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CIRCULAR ECONOMY IN BUILD ENVIRONMENT

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Abstract: A circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products for as long as possible. CE has been gaining popularity because it helps to minimize emissions and consumption of raw materials, open up new market prospects and principally, increase the sustainability of consumption and improve resource efficiency. Construction is one of the critical sectors in the transition to a Circular Economy due to its contribution to resource depletion, waste, and emissions. Despite its acknowledged limitations, the construction sector has been the focus of policies and regulations to improve its sustainability and circular economy capabilities. This study presents the State of the Art on circular economy implementation in the construction sector in the European Union. The analysis identified a growing number of publications since 2019, that can be divided into four areas: Resource and Waste Management, Sustainable Development Goals, Green Public Procurement, and Circular Economy.

Key words: Construction sector, Linear economy, Circular economy, State of the art

1. INTRODUCTION

Circular Economy is transition to an economy where resource consumption is in balance with the Earth's capacity to naturally regenerate those resources. The future of our economy, and especially the built environment, must recognize the fact that the model of endless exploitation does not work within the limits of our limited resources. While rapid reductions in carbon emissions and resource utilization must take priority over undirected economic growth, the circular economy can offer the opportunity to grow within our carbon budgets and planetary boundaries. Circular Economy (CE) is defined in contradistinction to the traditional linear economy. CE aims to tackle global challenges such as climate change, biodiversity loss, waste, and pollution by emphasizing the design-based implementation of the three base principles of the model: designing out waste and pollution, keeping products and materials in use, and regenerating natural systems."

Achieving a circular economy requires a fundamental system-level change in our economy. All levels of government, industry and civil society will have to come together behind the common goal of moving from our current extractive and wasteful linear economy to a regenerative, circular one. We are at a turning point. We can continue to try to adapt business as usual and make minor improvements to a failing system, or we can make fundamental changes at the system level and create a resilient, collaborative and forward-looking construction sector that is fit for the future. Our current linear economy and focus on economic growth maintain levels of carbon emissions and resource use that exceed our planetary boundaries.

So far, our efforts to separate the economy from these influences have largely failed, compared to the impact needed. The circular economy is an important piece of the puzzle for solving the challenges we face. Our current system is contributing to climate and biodiversity crises. To have any chance of solving these interconnected crises, we must shift to a new way of thinking, working and delivering; the circular economy must be part of the equation, to minimize the use of virgin resources in the built environment and maximize reuse at higher value.

2. THREE HORIZONS MODEL

The Three Horizons Model-THM (Figure 1) is a way of structuring our thinking about the transition towards an emerging future, giving us a simple tool to handle the complexity of multiple facets of change happening at the same time, and over time. It acts as a roadmap to resolve tensions between incremental change and radical transformation and shows how to move from a linear to a circular economy.

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Horizon 1: The current dominant system, or business-as-usual. Thinking within this horizon means managing existing realities for the system to remain successful. The Three Horizons Model assumes that this system is no longer fit for purpose under emerging conditions and will need to adapt and/or decline.

Horizon 2: The innovations that help us transition from our current system (Horizon 1) towards the emerging future (Horizon 3), by showing us that a new system is possible. Note that these innovations might not always be supporting the emerging future (H2+) but can manifest the current system in new ways (H2-). Careful evaluation of which Horizon they support is paramount.

Horizon 3: The emerging future of a radically different world and vision to aspire to that should become the new business-as-usual over time.

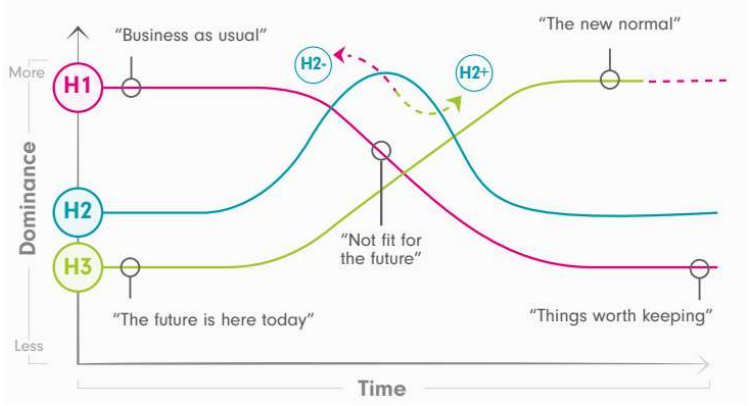


Figure 1 - The Three Horizons model as roadmap to Circular Economy

In a complex world, each of these horizons is needed to create meaningful change by bringing these different perspectives together in a constructive way to face the challenges ahead. The built environment industry's current "business-as-usual" approach is an extractive and is presented by "use and dispose" principals (Horizon 1- linear economy). The circular built environment is incorporated in Horizon 3.

