Sustainable building: Circular economy as a key factor for cost reduction

Martin Marek[1*], and *Zdenek* Krejza[1]

[1]FCE BUT Faculty of Civil, Veveří 331/95 602 00 Brno, Czech Republic

Abstract. This article explores the role of the circular economy in achieving sustainability in the construction industry, with a focus on cost reduction. Sustainable building practices are vital for addressing environmental concerns, and the circular economy offers transformative solutions. By emphasizing reuse, recycling, and responsible resource management, the circular economy reshapes traditional construction approaches. The paper examines how adopting circular economy principles can significantly reduce costs throughout a building's life cycle. It discusses case studies and successful implementations, showcasing innovative strategies to minimize waste and optimize resource use. Topics include integrating circular economy practices in design and construction, the economic benefits of material reuse and recycling, and the long-term financial advantages of sustainable building. The article highlights the importance of stakeholder collaboration, policy frameworks, and technological innovations in driving circular economy adoption. By demonstrating the economic benefits of sustainable building through the circular economy, this article aims to promote environmentally conscious construction practices and inspire stakeholders to embrace cost-effective and sustainable solutions for a greener future.

1 Introduction

In the quest for sustainable development, construction stands as a key player. As an industry responsible for significant resource consumption and waste generation, it faces increasing pressure to adopt more environmentally friendly practices. Among these is the circular economy, which offers not only environmental benefits but also significant cost reductions. [1].

The concept of the circular economy revolves around the principles of reducing, reusing, and recycling resources to minimize waste and optimize resource utilization throughout the lifecycle of buildings and infrastructure projects. By shifting from the traditional linear model of "extract, produce, dispose" to a circular approach where materials and products are used for as long as possible, the construction industry can significantly reduce its environmental impact while increasing its economic efficiency [2].

This article explores the transformative potential of the circular economy within sustainable construction, examining how the adoption of circularity can lead to substantial

* Corresponding author: martin.marek3@vutbr.cz

cost savings at various stages of construction projects. From material acquisition and construction processes to building operation and end-of-life considerations, we explore the opportunities and challenges associated with integrating circular principles into the construction framework.

Join us on a journey through the principles, practices, and applications of circular economic strategies in sustainable construction, where we uncover the vast potential for cost reduction and environmental protection that lies at the intersection of circularity and construction.

2 The fundamental principles of the circular economy

When utilizing the circular economy, it is necessary to consider the fundamental principles which are:

1. **Waste reduction and recycling**
2. **Reuse and renewable resources**
3. **Extending the lifespan of products**
4. **Design for disassembly and reusability**

The concept of the circular economy stands in sharp contrast to the traditional linear model of resource management, which focuses on continuous growth, production, consumption, and ultimately disposal. Unlike this, the circular economy emphasizes minimizing waste and losses, and instead focuses on extending the lifespan of products and materials and their repeated use. This shifts away from one-time consumption to a system that supports renewable resources, recycling, and reuse, bringing long-term economic and environmental benefits and reducing the negative impacts on the environment associated with the linear resource management model.

3 Applications of the circular economy in construction

The application of circular economy principles in construction aims to maximize sustainability and resource efficiency. The primary objective is to minimize waste while promoting the recycling and reuse of materials and products throughout the entire lifecycle of buildings. This approach seeks to transition from the traditional linear model of "produce, use, dispose" to a more sustainable model centered on "produce, use, recycle." [3].

Key aspects of implementing circular economy practices in construction include:

1. Design for disassembly and reuse: Buildings and structural elements are designed to facilitate easy disassembly, with materials intended for reuse or recycling at the end of their lifecycle.
2. Use of recycled and renewable materials: Prioritizing materials sourced from recycled resources or renewable sources, such as recycled metals, sustainably sourced wood, or bioplastics.
3. Waste minimization: Employing efficient planning and production processes to reduce waste generated during construction and demolition.
4. Extending the lifespan of materials and structures: Utilizing techniques and materials that enhance the durability of buildings, thereby reducing the need for new construction materials.

