

Article

Cultivating Sustainable Construction: Stakeholder Insights Driving Circular Economy Innovation for Inclusive Resource Equity

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Abstract: Due to its intricate production processes, complex supply chains, and industry-specific characteristics, the construction industry faces unique challenges in adopting circular economy (CE) principles that promote resource equity. To address this issue, this study aims to delve into identifying stakeholders' opinions and perceptions regarding key CE strategies across different stages of the building life cycle (BLC). Both European and non-European stakeholders within the "CircularB" COST Action network and beyond participated in this research. Three methods were employed to assess stakeholders' opinions: an online survey, a structured survey with a semi-guided workshop, and creative thinking round table discussions. Natural language processing (NLP), specifically topic modelling and sentiment analysis, was used to analyse the data collected from the online survey, which gathered text-based opinions from 209 participants on the cost-benefit aspects of circularity strategies. The structured survey, which collected data from 43 workshop participants, evaluated the perceived importance of CE strategies across various BLC phases and assessed the adoption of selected CE strategies in current or past projects. Finally, the Six Thinking Hats® activity, employed in the round table discussions, generated ideas from 25 professionals regarding the broader implementation challenges and opportunities of CE in construction. The research findings highlight the need to bridge the gap between theory and practice by fostering active industry stakeholder involvement in the transition to a CE model. The analyses of the collected stakeholder opinions through the three activities contribute to proactive and collaborative efforts aimed at advancing resource equity in the construction sector and promoting just and inclusive resource use. In summary, this research offers a comprehensive understanding of stakeholders' opinions on CE strategies and provides guidance for the development of targeted policies and strategies to accelerate the integration of CE principles in the construction industry.

Keywords: stakeholder perception; sustainability; industry analysis; NLP; cost-benefit analysis; circular economy

1. Introduction

The construction industry is known to be conservative. Therefore, it is essential to acknowledge and consider the opinions and perspectives of stakeholders, especially



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when contemplating changes. Despite the continuous evolution of the industry with new technologies, materials, and processes, there is resistance to the adoption of sustainable construction principles [1]. The sector must actively embrace change while simultaneously addressing the evolving needs of stakeholders in a developing world, including considerations related to material use [2], environmental needs [3], energy utilisation [4], and sustainability needs [5].

Collaborative efforts to achieve fair resource utilisation are crucial. Thus, the success of any business model hinges on the engagement of key stakeholder groups [6,7], such as contractors, material providers, designers, engineers, service providers, clients, users, the local community, academicians, and government agencies and administrations. Considering their viewpoints and perceptions is imperative for identifying and mitigating potential risks and challenges within the sector. Additionally, the incorporation of stakeholders' perspectives aids decision-makers in prioritising strategic activities, directing attention towards overcoming barriers, and implementing strategies for new business models such as circular economy (CE) applications [8].

Recent advancements in the construction sector are creating a paradigm shift driven by key development concepts, such as sustainability, clean production, and carbon neutrality. These influential metaphors have profoundly influenced the sector, catalysing the emergence of innovative construction paradigms, notably sustainable, green, healthy, energy-zero, and passive houses. CE stands out as a prevalent and rapidly embraced metaphor in contemporary discourse. Active engagement of stakeholders in implementing CE practices is critical to effectively discern their needs and expectations. Notably, stakeholders' need for more awareness of the significance of CE, coupled with limited interest and motivation in embracing circularity, emerges as a pivotal barrier [9,10]. The construction sector plays a significant role in global resource consumption and waste generation. While recent research highlights the potential of sustainable business models such as those based on CE principles to address these challenges [11], their successful implementation requires constant collaboration among stakeholders [12]. However, current literature suggests that knowledge sharing and collaborative approaches for CE implementation within the construction sector are often limited [11–14]. This lack of collaboration can hinder the development and widespread adoption of CE practices. Addressing these barriers demands concerted efforts to promote open participation and dialogue among stakeholders. By doing so, the construction industry can significantly augment its transition towards embracing new business models, promoting sustainability and adopting CE practices.

Recent literature suggests that sustainable business models can be cultivated through various methods, including surveys and workshop designs. Typically, these methods are employed subsequent to a thorough literature review to comprehensively understand the subject [7]. In addition, engaging stakeholders in developing creative ideas is crucial for the success of a business model. Creative thinking tools such as brainstorming or the Six Thinking Hats® technique prove instrumental in generating ideas and perspectives that need to be observed by literature analysis [15]. The Six Thinking Hats® tool, in particular, stands out as a versatile and effective method to encourage individuals to approach a problem or idea from different angles, thereby promoting creativity and innovation.

Adopting CE principles in the construction industry presents distinctive challenges due to its intricate production processes, complex supply chains, and industry-specific characteristics. Recognising that stakeholders' perceptions constitute a main barrier to the adoption of the concept in the sector, identifying stakeholders' knowledge, attitudes, and perceptions regarding the adoption of key CE strategies at different stages of the building life cycle (BLC) emerges as the pivotal factor for achieving the targeted success.

This study aims to identify the participating stakeholders' knowledge, opinions, and perceptions of leading CE strategies within different BLC stages. Three instruments were used to handle the given research questions: (1) an artificial intelligence (AI)-powered natural language processing (NLP) analysis of the opinions collected from the CircularB COST Action CA21103 network through an online survey; (2) statistical assessments of the

perceptions of European-based stakeholders who participated in a CircularB workshop entitled “Creating a Roadmap towards Circularity in the Built Environment—State-of-the-Art”, focusing on the importance and adoption rates of CE implementation strategies; and, (3) performing and analysing critical and creative thinking round table discussions during the CircularB Stakeholders’ Day on 15 September 2023 in collaboration with the Horizon project RECONMATIC by using the Six Thinking Hats® approach and the Mentimeter tool, complementing the stakeholder engagement activities.

2. Materials and Methods

The study employed a three-stage methodology to gather and analyse stakeholders’ opinions, incorporating various tools and perspectives on different CE-related topics. These stages complemented each other to enhance the understanding of key issues (i.e., costs and benefits, importance and adoption levels, and challenges and opportunities) associated with the implementation of CE practices in the construction sector. The activities included collecting large text-based opinion data through an online survey, conducting semi-guided structured workshop activities with various stakeholders, and facilitating a specific and focused creative thinking session using round table discussions with active stakeholder participation. The methodology, which involved the selection and separation of stakeholder activities along with the tools and methods employed, suggests a novel approach, which is summarised in Figure 1. The breakdown of stakeholder activities, tools, and methods is presented in Figure 1. Further details on the data collection instruments, the scope of each method and activity, and their methodological aspects are elaborated in the following subsections.

