ECOLOGICAL AND LEGAL ASPECTS OF CONSTRUCTION WASTE MANAGEMENT: EU EXPERIENCE

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Annotation. The shift to a circular economy is a crucial part of the European Union's (EU) strategy for sustainable development, especially in the construction sector and its waste management practices. This research highlights the regulations and methods used to manage construction waste across the European Union. By examining EU directives, national case studies, and recent initiatives, the paper demonstrates both the progress made and the ongoing challenges in aligning construction and demolition waste management with the principles of a circular economy. Special focus is given to the EU's unified legal framework, economic incentives, technological advances, and behavioural barriers. The article emphasizes the need to address gaps in implementing and sharing standardized, sustainable waste management practices throughout the EU.

Key words: circular economy; construction and demolition waste; waste management policy; sustainable construction.

1. Introduction.

Currently, the transition to a circular economy from a linear production and consumption model is particularly relevant in the European construction sector, where construction and demolition waste accounts for approximately 37% of all waste generated and is anticipated to increase in the coming years [6]. This proportion has risen since 2012, when the construction industry produced 32.5% of all waste. Nevertheless, in most European countries, the recycling rate of construction waste exceeded 90% in 2018. This sector represents not only a significant economic pillar but also one of the most resource-intensive and polluting industries, generating between 1% and 90% of national waste streams across various Member States [5]. Despite some progress, substantial portions of construction waste still end up in landfills, underscoring the urgency for effective management and circular economy integration.

2. Analysis of scientific publications.

The scientific discourse regarding the management of construction and demolition waste (CDW) within the framework of the circular economy is rich and multidisciplinary. Researchers have approached the topic from legal, economic, environmental, and technical perspectives, providing valuable insights into both the achievements and persistent challenges in the European Union.

General Reviews and Circular Economy Policy

Baldassarre, B. and Saveyn, H. (2023) conducted a systematic analysis of EU publications on the circular economy, highlighting both progress made and existing gaps in policy enforcement and practical implementation across Member States [1]. Similarly, Dodick, J. and Kauffman, D. (2017) provided an extensive review of the European Union's Circular Economy Policy, identifying the strengths and weaknesses of existing legal frameworks and proposing measures to enhance resource efficiency and reduce environmental impact [8].

The European Commission's core strategic documents, such as the Closing the Loop – EU Action Plan for the Circular Economy (2015) [12], the New Circular Economy Action Plan (2020) [14], and the progress report on implementation (2019) [13], lay the foundation for legal and economic mechanisms to foster sustainable production and consumption. Marelli, L., Trane, M., Barbero Vignola, G., Gastaldi, C., and Guerreiro, M.M. (2025) assessed the EU Green Deal's achievements, emphasizing the role of circular economy policies in achieving decarbonization and competitiveness [27].

Suárez-Eiroa, B., Fernández, E., Méndez-Martínez, G., and Soto-Oñate, D. (2019) linked theoretical concepts of circular economy with practical tools for sustainable development, outlining operational principles necessary for effective implementation [28].

These studies confirm that while the EU has developed comprehensive policy frameworks, significant disparities persist between countries regarding implementation, monitoring, and stakeholder engagement.

Construction Waste Management and Secondary Raw Materials

A large body of research focuses on challenges and innovations in managing construction and demolition waste. Bilsen, V., Kretz, D., Padilla, P., Van Acoleyen, M., Van Ostaeyen, J., Izdebska, O., Eggert Hansen, M., Bergmans, J., and Szuppinger, P. (2018) analyzed investment and innovation initiatives for CDW recycling infrastructure across the EU, identifying operational, legal, and market barriers to achieving higher recycling rates [2].

Callegher, C.Z., Grazieschi, G., Wilczynski, E., Oberegger, U.F., and Pezzutto, S. (2023) assessed the composition of building materials across the European residential stock, providing critical data for evaluating circularity potential [3].

Lei Yu, Qian Ge, Ke Han, Wen Ji, and Yueqi Liu (2025) designed optimal subsidy schemes and recycling plans for sustainable construction waste management, emphasizing the economic mechanisms needed to overcome financial barriers in adopting circular practices [7].

Tazi, N., Idir, R., and Ben Fraj, A. (2021) explored opportunities and obstacles for achieving circularity in residential building materials, underscoring the importance of stock management and design for disassembly [29].