5. Modular and adaptable designs: Implementing structures that allow for easy modifications and alterations in the future, thus prolonging their lifespan and decreasing the demand for new resources.
6. Energy efficiency and renewable resources: Designing buildings with high energy efficiency and integrating renewable energy sources, such as solar panels or heat pumps, to mitigate carbon emissions.

Successfully implementing these principles necessitates collaboration among architects, engineers, builders, material manufacturers, and government entities. Transitioning to a circular economy in construction not only yields environmental benefits but also offers potential economic savings and fosters innovation within the industry.

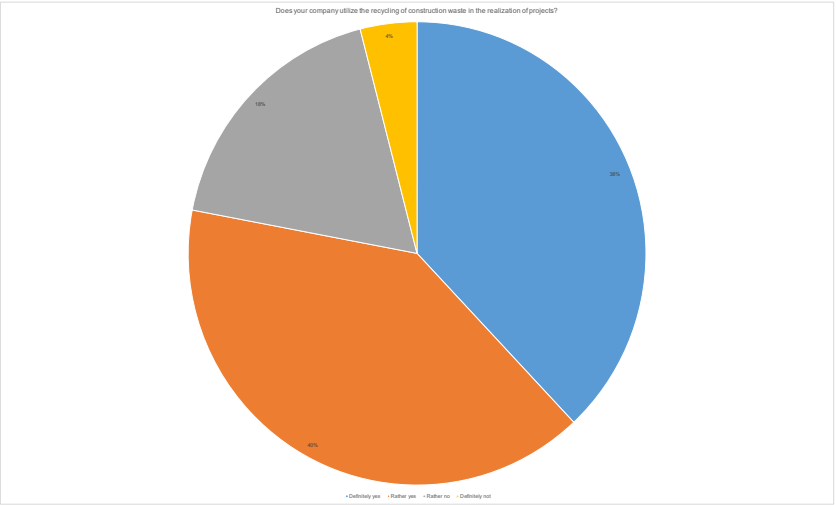

Figure 1 Does your company utilize the recycling of construction waste in the realization of projects? [4]

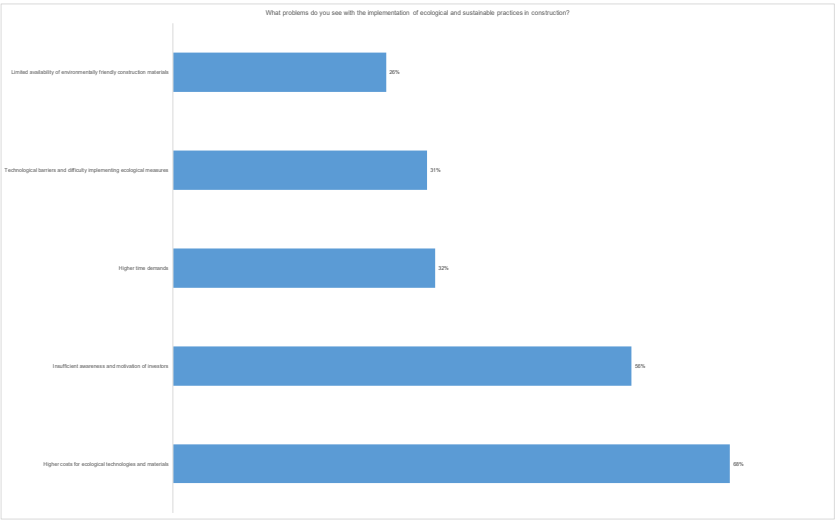

Figure 2 What problems do you see with the implementation of ecological and sustainable practices in construction?[4]

The survey within the construction industry is conducted by the company CEEC, which collects various data on ecology in construction.

The results of the survey among the largest construction companies in the Czech Republic are shown in Figure 1. The survey is regularly conducted by the company CEEC. Another question in the survey concerns the reasons why companies do not use ecological solutions in construction activities. The results are shown in Figure 2 [4].

By comparing the survey results from previous periods, it is possible to see an improving trend in the implementation of ecological practices in construction, thereby mitigating the impact of the construction industry on the environment. This is significant since the construction industry is one of the largest producers of waste in the entire industry in the Czech Republic.