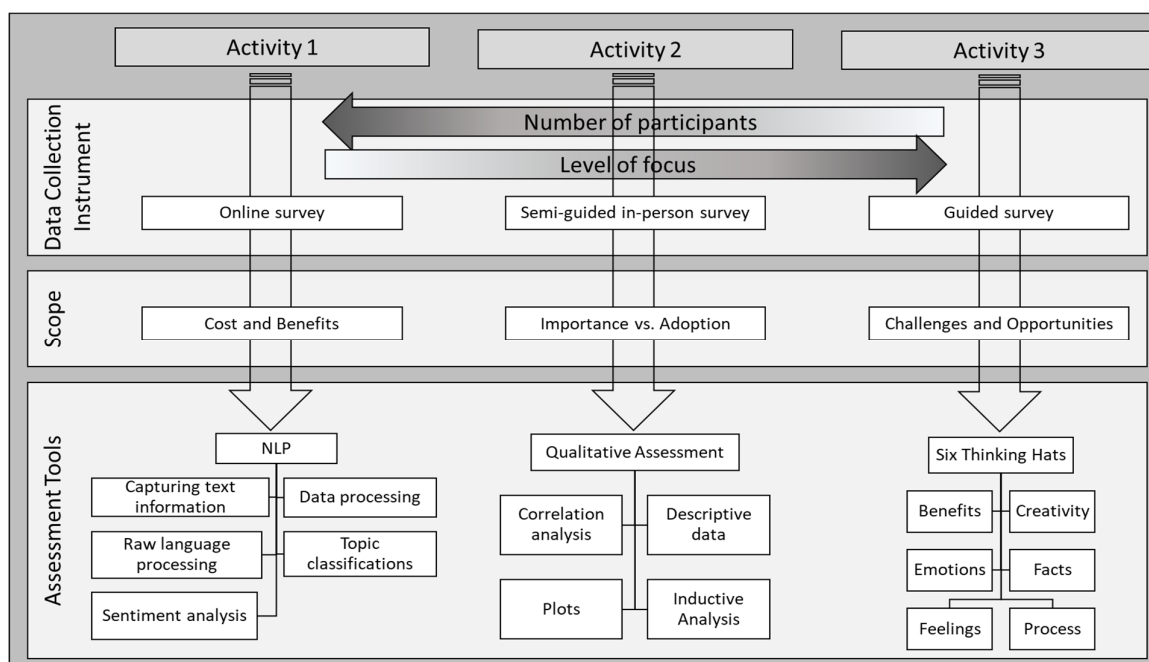


Figure 1. Study method, tools, and instruments.

2.1. CircularB COST Action CA21103 and Its Series of Workshops and Activities

The COST Action CA21103, “Implementation of Circular Economy in the Built Environment” (CircularB), is a networking initiative dedicated to research coordination and capacity building. Commencing in October 2022, CircularB is slated to extend over four years. Its overarching goal is to formulate a methodology for the development of a comprehensive circularity framework to ensure its inclusive application and assessment in new and existing buildings. This framework aims to support decision-making processes for all stakeholders in the value chain while also evaluating the implementation status of the European

Circular Economy Action Plan (CEAP). CircularB Action (<https://circularb.eu/>, accessed on 20 November 2023) brings together a diverse network of stakeholders hailing from 40 countries with a European majority. As part of its inaugural year activities, the Action held Workshop 1 Part 2 (WS1P2), entitled “Creating a Roadmap towards Circularity in the Built Environment—State-of-the-Art”, 12–15 September 2023. Spanning four days, WS1P2 convened in Cordoba, Spain, with the primary mission of discussing the CE State-of-the-Art Report, one of the deliverables of the Action. The workshop delved into various CE-related topics within the building sector and the built environment. These encompassed strategies and techniques for promoting circularity, tools and digital instruments for implementing and monitoring circularity in buildings, circularity criteria and key performance indicators (KPIs), circular business models, and standards and legislations supporting circularity.

Additionally, discussions centred on the role of different stakeholders in fostering circular value chains and feedback systems. The final day of the workshop was designated as ‘Stakeholders’ Day’, bringing together CircularB members, industry stakeholders, and policymakers. The Stakeholders’ Day aimed to draw conclusions from the preceding three days and take a broader audience perspective. Active discussions were held to understand the diverse perceptions of circularity principles.

2.2. Survey Instruments and Data Collection Methods

2.2.1. Online Survey for Opinion Collection on the Cost-Benefit Aspects of CE Practices

In the initial phase of this study, stakeholders’ opinions were collected through an online survey conducted within the CircularB network and additional networks recommended by its members. This approach ensured a comprehensive and representative sample size for the subsequent analyses. The survey first sought to gather basic information about the respondents, including their nationality, expertise, company size, and the specific stakeholder category they represented. Participants were then requested to provide written responses detailing their opinions on the costs and benefits associated with CE practices in the construction industry. They were prompted with the question, “Please describe a case where your company/organisation/institution has implemented CE practices. Elaborate on the perceived costs and benefits for your organisation”. An online tool, the Qualtrics platform, was employed to conduct the survey, which is accessible at the following link: https://nukz.qualtrics.com/jfe/form/SV_3mZiu5qJbxLfU2 (accessed on 1 September 2023). The survey was disseminated online from 1 June 2023 to 30 August 2023.

All research enquiries were scrutinised for ethical implications by the Nazarbayev University Institutional Research Ethics Committee. The committee granted approval (716/11052023), thus confirming the ethical soundness of the research methodology.

2.2.2. Semi-Guided In-Person Survey for CE Strategies’ Importance/Adoption Assessment

A survey instrument was developed to assess stakeholders’ opinions on the importance and adoption levels of implementing CE strategies within construction projects. These strategies were carefully selected from the existing literature and categorised according to the four lifecycle stages of construction activities: Planning and Design, Construction, Operation and End-of-Life. To maintain conciseness and manageability, up to six implementation strategies were listed under each lifecycle stage, resulting in a total of nineteen items being presented and queried.

The survey designed for this study was initially distributed to CircularB members on the third day of WS1P2. Subsequently, the same survey was provided to invited stakeholders during the Stakeholders’ Day (the fourth day of WS1P2). Both groups completed the survey documents manually, which were then collected for subsequent analysis.

Prior to commencing the survey, workshop participants were given detailed instructions on the particulars of the survey and how to complete it during an in-person session on the third day of the event (WS1P2). Subsequently, all participants were instructed to complete the survey under the semi-guidance of the research authors. The questionnaire

was designed in English, the common language of the event, to ensure that all participants felt comfortable answering each question.

The questionnaire was divided into three sections, which are described below:

- Section 1 contained questions on the socio-demographic parameters of the population under study, such as experience, gender, education, and occupation.
- Section 2 listed nineteen implementation strategies and asked participants to rate their importance on a 5-point Likert scale ranging from 1—Not important at all, 2—Slightly important, 3—Neutral, 4—Important, and 5—Extremely important.
- Section 3 was designed to evaluate the same implementation strategies for their adoption levels using a similar Likert scale, presented in Section 2.

