IMPLEMENTATION OF CIRCULAR ECONOMY IN THE BUILT ENVIRONMENT

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Summary:

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. The European Cooperation in Science and Technology (COST) recognized the importance of this topic and supported the Action CircularB (Implementation of Circular Economy in the Built Environment-CA21103). CircularB covers an integrated, interdisciplinary and transdisciplinary approach of CE implementation and assessment in the construction and real estate sector, namely buildings, building components, technical systems and construction products.

Key words: circular economy, built environment, circular value chain, sustainable development goals

IMPLEMENTACIJA CIRKULARNE EKONOMIJE U IZGRAĐENOM OKRUŽENJU

Rezime:

Suočavajući se sa sve većom zabrinutošću oko negativnih uticaja zgrada na životnu sredinu, vlade i opšte društvo širom sveta traže efikasnije i održivije gradnje. Stoga se cirkularna ekonomija (CE) pojavila kao nova paradigma inovativne prakse sa potencijalnom primenom u svim privrednim sektorima, a posebno u građevinskoj industriji. U skladu sa Evropskim Akcionim Planom o Cirkularnoj Ekonomiji (ECEAP), uloženi su višestruki napori da se kružno razmišljanje primeni u građevinskoj praksi i uključi cirkularnost resursa u okvire održivosti. Evropska asocijacija za saradnju u nauci i tehnologiji (COST) prepoznala je važnost ove teme i podržala akciju CircularB (Implementacija cirkularne ekonomije u izgrađenom okruženju-CA21103). CircularB pokriva integrisani, interdisciplinarni i transdisciplinarni pristup implementaciji i proceni CE u sektoru građevinarstva i nekretnina, odnosno zgrada, građevinskih komponenti, tehničkih sistema i građevinskih proizvoda.

Ključne reči: cirkularna ekonomija, izgrađeno okruženje, kružni lanac vrednosti, ciljevi održivog razvoja

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1. INTRODUCTION

World's population is constantly growing, facing new needs for new constructions. That is putting enormous stress on our environment and resources. The construction industry is responsible for circa 33% of greenhouse gas emissions, 40% of waste generation, and 40% of materials consumption [1,2]. 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 European Circular Economy Action Plan (ECEAP) [3] was adopted in 2020 with more concrete measures to reduce the pressure on natural resources and create sustainable development. The goal of the ECEAP is to enable an easier transition from the Traditional Linear Economy "take, make, dispose", to a Circular Economy that implies "take the raw materials only once, produce, use and recycle without producing waste", Figure 1.

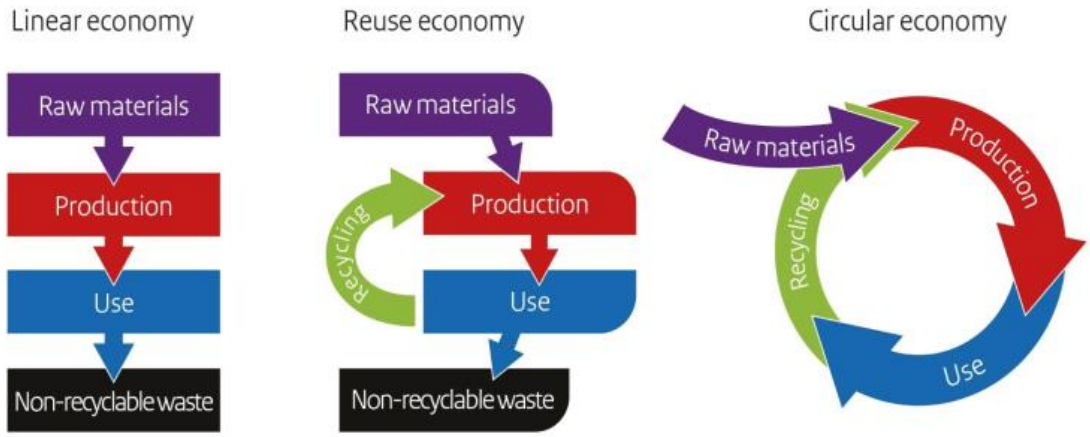


Fig. 1 Transition from Linear to Circular Economy

With very few examples of implementing CE into practice, the practical transformation of 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 subsidise those.

The application of CE principles in real estate, building design and use (adaptability, durability, waste reduction and high-quality management according to the European Commission [3]) 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 [4].

