

INTEGRATING THE CIRCULAR ECONOMY INTO ESG IN THE REAL ESTATE SECTOR: CURRENT PRACTICES, CHALLENGES, AND PATHWAYS TO STANDARDIZATION

Beata Wieteska-Rosiak^{1*}

¹Departament of Investments and Real Estate, Faculty of Economics and Sociology, University of Lodz, Poland, e-mail: beata.wieteskarosiak@uni.lodz.pl, ORCID: 0000-0003-0353-2558

* Corresponding author

ARTICLE INFO	ABSTRACT
Keywords: circular practices, ESG reporting, property, sustainable buildings	Climate change and resource depletion are issues accelerating the development of a circular economy (CE). The question arises of whether and how real estate companies, through their activities, support the development of the circular economy. To answer this, both qualitative and quantitative methods were used. Firstly, a review of the literature on the development of the circular economy was conducted. Secondly, the ESG reports and strategies of real estate and construction companies listed on the stock exchange were analyzed in detail, focusing on the development of circular construction, circular policies, goals, and principles against the background of the ESRS E5. The study identifies four key disclosure areas: organization, stakeholders, construction investments and surroundings, and the construction process. The reported circular economy practices are limited and vary in alignment with circular economy principles, the ReSOLVE model, and the 10R principles. The growing emphasis on ESG is driving the real estate sector to adopt circular economy solutions. Public authorities must support this change by creating favorable legal, economic, technological, and social conditions, which will lead to improvements in the quantity and diversity of the applied circular solutions, as well as the quality and transparency of reporting.
JEL Classification: M14, Q53, Q56, R11, R31	
Citation:	
Wieteska-Rosiak, B. (2025). Integrating the circular economy into ESG in the real estate sector: Current practices, challenges, and pathways to standardization. <i>Real Estate Management and Valuation</i> , 33(2), 109-122. https://doi.org/10.2478/remav-2025-0019	

1. Introduction

Global challenges, such as climate change, resource depletion, and environmental degradation pose significant issues for businesses, authorities, and society. Reducing greenhouse gas emissions, adapting to climate change, and adopting sustainable resource management practices are crucial for the real estate sector, which in the European Union (EU) is responsible for 38% of CO₂ emissions, 50% of resource consumption, and 35% of waste (European Commission 2024). Transitioning from a linear to a circular economy (CE) is a key development direction. Public sector strategies are being developed to promote CE principles in buildings and construction, given their significant raw material consumption and high potential for circularity (European Commission, 2020; Gemeente Amsterdam, 2020).

Environmental, social, and governance (ESG) criteria offer substantial potential for circular and responsible

actions in business, yielding significant financial, social, and environmental benefits (Shaheera Banu & Vimala, 2024). However, selecting appropriate indicators and measuring their impact on the CE remains challenging, affecting the consistency and comparability of reports (Soyka & Feldman, 2022; United Nations Office for Disaster Risk Reduction, 2024).

The Corporate Sustainability Reporting Directive (CSRD) aims to improve and standardize sustainability reporting for companies operating in the EU. It is part of the European Sustainability Reporting Standards (ESRS). The ESRS aims to ensure that companies provide consistent, comparable and transparent information on their environmental, social and governance performance. This information is crucial for investors, stakeholders and the general public to understand how companies are addressing the challenges of sustainable development. The ESRS includes the ESRS E5 standard, which focuses on

resource use and CE principles to support the EU's Circular Economy Action Plan (European Commission, 2020).

Understanding how CE practices in real estate companies align with circular design strategies (Gervasio and Dimova 2018; Mayor of London, 2022), the ReSOLVE model, which incorporates circular business strategies (Regenerate, Share, Optimise, Loop, Virtualise, and Exchange) (Zimmann et al., 2016; Alhola et al., 2019), and circular principles 10 R, which comprise refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, remine, and recover (Ocicka et al., 2022), is crucial. Despite this, research on these practices disclosed in real estate companies' ESG strategies and reports is lacking. Additionally, evaluating how companies implement ESRS E5 guidelines, including the quality and quantity of information and measuring outcomes, is necessary to identify reporting gaps and development needs in circular construction.

The article aims to shed light on the current trends in CE reporting within the ESG strategies of companies in the real estate sector, including the circular practices adopted and the directions for standardizing reporting in this sector. The findings contribute to the development of circular construction and highlight the need for standardized reporting in the sector. Circular construction means creating, using and reusing buildings, construction elements, products, materials and reusing space and infrastructure. The aim is to prevent the depletion of natural resources, and reduce environmental pollution and negative impacts on ecosystems (European Commission 2024). The main goal is to identify the current directions of information disclosure by real estate and construction companies in the area of the CE and to propose a uniform reporting framework. To achieve this objective, three research questions were formulated: (1) How do real estate and construction companies report on the CE in ESG? (2) What methods do companies disclose, and how do they align with circular principles and strategies? (3) What are the directions for CE reporting in the real estate sector?

2. Material and methods

Financial markets play an increasingly important role in promoting responsible investing. Stock exchanges, as trading platforms, support responsible investing by incorporating ESG criteria into their activities and by promoting and educating market participants in this regard. The study is based on an analysis of the

literature on the subject as well as ESG reports and strategies. The focus of the study was on companies listed on the WIG-real estate and WIG-construction indices of the Warsaw Stock Exchange. Both qualitative and quantitative methods were applied in the research. Between April and May 2024, a study was conducted on companies listed on both indices, identifying a total of 59 entities. Among them, 20 companies, including 11 development companies and 9 construction companies, had an ESG strategy or report for 2022 and 2023. The available strategies and reports were subjected to a detailed content analysis regarding the development of circular construction, policies, goals, and circular principles, including compliance with the ESRS E5 standard.

The content analysis process consisted of three stages. The first stage involved a thorough analysis of the documents to identify content related to the companies' approach to resources and the circular economy. The second stage involved appropriately categorizing the implemented solutions and relating them to the existing literature. The third stage allowed for a quantitative summary of the solutions. The identified circular practices were classified, which enabled the identification of four main areas of corporate reporting regarding resource use and the circular economy (see Tables 1 and 2). These practices were related to circular design principles, the 10 Rs principles, and the ReSOLVE strategy. The result of the study was a list of reporting directions and measurement support for the ESRS E5 areas (see Annex 1).

3. Results

3.1. Circular economy reporting by companies in the real estate sector

The study sheds light on the directions of circular actions and information disclosure by developers and construction companies. The structure, quantity, and detail of the information provided vary. The analysis of the strategies and reports of the listed companies highlighted the terminology related to the CE. It revealed that the terminology used varies, ranging from "resource use and circular economy" (as per ESRS E5) to "waste management," "sustainable management of resources," and "material use and circular economy." We recommend standardizing the terminology used and adopting the terminology proposed in ESRS E5.