File S1 in the Supplementary Materials provides a sample of the survey.

2.2.3. Round Table Discussions Using the Six Thinking Hats® Method

A pivotal event, the First CircularB Stakeholders' Day, was held on 15 September 2023. During this event, a dynamic round table discussion took place, facilitated by the audience engagement platform "Mentimeter", which served as a guiding tool through a real-time interactive questionnaire (<https://www.mentimeter.com>, accessed on 15 October 2023). The activity was further enriched by the incorporation of the Six Thinking Hats® methodology [16,17], fostering a comprehensive exploration of the diverse perspectives arising from the responses to seven Mentimeter Questions (MQs), summarised as follows:

- (MQ1) Sector of belonging;
- (MQ2) Local policies and regulations on CE and the built environment;
- (MQ3) In your opinion, who should lead and promote the CE objectives?
- (MQ4) What initiatives related to this topic are being implemented in your city or country?—Open discussions with the Six Thinking Hats® activity;
- (MQ5) Opportunities, gaps, and barriers of the initiatives;
- (MQ6) Propose indicators—that is, new or existing ones;
- (MQ7) Conclusions and future steps.

To ensure a structured and insightful exploration, the methodology for this discussion and data collection was carefully structured and included the following key components:

1. Selection of questions: The survey questions were meticulously selected to acquire comprehensive data on the CE aspects of construction and demolition waste (CDW). These questions were designed to investigate prevailing policies, initiatives in different countries, KPIs, perceptions of the adoption process, and next steps needed to achieve CE objectives in the urban built environment.
2. Mentimeter survey integration: Mentimeter served as an interactive polling and presentation tool to guide the discussion, ensure participation, and gather real-time responses. This technology facilitated active participant engagement and provided immediate feedback to ensure an engaging and dynamic discourse.
3. Six Thinking Hats®: This methodology [16,17] was adopted to structure the discussion and promote diverse viewpoints. By assigning different "hats" to participants, they were encouraged to consider each question from six distinct perspectives: information, emotions, benefits, risks, positive judgments, creative possibilities, and a synthesis of ideas. This approach allowed for a comprehensive exploration of the responses and promoted a holistic understanding of the subject.
4. Discussion structure: The discussion was organised around three of the seven carefully curated questions, with each question serving as a focal point for discussion. The central enquiries were crafted to gather valuable insights on ongoing initiatives (MQ4), opportunities and barriers (MQ5), and key indicators (MQ6) related to the study of CE principles within the CDW sector. Following the online collection of responses (on screen), the most highly rated or most popular responses given by the participants were selected and discussed. This methodological approach required each participant

to “put on” a specific “thinking hat” that best resonated with their viewpoint before sharing their insights.

5. Data analysis: The responses obtained through Mentimeter were analysed to gain valuable insights and patterns. The Six Thinking Hats® approach also assisted in identifying nuances and contradictions in the data and enabled a deeper understanding of the complex issues around CDW aspects in the context of CE.

This methodology provided a multi-dimensional perspective on the challenges and opportunities associated with CE in CDW, aligning with our objective of gathering valuable information to advance the study in this domain.

2.3. AI-Powered NLP

The analysis of stakeholders’ opinions involved both descriptive and predictive NLP approaches using the responses from the online survey (see Section 2.2.1).

In the descriptive analysis, topic modelling was employed utilising BERT-Topic [18], an implementation of the BERT model suitable for topic modelling. First, a pre-trained MiniLM model [19] was used to extract embeddings from the stakeholders’ opinions. Subsequently, the Uniform Manifold Approximation and Projection (UMAP) algorithm [20] was used to reduce the embedding dimensionality from 384 to 15 dimensions. Finally, the Hybrid Density-Based Spatial Clustering of Applications with Noise (DBSCAN) clustering algorithm [21] was employed to combine the opinions based on their topics.

In the predictive analysis, as described in a previous paper by the authors [22], the focus was on building a model to estimate stakeholders’ sentiments based on the text of their opinions. The dataset was partitioned in a ratio of 80/10/10, with 80% for training a sentiment classification model, 10% for evaluation, and 10% for testing the model. For classification, various state-of-the-art models were trialled to determine the best-performing model architecture for this particular task. The result of these experiments was the development of the best-performing model, which was transformed into a web service for sentiment analysis (available at <https://ce-sentiment.streamlit.app/>, accessed on 20 August 2023).

3. Results and Discussion

3.1. Stakeholders’ Opinions for Cost–Benefit Analysis Using NLP—Online Survey

3.1.1. Topic Modelling

For topic modelling, the selection of the number of topics was determined through a comprehensive analysis of the collected content. Factors, such as topic similarity and the logical consistency of the words comprising each topic, were carefully considered. This approach facilitated the amalgamation and categorisation of related content under a unified topic. Figure 2 provides a visual representation of the four topics modelled and highlights the most frequently occurring words.

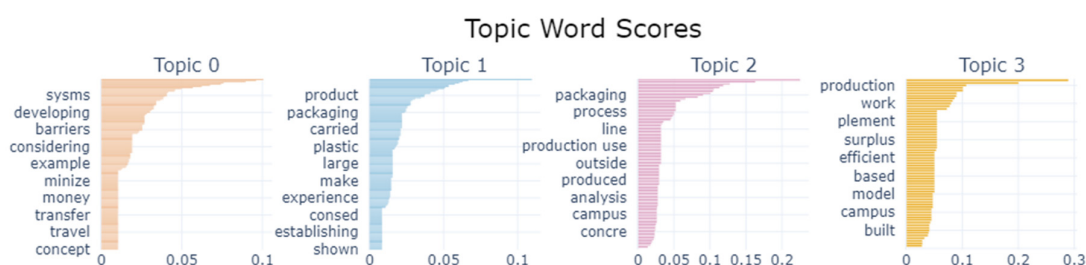


Figure 2. Word frequency bar charts for topics modelled based on collected survey data on CE in construction.

- Topic 0—Barriers—The scope of this topic delves into the examination of ‘barriers’, encompassing the study of difficulties that impede progress towards the realisation of CE. The findings underscore the recognition by stakeholders of the challenges that arise when transitioning from a linear to a circular model. It is critical to acknowledge

that these barriers are merely associated with ‘systems’ concerns—stakeholders have a prime concern regarding systemic barriers rather than operational and behavioural ones. The significance of the systemic perspective in CE development (and barriers analysis) can also be found in other academic work [23,24].