The multitude of definitions of CE, and more specifically circularity in the built environment, does not contribute to a coherent, systematic approach. CE needs to be viewed as a business strategy, not only waste management or a design strategy. Optimising buildings' use should also be spotlighted instead of only viewing those as potential material banks where components and materials can be recovered, reused or recycled for new constructions [4,5]. Still, recovered materials from existing buildings face a critical barrier in their technical compatibility and quality appraisal, which put their direct reuse in question, leading to down-cycling processes and engaging extra resources and energy flows.

On the other hand, less has been said about the design aspect of circularity integration in buildings (e.g. design for disassembly (DfD), design for adaptability (DfA), design for change (DfC) etc.) and the role of building professionals and supply chain elements in

embodying the CE principles into the building sector [6]. In other words, existing practices and concerns focus on the CE principle of "closing the loop" which assumes intensified reuse and upcycling of materials and components.
Most existing knowledge in Circular Economy 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 policymakers. Besides, best practices are oriented toward large investments and therefore too complex to be adopted by Small and Medium Enterprises (SMEs). From that aspect, the main aim of the COST Action CircularB is: to define the methodology, to develop a common circularity framework for inclusive application and assessment in new and existing buildings, to support decision-making for all value chain stakeholders, to develop Key Performance Indicators (KPIs) based on current best practices of CE construction and appraise the implementation level of the ECEAP.
The CircularB Action aims to develop a common international framework of a circularity rating tool with Key Performance Indicators (KPIs) based on current best practices of CE construction, state-of-the-art and ECEAP. The tool's framework will allow local application and adaptation by different COST countries and regions. By developing a benchmark database – based on each country/region conditions, culture and traditions – the direct use of the tool is enabled, supporting both designers in developing more sustainable buildings and national/local governments in assessing and promoting their CE targets. Furthermore, construction, assembly, adaptability, deconstruction and business model guidelines will be identified for new and existing buildings to enhance CE in buildings and promote stakeholder knowledge. The rating tool will also be integrated into the Open BIM workflow for better-informed design decisions, automated assessment, efficient value chain management, and circular feedback using central BIM models.

2. CIRCULAR ECONOMY PRINCIPALS AND TOOLS

The CE principle of "slowing the loop" that suggests increasing the life span of buildings and products by preserving their value, quality, and efficiency to the highest possible extent has received less attention so far. This can be justified by the 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 frameworks is "narrowing the loop" which 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.
Considering the CE principals, several tools have been developed to support the decision-making of designing or/and assessing buildings for circularity. However, many of these tools serve the same purpose with slight differences in goal and scope. The majority were developed to focus on specific aspects of circularity without considering other 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 potentials, such as Materials Passports (MP), Circular Materials Platforms, Material Circularity Index and material flow analysis (MFA) tools. However, these tools fail to address a comprehensive circularity conception and lead to a loss of criticality when used individually since they do not appraise all the other important design aspects, e.g. building composition and connectivity between elements, durability and service life of building components. This is because circularity values come up when specified intrinsic properties (material and product characteristics)

cross with relational properties (building design and use characteristics). A building, e.g., can be made of 100% circular materials and products, but when those are unreachable for replacement or maintenance, the building system becomes non-circular.
Multiple sustainability rating tools were used to assess circularity, considering the added value to sustainability. LCA-based tools such as SimaPro, ReCiPe and Open LCA are widely used for the sustainability assessment of buildings. Using LCA tools in the context of circularity assessment considering end-of-life options results in more comprehensive assessments. Yet, these tools only addressed the environmental consequences without other aspects. Similarly, LCC-based tools are used to address the economic aspect of circularity in buildings, 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 [7]. They also rely in parts on inaccessible data for S-LCA or Social Life Cycle Assessment.
Assessment is a relatively recent type of LCA, which has been investigated to complement the triple bottom line of sustainability towards a common sustainability framework. However, S-LCA has rarely been investigated to calculate the social and socio-economic impacts of product circularity.
The multiple aspects addressed by the different types of tools and the similarities among the majority of objectives point out the need to create complementarity rather than establish new ones from scratch. Still, the majority of existing tools so far are developed to support design decisions and perform comparative analyses 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 fully benefit from circular strategies implementation, supply chain management and monitoring should be key.
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 recognised its influence on building sustainability, mainly on decision support, material information storage, managing the building end-of-life scenarios and waste minimisation [8,9]. Despite the great opportunity to link BIM with CE principles, it is still a growing topic with few related investigations. BIM has been widely integrated into some circularityrelated fields, as automated LCA, LCC or sustainability assessment [10]. The role of BIM for circular thinking concerns the capability to accumulate multidisciplinary lifecycle information about a building, together with the possibility of process automation [8].

