignment on definitions establishes a common language across the industry that supports the development of circular strategies and measurement of circularity. The built environment value chain should adopt a **unified definition of what makes a building circular** and accept the use of the above while recognizing that there is still room for improvement.

The need for a system-level approach

The built environment represents a complex system made of many products that different actors develop, and each of them has the power to influence the overall circularity of buildings, from their design, making better use of space, current and future use of material, type of energy and more. For this reason, we believe that we ought to give the reader an explanation of the built environment value chain to develop a better understanding of the difficulties faced when measuring the circularity of buildings.

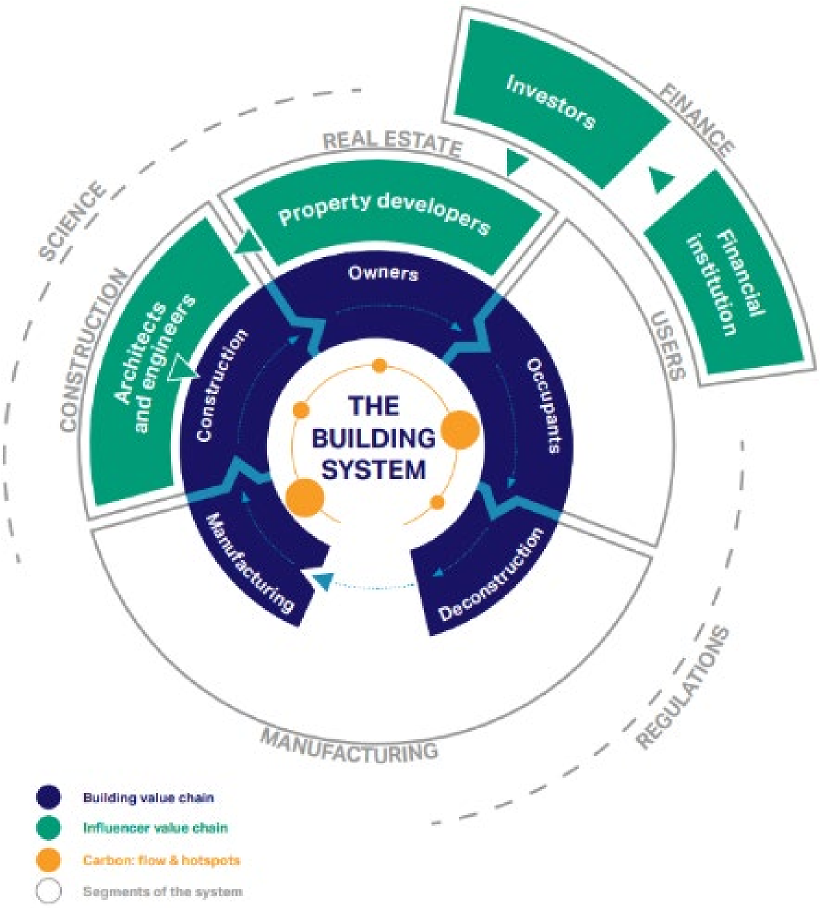

Figure 1: The value chains of the building and construction system[7]

Figure 1 represents our view of the structure and connections between the system's different private sector actors. In this model, stakeholders are part of two connected and converging flows: the **building value chain** and the **influencer value chain**.

For more information, you can refer to WBCSD's The Building System Carbon Framework [7] report.

2. Circular principles

The previous chapter of the paper explained the process of the study and why it was important to conduct such a study. The chapter provided a general understanding of what a circular building is and defined the built environment system and its complexity. This chapter will go into more detail about understanding how to apply the circular principles to buildings and illustrate the criteria to follow to classify the circularity of buildings.

Currently, there is no clear understanding of how to measure the implementation of circular principles in buildings. Consistent circularity measurement and the adoption of a standardized approach are important, as they can allow stakeholders to understand the level of circularity of their buildings and determine actions toward improving their performance, accelerating the shift toward a sustainable built environment.[3] The circular principles formulated by the Ellen MacArthur Foundation[10] help clarify which actions need to be taken to improve circularity. There are three principles connected to the design, the retainment of value and the regeneration of nature, and Box 1 applies these circular principles to a building, describing what intervention points need to be measured to align to these circular principles.

BOX 1: Circular principles applied to buildings

1) **Design out waste and pollution: What if waste and pollution were never created in the first place?**
   This requires measuring emissions, and air, land and water pollution, as well as structural sources of pollution, such as traffic. It applies to a building while it is in use, but also to different life cycle stages, such as construction, maintenance and demolition. The objective is to enable and measure reuse, refurbishment, remanufacturing (and recycling as a last resort) and the identification of end-of-use options for new assets, materials and products installed. This requires collaboration across the supply chain and defined end-of-life options or closed loop supply chains within contracts.

2) **Keep products and materials in use: what if we can build an economy centered around reusing existing products and materials rather than creating new ones?**
   The measurement and reduction of energy, labor and material use across a building's life is needed. This requires a consideration of how the building is being used and how this use could be extended and dematerialized. It also includes the measurement and reduction of products and material altogether, such as inherent finishings avoiding the need for paint, or exposed ceilings. Understanding and measuring longevity will determine the durability or adaptability and ease of reconfiguration of elements within a building. Design for disassembly should also be considered to enable the repair and reuse of building products and material that can be easily separated, swapped out and recycled.

3) **Regenerate natural systems: What if we could not only protect, but actively improve the environment?**
   Measuring the use of renewable materials and energy, particularly those that are regenerative in nature is needed. For example, have renewable building materials such as wood being specified, and do they offer certification that demonstrates the regeneration of natural systems such as FSC?

Applying circular principles to a building shows that measuring circularity requires the consideration of many factors along its life cycle, like understanding the distance and timing factors of building materials, a building's design, materials and end of life. This requires value-chain wide data collection and collaboration to make necessary calculations. A standardized approach to measuring buildings is necessary to facilitate industry-wide adoption and allow for this collaboration. In a broader context, a standardized approach can also support the recovery of different materials and products and the infrastructure necessary to facilitate circular buildings.

The circular principles work directly with reducing the use of natural resources and reducing the production of waste through the extension of the value of the product analyzed.
In this sense, when looking at material outflow, this paper will refer to the waste hierarchy, which is used as a fundamental approach to guide stakeholders toward evaluating which solutions are more environmentally sustainable than others. The waste hierarchy is established in the [Waste Framework Directive,][11] which lays down some basic waste management principles and follows the principle of keeping products and materials in use for as long as possible while conserving their original value. It looks at products and materials as resources and aims to design waste out of the system by influencing consumption habits and rethinking business models.[12]