The ESRS E5 standard, specifically in area E5-1 (Policies related to resource use and circular economy), recommends that companies address their policies on

resource use and the CE. Real estate companies can demonstrate how they are moving away from the use of non-renewable primary raw materials and increasing the proportion of renewable resources in their acquired materials. They may also refer to internal sustainability standards, certifications, and Circular Business Models (Minunno et al., 2018; Jonker et al., 2022).

In the analyzed ESG documents, companies commit to reducing the impact of buildings and construction on climate change, minimizing environmental impact, reducing demand for energy and water, improving biodiversity, adapting to climate change, and advancing the CE. They refer to the 17 Sustainable Development Goals. They emphasize the need to limit global warming to 1.5°C and the need to achieve climate neutrality by 2050. All of the entities set targets for reducing greenhouse gas emissions in the short term, medium term (2030), or long term (2050).

The study found that in the adopted CE policies, only one real estate company referenced the ReSOLVE model and one referred to the Rs principles, i.e. refuse, reduce, reuse and recycle. This suggests that those policies lack references to fundamental circular strategies and principles. Companies exhibit significant originality in their policies, referring to internal sustainability standards. Thus, measuring E5-1 is challenging. To combat this, companies should include references to the ReSOLVE model, the 10Rs principles, and circular building design principles.

Disclosure Requirement E5-2 (Actions and resources related to resource use and circular economy) requires companies to disclose the actions and resources they will use now and in the future to achieve their policies related to resource use and the CE. In this section, the company should address the actions taken in relation to the waste hierarchy (Prevention, Reuse, Recycling, Recovery, Disposal) (European Union, 2008). According to the hierarchy, the most desirable solutions are those at the Prevention and Reuse levels, followed by Recycling. Approaches based on waste incineration with or without energy recovery, as well as landfilling, are considered less desirable, falling under Recovery and Disposal.

The analysis of ESG documents allowed us to categorize the various circular practices into four areas: organization, stakeholders, construction investment, and construction process. These areas cover certifications and resource savings, stakeholder engagement, investments in buildings and surroundings, and the construction process (see Table 1).

In Area 1, organizations report their certificates which are the ISO 14001 standard. Companies disclose practices related to resource consumption in office spaces, focusing on reducing energy and water consumption and improving waste management. Solutions include building management systems, upgraded HVAC systems, water-saving fixtures, electronic document management, and internal resale of furniture and vehicles.

In Area 2, educational practices related to sustainability and the CE for both internal and external stakeholders are disclosed. They include employee training on waste management and proper waste segregation at branches and construction sites. It also covers environmental education for tenants during the handover of properties, as well as for subcontractors and business partners regarding environmental management. Practices disclosed include the selection of sustainable suppliers and contractors based on their waste management approaches (e.g., waste segregation on-site, waste minimization, and the reuse of unused materials) and ISO 14001 certification. Another practice is to choose local materials and suppliers to reduce carbon footprints, pollution, and noise.

In Area 3, within the building category, practices mainly focus on the design of structures, the materials used, and construction technologies. The design phase has a decisive impact on the entire lifecycle of a circular building (Basbagill et al., 2013). The circular practice disclosed in ESG involves the use of materials and solutions that allow for safe disassembly, reuse, or recycling. Design considerations such as the ease of product replacement without altering the building's structure, as well as the flexibility for rearranging and replacing building elements, help unlock the circular potential of the building throughout its entire lifecycle.

A circular practice in the building materials category involves the use of eco-friendly and low-emission materials. These include products with a low carbon footprint, minimal environmental impact, and that are free of harmful substances. Such materials often have an Environmental Product Declaration (EPD), eco-certifications or come from suppliers with ISO 14001 certification. They are made from renewable resources, are recycled or recyclable, and can be reused. Additionally, photocatalytic paint or concrete are other examples of materials that help reduce air pollution. Using high-quality and durable materials is also a practice that extends a building's lifespan and usability.

Another disclosed practice is the use of Building

Information Modeling (BIM). BIM enables intelligent building modeling by creating a 'digital twin', allowing collaboration and information exchange among all project stakeholders throughout the building's lifecycle. It optimizes solutions and resources, increases productivity and efficiency, improves communication, and enhances the construction process while tracking progress and reducing costs and project clashes (Al-Ashmori et al., 2020). This technology supports building design by optimizing material needs and solutions and reducing waste. It also helps rationalize planning, procurement, and logistics processes for building materials during construction.

At the design stage, circular practices such as the collection and reuse of rainwater and greywater are also considered. Additionally, the reports emphasize the design and implementation of renewable energy sources, such as photovoltaic panels, to reduce buildings' energy demand and decrease reliance on non-renewable resources in line with CE principles.

Practices in the category of construction technologies include the development of modular and prefabricated components and buildings, such as stairs, floors, and entire structures. These technologies help reduce the demand for natural resources and minimize waste generation.

Practices in the category of spatial planning include the revitalization and renovation of buildings, supporting the sustainable development of cities and urban areas. This practice involves the use of existing structures as well as already developed (contaminated, low ecological value) lands, which helps reduce the demand for primary resources. Additionally, it contributes to urban development and the CE while improving the quality of life. Other practices include undertaking projects in urban areas to limit urban

sprawl, implementing the 15-minute city strategy, and investing in mixed-use developments.

In Area 4, Category of Construction Sites, companies disclose practices related to sustainable waste segregation and recycling. On construction sites, companies aim to reduce waste generation, properly segregate waste, and designate areas for hazardous waste storage. A waste management and monitoring system is implemented, with waste directed to appropriate entities for safe disposal and recycling. During demolitions, effective waste management practices are employed to maximize recovery and recycling. Another practice involves reducing the demand for raw materials and optimizing their use to minimize waste production, e.g., planning the sequence of construction activities and limiting the removal of earth from the site. Companies also strive to utilize and generate renewable energy on construction sites (for buildings and site operations). Other practices include recovering and reusing materials and products for their original or new functions. For example, excavated soil and demolition rubble are used for surface stabilization, glass waste is redirected for window production, and construction material pallets are returned to suppliers. Reusing formwork, sales pavilions, and fences on subsequent construction sites is also practiced.

In the category of construction equipment and machinery, practices include renting small equipment, mobile cranes, scaffolding, containers, fencing, and printing services, following the principle of "product as a service." In the transport category, practices focus on using low-emission transportation and shortening supply chains by selecting local raw materials and products.

Table 1

Areas, Categories, and Disclosed Circular Practices in ESG Reporting by WIG Real Estate and Construction Sector Companies		
Area	Category	Disclosed Circular Practices
Organization	Certification	ISO 14001 (5 companies).
	Office Spaces	- Energy efficiency: Building management systems, modernization or installation of HVAC systems (8 companies). - Water management: Water-saving systems (4 companies). - Waste management: Waste segregation and recycling, paper reduction through electronic documentation, internal resale of furniture and vehicles (3 companies).
Stakeholders	Internal/External	- Education on sustainability and circular economy (employees, subcontractors, business partners, tenants) (9 companies). - Selection of sustainable suppliers and contractors (8 companies). - Use of local materials/suppliers (6 companies).