3. MAIN GOALS OF COST ACTION CIRCULARB

Existing frameworks to implement and assess circularity suffer from a mismatch between supply and need. There is an oversupply of theoretical guidelines and tools that illustrate the basic principles of the CE in buildings. Yet, most of the tools serve the same purpose while there is a need for practical evidence about the utility of these tools and their impact on the design process to highlight best practices.
Considering all previously announced, the CircularB COST Action proposes a holistic framework to create, assess and benchmark circularity in buildings taking into consideration all the lifecycle stages from planning to end-of-life options with all the associated input-output flows of materials, as well as the engagement of a diverse group of stakeholders with interlocking specialities.
Within this context, this COST Action CircularB will attempt to answer the following Research Questions:

- How can circularity be defined as a complex character in buildings?
- How can the principles of circularity be integrated into all stages of a building lifecycle, from its conception to the end of its life considering all of its

components, products and systems already during the design of new buildings and larger renovation projects?

- What are the drivers and the barriers of integration of circularity strategies in buildings for COST countries and beyond at the different levels? Are there any best practices established?
- Since existing circularity indicators and assessment frameworks are not satisfactory for delivering a holistic approach to circularity implementation in buildings, what are the other complementary aspects still missing considering all technical, technological, economic, environmental, legal and social factors? How can they be brought together into one inclusive model? Is there a chance to express the circularity as a complex character in one indicator or index or is there a need for a set of indicators?
- Is it possible to quantify the circularity potential of a building, taking into account among others the emerging potentials for disassembly, adaptability, deconstruction, reuse and durability? Is this an application case for module D1 in LCA?
- Does circularity contribute to increased sustainability? What is the relation between sustainability as an overall target and circularity as a partial strategy to support a more sustainable development?
- How to assess the advantages and sustainability of circularity measures? Are there any trade-offs?
- How can the stakeholders within the quadruple helix contribute to achieving building circularity?
- What is their respective role in achieving a circular value chain? And what incentives are needed to make their roles more efficient?
- What strategies and tools should be developed to enable the transformation along the full value chain?
- Are there additional requirements in the design and development for new (next generation) products?
- How will circularity contribute to the availability of secondary materials?
- What kind of new business models are there – from leasing systems to taking back options?

3.1. ORGANIZATIONAL SETTING OF CIRCULARB

The CircularB COST Action aims at delivering a holistic approach to circular buildings including all technical, technological, social, legal, economic and environmental aspects. In order to cover all of the proposed aspects, the research is divided into 4 Working Groups (WGs). The first three interconnected WGs (WG1, WG2, WG3) are focused on the scientific development of the Action, while the fourth (WG4) carries out the monitorisation and coordination of all Action activities and tasks, ensuring active participation of all involved partners, besides communication and dissemination of Action's outcomes.

3.1.1. WG1 - Circularity strategies and best practices

This WG works on developing innovative methods to apply circularity strategies in design and construction activities and identify best practices. Furthermore, this WG aims to create integrated design and engineering solutions for dynamic and circular buildings which by design provide an answer to circularity challenges of resource efficiency and waste prevention through embedding concepts of DfA, DfD, DfC and reversibility among others for new and existing buildings.

3.1.2. WG2 - Circular value chain and stakeholder engagement

This WG works on analysing the full value chain of circular buildings and circular materials and components. The main aim of this WG is to establish a stakeholder platform where an interdisciplinary dialogue can be held among key players including academia, industry, suppliers, governmental bodies and local authorities, construction professionals and the general public. Participatory dialogue among stakeholders is a key to ensuring a closed-loop value chain management and creating new collaboration patterns and business model ideas addressing individual requirements and shared interests.

3.1.3. WG3 - Circular KPIs framework

The WG3 aims to identify and develop relevant, reliable and replicable circular KPIs that can measure the circularity index of new and existing residential buildings. The KPIs will be cross-country (COST countries) applied and based on current and best CE practices, CE Action Plans, governmental reports and national/international practices. Additionally, the KPIs will be grouped under Governmental/Institutional, Environmental, Social, Economic, and Technical dimensions to propose developing an international rating framework. Such a framework will act as a complementary and detailed circular assessment of recognised sustainability schemes to support decision-making.