Collectively, these works illustrate that despite promising initiatives, technological, legal, and market limitations continue to hinder the transition to circular construction practices.

Technical Solutions, Recycling, and Innovations

Technical barriers and innovation remain central themes in the literature. Condotta, M. and Zatta, E. (2021) emphasized the underutilization of design-for-reuse principles in architecture, noting the regulatory gaps that impede the adoption of modular, reusable building elements [4]. However, technical barriers such as insufficient waste sorting on-site, material contamination, and lack of modular construction practices hinder efficient recycling processes. While selective demolition and high-value material recovery show promise, their large-scale application remains limited, necessitating further technological development and regulatory alignment.

Other Relevant Research and Statistics

Statistical analyses, such as those by Statista (2023), reveal that construction waste represents approximately 37% of all waste generated in the EU, with considerable variation between countries [5, 6]. Dziedzic, R., Pondicherry, P., and Dziedzic, M. (2025) reviewed national policy instruments, highlighting the uneven implementation of circular construction principles across Member States [9].

Lederer, J., Gassner, A., Fellner, J., Mollay, U., and Schremmer, C. (2021) quantified future raw material consumption and demolition waste generation in urban sectors, offering valuable forecasts for circular resource management [25].

In a related study, Lederer, J., Gassner, A., Keringer, F., Mollay, U., Schremmer, C., and Fellner, J. (2020) mapped material flows and stocks in urban buildings, illustrating resource recovery potential [26].

Innovative solutions, such as reusable timber panels promoted by the European Commission [20], and the findings of Laurent Chateau (2016) on barriers to product reuse in construction [23], underscore the need for regulatory coherence, technological advancement, and capacity building.

The European Construction Sector Observatory (ECSO) [18] also emphasizes monitoring sector performance and promoting knowledge exchange to facilitate the transition to sustainable practices.

Scientific literature consistently emphasizes the strategic role of legal frameworks, economic incentives, and technological innovations in promoting circular construction practices. However, the research also identifies persistent challenges, including fragmented implementation, legal inconsistencies, technical limitations, and insufficient awareness. Addressing these gaps requires coordinated efforts among policymakers, industry stakeholders, and the scientific community to achieve the EU's ambitious circular economy targets in the construction sector.

3. The purpose of the work.

The purpose of this article is to analyse the ecological and legal aspects of construction waste management within the European Union, focusing on best practices, regulatory measures, challenges, and opportunities for advancing a circular economy in the construction sector. The work aims to highlight both successful policy implementations and areas that require improvement to achieve sustainable construction waste management across EU Member States.

4. Presenting main material.

The circular economy model has attained strategic significance within European Union policies, particularly in sectors with substantial environmental impacts such as construction waste. In this regard, the management of construction waste has emerged as a pivotal concern within the EU's framework for sustainable development and waste minimization [16]. In response, the European Union has intensified its initiatives, implementing new regulations, directives, and targets to incentivize member states to adopt circular economy principles more comprehensively. Recent measures include, among others, the aspiration to increase the recycling and reuse rates of construction waste to 70%, reduce landfill waste, and enhance the quality of recycled materials, initiatives integrated into the European Green Deal and the Circular Economy Action Plan [14]. These initiatives are further supported by the establishment of specific objectives aimed at increasing recycling rates and encouraging the reuse of high-value waste [23]. Nonetheless, disparities in national implementation and enduring structural challenges cast doubt on the uniform efficacy of these policies across EU Member States, as indicated by statistical data [5, 6].

In response to increasing environmental pressures and the requirements for sustainable development, the European Union has established an ambitious regulatory framework aimed at transforming the management of construction and demolition waste. EU policy aims not only to reduce the amount of waste sent to landfills but also to promote innovation throughout the entire product life cycle, including sorting, recycling, and reuse of construction materials. Different EU Member States, depending on their national contexts and capacities, have implemented these directives with varying outcomes. Consequently, Europe is emerging as a hub of innovation and best practices, providing valuable insights into effective strategies for the sustainable management of construction waste. Nevertheless, over time, the production of construction waste continues to escalate, with a considerable portion still being directed to landfills. One of the European Union's current objectives is to increase the recycling and reuse rate of construction waste to 70% by weight, focusing on reducing landfill waste and improving the quality of recycled materials. This initiative aligns with the new Circular Economy Action Plan introduced under the European Green Deal [14].