To achieve this emerging future and vision of a regenerative, circular economy, a set of strategic objectives provides a tangible trajectory in environmental, social and economic terms.

Environmental:

- Planetary boundaries are not exceeded,
- The true value of raw non-regenerative materials is reflected in their price (balance tips in favor of secondary materials),
- Zero carbon trajectory.

Social:

- Mindset shift in high-income nations – consumption behavior and high-consumption lifestyles,
- Less demand for 'new' things,
- Low-resource lifestyles,
- Established routes for sharing resources and information,
- Fairer distribution of resources we use,
- Holistically take on our role as stewards of the built environment.

Economic:

- Reliant on regenerative, renewable, and inclusive resource flows,
- Urban development supports localized loops (e.g. knowledge, space, and tools needed to maintain, reuse, upcycle and recycle materials locally and regionally),
- Creation of new sustainable market opportunities such as secondary materials market as well as the market for eco-designed products,
- Focus on a thriving economy beyond GDP growth.

3. CIRCULAR ECONOMY IN BUILD ENVIRONMENT-STATE OF THE ART

The built environment plays a crucial role in economic progress and social welfare. Nonetheless, the construction industry imposes dreadful environmental impacts and is responsible for almost 33% of greenhouse gas emissions, 40% of waste generation, and 40% of materials consumption [1]. In response to these figures, the European Commission launched the first Circular Economy Action Plan (ECEAP) in 2015, which holds particular promise for achieving multiple Sustainable Development Goals (SDGs), including SDGs 6 on energy, 8 on economic growth, 11 on sustainable cities, 12 on sustainable consumption and production, and 13 on climate change. A new Circular Economy Action Plan (CEAP) was adopted in 2020 with more concrete measures on reducing the pressure on natural resources and creating sustainable development. Circular Economy (CE) action plans have put a major focus on the construction and real estate sector and building activities by developing strategies and policies to promote more efficient utilization of natural resources like primary raw materials (ore, minerals, biomass, fossil energy carriers) and waste hierarchy of reduce-reuse-recycle. Above all, recent endeavours for delivering more concrete measures also include the development of new standardisation activities like CEN/TC 350/SC 1 and ISO 59004.

The application of CE principles in building design (adaptability, durability and waste reduction and high quality management according to European Commission [2] and use is mainly focused on new buildings where circularity can be embedded and facilitated since the early design stage and consequently throughout the whole life cycle of a building and its components and materials. Conversely, circularity in the context of existing buildings is not so far defined. Moreover, the multitude of definitions of a circular economy, and more specifically circularity in the built environment, does not contribute to a coherent systematic approach. The focus in this regard is currently limited to viewing those as potential material banks where components and materials can be recovered, reused or recycled for new constructions while optimizing their use is rarely discussed. Still, recovered materials from existing building face a critical barrier from aspect of their technical compatibility and quality appraisal which put their direct reuse in question, the reason why they end up down-cycled engaging extra resources and energy flows. Besides, the majority of research on Circular Building (CB) has mainly addressed techniques for measuring and assessing lifecycle outcomes of buildings and their materials or innovative materials for circularity, as well as on recycling construction and demolition waste (CDW) [3]. On the other hand, less has been said regarding the design aspect of circularity integration in buildings (e.g. design for disassembly (DfD), design for adaptability (DfA), etc.) and the role of building professionals and supply chain elements in embodying the CE principles into the building sector.

In other words, existing practices and concerns give a major focus to the CE principle of "closing the loop" which assumes intensified reuse and upcycling of materials and components (Figure 2).