- **Topic 1—Product**—Effective alignment with sustainability goals in product design can be achieved by simplifying the disassembly process, employing standardised and interchangeable parts, and maintaining more consistent material streams [25]. Circular product design adopts a holistic approach, emphasising the preservation of product quality and functionality, progressing adaptive reuse, and developing innovative circular business strategies distinct from conventional linear frameworks [26]. The frequency bar chart underscores the significance of circular product design, considering aspects, such as ‘packaging’ and ‘plastic’ materials.
- **Topic 2—Packaging**—The word frequency plot visualises the significance of the packaging process for the development of circularity in the building sector. Consequently, the packaging process can be reconsidered to make it less waste-producing, for example, by incorporating biodegradable packaging [27]. Other scientific works also argue the importance of innovative packaging that contributes to CE development [28,29].
- **Topic 3—Production**—The frequency chart for Topic 3 shows stakeholders’ concerns about the surplus and overhaul of production, which needs to become more efficient within the framework of CE in the construction industry. Sustainable production (and consumption), as a methodology of practices diminishing waste through improved product design and the promotion of material reuse and recycling, is critical to CE, as highlighted in other studies [30–32].

3.1.2. Sentiment Analysis for Countries

Figure 3 shows the dispersion of sentiments across various countries—that is, in the countries with a response rate exceeding 15. The figure illustrates a notable prevalence of neutral sentiments across all countries, suggesting that respondents from these regions generally express neither positive nor negative views. This neutrality is likely attributed to a lack of awareness and knowledge among stakeholders about the long-term benefits of the CE concept [33–35]. Most practices are relatively new, with countable examples of best practices, and there has not yet been sufficient time to prove their efficiency and effectiveness in the long term. In contrast, the study by De Lima et al. [36] reported a prevailing number of positive sentiments, followed by neutral sentiments, while negative sentiments were minimal. However, Cody et al. [37] claim that there is a larger number of negative sentiments in tweets containing the word “climate” due to the frequent use of this term in the context of natural disasters, bills, etc.

Nevertheless, an intriguing observation emerges as Türkiye, Spain, and Norway stakeholders stand out with the highest count of negative sentiments. This pattern hints at the prevalence of concern or dissatisfaction in these particular groups. Marco-Fondevila et al. [38] claim that businesses have neither faced institutional mandates to adopt CE practices, nor felt considerable pressure from their stakeholders in this regard, which partly supports the findings of this study on the presence of negative sentiments. Another study indicates that Turkish stakeholders possess a limited and varied comprehension of activities related to circularity [39].

On the other hand, stakeholders from Kazakhstan are the most forthcoming with positive sentiments, indicating a high level of satisfaction or optimism about the costs and benefits of CE in construction. Torgautov et al. [40] also discuss optimistic views regarding some CE practices in Kazakhstan’s construction sector. The sentiment analysis presented in Figure 3a serves as a useful tool to understand the geographical variance in attitudes and responses towards CE.

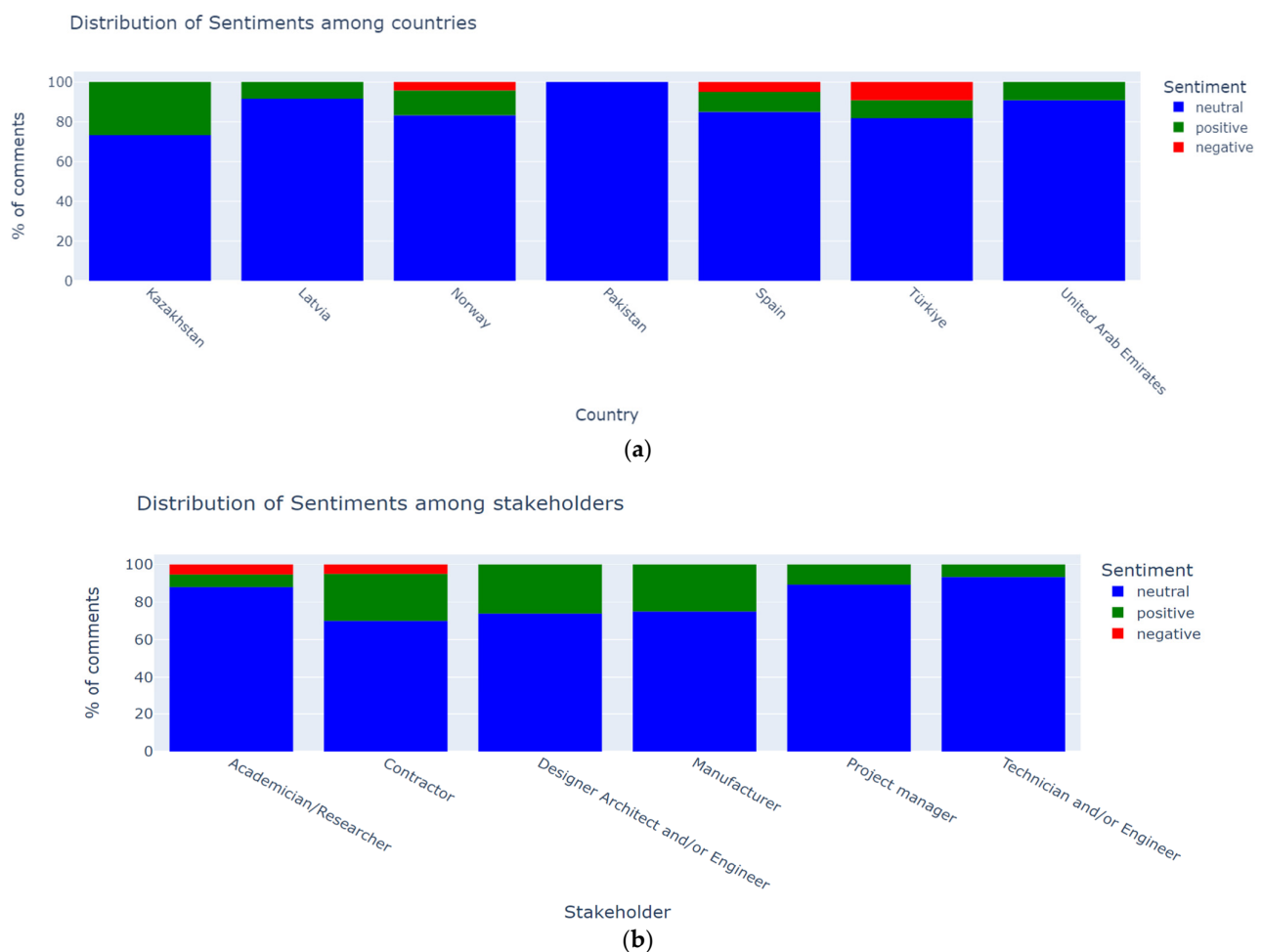


Figure 3. Sentiment chart of the collected survey data on CE in construction (a) by countries and (b) by stakeholders.