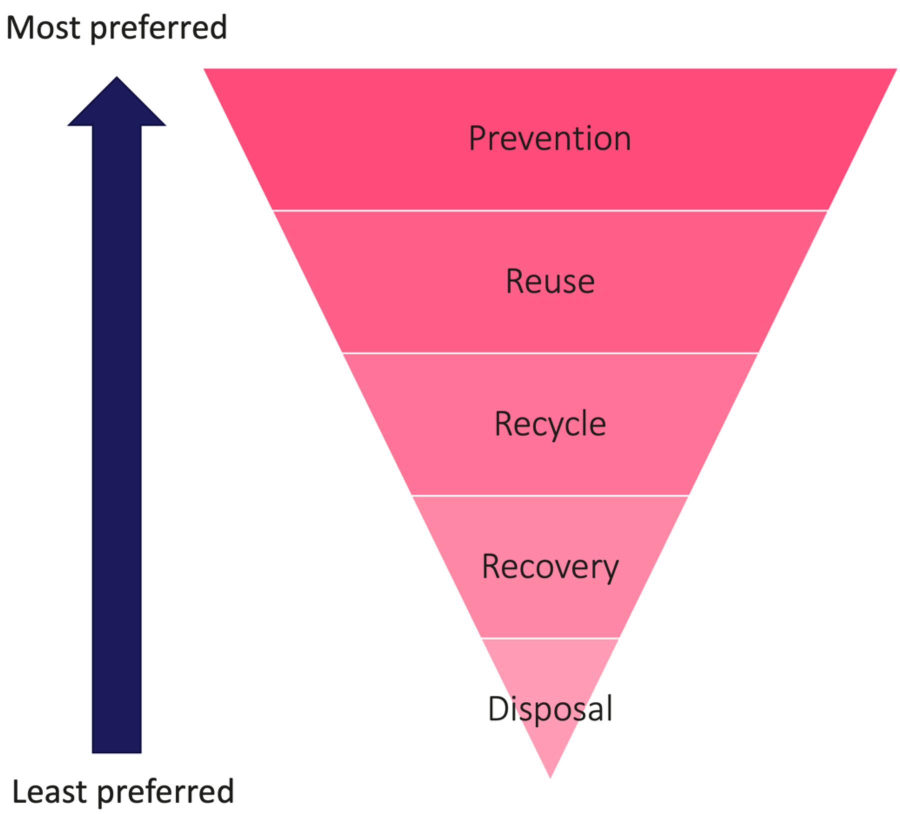

Figure 2 European Commission's waste hierarchy[12]

Figure 2 is a representation of the waste hierarchy provided by the European Commission: [10]

- Prevention: Measures taken before a substance, material or product becomes waste, that reduce:
    - the quantity of waste, including through the reuse of products or the extension of their lifespan;
    - the adverse impacts of generated waste on the environment and human health;
    - the content of hazardous substances in materials and products.
- Reuse: Operation by which a product, or a part thereof, having reached the end of one use stage, is used again for the same purpose for which it was conceived.
- Recycling: Any recovery operation by which waste materials are reprocessed into products, materials or substances, whether for their original or other purposes.
- Recovery: Any operation by which waste serves a useful purpose by replacing other materials that would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function in a plant or the wider economy.
- Disposal: Any operation which is not recovery, even where the operation has as a secondary consequence the reclamation of substances or energy.

Following the waste hierarchy, it is clear that the best approach is to prevent the production of waste, and this must be considered from the design phase. Therefore, it is important to rethink products to make them as sustainable as possible.

BOX 2: Sika's Roof Recycling Program:

Waste reduction starts with durable products that stand the test of time. Sika Sarnafil membranes continue to perform after decades of use in a wide range of climates. Our post-consumer recycling program recycles millions of square feet of used membranes from replaced roofs yearly, reducing the burden on landfills. Post-consumer recycling of roof membranes at the end of their useful life represents an opportunity to divert construction debris from the waste stream.

Sika roofing has invested in state-of-the-art **processing equipment** that enables **large-scale recycling of post-consumer vinyl roofs back into roofing products.** These products include walkway pads, protection membranes, and roofing and waterproofing membranes. We also **reduce waste at every step of the product life cycle**, converting more than 98% of vinyl raw materials from manufacturing and installation into new roofing and waterproofing membranes.

More information can be found on the Sika website by clicking on the following links: Roof Recycling (sika.com)[13] and PVC Roof Recycling (sika.com).[14]

3. Approach

In the previous chapters, we defined what a circular building is and discussed circular principles and important frameworks such as the European Commission's waste hierarchy, which help to shape our understanding of what circular strategies should include. These definitions and frameworks guided our study with our members and the development of this paper. In this chapter, we will outline the approach we followed in our work.

The study began by understanding the needs and challenges faced by the built environment value chain when implementing circular principles and measuring the circularity of buildings. We explored existing frameworks and tapped into members' knowledge to understand the key considerations for circular buildings. These are the initial steps toward enabling the consistent measurement of the circularity of buildings, no matter the location or type of building.

To develop this whitepaper, WBCSD members of the Built Environment pathway, together with companies representing different segments of the built environment value chain, consulted the Circular Transition Indicators (CTI).[15] CTI is a quantitative framework measuring circularity that can be applied to a variety of scopes, including buildings (Box 3). We used an online tool[16] developed for CTI assessments to apply each step of the framework. CTI requires specific knowledge and datasets that highlight what type of information is essential to measure in each phase of the study of a building. The participating companies chose the building they wanted to assess along with its typology, location and layer.

The suitability and value of applying CTI to measure the circularity of a building is discussed in Annex I. The Annex shows the strengths and weaknesses of CTI in measuring the circularity of a building and can be used as a baseline for developing an approach to measuring the circularity of buildings going forward.

The CTI framework approach dealt with the complexity of buildings and structured the different aspects to consider when measuring the circularity of buildings. The results and information gathered during this study are presented in the following four main categories:

- **Building-related aspects**: any type of information related to a building, from location and type of material used to construct buildings.
- **What to measure**: main indicators to include to measure the circularity of a building.
- **How to measure**: which data to collect.
- **Result interpretation**: how to interpret the results of the assessment.

BOX 3: Circular Transition Indicator (CTI)[15]

The Circular Transition Indicators (CTI) represents a simple, unbiased and quantitative framework to measure the circularity of products and business processes. It helps companies evaluate risks, identify the most impactful actions to become more circular and understand the effects of their circularity strategies on climate, nature and people.

The World Business Council for Sustainable Development (WBCSD) developed the framework in 2020 in collaboration with over 30 companies. It is updated annually to ensure alignment with emerging policies and developments in reporting standards. The newest version, Circular Transition indicators v3.0,[17] was released in May 2022 and is freely available. CTI is currently being integrated into reporting frameworks such as ISO and ISSB. To guide companies through the CTI process and circularity assessments, WBCSD developed an online tool[16] together with Circular IQ Circular IQ[18] that structures data and calculates outcomes.

Analysis of a building

For a better understanding of circularity within the building, it's important to use consistent terminology. Therefore, this chapter aims to explain the terminology used in this study. We suggest using the **Element, Layers, Products & Materials (ELPM) terminology**, which identifies a building as an **Element**, then recognizes that buildings are composed of **Layers,** made of **Products** (doors, windows, walls, etc.) and are built using **Materials** (wood, cement, steel, etc.) (Figure 3).

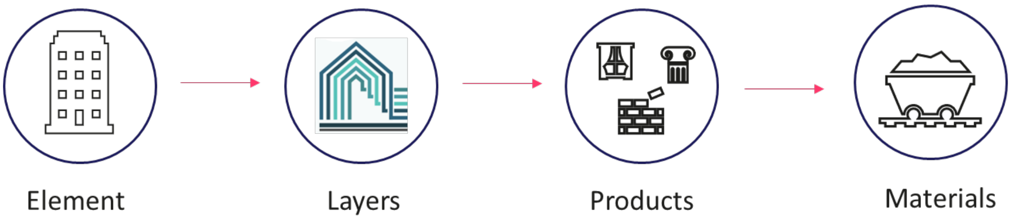

Figure 3: Analysis of a building

This terminology is a readaptation of the Building Value: A pathway to circular construction finance[19] study of EPM (Element, Product and Material), led by Circular Economy, Sustainable Finance Lab and Nederland Circular. The referred paper identifies the analyzed system as an element composed of products and built with materials. Hence, we refer to buildings as an element, as it is the final subject that we aim to analyze. To this terminology, we have added Layers as, to simplify the study of such a complex system, there is a need to create more sub-categories to gather as much data as possible as easily as possible.