Construction Investment and surrounding	Buildings and structures	• Design: Design for disassembly, reuse, or recycling; optimization of environmental solutions and resources (2 companies); Building Information Modeling (BIM) (3); rainwater or greywater collection and use (5); renewable energy (8 companies). • Materials: Eco-friendly or low-emission materials, high-quality (10 companies) and durable materials (2 companies) and materials that absorb harmful substances (3 companies). • Technologies: Modular and prefabricated components and buildings. (4 companies). • Certified Investments: Multi-criteria certification (e.g., BREEAM, LEED) (6 companies).
	Spatial planning	• Renovation or revitalization (6 companies). • Investments in urban areas to counter urban sprawl (2 companies). • 15-minute city strategy (4 companies). • Mixed-use spaces (1 companies).
Construction Process	Construction Site	• Waste segregation and recycling (9 companies) • Reduction of material and resource demand (6 companies). • Use and generation of renewable energy on-site (2 companies). • Recovery and reuse of materials and products (4 companies).
	Equipment and Machinery	• Rental of equipment and machinery (product as a service) (1 companies).
	Transport	• Use of low-emission transportation (4 companies). • Shortening supply chains through local sourcing (6 companies).

Source: Own study based on ESG analysis of WIG-real estate and WIG-construction index companies.

The ESG analysis reveals that circular practices align with the first three principles of the waste hierarchy: Prevention, Reuse, and Recycling. The range of solutions is diverse, demonstrating high circular potential. However, these practices are disclosed sporadically, suggesting that they are also implemented within real estate companies. Directly addressing CO₂ emission reductions, 19 entities made references, while 11 highlighted connections to the circular economy. Only 2 entities referred to the ReSOLVE model.

In the area of organization, companies most often include energy savings in their activities (8 companies). In the stakeholder area, the most frequently disclosed practice is sustainability education (9), followed by the selection of sustainable suppliers and contractors for waste management (8). In the construction investment and surrounding area, the most common practices include the use of eco-friendly and low-emission materials (10), renewable energy sources (8), revitalization or renovation (6) and certification (6). In the area of construction process, the most frequently indicated are waste segregation and recycling (9), reduction of material and resource demand and shortening supply chains (6).

Area E5-3 (Targets related to resource use and circular economy) requires companies to set goals related to resource acquisition and waste and material generation. Companies should define the level of the waste hierarchy each goal addresses and refer to ecological thresholds, both mandatory and voluntary, that are specific to the entity. Goals should be SMART: Specific, Measurable, Achievable, Realistic, and Time-

bound. These goals can be set for the entire organization, specific circular processes (e.g., waste segregation), or areas of operation (e.g., implementing modern technologies).

ESG documents primarily outline goals related to waste segregation levels on construction sites. However, there is a lack of targets concerning the use of renewable and non-renewable resources, implemented solutions, and waste generation. The goals do not adhere to the SMART criteria, lacking thresholds and indicators for measuring the goals. In the absence of mandatory thresholds in legal regulations, it is suggested that companies develop voluntary thresholds to build a competitive advantage in the market.

Disclosure Requirement E5-4 (Resource inflows) recommends disclosing information about the resources acquired by real estate entities, including raw materials, products, and fixed assets. This includes the total mass of materials and products used during the reporting period, the mass and percentage of materials from renewable sources or that are reused or recycled.

The study revealed that companies disclose resource and material usage in two ways: for all completed investments and for specific investments. Typically, the reported data includes weight and volume. However, this presentation does not indicate whether the amount of resources and materials used should be reduced. As investments generally increase, so does the overall quantity of resources used. Therefore, it is recommended that data be presented as indicators, such as the amount of materials per square meter of building volume, enhancing understanding

and comparability. The study also found a lack of reference to the disclosed data in relation to set goals and mandatory or voluntary thresholds.

Disclosure Requirement E5-4 (Resource inflows) also encompasses the land used for construction investments. Companies could use an indicator showing the proportion of investment areas that are either of low ecological value or previously altered by human activity. Additionally, they can present the percentage of investments completed on urbanized lands, aligning with efforts to limit urban sprawl and implement the 15-minute city strategy.

Area E5-5 recommends disclosing information regarding the generation of material resources, including waste. In the real estate sector, the product will be a building or a group of buildings, which should be described through the lens of circular principles, such as durability, reusability, reparability, disassembly, remanufacturing, refurbishment, recycling, biological recirculation, and optimized use. For waste, the reporting period should include the total amount of waste generated, measured in tons or kilograms, as well as the weight of waste and hazardous waste categorized by operations for preparation for reuse, recycling, or other recovery processes, incineration, landfilling, and the total amount and percentage of waste not subjected to recycling. This information should cover waste generated on construction sites as well as within the company's office premises.

The analysis revealed that companies present the total amount of waste generated, including hazardous waste. The data provided are general for all investments, with a lack of specific indicators, such as the amount of waste generated per cubic meter of investment; this makes it difficult to properly assess the state of waste management. It may also be challenging to determine exactly what happens to the waste once it leaves the construction site. Company responsibility can be based on waste segregation and choosing a specialized firm that directs suitable materials for reuse and recycling. This could be facilitated by a trusted database of companies specializing in waste collection and processing.

Area E5-6 (Potential financial effects from resource use and circular economy-related impacts, risks, and opportunities) requires companies to disclose quantitative or qualitative information about the anticipated financial effects. This includes providing details on risks and opportunities related to resource use and transitioning to a CE, along with their associated impacts over a specified time frame. In the

analyzed documents, this area is most often overlooked.

The research results are presented in a table, outlining reporting directions and measurement proposals for ESRS E5 areas (Appendix 1).

3.2. ESG Circular Practices in the Context of Circular Principles and Strategies

The disclosed circular practices have been related to principles and strategies of circular construction (Table 2). First, these practices are compared to principles of designing circular buildings, including building in layers, designing out waste, designing for longevity, designing for adaptability or flexibility, designing for disassembly, and using systems, elements, or materials that can be reused and recycled (Gervasio & Dimova 2018; Mayor of London 2022).

The first principle, *building in layers*, involves designing and constructing buildings in a layered manner, allowing for greater flexibility and adaptability of the building. Easy access to different layers facilitates maintenance, saves time, and reduces waste, as it is possible to replace or reuse individual layers or building components. However, the disclosed ESG practices do not indicate any clear incorporation of the building-in-layers principle during the design phase.

Another principle, *designing out waste*, focuses on reducing waste from construction to demolition by redirecting all generated waste for recycling or reintroducing it into the supply chain, thereby increasing its functional and economic value. Preferred construction solutions include modular and prefabricated structures. The analysis revealed the use of prefabricated and modular elements, as well as a responsible approach to waste management, including on-site waste segregation.