3.1.4. WG4 - Dissemination and results communication

This WG will ensure the maximisation of the Action's impact via various dissemination, communication, and outreach activities as well as identify opportunities to enlarge the Action's network and communicate with other networks and stakeholders.
The WGs links and interactions are presented on Figure 2.

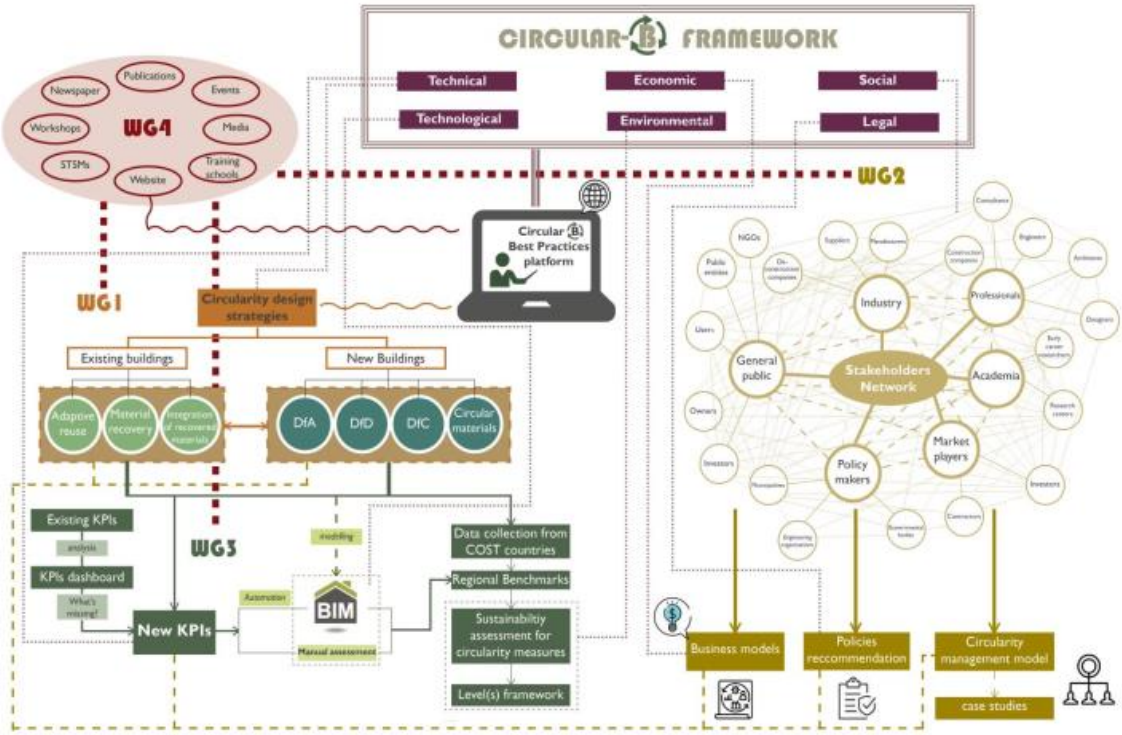


Fig. 2 WGs links and interactions

4. CONCLUSIONS

The CircularB Action is a COST (European Cooperation in Science and Technology) Action dedicated to developing an international circularity framework for the inclusive

operation and assessment of new and existing buildings. It supports decision-making for all stakeholders in the value chain and evaluates the implementation level of the European Circular Economy Action Plan (ECEAP). This international framework includes a circularity rating tool with Key Performance Indicators (KPIs) that can be applied and adapted by various countries and regions. The tool can be directly applied to each country/region's specific conditions, culture, and traditions by using a benchmark database that is tailored to its unique conditions, culture, and traditions. In addition to assisting designers in creating sustainable buildings, it assists national/local governments in the evaluation and promotion of Circular Economy targets.

The topics covered Circular Economy (CE) best practices, design strategies and tools, circular materials and building products, adaptive reuse of existing buildings, recovery and reuse of salvaged building materials and products from existing structures, case studies, barriers against CE implementation, efficient waste and circular resource management, circular buildings lifecycle management and decision making, stakeholders relationships and new potential actors in circular management models, CE supporting policies and legal barriers, circular business models, criteria and KPIs for circular building and materials, CE criteria in sustainability frameworks for buildings, digitalization and BIM, and standardization of CE definitions in buildings. In sum, these topics provide a comprehensive overview of the implementation of CE in the built environment.

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