**04.** An Interdisciplinary Approach to Circularity

# Understanding the intricate nature of circular building components

Dr. Thaleia Konstantinou
*Associate Professor, Chair of Building Product Innovation*
*Department of Architectural Engineering and Technology (AE+T)*

Buildings are complex structures made of numerous building products and onsite labour. Whilst materials are essential for that, we rarely compose buildings directly out of raw materials. We fabricate them using *standardised materials* like bricks or steel beams; or *components* like doors and windows that are manufactured from multiple commercial materials; or finally, assemblies, which are complex configurations of components. The façade is an example of an assembly. It comprises of different components or systems, such as windows, shading devices, structural elements, control systems and so on.

Following this taxonomy, the component scale is therefore allocated in between the material and building scales. Components are not monolithic and uniform building parts. Think for example of a window and the many different elements it comprises of. So, in order to better understand and manage circularity at component scale and by extension to assembly level, we should first try to identify all the elements the component consists of, their functionality, and their interfaces. And we can do that by carefully identifying the separate parts that make up the component. For the window that would be the window frame and the several hidden elements within the frame, but also the glass panes, the hinges and fittings and so on.

*Design* is central and can be seen as enabling for circularity. For example, we can design a window to be able to take it apart. However, unless there is a company to collect the parts and reuse or recycle them the components are not circular. And there needs to be value *economy* for the company to engage in such practices, economic or other. A financial concept or a business model to enable that, including all involved *stakeholders*, is essential. And the business model also needs to make provisions and manage the recovery of components as an integral part of its operation. For example, establish the adequate facilities for processing and storage and install a *technology* to track those resources. The example of the window exemplifies that all aspects are interlinked and need to work in synergy to realise the circularity potential of a component. *Making a component more circular means* thinking of all aforementioned aspects and *developing a comprehensive understanding of how they interrelate.*

*Benchmarking circularity principles for components*

We can try to optimize the circular performance of components using *Key Performance Indicators*, also referred to as *(KPIs)*, that focus on material input and output. These KPIs can help us identify where the materials that we use are coming from and if we have designed our component in a way that the resources can be recovered. Some frameworks considering the whole life cycle are useful to provide such indicators.

*Life Cycle Assessment or LCA* can be a useful methodology to understand the impact of our components. Based on LCA, we can look at indicators like the *global warming potential of materials, fossil fuel energy or renewable energy for production, recycled and reused materials content, or resources out of the components at the end of their life-cycle.* Such indicators relate, of course, to design decisions but also point to the link with other aspects. For example, the use of renewable energy is a technology that can be integrated in the design. However, to make it feasible, in most cases the production of renewable energy requires selling this to the network, so it becomes a business case that needs the right stakeholders. Or the indicator about recycled content. This depends on the selection of material, but also, in the end, the specific material supplier and product manufacturer.

Similarly, *Level(s)*, is another framework consisting of core sustainability indicators for buildings, commonly used in the European Union. Level(s) provides additional indicators such as *durability, bill of materials and demountability.*

Finally, the *R-Strategies* also prescribe a set of indicators to consider in a component's design and operation. Following the R strategies objectives, more nuanced indicators, or rather guidelines can be established such as *modular* or *low-tech design*. Furthermore, *the establishment of a financial concept, the involvement of the right stakeholders and the identification of the input and output of resources.*

To conclude, here are some key points to take away for designers and suppliers of building components, in order to promote circularity in the built environment. First comes, *minimizing resource input, waste, emission, water and energy leakage.* Furthermore, *slowing, closing, and narrowing energy and material loops*, particularly during the operation phase. Finally, at the end of life, *avoiding disposal and loss of economic and ecological value.* Design for Disassembly is key to enabling those strategies. However, additional aspects related to economy, management and stakeholders need to be considered for a comprehensive thinking of components' life-cycle.