3.1.3. Sentiment Analysis for Stakeholders

Figure 3b shows the distribution of sentiments across the various stakeholder categories, whereby we restrict ourselves to the categories that received more than 15 responses. It highlights a predominant trend in the data collected, with a substantial portion leaning towards a neutral sentiment. Notably, negative sentiments are primarily expressed by academicians and researchers.

In addition, contractors emerge as a significant group expressing both negative and positive sentiments. This observation could be attributed to their involvement in diverse aspects of construction, including regional, economic, and legislative considerations. For example, contractors perform CDW monitoring for the subsequent end-of-life actions of materials [11,13]. The literature shows that some contractors voluntarily implement CE-related practices, while others resist acknowledging their necessity, even under legislative pressure [11,13]. This dichotomy is reflected in the results of this study. The variance in the negative and positive sentiments of contractors can also be attributed to the differences in the regions in which they operate. Different regions impose different regulations, knowledge bases, and common practices, contributing to the observed discrepancy in sentiments.

The stakeholder categories of “Designer, Architect, Engineer” and “Manufacturers” exhibit notably high positive sentiments. Designers, contractors, and manufacturers are considered key stakeholders in collaborative efforts to realise CE goals [13]. An intriguing observation is the resonance of their positive perspectives, as evidenced by the results presented in this study. This divergence in sentiments is instrumental in understanding the

varied perspectives on the costs and benefits associated with the implementation of CE in the construction industry.

Overall, neutral sentiments prevail among stakeholders both across the different countries and within the various stakeholder categories, which may indicate uncertainty and limited awareness of the implications of CE in construction. This underscores the need for targeted initiatives, such as training and awareness campaigns to educate stakeholders about the benefits and challenges associated with CE [9,22,41].

The negative sentiments of academia representatives might stem from their critical analysis of current construction practices concerning CE principles. On the other hand, contractors' negative sentiments could be linked to their practical experience with the challenges and financial implications associated with the implementation of CE principles in construction projects. This, in turn, may be attributed to a lack of certain CE guidelines and an insufficient number of successful CE case studies [9,40]. The geographical variance highlighted in the results, with Türkiye, Norway, and Spain having a higher number of negative sentiments and Norway and Kazakhstan displaying a larger number of positive sentiments, suggests that local cultural and legislative factors play a critical role in shaping stakeholder attitudes towards CE [42,43]. Considering and addressing these localised influences is imperative to foster a more positive reception of CE principles.

3.2. Implementation Strategies for CE across Construction Life Cycle Stages: Importance and Adoption Analysis—Semi-Guided In-Person Survey

3.2.1. Respondents' Profile

Figure 4 provides a thorough insight into the data regarding the stakeholder type, the percentage of countries, the age of participants, and their experience. The top left graph shows the frequency data of the stakeholder type, while the top right graph displays the percentage of countries the participants come from. The bottom left graph shows the age of the participants, and the bottom right graph shows their experience.

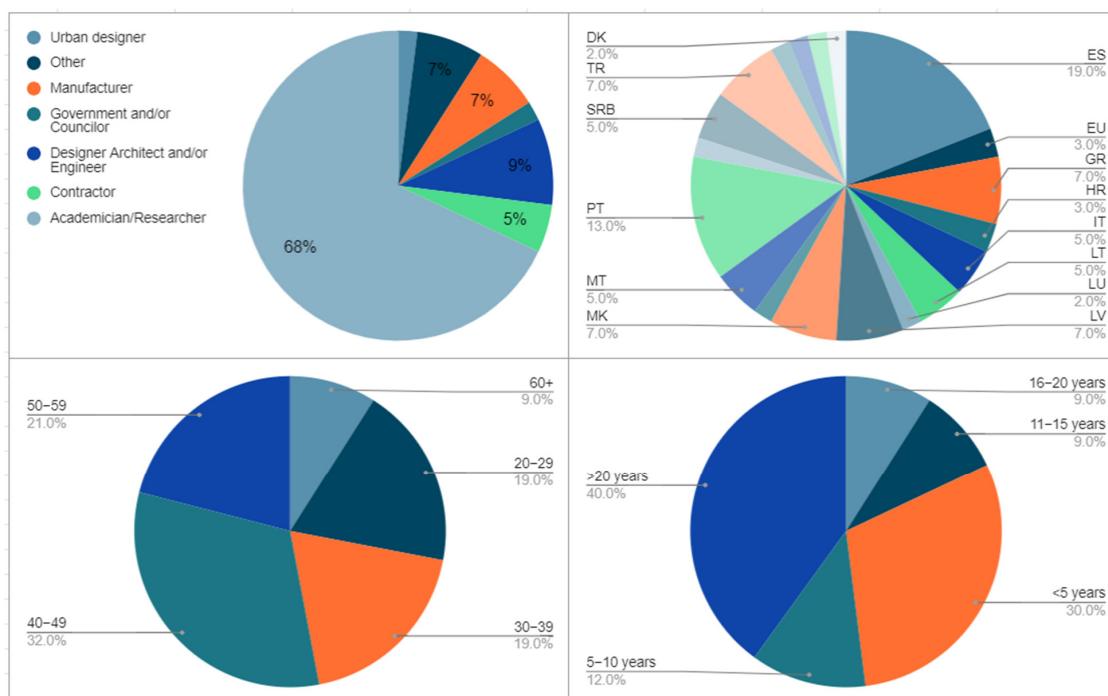


Figure 4. Frequency distribution of the stakeholder type (**top left**), the percentage of countries from which the participants come (**top right**), the age of the participants (**bottom left**), and their experience (**bottom right**). ES: Spain, EU: European Union, GR: Greece, HR: Croatia, IT: Italy, LT: Lithuania, LU: Luxembourg, LV: Latvia, MKD: North Macedonia, MT: Malta, PT: Portuguese, RO: Romania, SRB: Serbia, TR: Türkiye, UK: United Kingdom, AT: Austria, CZ: Czech Republic, and DK: Denmark.

The participants came from 19 countries, most of them being EU members. The total number of participants was 43, with Spain being the dominant country, as it hosted the stakeholder event. Of all participants, most were academics (68%). However, most stakeholders are involved in CE implementation activities from an academic perspective and have an extensive background in various sectoral domains. Various researchers highlighted the lack of sectoral participation in workshops [40]. CE is also no exception when it comes to convincing stakeholders to actively participate in the development stages to deliver a new approach to tackle business challenges [44]. This problem is particularly notable in the construction industry, where professionals are perceived as slow to adopt innovative practices from research-based projects. According to Hadiwattege and Senaratne [45], another reason for the low participation of sectoral stakeholders could be that academic research conducted in the field is often perceived by stakeholders as not relevant to the construction sector. The construction industry needs to keep up with the latest technologies and practices to remain competitive and efficient. However, the perceived lack of relevance in academic research makes it difficult to bridge the gap between theoretical knowledge and practical application in the construction industry. The participants mostly have many years of experience, with only 30% having less than five years of experience. The participants are mostly experienced individuals in their respective fields, particularly in CE.