The principle of *designing for longevity* involves using durable materials and components in buildings, reducing the need for maintenance, replacement, and repairs. This helps to lower costs and minimize the consumption of both renewable and non-renewable resources. The principle also includes the use of durable products to enhance resilience against natural hazards, climate change impacts, and anthropogenic threats (Gervasio & Dimova, 2018). Referring to the circular practices disclosed in ESG reports, it is important to highlight the use of durable and high-quality materials to extend the building's lifespan and improve its resilience to extreme climatic events. These practices align well with the principle of longevity.

The principle of *designing for adaptability or flexibility* involves incorporating features into the design of a building that ensure long-term usability. During the building's lifespan, external factors may necessitate a change in its function. For example, the decreased demand for office space due to the COVID-19 pandemic and the rise of remote work highlights the need for buildings to be adaptable. To enhance a building's resilience, its design should allow for easy and cost-effective adjustments to accommodate changing socio-economic conditions (Gervasio and Dimova, 2018; Engel et al., 2017; Gu et al., 2016). The study found a lack of practices aligned with this principle.

The principle of *designing for disassembly* aims to maximize the recovery of materials and building components. When replacing or demolishing a building, the design solutions allow products to be reused in other buildings or redirected to recycling. This principle encompasses a set of strategies to optimize

outcomes, such as reducing building complexity, developing a deconstruction plan, designing detachable connections, using prefabricated and modular construction, and designing components with standard dimensions (Cruz Rios et al., 2021). The disclosed practices include approaches focused on selecting materials to maximize their reuse or recycling, as well as the development of prefabricated and modular buildings. This indicates the application of this principle.

The final principle in this classification, *using systems, elements, or materials that can be reused and recycled*, involves deliberately considering the type and quality of the solutions and materials used, which translates into the potential for reuse or recycling of the materials. The materials disclosed in ESG practices are eco-friendly and low-emission; some come from recycling or have the potential for recovery or recycling, such as wood and steel. This indicates that they align with the discussed principle.

Table 2

Disclosed Practices in Relation to Circular Principles and Models					
Disclosed Practices in Relation to Circular Principles and Models					
Circular design principles		ReSOLVE model		10 Rs Principles	
Building in layers	-	Regenerate	+	Refuse (R0)	+
Designing out waste	+	Share	+	Rethink(R1)	+
Designing for longevity	+	Optimize	+	Reduce (R2)	+
Designing for adaptability or flexibility	-	Loop	+	Reuse (R3)	+
Designing for disassembly	+	Virtualize	+	Repair (R4), Refurbish (R5), Remanufacture (R6)	+
Using systems, elements or materials that can be reused and recycled	+	Exchange	+	Repurpose (R7)	+
				Recycle (R8)	+
				Remine (R9)	-
				Recover (R10)	-

Source: Own study based on ESG analysis of WIG-real estate and WIG-construction index companies.

The identified practices were further related to the ReSOLVE model (Schulze, 2016; Zimmann et al., 2016; Alhola et al., 2019). The *Regenerate* strategy emphasizes using renewable energy and materials, conserving and restoring ecosystems, and returning biological resources to the biosphere. Practices include using renewable energy in the fabrication of building materials, eco-friendly construction materials, and using renewable energy on construction sites, such as green roofs and biodiversity efforts.

The *Share* strategy focuses on the sharing economy, aiming to maximize resource use and extend the life of products through maintenance, repairs, and durable

design. Disclosed practices include renting equipment and machinery, and repeatedly using containers and fences, which is in line with the sharing economy strategy and Product as a Service. Another practice involves creating mixed-use spaces, maximizing resource and space utilization.

The *Optimize* strategy focuses on enhancing the efficiency and performance of products, reducing waste in production processes and throughout the supply chain, and utilizing advanced technologies such as drones, the Internet of Things, and 3D printing (Ocicka et al., 2022). Disclosed practices include the use of prefabricated elements, modular solutions, planning

work sequences to optimize material usage, and employing durable, high-quality materials. This also encompasses practices based on the use of BIM (Building Information Modeling) and BMS (Building Management Systems) technologies.

The *Loop* strategy focuses on keeping products and materials within closed loops through regeneration, renovation, and recycling, such as building and product renovations and material recycling. It involves maintaining the flow of resources and materials within technical and biological cycles. Disclosed practices include the reuse of humus and construction debris, revitalization and renovation projects, selecting investment sites with low ecological value, waste segregation on construction sites for recycling, and the use of recycled materials or materials with high potential for recovery and recycling.

The *Virtualize* strategy aims to replace physical products and services with virtual ones and remote delivery. Disclosed practices include the use of BIM based on intelligent digital twin models and electronic document management.

The *Exchange* strategy focuses on replacing outdated technologies with new ones, including environmentally friendly products and materials. Practices include the use of low-emission and eco-friendly materials such as wood or photocatalytic concrete.

In the next stage of the study, the applied practices were related to 10R-principles (Ocicka et al., 2022). The principle of *refuse* is based on rejecting materials and products, although when they are necessary, it recommends using more environmentally friendly options. The principle of *rethink* is based on increasing product usage and the sharing economy strategy. The principle of *reduce* focuses on decreasing resource demand and extending their usability over time. The principle of *reuse* involves reusing materials, products, and components in good technical condition for the same functions. The principles of *repair*, *refurbish*, and *remanufacture* can be related to disclosed practices regarding the revitalization and renovation of buildings. The principle of *repurpose* offers significant potential in the CE, especially in the development of industrial symbiosis (Sgambaro et al., 2024). In circular construction, cooperation between industries can present an opportunity to create new building materials (e.g., SCALIT material, www1).

The ESRS E5 standard refers to the 9Rs principles (Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle). Thus, it does not

refer to the *remine* and *recover* principles, which are the least preferred in the CE. The principle of *remine* concerns the use of materials and products after the landfill phase, while *recover* is based on recovering energy from waste that is not suitable for recycling through incineration. The disclosed practices also do not align with the principles of *remine* and *recover*, which is considered appropriate. However, they do align with the other circular principles of the 10Rs.

In summary, the disclosed circular practices only partially align with circular design principles, the ReSOLVE model, and the 10Rs principles. Circular practices are rarely found in ESG documents for companies in the WIG real estate and construction indices, likely due to limited adoption. This highlights the need for both private and public sectors to develop better practices, knowledge, and technologies to promote circular construction. Emphasizing economic and social benefits, in addition to environmental ones, may be key to increasing adoption in the real estate market (Wuni, 2022).

4. Discussion

Non-financial disclosures related to ESG aspects are valuable resources for all stakeholders in the real estate sector (Shaheera Banu & Vimala, 2024). ESRS E5 standardizes reporting on CE practices while also requiring companies, including those in the real estate sector, to disclose information related to significant resource consumption and waste production. However, support is needed in designing policies, setting goals, implementing actions and solutions, and measuring the expected outcomes for real estate market stakeholders.