The concept of Layers, based on the 6S model by Steward Brand (1994) and David Bergman (2011), is explained and clarified in the next chapter.

To give a bit of context and clarification, a material is a homogenous substance like cement, concrete, steel, glass or aluminum, while a product is a complete object that can fulfill a function, which can consist of multiple parts, components, compounds, and/or materials. Practical examples are introduced in the next chapter.

This terminology allows us to best dissect and analyze the complexity of buildings based on existing approaches.

The findings and suggestions presented in this paper can be applied to any building level (Element, Layers, Products and Materials).

Simplifying a building
After understanding the terminology, it is important to understand how a building works and its composition, to better identify the best approach to measuring its circularity.

In fact, buildings are complex systems that are challenging to capture in a single circularity assessment. To increase the granularity of data used in assessments, we recommend adopting the **6S model.** The 6S model divides and simplifies buildings into six fundamental materials layers: stuff, space plan, services, structure, skin and site. Besides physical layers consisting of products and materials, the circularity of a building is also influenced by how the building is used. The function of a building goes beyond simply offering shelter to human beings; it extends to activities that are embedded in a social and cultural context.[20] The way buildings are used reflects this social context, resulting in behavior impacting the circularity of a building. A seventh layer was added to the 6S model covering this social aspect (Figure 4).[6] This approach was also used for consistency and better integration with WBCSD's work on the decarbonization of buildings, which is summarized in the Buildings System Carbon Framework.[7]

Increasing the lifetime of each **Element, Layer, Product and Material (ELPM)** allows for the reduction of resource usage per unit of delivered service.

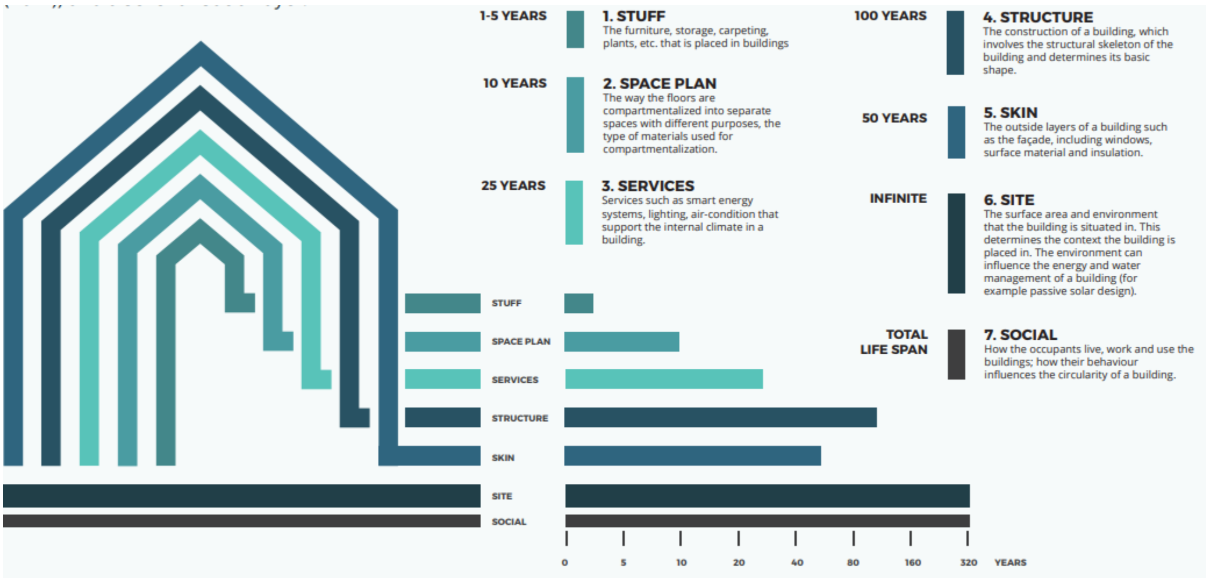

Figure 4 Building model consisting of six material layers (after Steward Brand [1994] and David Bergman [2011]) and a seventh social layer[3]

Below is a non-exhaustive list of products that can be found in each layer, because a building is composed of layers built by products:

- Structure: in the superstructure we have the frame, upper floors, roof, stairs and ramps, while in the substructure we can find the foundation, retaining walls, and more.
- Skin: external walls, windows and external doors.
- Space plan: internal walls and doors, floor and ceiling finishes.
- Service: building services and mechanical, electrical and plumbing (MEP) systems.
- Stuff: Fittings, furnishings and equipment.

BOX 3: Stora Enso - The Green House

Wooden construction elements are key enablers in refurbishment, as they can extend the lifespan of existing buildings. Stora Enso offers a variety of wood product solutions to renovate and extend the lifespan of existing buildings. For example, prefabricated wooden elements made from Cross Laminated Timber (CLT) or Laminated Veneer Lumber (LVL) improve the quality of the existing building stock while promoting energy efficiency and reducing greenhouse gas emissions. As lightweight materials, they can be used to build additional storeys on top of existing buildings to address space shortages in cities. A great example of this is the Green House refurbishment and extension in London. *More information can be found at Expanding an existing building with mass timber – The Green House, London - YouTube*[21]

More information can be found at the following link: Building Solution Stora Enso[22]

4. Measuring circular buildings: critical aspects

This chapter outlines key insights from our research on critical aspects to consider when measuring the circularity of buildings. The chapter is structured according to four main aspects for consideration:

a) **Building-related aspects**: this section outlines suggestions about the information that is related to the administrative and physical aspects of buildings, such as who owns a building, who collaborated on its construction, its location and the materials used in its construction.
b) **What to measure**: this section discusses the main aspects of a building that need to be measured to capture the circularity of a building.
c) **How to measure:** this section provides information about the data essential to measuring the circularity of buildings, which can be both qualitative and quantitative.
d) **Result interpretation:** this section includes suggestions about how stakeholders should interpret results to steer decision-making.

This chapter also provides various suggestions and feedback gathered from member companies on all relevant aspects that need to be considered when determining the methodology for circular building assessments, which are listed in Figure 5.