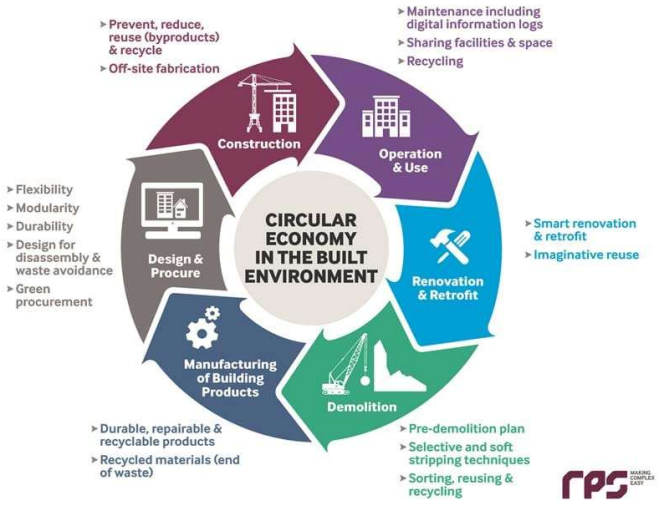


Figure 2 – Circular Economy in the build environment

Meanwhile, CE principle of "Slowing the loop" that suggests increasing building and product longetivity by preserving their value, quality, and efficiency to the highest possible extent has received less attention so far. This can be justified by the remaining influence of the prevailing construction and design culture during the last decades of viewing buildings as temporal products of limited life service and predefined destiny – Demolition. Another key principle of CE that is rarely addressed by existing strategies frameworks is "Narrowing the loop" that relies on using fewer resources per product. This principle is inspired from nature's processes that mainly use a limited chemical palette often consisting of six elements: carbon, hydrogen, oxygen, nitrogen, phosphorus and sulphur, while industrial manufacturers follow a different approach seeking out rare and toxic elements to reach the desired functional properties. Narrowing the loop delivers conditions for recycling by allowing efficient and facilitated material separation and recovery.

Moreover, several tools have been developed to support the decision making of designing buildings for circularity as well as accessing some aspects of their circularity. However, many of these tools serve the same purpose with slight differences in terms of goal and scope. The majority of the frameworks of these tools were developed to focus on specific aspects of circularity without considering other important aspects such as supporting products and materials choice by only substantiating material-related indicators based on their environmental impacts (e.g. aspects of health, non-toxic composition) and reuse and recycling potential such as Materials Passports (MP), Circular Materials Platforms, Material Circularity Index (MCI) (EMF, 2015) and material flow analysis (MFA) tools.

However, these tools failed to address a comprehensive circularity conception and led to a loss of criticality when used individually since they did not appraise all the other important design aspects e.g. building composition and connectivity between elements. This is because circularity values come up when specified intrinsic properties (material and product characteristics) cross with relational properties (building design and use characteristics). For example, a building can be made of 100% of circular materials and products but still, those being unreachable for replacement or maintenance make the building system non-circular.

Multiple sustainability rating tools were used to assess circularity considering it as an added value to sustainability. LCA-based tools such as SimaPro, ReCiPe, Open LCA are widely used for sustainability assessment of buildings. However, the use of LCA tools in the context of circularity assessment assumes the end-of-life options resulting in more comprehensive assessments. Yet, these tools only addressed the environmental results without other aspects.

Similarly, LCC-based tools are used to address the economic aspect of circularity in buildings and investigate the feasibility of circular solutions and conduct financial impact analysis of circular business models. Still, LCA and LCC methods are considered time-consuming and complex to base design choices on [4]. They also rely on many inaccessible data. S-LCA or Social Life Cycle Assessment is a relatively recent type of LCA which has been investigated as an endeavour to complement the triple bottomline of sustaibility (environmental, economic and social aspects) towards a common framework of sustainability. However, S-LCA has been rarely investigated to calculate the social and socio-economic impacts of products circularity.

Some frameworks provide strategies to implement circularity through practical guidelines and successful practices supporting the concept of learning by doing. A prominent example is the circular design guide put forward by the Ellen McArthur foundation. The guide consists of a series of methods based towards actions and aiming at building up a circular mind-set and reframing questions to get started with the circularity challenge. The value of this guide lies in experiencing, exercising and training through multiple methods to transform designers into being intuitive about circularity. This is because design practice is largely based on experience and less on tools [4].

More recent tools have been developed in the spectrum of the CE such as Circular Building Assessment Prototype (CBA) developed by the European Union (EU) project of BAMB, Circularity Calculator (IDEAL&CO, 2021) and Building Circularity Index. These tools introduce rating systems to calculate a circularity score aiming at objectifying the circularity performance of a building or a building element. However, they are criticised for their lack of participatory and practice-oriented approach which is fundamental to meet the need to appraise the impact of rating tools on the design process.