It should be noted that the EU introduced the NFRD (Non-Financial Reporting Directive, 2014/95/EU) to require non-financial reporting from companies with more than 500 employees, aiming to improve transparency regarding their impact on the environment, society, and the economy. However, the lack of standardization in reporting led to significant flexibility for companies in preparing their reports. In response to the weaknesses of the directive, the European Union introduced the new CSRD, which established mandatory reporting standards (ESRS) and expanded its scope to include more companies. Starting in 2025, it will apply to large companies meeting two of three criteria: employment of more than 250 employees, net revenues exceeding 40 million EUR, total assets exceeding 20 million EUR. From 2026, SMEs listed on stock exchanges will also be covered (www2). This means that we are currently at a stage of

significant changes in reporting, presenting an opportunity for increased corporate engagement in implementing circular and sustainable solutions. Studies have shown that previous reports prepared by companies highlighted the need for standardization due to their poor quality. The harmonization of reporting requirements not only organizes the disclosed information but also stimulates the growth of ESG actions taken by companies.

The analysis of ESG strategies and reports from companies listed in the WIG-Real Estate and WIG-Construction indices revealed a diversity of approaches to circular activities and information disclosure. In the environmental domain, all studied companies aim to reduce greenhouse gas emissions, as confirmed by its prominence in ESG reporting (KPM, 2024). The development of a CE contributes to the reduction of greenhouse gas emissions and the achievement of SDG (Sustainable Development Goals) targets (Almusaed et al., 2024; Cudečka-Puriņa et al., 2022).

The reduction of greenhouse gas emissions is shaped by EU policies aimed at developing a low-emission economy across all sectors, including construction (European Union, 2024). In real estate investments, achieving climate neutrality relies on, among other things, reducing energy demand through passive building solutions and renewable energy sources. These factors simultaneously enhance the attractiveness of investments and translate into financial benefits for buyers and tenants (Scherz et al., 2023; Chen et al., 2024). Reducing greenhouse gas emissions in terms of targets and thresholds is supported by EU policies and Member States' regulations. As a result, systematic and coherent guidelines translate into improved quality of disclosed information and implemented solutions. Standardized and mandatory emissions in reporting ensures consistent frameworks for calculating CO₂ emissions (Protocol, 2011).

In the CE, there is still a lack of regulations and policies to support reporting (Munaro & Tavares, 2023). One of the barriers to the development of circular construction is precisely the absence of appropriate legal regulations (Ghisellini et al., 2018; Campbell-Johnston et al., 2019). The introduction of clear regulations and mandatory thresholds would allow for their inclusion in reporting, including the establishment of SMART goals. When there are no clear guidelines, companies can set voluntary thresholds, which may vary. While voluntary thresholds set by real estate sector companies can fill the gap in the absence of

specific mandatory thresholds, they may also differentiate companies in terms of sustainable practices. This can lead to positive assessments from stakeholders, such as investors, rating agencies, and consumers (Shaheera Banu & Vimala, 2024).

The development of the CE should not be viewed solely as an ESG obligation for real estate companies. It is a natural progression from a linear to a circular economy across all industries (Vogiantzi & Tserpes, 2023). Public sector support is crucial for advancing the CE, positively impacting its outcomes and benefits for all stakeholders (de Melo et al., 2022; Shah & Rezai, 2023). Creating appropriate economic conditions (costs, incentives for companies, preferential loans), technological conditions (technology supply and availability), social conditions (ecological awareness, attractiveness of circular buildings), and institutional conditions is essential (Ghisellini et al., 2018; Campbell-Johnston et al., 2019). Overcoming barriers and enhancing success factors stimulate both the demand and supply of circular solutions and buildings. Additionally, broad-based education plays a significant role in the development of the CE (Kirchherr & Piscicelli, 2019; Renfors, 2024), as a lack of knowledge and awareness of solutions and benefits will limit its development.

Circular practices disclosed in the real estate sector are diverse, yet the opportunities and directions for their application in buildings and construction are significantly greater (Croxford et al., 2018; Nußholz et al., 2023; Hamida et al., 2025). Circular construction offers high potential in the revitalization and renovation of buildings (De Silva et al., 2023; Sáez-de-Guinoa et al., 2022). Modular and prefabricated technologies exhibit innovative potential for circularity (Minunno et al., 2018; Machado & Morioka 2021; Zairul, 2021; Garusinghe et al., 2023).

A key trend in construction is the development of low-emission and eco-friendly materials, including the use of Cross Laminated Timber (Ahn et al., 2022; Ramakrishna & Jose, 2022). Meanwhile, the construction of wooden buildings, including high-rise structures, is increasing (Orta Rial et al., 2020; Wiegand & Ramage, 2022). Modern technologies, including 3D building printing (Fonseca & Matos, 2023), drones (Choi et al., 2023), BIM (Charef, 2022), and the Internet of Things (Giovanardi et al., 2023) offer significant potential for the CE. The development of circular construction is also being driven by BREEAM (Building Research establishment Environmental Assessment Methodology) and LEED (Leadership in Energy and

Environmental Design) certification (Wong et al., 2024; Eissa & El-adaway, 2024). Finally, the concept of the 15-minute city, which supports resource savings by promoting walking through the strategic location of buildings with good access to public transport, commerce, services, social infrastructure, and green spaces, should also be highlighted (Abdelfattah et al., 2022).

In summary, there are numerous strategies that real estate companies can use to develop and integrate circular solutions into their operations. Nonetheless, it remains essential to promote the adoption of circular solutions in construction and to support these efforts through legal regulations. Implementing and accurately measuring the results of these solutions will improve information and reporting quality.

5. Limitations, future research and practice

The research is not without its limitations. The study covered companies from the WIG-real estate and WIG-construction indices, ultimately focusing on ESG information from only 20 entities. However, given the limited number of reports and disclosures available, the sample size is satisfactory; thus, the analysis of reports and strategies allowed us to formulate key conclusions and recommendations. The research highlighted the needs and limitations of currently disclosed information. Thus, future studies should include real estate entities required to report in 2025, and 2026. A comprehensive analysis of reporting would help define detailed guidelines and assess the maturity of CE practices within companies.

Future research should focus on identifying factors that could accelerate the development of circular construction investments. It would involve a holistic examination of best practices in the real estate market and consider the success factors for initiating and implementing investments. Key factors may include critical relationships between stakeholders, developed policies, existing financial and legal instruments, as well as economic and social aspects. Understanding the drivers of previous best practices will help pave the way for successful new circular construction investments.

6. Conclusions

Reporting in the real estate sector is varied in terms of the quantity and quality of information on the circular economy. There is a noticeable general and narrow approach to disclosing information in ESG reports and strategies, with policies, goals, thresholds, actions, solutions, and measurements requiring greater detail and transparency. Thus, there is a significant need for

support in reporting, including defining SMART goals and mandatory thresholds.

The research results identified four main areas related to disclosed circular practices: Organization, Stakeholders, Construction Investment, and Construction Process. The number of circular practices presented in ESG reports is currently low, most often relating to the use of eco-friendly and low-emission materials, sustainable stakeholder education, and sustainable supply chains. All practices narrowly align with circular building design principles, the ReSOLVE model, and, to a large extent, the 10Rs principles.