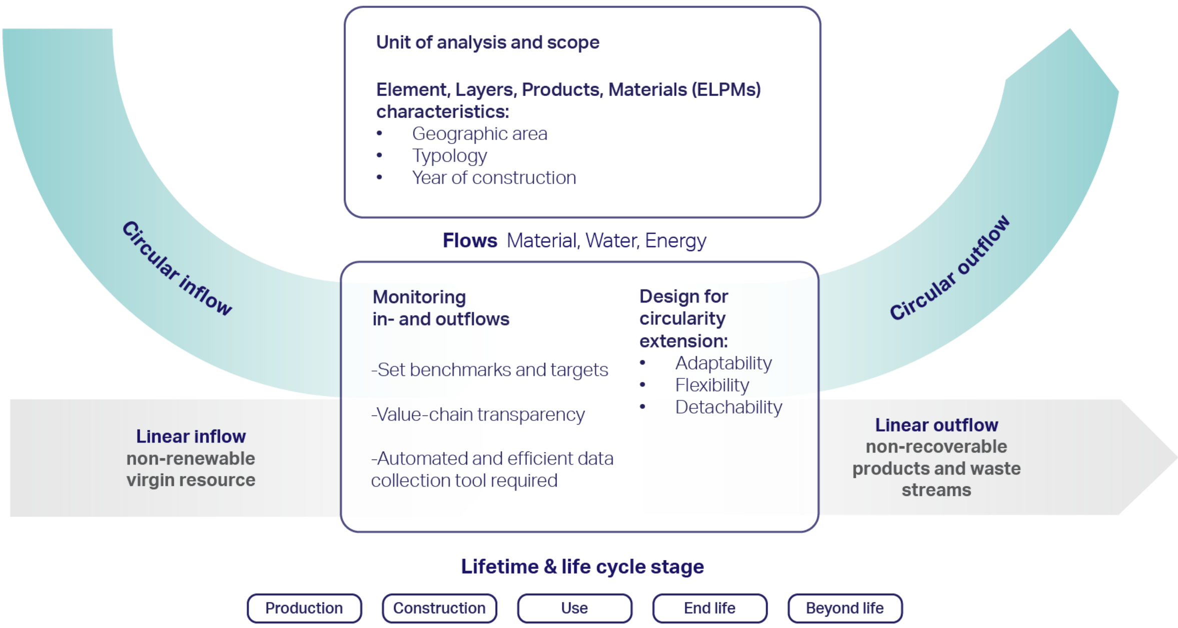

Figure 5 Building-related aspects: key considerations

4.1 Building-related aspects

During our study, we found that the first step of information gathering required to analyze a building is its **geographic location**, **typology** and **year** of construction. This information will influence the overall approach to the analysis, as legislation will change based on those characteristics and building requirements, which might make gathering information easier or harder.

Besides administrative information, a unit of analysis for the assessment needs to be determined. The exercise undertaken with WBCSD members showed that looking at a building through the lens of the **readapted S6 model** shown in Figure 4 is a useful approach to measuring circularity, as it offers the possibility to consider specific parts of a building. Dividing buildings into seven different layers and analyzing them through this subdivision can help stakeholders of the built environment value chain avoid missing essential information and develop more detailed data **granularity**.

To understand the lifetime of ELPM, it is important to take the **life cycle stages** of the building into consideration. This section focuses on the life cycle stages of construction, occupation and use (including refurbishment and alterations) and demolition and next life stages, but we also recognize the importance of the planning and procurement stage for the measurement of circularity. However, including those stages can eventually further complicate the analysis of the building as it will require the engagement of more stakeholders and the collection of more data. The life cycle stage of a building influences the approach to measuring circularity by determining the balance of focus needed across its design and purpose, its operation and utilization or its disassembly and recovery and recirculation of materials. The ELPM circularity degree might change based on the life stage: for each fundamental life stage of each of them, circular principles can be adopted. If a building is in the phase of design or in construction, considerations can be made to follow and circular principles, making its design and space flexible and adaptable. This makes it easier to reuse or recycle products and materials used in the building when its life ends. For already existing buildings, circularity can be improved through retrofitting and choosing products and materials that are either used or recycled. If a building is at its end of life, products and materials can be reused or recycled. Therefore, even if a building was not circular during its lifetime, it can still influence and provide opportunities for other buildings to improve their circularity.

The same concept can be applied to the products and materials used in buildings. They will have a different impact on the overall circularity depending on their life stage and content. If they are new and built with virgin material, they will negatively influence the degree of the circularity of buildings, while if they are used and have found a new purpose, the impact will be more positive. The possibility of reusing or recycling them will also positively impact overall circularity. It may be useful to create and refer to a model that identifies **critical moments** of each building's life cycle stage when measuring the circularity of buildings. In this paper, we define a critical moment as a point in time that can destabilize or change the balance of a building. Examples include the moment when stakeholders discuss the principles to follow during the design phase, retrofitting needs during the operational phase or when to replace furniture.

4.2 What to measure

This study identifies what should be measured to fully capture the circularity of a building. This section introduces the aspects found to be relevant in measuring the circularity of buildings, which can be split into four categories with different goals:

- **Closing material loops** aims to close material loops by designing buildings for longer use with secondary materials and recovery of materials at the end-of-life.
- **Extending product lifetimes** aims to retain product quality and extend material lifetimes.
- **Measuring impact** aims to provide insights on the impact of circular strategies on achieving environmental and social objectives.
- **Design for circularity** aims to explain how the design phase has an impact on the overall circularity of buildings.

Closing material loops
It is essential to **assess and shortlist** the products and materials present in buildings, and what is added and removed during their lifetime. Circularity should be measured using the materials entering and exiting the building system. Considering material inflow, ELPM built with **material content** that is reused or recycled and not virgin improves the circularity of buildings – this is valid for both retrofitted and new buildings.[6] Therefore, we suggest making use of a metric that will allow the measurement of the the circularity of material inflow that can capture this, such as *percentage of circular material inflow* in the CTI methodology.

To recover materials at their end of life, a key consideration is the **detachability factor,[28]** which indicates "the degree to which objects are demountable at all scales without compromising the function of the object or surrounding objects. With the aim of protecting the existing value." [23]
A high level of detachability will support the retention of the value of ELPMs and increase the possibility for them to be reused, refurbished, remanufactured, repurposed and recycled, as well as help avoid incineration and landfill as much as possible.[23] When looking at the detachability factor, it is also essential to take into consideration the energy and water usage to detach. This will influence the overall circularity of the building. We recommend using the detachability factor when measuring the circularity of buildings to understand what can be reused and recycled at different life-cycle stages.

Besides potential recovery, it is crucial to track what is actually recovered at the end of life. Unfortunately, the industry is not yet ready for this, as knowledge, technology and collaboration must be improved.

Mass or volume of materials used in a building is an important consideration in measuring circularity, but not the only one. Additional variables must be taken into consideration, such as how materials were transported and how the final product was produced.

Extending product lifetime
Another aspect that we suggest considering when measuring the circularity of buildings is the lifetime of products and materials in the measurement of building circularity. The degree of circularity of ELPMs should be measured and represent a specific **value based on their** lifetime. The usage of ELPMs will change the circularity of a building and have environmental, economic and social impacts. The lifetime of ELPMs is gauged by measuring durability, but the flexibility and adaptability

of spaces in buildings can also ensure longer lifetimes. Within a lifetime, it is important to consider the **discount factor,** which is based on the estimated lifetime of each ELPM in relation to a building's life period.

The discount factor is a commonly used concept in financial cash flows. It is a ratio that represents the change in the value of money in the future. It is used to translate future financial cash flows into a 'net present value' and this rate differs between investors depending on their structure, risk profile and preferences. This has the advantage of enabling a direct comparison of financial performance between investments incorporating time weighted analysis rather than static financial performance.[24]

In the built environment, when it comes to measuring the circularity of buildings, accounting for a lifetime discount factor means that the lifetime of products and materials that are expected to have a shorter life, have less of an impact on the overall circularity of a building than the lifetime of products and materials that have a longer expected lifetime. This is because something built to last longer will prevent the creation of something new and will therefore reduce the need for more natural resources and create less waste over the years. This determination remains controversial, as some believe that a shorter lifetime – when recovery is sustainably and efficiently managed – may contribute positively to the circularity of buildings. This is based on the assumption that products and materials can be reused and recovered more often. The circularity of the building does not depend on the lifetime of ELPMs, but it will be influenced by it.

Measuring impact
Upon analyzing the result of the CTI assessment, members remarked how important it is to use energy indicators more consistently and transparently to ensure more comparable results in terms of the circularity of buildings. Defining any synergies with existing green building standards and certifications as well as relevant building codes will help align and accelerate the understanding and adoption of circular construction principles.

To achieve a sustainable built environment system, **whole life carbon considerations should be linked to circular principles**. This can help establish a broader overview of how buildings function and an understanding of what to change to make them more sustainable. Therefore, the measurement of circularity should not replace whole life carbon analysis, instead they should complement each other.