3.2.2. Stakeholders' Opinions on CE Implication for Life Cycle Stages

The workshop survey consisted of three parts. Following the general stakeholder data, respondents were asked to rate the importance and adoption of 19 selected strategies for implementing circularity that had been identified following the literature review. These strategies were categorised based on the life stages of typical construction projects: Planning and Design, Construction, Operation, and End-of-Life [33].

The average scores of adoption and importance levels for the 'Planning and Design' and 'End-of-Life' stages showed the most significant difference (Figure 5), with a difference in rating value of 1.5 and the largest standard deviations between the importance and adoption levels. Stakeholders expressed varying opinions about the low adoption levels and perceived inadequacy in addressing certain aspects of the implementation of CE practices, such as the 'Design and Planning' and 'End-of-Life' stages. These differences highlight the need for more effective approaches to the implementation of CE practices. Recent literature highlights the importance of rethinking the design of construction products and projects from the perspective of CE principles [46]. This includes placing manufacturers and designers at the forefront of the circular design process, with the aim of creating circular, durable products that can be reused or repurposed at the end of their life cycle.

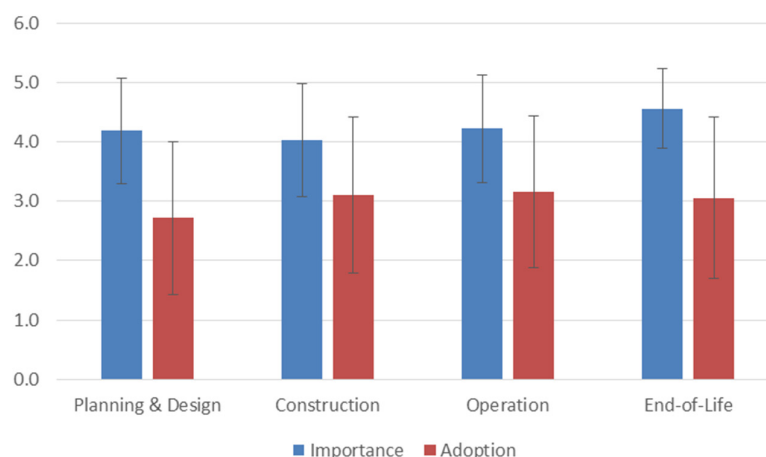


Figure 5. Overall average scores and standard deviations for the implementation of CE strategies throughout the building lifecycle stages, measuring both importance and adoption.

Moreover, it is essential to regard buildings as material stocks that can potentially be reused or repurposed at the end of their life [47]. Adopting a holistic view of buildings would enable stakeholders to identify opportunities for the recovery, reuse, and recycling of materials, thereby reducing waste and promoting CE [46]. These results address the gaps in the implementation of CE practices by adopting a more comprehensive approach that considers the design, planning, and end-of-life stages of construction products and projects. This would require collaboration between stakeholders, including manufacturers, designers, and builders, to create sustainable and durable products that contribute to CE.

The respondents rated the end-of-life stage as the most important stage for CE implementations, with an average score of 4.6, which is close to the maximum score of 5 (extremely important). The standard deviation was the lowest among all the stages, indicating that the most important CE implementations for construction projects were addressed in the end-of-life stage. Interestingly, their adoption levels were rated the lowest, with an average of 3.1. The importance ratings for the life stages were ranked highest to lowest as follows: end-of-life, operation, planning and design, and construction; the adoption rates followed the order of planning and design, operation, end-of-life, and construction.

In general, CE implementation strategies can be implemented in different life stages of buildings. Both branches of the literature are justifiable, as CE implementation strategies are largely dependent on the life stage of a building or a project. For instance, a new construction project may implement CE principles at the design stage, whereas an older building may require significant retrofitting and renovation to achieve circularity. Two branches of research have emerged from the existing literature, each with its own focus and priorities. The first branch is concerned with new construction projects and emphasises the importance of making the right choices and using proper materials, design principles, and tools to achieve high circularity. This division is based on the idea that the design stage is the most critical phase in the lifecycle of a building and that the right decisions and actions taken at this stage can significantly influence the circularity of the building [36,48]. The second branch of literature deals with the renovation of ageing buildings and the demolition of buildings, highlighting end-of-life stage strategies as crucial. This approach is also based on the idea that the end-of-life stage is the most critical phase in the lifecycle of a building and that the right decisions and actions taken at this stage can significantly impact the circularity of the building. This division of research focuses on the challenges of renovating and retrofitting older buildings, as well as the issues related to their demolition and disposal [48,49]. The stakeholders recruited in this study were from across Europe, where ageing buildings and infrastructure are prominent cases [50]. Most of them considered the end-of-life stage to be the most important implementation strategy, highlighting the need for careful planning, material selection, and disposal methods to achieve sustainable outcomes.

3.2.3. Stakeholders' Opinions on CE Implication Strategies

Figure 6 presents a comprehensive analysis of the stakeholders' responses to CE implementation strategies, highlighting the importance of prioritising the strategies with the highest potential to promote circularity in the construction industry. The graph on the bottom right-hand side of the figure shows the correlations (R-values) between the adoption and implementation responses for each corresponding strategy. The correlation analysis was performed to determine whether there was any agreement between opinions on the importance and adoption levels. The *p*-values of the paired, one-tailed *t*-test were all less than 0.05, indicating that the correlation analysis was statistically significant.