There is considerable potential for real estate companies to implement circular practices, as there is a growing demand for more responsible and circular approaches. Investors, developers, and construction companies, which previously had limited sustainability initiatives, now face the challenge and opportunity to develop new strategies and directions, ultimately enhancing the attractiveness and competitiveness of their products and services.

The development of ESG and non-financial reporting according to ESRS E5 serves as a regulatory impetus for the development of the CE. This stimulates the real estate sector to seek and implement circular solutions. The demand driven by companies should generally increase the supply of circular solutions. However, the responsibility for advancing circular buildings cannot solely fall on private entities, developers, investors, and construction companies. Therefore, it is essential to engage the public sector, both governmental and local, to stimulate the development of the CE across all industries. This will enable better synergy of actions, solutions, and the development of industrial symbiosis. As a result, it will be possible to develop circular construction, promote sustainable urban and regional development, and enhance the quality and transparency of reporting and responsible actions by companies in the real estate market.

References

- Abdelfattah, L., Deponte, D., & Fossa, G. (2022). The 15-minute city: Interpreting the model to bring out urban resiliencies. *Transportation Research Procedia*, 60, 330–337. <https://doi.org/10.1016/j.trpro.2021.12.043>
- Ahn, N., Dodoo, A., Riggio, M., Muszynski, L., Schimleck, L., & Puettmann, M. (2022). Circular economy in mass timber construction: State-of-the-art, gaps and pressing research needs. *Journal of Building Engineering*, 53, 104562. <https://doi.org/10.1016/j.jobe.2022.104562>
- Al-Ashmori, Y. Y., Othman, I., Rahmawati, Y., Amran, Y. M., Sabah, S. A., Rafindadi, A. D. U., & Mikić, M. (2020). BIM benefits and its influence on the BIM implementation in Malaysia. *Ain Shams*

- Engineering Journal, 11(4), 1013–1019. <https://doi.org/10.1016/j.asej.2020.02.002>
- Alhola, K., Ryding, S. O., Salmenperä, H., & Busch, N. J. (2019). Exploiting the potential of public procurement: Opportunities for circular economy. *Journal of Industrial Ecology*, 23(1), 96–109. <https://doi.org/10.1111/jiec.12770>
- Almusaed, A., Yitmen, I., Myhren, J. A., & Almssad, A. (2024). Assessing the impact of recycled building materials on environmental sustainability and energy efficiency: A comprehensive framework for reducing greenhouse gas emissions. *Building (London)*, 14(6), 1566. <https://doi.org/10.3390/buildings14061566>
- Basbagill, J., Flager, F., Lepech, M., & Fischer, M. (2013). Application of life-cycle assessment to early stage building design for reduced embodied environmental impacts. *Building and Environment*, 60, 81–92. <https://doi.org/10.1016/j.buildenv.2012.11.009>
- Benchmark, G. P. W. (2024). <https://gpwbenchmark.pl/en-opisy-indeksow> 08.08.2024
- Campbell-Johnston, K., Cate, J., Elfering-Petrovic, M., & Gupta, J. (2019). City level circular transitions: Barriers and limits in Amsterdam, Utrecht and The Hague. *Journal of Cleaner Production*, 235, 1232–1239. <https://doi.org/10.1016/j.jclepro.2019.06.106>
- Charef, R. (2022). The use of Building Information Modelling in the circular economy context: Several models and a new dimension of BIM (8D). *Cleaner Engineering and Technology*, 7(2022), 100414. <https://doi.org/10.1016/j.clet.2022.100414>
- Chen, L., Hu, Y., Wang, R., Li, X., Chen, Z., Hua, J., Osman, A. I., Farghali, M., Huang, L., Li, J., Dong, L., Rooney, D. W., & Yap, P. S. (2024). Green building practices to integrate renewable energy in the construction sector: A review. *Environmental Chemistry Letters*, 22(2), 751–784. <https://doi.org/10.1007/s10311-023-01675-2>
- Choi, H. W., Kim, H. J., Kim, S. K., & Na, W. S. (2023). An overview of drone applications in the construction industry. *Drones (Basel)*, 7(8), 515. <https://doi.org/10.3390/drones7080515>
- Croxford, B., Mendoza, R., Portal, S., & Rovas, D. (2018). Circular options for building services: Case Studies; 22 Gordon Street, Arup Circular Building. UCL Institute for Environmental Design and Engineering.
- Cruz Rios, F., Grau, D., & Bilec, M. (2021). Barriers and enablers to circular building design in the US: An empirical study. *Journal of Construction Engineering and Management*, 147(10), 04021117. [https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0002109](https://doi.org/10.1061/(ASCE)CO.1943-7862.0002109)
- Cudečka-Puriņa, N., Atstāja, D., Koval, V., Purviņš, M., Nesenenko, P., & Tkach, O. (2022). Achievement of sustainable development goals through the implementation of circular economy and developing regional cooperation. *Energies*, 15(11), 4072. <https://doi.org/10.3390/en15114072>
- de Melo, T. A., de Oliveira, M. A., de Sousa, S. R., Vieira, R. K., & Amaral, T. S. (2022). Circular economy public policies: A systematic literature review. *Procedia Computer Science*, 204, 652–662. <https://doi.org/10.1016/j.procs.2022.08.079>
- De Silva, S., Samarakoon, S. S. M., & Haq, M. A. A. (2023). Use of circular economy practices during the renovation of old buildings in developing countries. *Sustainable Futures : An Applied Journal of Technology, Environment and Society*, 6, 100135. <https://doi.org/10.1016/j.sfr.2023.100135>
- Eissa, R., & El-adaway, I. H. (2024). Circular Economy Integration in LEED: A decade of materials and resources credit achievement patterns. *Journal of Management Engineering*, 40(6), 04024047. <https://doi.org/10.1061/JMENEA.MEENG-6100>
- Engel, A., Browning, T. R., & Reich, Y. (2017). Designing products for adaptability: Insights from four industrial cases. *Decision Sciences*, 48(5), 875–917. <https://doi.org/10.1111/dec.12254>
- European Commission. (2020). A new Circular Economy Action Plan For a cleaner and more competitive Europe. COM/2020/98 final.
- European Commission. (2024). Buildings and construction. https://single-market-economy.ec.europa.eu/industry/sustainability/buildings-and-construction_en?prefLang=pl (22.07.2024)
- European Commission. (2024). Circular construction and materials for a sustainable building sector. [https://build-up.ec.europa.eu/en/resources-and-tools/articles/circular-construction-and-materials-sustainable-building-sector\(09.12.2024\)EuropeanUnion.2008.Directive2008/98/EC,https://eur-lex.europa.eu/EN/legal-content/glossary/waste-hierarchy.html](https://build-up.ec.europa.eu/en/resources-and-tools/articles/circular-construction-and-materials-sustainable-building-sector(09.12.2024)EuropeanUnion.2008.Directive2008/98/EC,https://eur-lex.europa.eu/EN/legal-content/glossary/waste-hierarchy.html)
- European Union. (2024). Energy Performance of Buildings Directive. EU/2024/1275
- Fonseca, M., & Matos, A. M. (2023). 3D construction printing standing for sustainability and circularity: Material-level opportunities. *Materials (Basel)*, 16(6), 2458. <https://doi.org/10.3390/ma16062458>
- Garusinghe, G. D. A. U., Perera, B. A. K. S., & Weerapperuma, U. S. (2023). Integrating circular economy principles in modular construction to enhance sustainability. *Sustainability (Basel)*, 15(15), 11730. <https://doi.org/10.3390/su151511730>
- Gemeente Amsterdam. (2020). Amsterdam Circular 2020-2025 Strategy.
- Gervasio, H., & Dimova, S. (2018). Model for life cycle assessment (LCA) of buildings. Publications Office of the European Union.
- Ghisellini, P., Ji, X., Liu, G., & Ulgiati, S. (2018). Evaluating the transition towards cleaner production in the construction and demolition sector of China: A review. *Journal of Cleaner Production*, 195, 418–434. <https://doi.org/10.1016/j.jclepro.2018.05.084>
- Giovanardi, M., Konstantinou, T., Pollo, R., & Klein, T. (2023). Internet of Things for building façade traceability: A theoretical framework to enable circular economy through life-cycle information flows. *Journal of Cleaner Production*, 382, 135261. <https://doi.org/10.1016/j.jclepro.2022.135261>
- Gu, P., Xue, D., & Nee, A. Y. C. (2009). Adaptable design: Concepts, methods, and applications. *Proceedings of the Institution of Mechanical Engineers. Part B, Journal of Engineering Manufacture*, 223(11), 1367–1387. <https://doi.org/10.1243/09544054JEM1387>
- Hamida, M. B., Remøy, H., Gruis, V., & Jylhä, T. (2025). Circular building adaptability in adaptive reuse: multiple case studies in the Netherlands. *J. Eng. Des. Technol.* (ahead-of-print). <https://doi.org/10.1108/JEDT-08-2022-0428>
- Jonker, J., Faber, N., & Haaker, T. (2022). Quick Scan Circular Business Models: inspiration for organising value retention in loops.
- Kirchherr, J., & Piscicelli, L. (2019). Towards an education for the circular economy (ECE): Five teaching principles and a case study. *Resources, Conservation and Recycling*, 150, 104406. <https://doi.org/10.1016/j.resconrec.2019.104406>
- Machado, N., & Morioka, S. N. (2021). Contributions of modularity to the circular economy: A systematic review of literature. *Journal of Building Engineering*, 44, 103322. <https://doi.org/10.1016/j.job.2021.103322>
- Mayor of London. (2022). London Plan Guidance, Circular Economy Statements. London https://www.london.gov.uk/sites/default/files/circular_economy_statements_lpg_0.pdf 14.06.2023
- Minunno, R., O’Grady, T., Morrison, G. M., Gruner, R. L., & Colling, M. (2018). Strategies for applying the circular economy to prefabricated buildings. *Buildings*, 8(9), 125. <https://doi.org/10.3390/buildings8090125>