Moreover, there is no clear between the outcome of these tools and the actual environmental impact of the investigated solution. The Level(s) framework developed by the European Commission introduced a more inclusive approach towards circularity in this regard. The consideration of circularity in Level(s) is mainly featured in macro-objective 2 - resource efficiency and circular material lifecycles - which consists of lifecycle tools namely 2.1 Bill of quantities, materials with their functional performance and service life planning. 2.2. Design for adaptability and design for disassembly.

These life cycle tools are not indicators by themselves. Still, they are important to determine several other indicators such as indicator 1.2 Life cycle global warming potential and 2.3 Construction and demolition waste. Each scenario has different impacts in terms of input and output flows along a building's lifecycle. The evaluation of lifecycle scenario tools enables comparisons in terms of resource efficiency allowing to define advantages and barriers for each and identify potential trade-offs. However, the realisation of trade-offs between different scenarios which make more sense in real life is not clearly identified. Although Level(s) provides guidelines for doing simplified, detailed or optimization studies, it delivers a less concrete framework for circular design strategies such as design for adaptability which is limited to simple checklists. Moreover, the market uptake of Level(s) is still limited and a stong position still has to be found in the playing field of international frameworks such as LEED and BREEAM and national frameworks.

The multiple aspects addressed by the different types of tools and the similarities among the majority of objectives point out the need of creating complementarity among these tools rather than establishing new ones from scratch. Still, the majority of existing tools are developed so far to support design decisions and perform comparative analysis but not to create solutions and strategies to implement circularity in buildings bearing in mind that the role of design is not merely at the initial planning process but rather persisting along the life cycle of products and services and remains relevant at any point.

To ensure a full benefit of circular strategies implementation, the supply chain management and monitoring should be key. The issues of process circularity have been posed by multiple scholars and practitioners taking into consideration the complexity of the process. This includes ensuring an efficient information flow among partners and stakeholders [4]. In this regard, the need for matchmaking tools to connect verified stakeholders is surfaced. Also, a smooth process calls for legal support and guiding policies that ensure compliance with circular strategies.

The emergence of Building Information Modelling (BIM) has created new opportunities to improve process efficiency and productivity. Among the several applications of BIM for the construction industry, authors have recognized its influence on building sustainability, mainly on decision support, material information storage, managing the building end of life scenarios and waste minimization [5]. Despite the great opportunity to link BIM with circular economy principles, it is still a growing topic with few related investigations. BIM has been widely integrated into some circular-related fields, as automated LCA, LCC or sustainability assessment [6]. The role of BIM for circular thinking concerns the capability to accumulate lifecycle multi-disciplinary information about a building, together with the possibility of process automation.

The application of circularity strategies in the buildings sector is still hindered by the lack of innovative business models that ensure implementation without comprising economic viability and value capture by market actors. The most common archetypes discussed in the literature are either oriented towards Product-Service Systems (PSSs) or recycling practices [7]. However, they mainly target companies belonging to specific industries (particularly electric and electronic products). Moreover, most of the existing knowledge is based on theoretical or/and analytical studies that often do not involve companies or common stakeholders but rather deliver theoretical concepts merely serving as suggestions to companies and policy makers. Besides, best practices are oriented towards large investments and therefore too complex to be adaptable by Small and Medium Enterprises (SMEs). With very few examples implementing CE into practice, the practical transformation from a linear business model into a circular one is still the main research gap in terms of consolidated circular practices steering companies towards improving the circularity of their products or services and incentivizing policies to subsidize those.

4. CONCLUSION

Facing the increasing concerns about the negative environmental impacts of buildings, governments and general society worldwide have been seeking more efficient and sustainable constructions. Hence, the Circular Economy (CE) emerged as a new paradigm of innovative practice with potential application to the construction industry besides other economic sectors. Following the European Circular Economy Action Plan (ECEAP), multiple efforts have been made to apply circular thinking to construction practices and include resource circularity into sustainability frameworks, such as Level(s). However, despite the endeavors, there is still a lack of a standard tool that fully implements the circularity potential, classifies buildings accordingly, and assesses the realization level of the ECEAP.

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