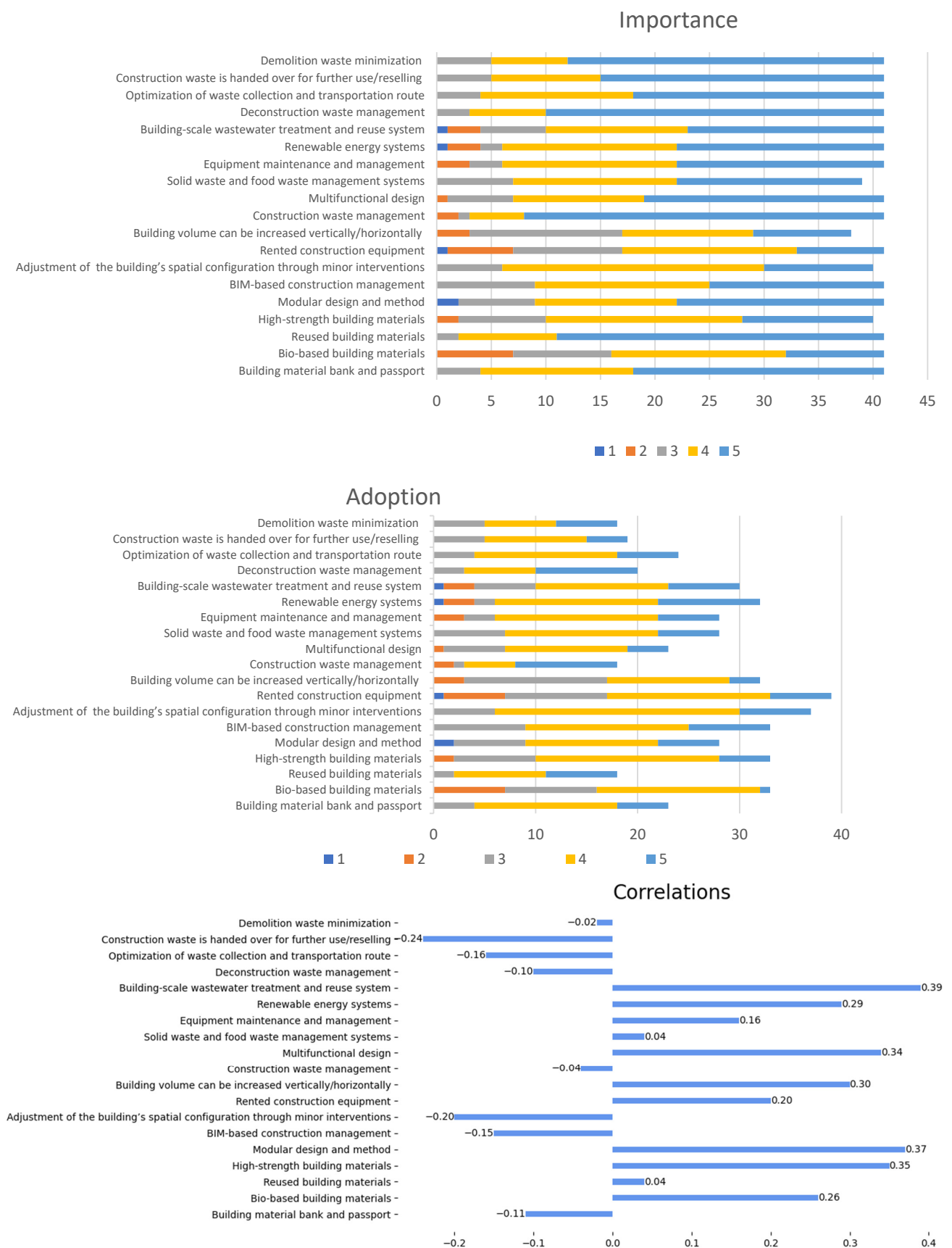


Figure 6. Average values of the stakeholder responses for the CE implementation strategies for their importance and adoption.

The results showed that most of the end-of-life strategies had negative correlations, which implies that the importance of these strategies was not reflected in their adoption levels. Stakeholders identified deconstruction waste management, optimising waste collection and transportation routes, handling construction waste for further use/resale, and minimising demolition waste as the strategies with high importance but the lowest adoption levels. It is important to highlight the current performance of European countries in CDW recovery, in addition to the discussion presented earlier in this section on lower adoption rates. According to the latest review by Zhang et al. [51], there are significant differences in CDW recovery across Europe. In the Netherlands, for example, the recovery rate has been 100% since 2010, while in Montenegro it remains at 0%, as most CDW is landfilled. As one can see, the workshop was dominated by participants from the lower ranks of this list.

On the other hand, the four strategies with the highest positive correlations were building-scale wastewater treatment and reuse systems, modular design and methods, the use of high-strength building materials, and multifunctional design. The R-values for these strategies were 0.39, 0.37, 0.35, and 0.34, respectively. These findings provide valuable insights into the prioritisation of strategies for construction industry leaders and decision-makers. The high-importance–low-adoption strategies require prioritised investment to improve the overall performance of construction projects and enhance their circularity level. The highly adopted and highly important strategies must be maintained and further improved to ensure a faster and more reliable circularity response in the future.

3.2.4. Stakeholders' Opinions Based on Their Countries

The scores provided by stakeholders from different countries were analysed to gain insights into the different life stages of construction projects. The analysis led to the calculation of average scores for each life stage, which are presented in Figure 7. However, it should be noted that some stakeholders chose not to provide scores for certain life cycle stages due to their lack of expertise in these areas. Consequently, certain countries did not submit any scores for certain stages. For instance, Croatia did not provide a score for adoption levels. In addition, stakeholders involved in European-level policymaking were represented using the EU code. Stakeholders from five countries—the Czech Republic, Portugal, Croatia, Serbia, and Malta—scored the highest importance, while stakeholders from Lithuania and Luxembourg scored the lowest. Furthermore, nine countries—Türkiye, Romania, Portugal, Malta, North Macedonia, Latvia, Lithuania, the Czech Republic, and Austria—rated the adoption levels higher than the other countries. Stakeholders' opinions on adoption rates revealed interesting results for some countries, as their importance assessments did not match their adoption rates. For example, German stakeholders gave a high total score for the importance of implementation strategies, but their adoption rates received the lowest score. On the other hand, Lithuanian stakeholders gave the highest adoption rate score but the lowest importance score.

According to the results of [51], European countries can be ranked from best to worst in terms of the landfilling rate of minerals as follows: Lithuania, Luxembourg, Italy, the United Kingdom, Latvia, Greece, Germany, Portugal, the Czech Republic, Australia, Croatia, Spain, and Romania. This ranking aligns well with the adoption rankings in our study. For instance, Lithuania exhibits the lowest disposal rate and the highest recovery rate and received the highest adoption ranking for CE strategies in our study. Spain and Romania are in the lowest bar in [51], just as they are in the same bar in our opinion rankings. Greece and the United Kingdom, on the other hand, have the lowest adoption rates in our rankings, but were in the middle bar in the aforementioned study.