The EU Waste Framework Directive 2008/98/EC [17] was enacted in 2008 to enhance the recycling rates of construction waste within EU Member States. According to this directive, all member states are required to implement all necessary measures to achieve a minimum of 70% reuse, recycling,

or other recovery of safe construction waste by 2020. Furthermore, after 2015, the European Commission approved a new Circular Economy Action Plan titled "Closing the Loop – EU Action Plan for the Circular Economy." [12]. The plan aims to stimulate employment, economic growth, and investment, while promoting the development of a sustainable, low-carbon, resource-efficient, and competitive economy. The legislative proposals endorsed within this framework concentrate on modifying production and consumer behaviours through reuse and recycling, as well as enhancing waste management practices to minimize landfill disposal. Consequently, this approach aims to close the product life cycle, thereby supporting a circular economy across all stages of the value chain. Furthermore, additional measures are proposed to facilitate implementation, encourage economic incentives, and enhance extended producer responsibility schemes [8]. The plan contains 54 measures, which, among other things, include the following:

i. Develop product requirements related to durability, maintainability, and recyclability in line with the Eco-design Directive 2009/125/EC [10].

ii. Clarify rules on by-products to facilitate industrial symbiosis, whereby by-products from one industry become resources for another. Include guidance in the Best Available Techniques (BREF) reference documents [11] for waste management and resource efficiency.

iii. Conduct a study on the provisions on repair information under the Eco-design Directive 2009/125/EC on energy [10].

iv. Review waste legislation.

v. Identify best practices in waste collection systems.

vi. Develop pan-European quality standards for recyclable materials.

vii. Develop pre-demolition assessment guidelines for the construction sector.

viii. Develop a voluntary industry protocol for recycling construction waste.

ix. Develop key indicators for assessing the environmental performance of a building's life cycle, as well as concepts for their effective use.

x. Develop a circular economy monitoring system.

Additionally, it is pertinent to highlight the development of a framework aimed at fostering sustainable investment, which includes relevant taxonomies on production waste [19] and regulations on construction products [21], adopted within the context of the Council of Europe's Law concerning clean and innovative construction products [22]. Other recent initiatives undertaken by the European Commission's Joint Research Centre, concerning modular and reusable panels for construction, are currently undergoing evaluation. The project primarily focuses on reducing environmental impact and promoting a circular economy within the construction sector through the adoption of reusable and adaptive design methodologies that ensure structural resilience and facilitate prompt reconstruction in areas affected by conflict and humanitarian crises [20]. Nevertheless, notwithstanding these advancements, substantial challenges persist, particularly concerning the collection, sorting, and design for the reuse of construction waste. Recent research indicates that numerous facets of the value chain within the circular economy continue to require enhancement to attain optimal efficiency [1, 2, 9, 27].

In March 2019, the European Commission was provided a comprehensive report entitled "On the implementation of the Circular Economy Action Plan" [13].

According to the report referenced herein, all 54 initiatives outlined in the Circular Economy Action Plan have been executed, although work on specific measures will persist beyond 2019. Considering this, the formulation of dependable strategies and innovative technologies for the recycling of construction waste is imperative to: (1) augment the proportion of materials derived from construction waste utilized in new residential developments; (2) enhance the technical and economic value of materials obtained from construction waste; (3) minimize future emissions of

construction waste from subsequent generations of buildings. Such measures will contribute to: (4) advancing the energy efficiency of buildings.

Nevertheless, the implementation of these measures remains inconsistent, and numerous member states encounter difficulties in achieving the 70% target with high-quality reuse. Construction waste is also considered within critical raw materials policies, as it represents a significant urban source for the recovery of critical, strategic, and high-value materials such as copper and aluminium [3, 25, 26, 29]. Construction and demolition waste also encompasses substantial quantities of raw materials such as steel, iron, aggregates, and glass, which are vital for various industries. Recovering these materials from construction waste not only diminishes reliance on imports but also enhances the competitiveness of the European Union and guarantees the supply of materials essential for strategic sectors of the European economy, including electronics, automotive, and renewable energy. Furthermore, this practice contributes to the decarbonisation roadmap outlined in the European Clean Industry Agreement [15]. While there's a shared regulatory framework, its implementation can vary greatly from one country to another. These differences stem from variations in administrative resources, infrastructure, and socio-economic conditions, which can impact how effectively construction waste is managed nationwide.