4 Benefits of the circular economy for cost reduction

The circular economy brings significant benefits not only to the environment but also to cost reduction in construction. Integrating circular economy principles into construction projects and practices can lead to savings in materials, energy, and ultimately money.

According to the 2020 Global Status Report for Buildings and Construction, 23% of construction companies have measurable goals to reduce the environmental impact of their activities, while the remaining 77% do not have such goals established [5].

Here are some of the key ways in which the circular economy can help reduce costs in construction:

4.1 Reducing material costs

Using recycled or renewable materials can often be less expensive than purchasing new, primary materials. Recycling construction waste and its reuse in construction projects can reduce the demand for new raw materials and related costs.

4.2 Material use efficiency

More accurate planning and the use of modern manufacturing techniques can reduce the amount of waste produced during construction. This means that less material is lost, and waste disposal costs are lower.

4.3 Extending the lifespan of buildings

Designing buildings and infrastructure with disassembly and reuse of materials in mind can significantly extend the lifespan of materials and the buildings themselves. This means that investments in construction projects can have a longer payback period, and less frequently is it necessary to spend resources on repairs or new construction.

4.4 Optimizing operational costs

Buildings designed for energy efficiency and the use of renewable energy sources can significantly reduce energy costs. This can include everything from passive solar design to the installation of solar panels and rainwater harvesting systems.

4.5 Creating new business opportunities

The market for recycled materials and services associated with the circular economy is growing. Companies focusing on innovation and the use of circular principles can discover new business models and opportunities for growth, reducing overall costs.

4.6 Reducing risk and price volatility

Dependence on recycled and locally available materials can reduce the risk of price shocks associated with global raw material markets and supplies. This allows construction companies to better plan costs and budgets.

Implementing these principles requires an initial investment in design, technologies, and processes, but long-term savings and environmental benefits bring significant financial and ecological advantages.

According to CEEC Research analysis, construction companies are capable of recycling a large amount of construction waste and reusing it. Sixty-six percent of the surveyed construction companies in Czech Republic. manage to recycle and reuse about 20% of the material. About 21% of companies can reuse between 21–40% of the waste. Thirteen percent of companies even return more than 41% of the total volume of waste back into the construction process. However, only a quarter of companies have measurable guidelines for reducing environmental waste. The rest do not focus on this issue in detail. Only 26% of companies are willing to invest more in recycling, research, or the development of environmentally friendly technologies and materials [4].

5 Obstacles and challenges

Transitioning to the circular economy in construction brings numerous advantages but also faces a significant number of obstacles and challenges. These challenges are often multifaceted and necessitate innovative approaches and shifts in mindset among all stakeholders, including material manufacturers, builders, architects, regulators, and building users. Embracing a circular economy model requires a comprehensive understanding of various interrelated factors and a concerted effort to implement sustainable practices across the construction industry.

The main obstacles and challenges include

5.1 Regulatory and legislative barriers:

Construction standards and regulations are frequently based on traditional, linear approaches to building and infrastructure development. These standards may not support, or may even prohibit, the use of recycled materials or the construction of buildings designed for easy disassembly and reuse. Overcoming this barrier involves advocating for regulatory changes that facilitate the use of sustainable materials and construction practices, which can be a lengthy and complex process requiring collaboration with policymakers and regulatory bodies [6,7].

5.2 Lack of awareness and understanding:

Many stakeholders in the construction industry, including developers, contractors, and even clients, may have limited awareness of the benefits associated with the circular economy. Additionally, they may lack sufficient knowledge on how to implement these principles in

their projects. This challenge highlights the need for extensive educational campaigns and training programs to disseminate information about the advantages of circular practices and provide practical guidance on their implementation [8,9].

5.3 Lifecycle assessment challenges:

Assessing the environmental impact of products and materials throughout their entire lifecycle—from production and use to disposal and recycling—is a complex and time-consuming process. However, this analysis is crucial for understanding the true benefits of recycling and reusing materials, as well as for making informed decisions about sustainable practices. Developing standardized methods and tools for lifecycle assessment can help streamline this process and provide clearer insights into the long-term benefits of circular economy principles [10].