Design for circularity
Closing material loops, extending product lifetimes and reducing impact start with a building's design phase. All circularity principles must be taken into consideration from the very beginning, since making the right decisions during the **design phase** enables and empowers the circular model.[2] ARUP and the Ellen MacArthur Foundation worked together to develop a Circular Building Design Toolkit[25] that aims to help stakeholders understand how circular their buildings are from the design phase and help them improve their buildings in terms of sustainability. Qualitative and quantitative aspects are of equal importance, which makes the **adaptability, disassembly and flexibility** of a building key considerations when conducting a study to measure its impact.

The local availability, durability, performance, circularity and carbon life cycle of products and materials are fundamental comparison criteria when evaluating options for a given design. Price should also be considered, but only in the context of life cycle costs over the expected lifetime that has been designed for. Reviewing upfront and total costs of ownership (taking into consideration energy savings or reduced maintenance over expected design life) can highlight more sustainable material options and value-added benefits.

The study group has highlighted that it might not be possible to assess all the topics mentioned throughout the chapter, as it would include too much information to deal with at the same time. **A materiality approach** should be developed for buildings that prioritizes the most important elements of measuring circularity. This prioritization could start with data about the material with the highest impact, steering companies to where it is best to focus their efforts.

To improve and simplify the measurement of the above-mentioned topics, it is important to create benchmarks and define standards to give stakeholders a method for comparison. For this matter, the European Taxonomy, a classification system that helps standardize and define key sustainability terms, could be of help. The EU is currently drafting the Substantial Contribution to Circular Economy criteria[26] and they include indications for buildings regarding content material that ELPMs should contain to be considered circular. More information can be found in Annex II.

BOX 4: Holcim, Susteno – resource-saving cement
Susteno is a solution Holcim uses to embrace the urban mining concept through upcycling Construction & Demolition Waste (CDW) to build new from old and reduce consumption of virgin resources. Susteno is the first and only resource-saving cement in Europe that uses up to 20% high-quality processed mixed granulate demolition waste in the manufacture process, providing a cement that doesn't compromise on performance while closing the loop for construction materials. Susteno cement is used in Holcim's low carbon ECOPact+ concrete, which combines >20% recycled material – including aggregates sourced from CDW – diverting waste from landfills and reducing the consumption of virgin natural resources. More information can be found at Resource-Saving Cement | Susteno | Holcim[27] and Green Low Carbon Concrete | ECOPact | Holcim[28]

4.3 How to measure

This section provides explanations about which data is essential to measuring the circularity of buildings. It is divided into more sub-sections that will provide an explanation of the importance of qualitative and quantitative data, the need for completeness and the complementarity of data and its transparency.

Quantitative and qualitative data

The members participating in the study recognize that qualitative information is equally important as quantitative information. Both aspects provide critical insights into a building; however, many challenges arise when it comes to data collection in both cases. Qualitative information refers to the type of materials used to obtain the final product: how use intensity and time may impact quality and performance, and how design may impact circularity. This type of information is difficult to provide, as guidelines are not yet in place.

Quantitative information refers to the measurement of ELPMs: from measuring the amount of material used to their source type (all virgin, partly recycled or reused can be considered circular). Data demand can foster **collaboration across the value chain**. It is especially important to involve manufacturers, as they are the stakeholders with the most detailed information when it comes to granular data about products and materials.

One tool that can be of support when it comes to collaboration and data collection, both qualitative and quantitative, is the Digital Building Logbook, which is a common repository for all relevant building data. It facilitates transparency, trust, informed decision-making and information sharing among building owners and occupants, financial institutions and public authorities within the construction sector.[29] More information can be found in Annex II.

Completeness and complementarity

When measuring circularity, data must be reflected through **relevant units of measurement** based on stakeholder needs, and the measurement of a building's circularity should be evaluated in light of its **impact** on other **environmental and social indicators**. A circularity evaluation should **complement** and not substitute existing and commonly used sustainability frameworks. A circular building is powered by renewable energy and makes efficient use of water within its local context. While energy and circular water use are not the focus of this paper, these should always be included in an evaluation of a building's circularity. Considerations on how energy use contributes or hinders a building's circularity would benefit from alignment with existing green building standards and certifications.

Needs for transparency and data collection

When a building already exists, accessing the required information may be challenging, as often this data has not been collected. For new buildings, a challenge may consist of accessing all the relevant information from each stakeholder involved in the construction of a building. Stakeholders in the built environment value chain may be reluctant to share specific data about their products because of competitive aspects. Open and transparent data is needed, and stakeholders should be able to consult it. According to the experience of some WBCSD members, this solution is still not viable, as stakeholders in the built environment value chain – mainly manufactures and suppliers – are not willing to share data for privacy matters, and market incentives are not yet in place to ensure that materials are indeed used to their maximum value. Data transparency may be fostered by the wider adoption of circular principles across the built environment value chain.

Making data available and transparent is supported by the European Union which, in March 2022 announced the introduction and further use of the Digital Product Passport (DPP), which aims "to provide information on the origin, composition, and repair and disassembly possibilities of a product, including how the various components can be recycled or disposed of at end of life. This information enables the upscaling of circular economy strategies such as predictive maintenance, repair, remanufacturing and recycling. It also informs consumers and other stakeholders of the sustainability characteristics of products and materials to promote better informed purchase decisions." [30] More information about the DPP can be found in Annex II.

Beyond individual buildings, a sustainable built environment will only be achieved if circular building principles are applied at city or regional levels. In fact, a broader context could support a better reuse of different materials and products in different contexts. For those that wish to apply such principles on a large scale, it is necessary to know the key considerations in measuring the circularity of buildings.

4.4 Result interpretation

The phase of understanding what data is essential and how to measure the circularity of buildings is followed by understanding what to do with this data. Therefore, a tool that can collect and store data is essential.

A measurement tool should support the measurement and tracking of the circular principles within buildings. Moreover, a tool needs to be **automated and efficient,** as buildings manage a significant quantity of data. Current tools on the market to track the circularity of buildings require users to input data manually, which is time consuming and might make built environment stakeholders reluctant to engage in this activity.

WBCSD could play a leading role by creating and adopting guidelines that make the task of measuring the circularity of buildings easier. Principles and information about circularity could be connected to digital products and tools – such as Building Information Modeling (BIM) software – and digital inventories could be connected to supply chains and their product models. These tools could facilitate the following processes:

- Converging on a sequence and process to measure the circularity of buildings will be crucial to facilitate the implementation of circular principles and harmonize data collection and analysis.
- It would be optimal to analyze the value chain and understand at what stage of the building life each stakeholder is engaged in and what their role is in terms of improving the adoption of the circular principles, and for each stage **KPIs** should be identified.
- The tool could measure progress according to a set benchmark for circular principles. This would help steer the direction of improving circularity.
- Finally, it is important to define a communication strategy on how to disclose the results of circularity assessments.

5. Recommendation & next steps

Efforts are being made to improve the circularity of buildings, though there is a need for the built environment to evolve to finalize the development of a full set of indicators and accompanying metrics that can comprehensively measure the circularity of buildings. Further studies into the circular principles and how to measure them are required.

Measuring the circularity of buildings requires collaboration across the value chain, knowledge of geographic areas, typology and the year of construction buildings and greater transparency when it comes to data collection and accessibility. Measuring circularity with consistency and adopting a standardized approach can allow stakeholders to better understand their building's level of circularity and subsequently identify actions to improve their performance while accelerating the shift toward a sustainable built environment.[3] Further, the built environment requires a tool that allows for automated tracking of materials and their properties, which is connected to technologies such as BIM and the Digital Building Logbook.