Despite the significant progress made in Europe in integrating the circular economy into construction waste management, several challenges remain across all stages of the value chain. These challenges are not only technical but also regulatory, economic, and behavioural. They represent the primary obstacles to the broader adoption of circular practices; however, they also present opportunities for future innovation and improvement. Several key challenges can be identified, such as:

1. Technical and operational barriers.

Construction sites frequently lack adequate waste sorting systems, resulting in the production of mixed waste that diminishes the potential for recycling [4]. The contamination of construction waste compromises the quality of materials and limits their suitability for high-value applications. Furthermore, selective demolition and on-site sorting are still underutilized, despite their demonstrated advantages in enhancing material recovery rates.

2. Legal gaps in design for circularity.

Numerous structures are not engineered for end-of-life recovery, thereby substantially limiting their potential for reuse. Legal frameworks seldom mandate circular design [28]; however, the Eco-Design Directive, alongside various national initiatives, are progressively promoting the adoption of modular and collapsible materials. Environmental legislation could assume a more proactive role by integrating circular design principles within building codes and permitting processes.

3. Lack of harmonised standards.

Without common quality standards for recycled building materials in the EU, market confidence is hurt, and cross-border trade is limited [7]. A standardized European certification system could help reduce this barrier by facilitating the easier incorporation of recycled materials into mainstream supply chains.

4. Insufficient economic incentives.

Circular economy practices often entail higher upfront costs, creating barriers for companies to invest in sustainable construction. Although some Member States offer tax credits and subsidies [24], these measures are unevenly distributed and poorly adapted to real economic conditions.

5. Lack of awareness and training.

The insufficient awareness and lack of specialized training among construction professionals and waste market operators pose significant obstacles to implementing a circular approach to waste management. Numerous stakeholders remain uninformed regarding the composition of building materials, thereby limiting their capacity for recovery at the end of their useful life [24]. Knowledge-sharing platforms and professional training are vital for bridging this gap.

Economic incentives are instrumental in encouraging circular economy practices; however, they are frequently inadequate or improperly targeted. Examples of effective policies include subsidies for projects utilizing recycled materials, taxes on primary raw materials, and tax credits for corporations that implement sustainable practices, all of which can expedite the transition towards a circular economy [24]. A more effective design of these incentives, tailored to the economic realities of various nations, could promote broader adoption of recycling and reusing practices. Ultimately, a significant impediment is the deficiency of awareness and training among participants in the construction industry. Waste management operators are typically unaware of all materials incorporated into products, thereby diminishing the probability of their recovery at the end of their lifecycle. It is therefore essential to foster the dissemination of knowledge; this initiative also underpins the European Construction Sector Observatory [18]. Many professionals are not fully aware of the benefits of the circular economy and the latest recycling and reuse methods. To bridge this gap, ongoing training programs and awareness campaigns are essential. These initiatives will contribute to promoting the broader adoption of circular practices, thereby making a beneficial impact on our environment [24]. These efforts should integrate practical knowledge about the economic and environmental benefits of sustainable waste management.

5. Conclusions.

Construction waste represents a significant environmental challenge and an opportunity for environmental and legal innovation in the European Union. While EU policy has established a solid framework for the circular economy, its actual implementation remains uneven and is hampered by legal, economic, and technical barriers.

Overcoming these challenges requires: (1) strengthening legal frameworks for circular design; (2) introducing harmonized standards for recycled materials; (3) expanding economic incentives tailored to industry realities; (4) enhancing professional training and awareness campaigns; (5) supporting research and technological innovation in material recovery.

The transition to sustainable construction waste management is essential for achieving EU environmental goals, promoting resource efficiency, and ensuring long-term competitiveness. Further harmonization of policies and practical solutions will facilitate the EU's shift towards a circular economy, contributing to environmental protection and sustainable development.

Best practices from leading countries offer valuable insights, but a truly harmonised approach requires further regulatory alignment, stakeholder engagement, and long-term investment. Environmental laws need to grow and adapt to better support waste prevention, management, and a overall shift towards sustainable development and protecting our environment. It's about creating a system that encourages positive change for our planet.

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