- Munaro, M. R., & Tavares, S. F. (2023). A review on barriers, drivers, and stakeholders towards the circular economy: The construction sector perspective. *Clean. Resp. Consum.*, 8, 100107. <https://doi.org/10.1016/j.clrc.2023.100107>
- Nußholz, J., Çetin, S., Eberhardt, L., De Wolf, C., & Bocken, N. (2023). From circular strategies to actions: 65 European circular building cases and their decarbonisation potential. *Resources, Conservation & Recycling Advances*, 17, 200130. <https://doi.org/10.1016/j.rcradv.2023.200130>
- Ocicka, B., Wieteska, G., & Wieteska-Rosiak, B. (2022). Toward circular product lifecycle management through Industry 4.0 technologies. In *Handbook of Sustainable Development Through Green Engineering and Technology* (pp. 69–106). CRC Press. <https://doi.org/10.1201/9781003127819-5>
- Orta, B., Martínez-Gayá, J. E., Cervera, J., & Aira, J. R. (2020). Madera en altura, estado del arte. *Informes De La Construcción*, 72(558), 346. <https://doi.org/10.3989/ic.71578>
- Protocol, G. G. (2011). Greenhouse gas protocol. Sector toolsets for iron and steel-guidance document, 1-12. <https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf>
- Ramakrishna, S., & Jose, R. (2022). Principles of materials circular economy. *Matter*, 5(12), 4097–4099. <https://doi.org/10.1016/j.matt.2022.11.009>
- Renfors, S. M. (2024). Education for the circular economy in higher education: An overview of the current state. *International Journal of Sustainability in Higher Education*, 25(9), 111–127. <https://doi.org/10.1108/IJSHE-07-2023-0270>
- Rotterdam. (2024). Rotterdam roofscape, different types of sustainable roofs. https://static1.squarespace.com/static/5f082078d610926644d22e00/t/621e3b2a1ee23c373149cac0/1646148404157/URBANISTE_N_Rotterdam_Rooftop_Potential_EN.pdf, (25.07.2024)
- Sáez-de-Guinoa, A., Zambrana-Vasquez, D., Fernández, V., & Bartolomé, C. (2022). Circular economy in the European construction sector: A review of strategies for implementation in building renovation. *Energies*, 15(13), 4747. <https://doi.org/10.3390/en15134747>
- Scherz, M., Hoxha, E., Maierhofer, D., Kreiner, H., & Passer, A. (2023). Strategies to improve building environmental and economic performance: An exploratory study on 37 residential building scenarios. *The International Journal of Life Cycle Assessment*, 28(7), 828–842. <https://doi.org/10.1007/s11367-022-02073-6>
- Schulze, G. (2016). Growth within: A circular economy vision for a competitive Europe. *Ellen MacArthur Foundation and the McKinsey Center for Business and Environment*, 1-22. *Ellen MacArthur Foundation, Mapping Circular Economy Indicators to EU Reporting Requirements*, <https://www.ellenmacarthurfoundation.org/circulytics-esrs> (19.07.2024)
- Sgambaro, L., Chiaroni, D., Lettieri, E., & Paolone, F. (2024). Exploring industrial symbiosis for circular economy: Investigating and comparing the anatomy and development strategies in Italy. *Management Decision*, Ahead-of-print. <https://doi.org/10.1108/MD-04-2023-0658>
- Shah, M. U., & Rezai, R. (2023). Public-sector participation in the circular economy: A stakeholder relationship analysis of economic and social factors of the recycling system. *Journal of Cleaner Production*, 400, 136700. <https://doi.org/10.1016/j.jclepro.2023.136700>
- Shaheera Banu, Z., & Vimala, V. (2024). Integration of ESG principles: An initiative for transformation from linear economy to circular economy. *Theoretical and Applied Economics, Asociatia Generala a Economistilor din Romania / Editura Economica*, 0(2(639), S), 183-196.
- Soyka, P. A., & Feldman, I. R. (2022). Climate change adaptation – ESG investing’s most important, missing piece? *Special Report*. https://www.adaptationleader.org/wp-content/uploads/2022/09/Climate_Change_Adaptation_ESG_Investings_Most_Important_Missing_Piece.pdf
- United Nations Office for Disaster Risk Reduction. *Standard Chartered Bank, KPMG International*. (2024). Guide for adaptation and resilience finance, <https://www.undrr.org/publication/guide-adaptation-and-resilience-finance>
- Vogiantzi, C., & Tserpes, K. (2023). On the definition, assessment, and enhancement of circular economy across various industrial sectors: A literature review and recent findings. *Sustainability (Basel)*, 15(23), 16532. <https://doi.org/10.3390/su152316532>
- Wiegand, E., & Ramage, M. (2022). The impact of policy instruments on the first generation of Tall Wood Buildings. *Building Research and Information*, 50(3), 255–275. <https://doi.org/10.1080/09613218.2021.1905501>
- Wong, D. H., Zhang, C., Di Maio, F., & Hu, M. (2024). Potential of BREEAM-C to support building circularity assessment: Insights from case study and expert interview. *Journal of Cleaner Production*, 442, 140836. <https://doi.org/10.1016/j.jclepro.2024.140836>
- Wuni, I. Y. (2022). Burden of proof beyond the triple bottom line: Mapping the benefits of circular construction. *Sustainable Production and Consumption*, 34, 528–540. <https://doi.org/10.1016/j.spc.2022.10.006>
- www 1. <https://materialdistrict.com/material/scalite/> 26.07.2024
- www 2. https://www.csrinfo.org/wp-content/uploads/2024/02/20240206_Material_do_pobrania_CSR_D.pdf 06.12.2024
- Zairul, M. (2021). The recent trends on prefabricated buildings with circular economy (CE) approach. *Cleaner Engineering and Technology*, 4, 100239. <https://doi.org/10.1016/j.clet.2021.100239>
- Zimmann, R., O'Brien, H., Hargrave, J., & Morrell, M. (2016). Circular economy in the built environment. *ARUP*.