This study identified more key considerations when it comes to measuring circularity:

- Analyze the building by dividing it into layers, thus simplifying the task of collecting as much granular data as possible.
- Use consistent terminology to make analyses understandable for everyone. We advise using the ELPMs (Element, Layer, Product, Materials) terminology, as it was the language that best fit the knowledge and experience of participants in this study and was easily understood by everyone.
- Design for circularity across a building's different life phases. This means including aspects such as:
    - Closing material loops
    - Designing for lifetime extension
    - Detachability
    - Adaptability
    - Flexibility
- The lifetime of ELPMs should be considered along with measuring the circularity of inflows and outflows. This could be included as a discount factor on the overall circularity of the layers.
- Measuring circular inflows and outflows while monitoring the type of material (percentage of reused and recycled material, along with end-of-life recovery). For this to happen, it is important to set benchmarks, standards and KPIs.
- Water and energy inflows and outflows should be included in the circular assessment along with a carbon life-cycle analysis.
- Circular evaluations should be complementary and not a substitute for environmental assessments.
- Qualitative and quantitative data are equally important in circular evaluations.
- Organizations like WBCSD can contribute and take the lead around setting the right path to prioritization guidelines when measuring the circularity of a building.
- Focus efforts on areas of greatest impact and stimulate greater openness and transparency when it comes to data, and influence and stimulate the market to develop an automated tool that can collect and store data.

This paper is the first step in a broader effort that aims to develop and facilitate the adoption of a standardized approach to measuring the circularity of buildings. The objective of this work will be to set the baseline to understand the level of circularity of a building and enable stakeholders to take responsibility and develop awareness of their choices and actions at each stage of a budling's life cycle. WBCSD's Built Environment pathway will continue developing this white paper and work with companies and organizations interested in understanding what current solutions and approaches stakeholders use to measure the circularity of buildings, reduce fragmentation and create a standardized approach that will build on the recommendations highlighted throughout this paper.

Annex I: Measuring circularity of buildings using CTI

Why apply CTI to a building

Transparency and alignment on circular metrics are critical to establishing a common language across industries and governments aimed at developing strategies and measuring progress on circularity. To facilitate value chain collaboration in the circular economy, WBCSD has developed the Circular Transition Indicators (CTI).[15] What makes this framework unique is its ability to quantitatively measure circularity in a simple, comprehensive yet flexible manner, regardless of material, sector or technology. The framework focuses on circular and linear mass flows that enter and leave the company boundaries, in which design, procurement and recovery models are crucial levers to determine how well it performs. More information on CTI is available in the Circular Transition Indicators v3.0.[17]

Initially published in 2020, CTI has already been applied across many different industries to measure the circularity of materials, products, production facilities and entire companies. In the built environment, it was used to measure the circularity of cement production,[31] chemical products integrated in a building,[32] and entire municipalities. CTI has not yet been applied to buildings. Following the publication of CTI, circularity assessments of buildings were conducted to show the value and suitability of adopting this framework to measure their circularity. This Annex shows the strengths and weaknesses of CTI in measuring the circularity of a building and identifies opportunities for improvement.

How is material circularity measured in CTI?

CTI's main indicator – **percentage of material circularity** – was selected to measure the circularity of buildings. **The percentage of material circularity** focuses on the materials flowing through the system and provides insights into its ability to minimize resource extraction and waste material. CTI includes additional indicators to measure progress, efficiency and the impact of circularity. These additional indicators were excluded from the assessment.

The percentage of material circularity is formed by three indicators that measure circularity at the following key intervention points:

- **Inflow:** Measures how materials are sourced. Inflow can either be considered 1) virgin (materials not used before), 2) non-virgin (materials used in a previous cycle) or 3) renewable (bio-based resources that are sustainably grown and managed). Non-virgin and sustainably sourced renewable materials are considered *circular inflow*.
- **Outflow recovery potential: Measures** how a company designs its products to enable the technical and biological recovery of materials (e.g., by designing for disassembly, repairability, recyclability, biodegradability, etc.).
- **Outflow actual recovery:** Measures how much a company's outflow is actually recovered and reintroduced into the economy. This can occur through direct recovery strategies, such as buy-back schemes, or indirect recovery, such as second-hand markets or recycling.

The percentage of material circularity is calculated by taking the weighted average of circular inflow and circular outflow (Figure 6). Circular inflow is the mass of all non-virgin or sustainably sourced renewable materials used in a given building. Circular outflow is calculated by multiplying the recovery potential factor by the actual recovery percentage of materials.

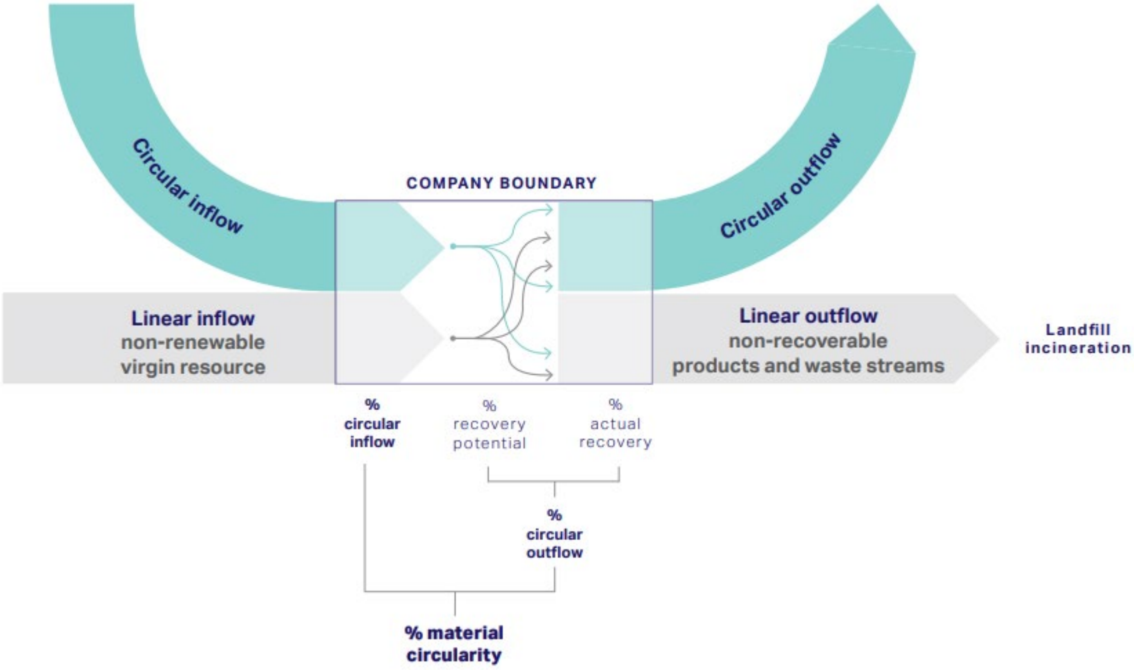

Figure 6: Illustration of material flows[17]

How do the key considerations fit with CTI?

This report identified several key considerations around 1) building-related aspects 2) what to measure 3) how to measure and 4) results interpretation. Table 1 provides an overview of the key considerations and assesses the suitability of the CTIs to cover key elements.