5.4 Limited availability of recycled materials:

In some regions, it may be challenging to obtain recycled materials that meet the necessary quality standards and are available in sufficient quantities. This scarcity complicates their use in construction projects, as it may be difficult to source enough materials to meet project demands. Addressing this issue involves increasing the capacity for recycling and processing materials locally, as well as fostering markets for secondary materials to ensure a steady supply of high-quality recycled resources [11,12].

5.5 Initial costs and investments:

Transitioning to a circular economy model often requires significant initial investments in new technologies, materials, and worker training. These upfront costs can be a barrier for many organizations, especially smaller companies with limited financial resources. To mitigate this challenge, it is important to highlight the long-term economic benefits of circular practices, such as reduced material costs and improved efficiency, and to seek financial incentives or support from governments and industry bodies [13].

5.6 Market barriers:

Existing market structures tend to favor linear economic models, which focus on production, use, and disposal without considering the long-term environmental impacts or the potential for resource recovery. These structures may undervalue the long-term savings and environmental benefits that the circular economy offers. Overcoming market barriers involves promoting the value of sustainable practices, creating demand for circular products, and encouraging investment in circular business models [14,15].

5.7 Technological and innovation challenges:

Developing new materials and construction techniques that are fully compatible with circular economy principles requires intensive research and innovation. This process includes creating materials that can be easily recycled or repurposed, designing buildings for disassembly, and developing construction methods that minimize waste. Supporting research and development in these areas is essential for advancing the technologies needed to implement circular practices effectively [16].

Overcoming these obstacles and challenges will require coordinated efforts at all levels, from government and regulatory bodies to industry associations, academic institutions, and individual businesses and consumers [17].

Key actions include:
Supporting research and development: Investing in research to develop new materials, technologies, and methods that align with circular economy principles is critical. This support can come from government grants, industry partnerships, and academic collaborations.

Mproving legislation and standards: Advocating for changes in construction standards and regulations to support circular practices is necessary. This includes updating building codes, creating incentives for using recycled materials, and establishing guidelines for designing buildings for disassembly.

Raising awareness and education: Launching educational campaigns and training programs to inform stakeholders about the benefits of the circular economy and provide practical guidance on implementing these principles is vital. This effort should target all levels of the construction industry, from top executives to on-site workers.

Fostering innovation and technological progress: Encouraging innovation in construction techniques and materials is essential for integrating circular economy principles. This can be achieved through innovation hubs, industry competitions, and collaborative projects that bring together various stakeholders to develop and test new ideas.

Creating economic incentives: Developing financial incentives and support mechanisms, such as tax breaks, grants, and subsidies, can help offset the initial costs of transitioning to circular practices. These incentives can make it more attractive for companies to invest in sustainable technologies and methods.

By addressing these challenges through a comprehensive and collaborative approach, the construction industry can successfully integrate circular economy principles, leading to significant environmental, economic, and social benefits.

6 Current state in construction

Current standards and regulations focus on a wide range of sustainable and quality elements in the field of construction. They aim to contribute to the development of better and healthier living conditions. Utilizing these standards can lead to minimizing the negative impact of
construction activities on the surrounding environment and simultaneously increasing the well-being of the inhabitants of these buildings.

LEED (Leadership in Energy and Environmental Design), used by 13% of construction companies, is an internationally recognized system for assessing the ecological sustainability of buildings. This system, developed by the United States Green Building Council (USGBC), offers a methodology for planning, implementing, and managing "green" buildings with high energy efficiency and low environmental impact. Projects are evaluated based on meeting certain criteria, including energy savings, interior quality, and sustainable construction practices [18].

Twelve percent of surveyed builders prefer BREEAM (Building Research Establishment Environmental Assessment Method), a method and system for assessing the sustainability of buildings widely used primarily in the United Kingdom, but also in other countries. Developed by the Building Research Establishment (BRE), BREEAM provides

standards for evaluating various aspects of buildings, from energy efficiency to material use and health aspects [19].

The Passive House Standard (or "Passivhaus"), applied by 9% of respondents, is an approach and standard for extremely energy-efficient buildings. It emphasizes the importance of high levels of insulation, building airtightness, and heat recovery from ventilation, aiming to minimize the energy demand and ensure optimal living conditions for users.