Appendix 1

Reporting directions and measurement proposals for ESRS E5 areas.

Area ESRS E5	Real Estate Sector	Reporting Directions in the Real Estate Sector	Examples of Qualitative (Y/N) or Quantitative Measurement
E5-1	Policies related to resource use and circular economy	• Circular company policy, including in relation to employees, suppliers, and subcontractors • Sustainable procurement policy • ReSOLVE model • Circular solutions in relation to the 10 Rs principles	• Does your company policy include a circular approach when selecting suppliers and subcontractors? • Do you have an internal sustainable procurement policy?

		- Implemented circular business models - Certificates obtained (ISO 14001, ISO 9001)	- Does your company policy refer to the ReSOLVE model/10R principles/circular building design principles? - Do you have ISO 14001/9001 certification?
E5-2	Actions and resources related to resource use and circular economy	- Stakeholder training on the circular economy - Revitalization and renovation of city and municipal assets - Application of the 15-minute city strategy and combating urban sprawl - Development of mixed-use spaces - Use of modern technologies (e.g., BIM, Internet of Things, BMS, drones) - Development of sustainable transportation (sustainable mobility, eco-friendly transportation) - Multicriteria certification (BREEAM, LEED) - Circular building design principles - Use of low-emission and eco-friendly materials, including certified, with EPD declarations, high quality and durability, from recycling or recyclable - Development of prefabricated, modular, and wooden investments - Reference actions to the 10R principles (tabular format) - Selection of a responsible waste management company	- Do you train employees/suppliers/business partners in circular economy practices? - Do you support building revitalization/renovation processes? - Are you developing a 15-minute city strategy? - Do you use modern technologies? - Are you advancing certified construction? - Do you apply circular principles in the design phase? - Do you use low-emission materials? - Do you use prefabricated/modular/wooden technologies? - Which of the 10Rs solutions do you incorporate into investments? - Do you responsibly select waste management companies?
E5-3	Targets related to resource use and circular economy	- SMART goals related to mandatory national and EU thresholds for short-term, medium-term (2030), and long-term (2050) - Goals related to voluntary thresholds - Goals related to the waste management hierarchy	- Do you have circular economy-related targets? Measurement example (Ellen McArthur Foundation 2024): No targets/Targets are being developed either for a relevant concept (e.g. materials circulation) or circular economy explicitly/Targets have been developed on the organizational level, but are not SMART targets/SMART targets have been developed on the organizational level/SMART targets have been developed on the organizational level and further down on a sub-unit/Innovation/Corporate strategy/Corporate finance/ Supply chain management (incl. procurement)/Production (plant or process) management/ Sales and marketing/Circular economy/sustainability function or equivalent - Are targets related to mandatory/voluntary thresholds? - Are SMART targets related to the waste management hierarchy?
E5-4	Resource inflows	- Use of renewable materials (e.g., timber, glued laminated timber, OSB board, formwork plywood) - Use of non-renewable materials (e.g., concrete, reinforcement, bricks, concrete blocks, silicate blocks, ceramic blocks) - Area of low ecological value land used for investments	- Share of renewable materials used in construction (percentage of total materials) - Share of recycled materials used in construction (percentage of total materials) - Share of materials with EPD declarations (percentage of total materials) - Share of FSC/PFSC certified wood materials (percentage of total wooden materials) - Share of reused materials (percentage of total materials)

			• Share of low ecological value/contaminated land used for investment (percentage of total land for investment) • Share of investment land in urban areas (percentage of total investment land) • Percentage of purchased land that is previously urbanized • Consumption of Cross Laminated Timber (m³) • Consumption of formwork plywood (m³) • Consumption of OSB boards (m³) • Consumption of concrete (m³) • Consumption of reinforcement (tons) • Consumption of silicate blocks (units) • Share of energy from renewable sources in construction (percentage of total energy) • Share of circular water in construction (percentage of total water)
E5-5	Resource outflows	• Number of buildings constructed according to circular principles • Mass of non-hazardous waste generated (e.g., brick rubble, insulation materials, mixed materials, plastics, packaging, wood) • Mass of hazardous waste generated	• Percentage of investments that incorporate circular design principles out of total investments by type • Percentage of waste sorted on construction sites out of total waste • Percentage of waste sent for recycling out of total waste • Percentage of waste sent for reuse • Total amount of waste generated (tons) • Amount of waste generated by type (tons)
E5-6	Potential financial effects from resource use and circular economy-related impacts, risks, and opportunities	• Expected Financial Effects Related to Resource Use and the Circular Economy • Risks and Opportunities Related to Resources and Transitioning to a Circular Economy	• Do you have specific financial implications? • Do you have specific risks and opportunities?

Source: Own study based on ESG analysis of WIG-real estate and WIG-construction index