Table 1: Suitability of CTI to address key considerations of measuring the circularity of a building

Step	Key considerations for buildings	CTI	Suitability?
Making a CTI assessment			
1. Setting the scope of the assessment	• Unit of analysis: buildings are made of elements (consisting of products and materials) composed of layers, as described in the 6S model.[3] • Specify: type of building, geography, legislation, life cycle stage of a building and the age of ELPMs. • Timeframe: make the assessment based on the lifetime and life stage of the ELPMs.	CTI enables the full analysis of a company, production facility, product, material or layer. CTI is flexible in adopting boundaries and determining a timeframe.	
2. Selection of indicators	• Circular metrics need to measure circularity as it relates to the definition of a circular building.[2] *A circular building optimizes the use of resources while minimizing waste throughout its entire life cycle. The building's design, operation and deconstruction maximize value over time using:* ○ *Durable products and services made of secondary, non-toxic, sustainably sourced or renewable, reusable or recyclable material;* ○ *Space efficiency over time through shared occupancy, flexibility and adaptability;* ○ *Disassembly, reuse or recycling of embedded products, materials, and systems.*	CTI includes ten different indicators measuring the effectiveness in closing material loops, assessing resource-efficiency, lifetime, value of circularity and impact on sustainability. CTI can measure the majority of elements that constitute a circular building but does not yet include metrics specific to buildings.	
	• Key indicators must be complemented with carbon and environmental indicators.	CTI recognizes its framework needs to be complemented by other methodologies to establish a full picture of the environmental impacts associated with a building.	

	• The design phase is essential to understanding the circularity of a building. • The detachability factor[23] is a key consideration in determining circularity.	The percentage of material circularity indicator measures recovery potential, which is the same as the detachability factor.	
	• A discount factor should be included to account for the lifetime of the ELPMs.	CTI currently does not measure material lifetime within the percentage of the material circularity calculation.	
3. Data collection	• Data needs to be as granular as possible, but given the complexity of building systems, granularity can be adapted to the scope and needs of a study. A proper balance is needed between data accuracy and effort. • This granularity could differ per ELPMs.	Companies can determine the level of data granularity that fits the purpose of an assessment. The collection of company-specific data is preferred over the use of databases, especially for waste handling.	
4. Results interpretation	• Collecting and storing information for monitoring is essential, especially to track what is going in and out of a building when looking at ELPMs.	The CTI tool developed by Circular IQ has a functionality that allows for the tracking of progress across assessments.[18]	
	• To optimize and make best use of ELPMs, data should be open and transparent.	CTI aims to facilitate a common approach along the value chain. It encourages the sharing of data to pursue shared circularity goals.	
Tool specifics	• The tool needs to be automated and time efficient. Opportunity to connect to a digital product passport, BIM and other digital tools.	CTI is exploring options to automatically upload the material inventory from digital product passports.	

What are the opportunities and challenges of using CTI?

Flexibility in application

Using CTI to measure circularity has the significant advantage of its flexible nature: the scope and unit of analysis allow for the assessment of an entire company, production facilities, products and materials within any timeframe. CTI allows users to analyze the layers of a building separately, adopting different lifespans. It requires a clear formulation of the unit under assessment, in which the type of building and geography must be disclosed.

CTI as the foundation for building metrics

There are several circular principles that make up the definition of a circular building as formulated by WBCSD (2021)[2]. This definition defines a circular building as one that minimizes waste and uses products made of secondary, non-toxic, sustainably sourced, renewable, reusable or recyclable materials. CTI measures the circularity of material flows on two levels: 1) circular inflow (non-virgin or sustainably sourced renewable materials) and 2) circular outflow (design for reuse, recycling, repair and actual collected, recovered materials). An average is calculated between the two that determines total circularity. CTI has well-established definitions aligned with developing international standards of what can be considered circular inflow or outflow. This approach can significantly support this definition of circular buildings and enable easy target setting across industries.

This study identified the detachability index as a key consideration to take onboard. The detachability factor is the degree to which objects are demountable at all scales without comprising other objects.[23] This relates directly to CTI's concept of Recovery Potential, which measures the effectiveness of designing products that can be recovered. The main opportunity to improve recovery potential is through increasing modularity. Recovery potential is a key element of CTI's percentage of material circularity indicator.

Evolving CTI metrics

The definition of circular buildings also constitutes out of space efficiency over time through shared occupancy, flexibility and the adaptability of buildings. CTI does not have an indicator to measure these optimizations, which can often be qualitative indicators at best. These extra indicators can be developed when creating a sector-specific version of CTI. Another element that CTI does not directly measure in the percentage of material circularity equation is lifetime. While CTI includes two separate indicators on lifetime, incorporating a lifetime discounting factor in the calculation of the percentage of material circularity is regarded as a useful development in CTI for the built environment.

Measuring environmental impact

Throughout this paper, the need for an approach that – besides circularity – measures environmental and social impacts have been expressed extensively. CTI is developing indicators that express the impact of circular strategies on all these aspects but does not constitute a full environmental assessment. CTI offers insights into the circularity of the mass flows of a building, which is already a major step in mitigating impacts. However, light materials can have a considerable impact on the environment, making the weight of materials used only one of the key considerations to realizing circular buildings. CTI stresses that circularity should never be assessed in isolation and should be complemented by other existing sustainability assessments – such as LCA – that are able to capture environmental impacts with the appropriate granularity.

Next steps

These results show that CTI can serve as a baseline for developing and adopting an approach to measuring the circularity of buildings. The percentage of material circularity in CTI is a good starting point for the methodology, but industry-specific guidance and additional indicators (including qualitative indicators) need to be developed to accurately measure the circularity of a building.

Annex II: Data collection tools and strategies in the built environment

The built environment recognizes that the implementation and adoption of the key circular economy principles of designing out waste and pollution, keeping products and materials in use and regenerating natural systems can support the decarbonization of the system, improve collaboration across the value chain and support the shift toward a more sustainable system.[2]

"The availability of consistent and reliable data can contribute to better design, construction and management of buildings, improved market information and transparency, the creation of innovative services and business models, as well as more effective policymaking." [29]

For these same reasons, different approaches and tools have been developed and adopted by public and private parties around the world to support the use of circular principles.

The Digital Building Logbook

The first tool that comes to mind when talking about collection and data accessibility is the "Digital building logbook". We must specify that the Digital Building Logbook name is used only in Europe, as it has been developed by the European Union but in the different global geographic areas (but also in Europe), it goes by different names based on the scope of the analysis of the building. Some of the known names are Material Passport, Building Passport, Energy Passport and Renovation Passport.

In general, what can be identified as the Digital Building Logbook is a common repository for all relevant building data; it facilitates transparency, trust, informed decision-making and information sharing among building owners and occupants, financial institutions and public authorities within the construction sector.[29]
The above mentioned tools have the same scope, but they focus on a specific topic.

Data in the built environment is still scarce compared to other industrial sectors and is often unreliable and limited in terms of accessibility. This can be connected to the fact that the value chain is generally fragmented and lacks collaboration and communication. This type of tool encourages the collection of data and its transparency and aims to make specific data available to a wider range of market players and set a standardized approach to collect data, depending on the scope of the analysis of a building.[29]

The above-mentioned goals are shared by WBCSD and are therefore referenced in this paper, which is why it is important to mention this tool, as it indirectly supports the measurement of circularity.