Five percent of surveyed companies use the WELL Building Standard, which focuses on the health and well-being of people in building interiors. This standard sets criteria for air quality, water, nutrition, physical activity, mental health, and other factors affecting the health and well-being of building users. The WELL Standard is used to certify buildings that support the healthy and happy life of their inhabitants.

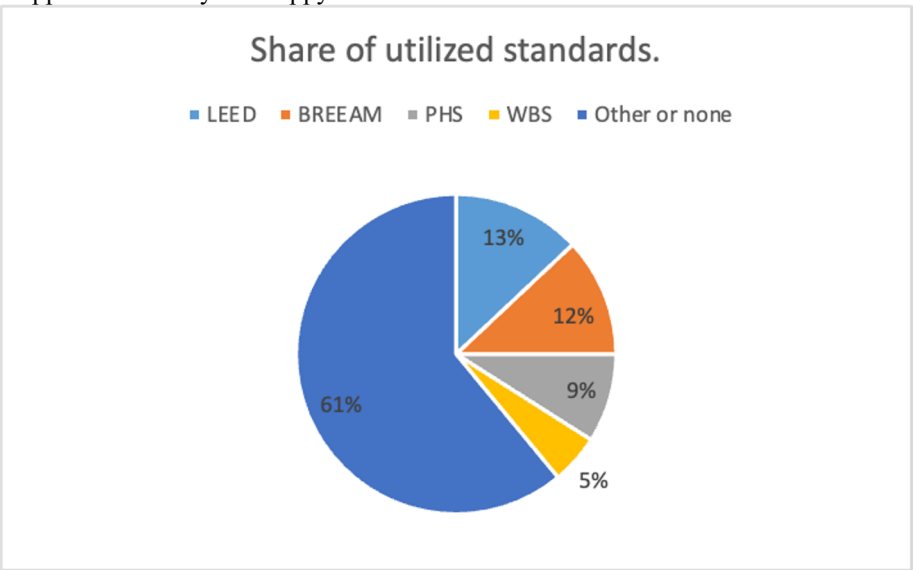

Figure 3 Share of utilized standards.

In Figure 3, the percentage share of utilized standards is visible. The graph shows that there is still no universal standard implemented worldwide; each country creates its own. Some companies create additional stricter standards to gain a competitive advantage over others. From the perspective of transparency and comparability, this situation is unsatisfactory, as it requires understanding all the standards being used when making comparisons

According to construction companies, the greatest obstacle to ecological measures is their costliness, making the willingness on the investor's side so crucial. At the same time, 26% of construction companies want to invest more in recycling or research and development of environmentally friendly technologies and materials in the future. For 32% of construction companies, using new technologies is time-consuming. Another 26% of businesses mention the problem with the availability of such materials.

Higher costs for acquiring cleaner materials or technologies are cited as a brake on their wider use by 68% of the surveyed construction companies, while 56% of companies encounter insufficient awareness among investors about environmental issues [4, 19-24].

7 Conclusion

Sustainable construction represents not only a response to the growing environmental challenges of today but also offers solutions for cost reduction and increased efficiency in the construction industry. In this context, the circular economy emerges as a key factor that can significantly contribute to transforming the construction sector towards more sustainable and economically advantageous practices.

Switching to a circular economy in construction involves decreasing material usage, maximizing resource efficiency, prolonging the lifespan of construction components, and reducing overall waste. These strategies not only diminish the environmental footprint of construction projects but also lead to substantial financial benefits through more efficient material use, lower operational costs, and decreased waste disposal expenses.

Nevertheless, to fully exploit the potential of the circular economy in construction, it is crucial to address existing barriers and challenges. This requires legislative and regulatory reforms, heightened awareness and expertise among builders and designers, the development of markets for recycled materials, and support for innovation and technological advancements.

In conclusion, the circular economy offers the construction industry a path to sustainability that is economically beneficial and environmentally responsible. Its successful implementation requires coordinated effort from all stakeholders and an approach focused on long-term sustainability and innovation. By adopting circular principles, the construction industry can play a key role in building a sustainable future for the next generations, while also achieving substantial savings and improving its competitiveness.

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