The current market offers different possibilities for the Digital Building Logbook which, as mentioned, change name based on the purpose of the study. WBCSD in March 2022 has conducted a study to understand what tools are available worldwide and gathered a few of them in the following table, gathering them by purpose:

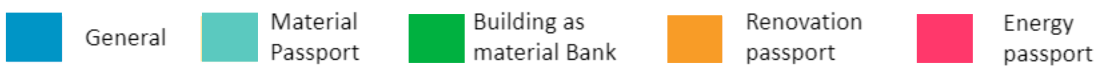

Figure 7 Legend colors for Table 2

Table 1 Data collection tools

Name	Where does it work	Private/public funding	What does it cover	Objective	Link
Platform CB'23	NT	Funded by the Netherlands government	Material passport	Standardization of framework and guideline for the use of material passport	Link
PCSD	LU	Funded by the Luxemburg government	Material	Improve the circularity of the material in the BE	Link
Madaster	NT, DE, CH, LU, NW, Be	Private company	Material	Documenting, registering and archiving of the materials applied in buildings and construction objects	Link
CAPSA & Global ABC	EU + outside EU	Global ABC and governments + private	Material, emission, energy	Managing a building stock and planning refurbishment work.	Link
ORMS	UK +IE	Private company	Material	Create a database of materials	Link
Building Circularity Passport	DE	Private	Material, emission,	Enabling the recyclability of a building in collaboration with architects, all planning disciplines as well as the construction firms	Link
Multiple tools (ETHZ)	CH	University	Material	Extend Buildings and material value and life	Link
Building Material Scout	DE	Private	Material	The Building Material Scout helps all stakeholders involved in to gain easy access to healthy, intelligent and sustainable materials and building products.	Link
Construcia	ES, PR	Private company	Material, Emissions	identify, quantify and situate materials and products in the construction space for their correct recovery at the end of the cycle of use	Link
BAMB	EU	Funded by EU	Material	Collecting data about materials used in the buildings	Link
PAS-E	ES	Private	Material, Energy	Follows the recommendations of the latest European Building Energy Directive in order	Link

				to achieve the best possible result in step-by-step renovation.	
BIM4EEB	EU	Funded by EU	Material	Facilitate the process of residential buildings renovation	Link
Concular	DE	Private company	Material, emissions	Digitalization as material passports, cost-effective procurement until deconstruction starts and measurable savings of costs, waste and GHG emissions	Link
Aldren	EU	Funded by EU	Material and Energy	Dynamic instrument to be used and updated over time along the renovation path to deep renovation	Link
X-Tendo	UK, IE	Funded by EU	Energy and emissions	It will develop a toolbox to assist the implementation of the features into existing EPC schemes, to provide public authorities with improved compliance, reliability, usability and convergence of the next generation of energy performance assessments and certification.	Link
IBroad	Tested in Bulgaria, Poland, Portugal and Germany	Funded by EU	Energy and emissions	iBRoad focuses on individual building renovation roadmaps and building logbooks, in support of deep renovations in the residential sector.	Link

The Digital Product Passport (DPP)

In 2020, the European Commission (EC) adopted the Circular Economy Action Plan (CEAP),[33] which is part of the main building blocks of the European Green Deal,[34] the new agenda for sustainable growth in Europe. The aim of this action plan is to use circular principles to reduce the pressure put on natural resources, create sustainable growth and jobs, achieve the EU's 2050 climate neutrality target and halt biodiversity loss.

The new Ecodesign for Sustainable Products regulation is the basis of the EC's approach to circular and environmentally sustainable products. The regulation, which builds on the CEAP's existing Ecodesign Directive, establishes a framework that allows for the setting of various requirements along the entire life cycle of products. This includes targets on how products are designed, promoting circular economy processes, encouraging sustainable consumption and ensuring that waste generation is prevented and that resources used are kept within the EU economy at their highest value for as long as possible. It also introduces legislative and non-legislative measures targeting areas where action at the EU level can bring about significant added value.[34]

Under the Ecodesign for Sustainable Products regulation, the EC is developing the Digital Product Passport (DPP), which is defined as a product-specific data set that can be electronically accessed through a data carrier to, "electronically register, process and share product-related information amongst supply chain businesses, authorities and consumers." [30] "The DPP aims to provide information on the origin, composition, and repair and disassembly possibilities of a product, including how the various components can be recycled or disposed of at end of life. This information enables the upscaling of circular economy strategies such as predictive maintenance, repair, remanufacturing and recycling. It also informs consumers and other stakeholders of the sustainability characteristics of products and materials to promote better informed purchase decisions." [30]

CEAP has selected seven categories to prioritize, including the built environment. The EC's objective is to prepare for the implementation of at least three DPP industries, starting in 2023 with key priority industries – batteries, electronics and a decision is still pending on the third priority.[35]
The DPP is in the scoping phase, and more details will be provided on data standardization and specifications in the coming years.[35]

The DPP and its implementation show that policymakers understand that the application of circular principles can support the establishment of more sustainable industries. The initiative supports the focus on the retainment of the value of materials and products, connecting it directly to the collection and sharing of data, which is essential to measuring the circularity of buildings. It also sets the base for a standardized international approach to collecting and storing accessible data, which will help reduce the fragmentation of the built environment value chain.

The European Taxonomy

A taxonomy is a classification system that helps standardize and define key sustainability terms. This is particularly useful for multiple stakeholders – including policymakers, investors and companies – as a common framework to assess if projects and activities are environmentally sustainable, ensuring consistency and reliability, which stops increased fragmentation and inequality in the industry. Moreover, this can be used as the basis for decision-making and helps avoid greenwashing. The European Taxonomy was developed as part of the objectives of the above-mentioned European Green Deal, which contributes to achieving EU climate and energy targets for 2030. These objectives focus on the importance of direct investment in sustainable projects and activities.[36]

There are four overarching conditions for economic activity to qualify as environmentally sustainable that form part of the Taxonomy Regulation,[36] and six objectives for the different industry sectors. Details for the built environment can be found in the following document: Annex to the platform on Sustainable Finance's report with recommendations on technical screening criteria for the four remaining environmental objectives of the EU taxonomy (europa.eu).[37]
As a general summary, the Substantial Contribution to Circular Economy criteria are:

- Construction and demolition waste treated according to the EU Waste Protocol and 90% (by weight) prepared for reuse/recycling, according to the Level(s) indicator 2.2.
- LCA according to Level(s) is carried out and results are made publicly available.
- Resource efficient, adaptable, flexible and easy-to-dismantlable construction designs and techniques supporting circularity (according to Level[s]) indicators 2.3 and 2.4.

- Assets comprised of at least 50% from a combination of reused components (min 15%), recycled content (min 15%) or responsibly sourced renewable materials (max 20%).
- No asbestos or substances of high concern, according to REACH.
- Electronic tools for description of materials and components.

The "Do No Significant Harm"(DNSH)[38] criteria set out in Regulation (EU) 2020/852 of the European Parliament and EC serves to establish technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or climate change adaptation. Moreover, the criteria help determine whether the economic activity in question causes no significant harm to any of the other environmental objectives. They are:

1. Climate change mitigation
2. Climate change adaptation
3. Sustainable use and protection of water and marine resources
4. Pollution prevention and control
5. Protection and restoration of biodiversity and ecosystems

In addition to complying with the minimum requirements established by the European Taxonomy, the regulation requires adherence to:

- OECD Guidelines for Multinational Enterprises
- UN Guiding Principles on Business and Human Rights
- ILO on Fundamental Principles and Rights at Work
- International Bill of Human Rights

This type of guideline can support the creation of a common language, standardization and benchmarks essential to measuring circular principles.

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Disclaimer

Acknowledgments

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We thank the member companies participating in the study that led to the realization of this paper: Arcadis, ARUP, Ashurst, Holcim, Johnson Controls, KPMG, Majid al Futtaim (MAF), Saint Gobain, Sika, Stora Enso, Swire and SwissRe.

A special thanks to the following contributors: Luke Bywaters, Strategy Advisory Manager at KPMG, Robert Ryan, Group Sustainability, Head of Sustainable Construction at Holcim and Jeremy Chilton, Head of Global Project Support at Sika.

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