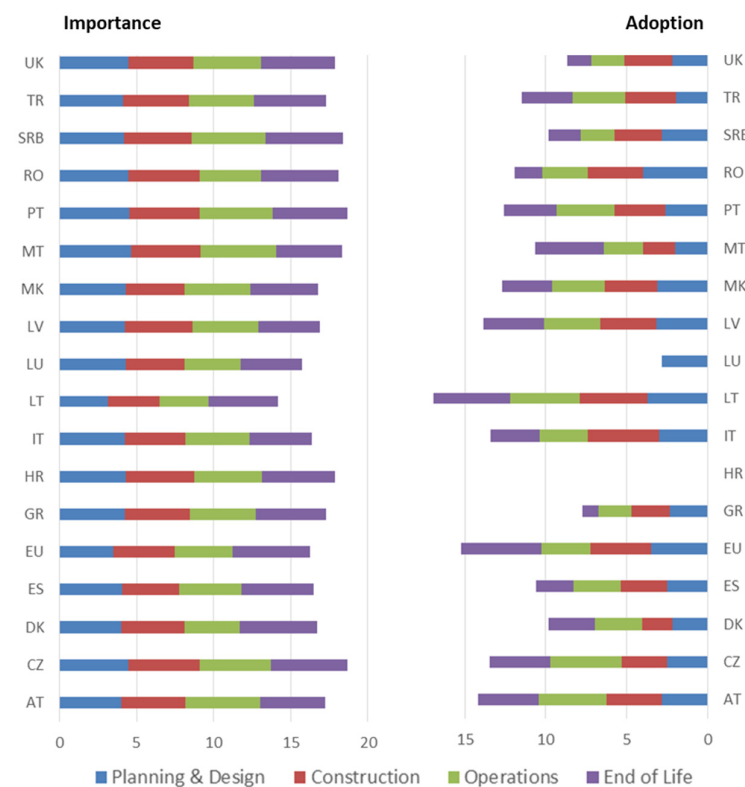


Figure 7. Average values of the stakeholder responses from participating countries for the CE implementation strategies for their importance and adoption.

3.3. Results of the Critical and Creative Thinking Round Table Discussion Using the Six Thinking Hats® Technique and the Online Mentimeter Tool

In this section, we present the outcomes of the pivotal discussion activity marked by the implementation of Mentimeter as a guiding tool and the incorporation of the Six Thinking Hats® methodology. This methodical approach aims to unveil the multifaceted insights and conclusions that emerged from our engagement with participants [52].

First and foremost, we analysed stakeholder participation, revealing that a total average of 24 participants actively engaged in the discourse. Table 1 provides a comprehensive overview of the participant rate and the number of responses received for each question.

Table 1. Participation results in the Mentimeter survey.

Question (MQs) [†]	MQ1	MQ2	MQ3	MQ4	MQ5	MQ6	MQ7
Participation rate	88%	50%	83%	83%	75%	58%	42%
Responses received	32	17	47	29	46	19	10

[†] MQs: Mentimeter Questions.

The information displayed underscores a notable level of interest among the participants in questions MQ3—pertaining to the leadership in CE, MQ4—focusing on initiatives, and MQ5—exploring opportunities, needs, and barriers. It is important to note that MQ1, which concerns sector mapping for stakeholders, is not included in this assessment, as its nature serves primarily as a foundational reference point rather than a direct point of interest. The results for each question are presented below.

MQ1: Sector of belonging

In analysing the results of this first question, a striking pattern emerges in relation to the participants' sector of affiliation. The overwhelming majority of the respondents are

firmly rooted in academia and university settings, a testament to the academic curiosity and engagement of this group. However, the diversity of sectors represented among the remaining participants makes these findings even more intriguing. Our survey reveals a rich tapestry of professionals from various fields, including waste management, industry construction, business, engineering (civil buildings; public infrastructures, e.g., roads, canals, and ports; and agricultural sector), and the public administration sector. This remarkable diversity underscores the broad interest and relevance of our research across a wide spectrum of industries, ultimately reinforcing the importance of the topic at hand [53–56].

MQ2: Local policies and regulations on CE and the built environment

The responses about policies and regulations in the context of the built environment have provided valuable insights. It is encouraging to note that respondents identified a range of measures associated with addressing CDW, the imperative for the classification of aggregates, and the adoption of recycling-oriented deconstruction practices. Additionally, references to policies, such as the “Net Zero Policy 2035” and the “Waste Management Policy” in the UK and the “Circular Economy Law” in Andalusia (Spain) underscore a growing awareness of the need for sustainable and circular practices in the construction sector.

However, it is important to also recognise the limitations of these policies. Some respondents pointed out that, in certain countries, these policies are primarily focused at the macro level, while, in other countries, there is a conspicuous lack of support for CE. Moreover, there are regions where policies are limited in scope and implementation and where professionals may lack a comprehensive understanding of the principles of CE. These nuances highlight the challenges and opportunities for further advancing CE practices in the built environment, calling for a more comprehensive and inclusive approach to policy development, knowledge, skills, and education within the built environment [57,58].

MQ3: Leading and promoting CE objectives

The survey results provided a clear consensus on the pivotal role that public administrations should play in spearheading and promoting CE principles and achieving its objectives [59]. Most respondents pointed towards various levels of government—national, regional, and local—as key drivers in this endeavour. Participants emphasised the crucial involvement of policymakers, municipalities, local administrations, and city councils in shaping and implementing CE initiatives [60]. Notably, the European Commission and the European Union were also acknowledged, albeit less frequently, as influential entities in steering CE agendas.

In addition to public institutions, there was a minority recognition of the importance of involvement from universities and academia, as well as a nod towards the role of private sector actors, such as companies, industries, engineering associations, and asset owner stakeholders. This multifaceted perspective highlights the need for collaborative efforts involving a spectrum of stakeholders to effectively advance the principles and practices of CE [61,62].

MQ4: Implementing initiatives in European cities

The survey responses shed light on a global landscape of CE initiatives within the built environment, revealing recurring themes and noteworthy efforts. Notably, participants from different European countries echoed the implementation of initiatives centred around energy efficiency; strategies for managing CDW, circular and smart cities; circular buildings, design and production objectives; the recovery of high-value waste materials (e.g., metals); the setting up of storage and waste classification depots; and the establishment of construction waste exchange centres. In addition, innovative practices, such as the utilisation of prefabricated buildings, the deconstruction and disassembly of building elements, Building Information Modeling (BIM), Life Cycle Assessment (LCA), and the incorporation of recycled materials, particularly aggregates, garnered attention. The survey underscored a concentration of these initiatives in countries, such as the United Kingdom and Spain, indicating a growing momentum in these regions [63,64].

Intriguingly, the survey activity spurred a rich exchange of opinions and questions, fostering a dialogue to enhance information sharing. A unanimous sentiment emerged regarding the imperative need for regulatory adjustments that support and encourage such initiatives, underscoring the shared belief in the pivotal role of adapted regulations in propelling CE forward in the built environment.

MQ5: Opportunities, gaps, and barriers of European and Spanish local initiatives

The analysis of the responses regarding perceptions of opportunities, gaps, and barriers to CE initiatives in the built environment reveals a consistent pattern. At the top of the identified barriers are issues related to regulation, legislation, and the lack of standards, with the complexities and constraints of existing frameworks posing significant hurdles. Awareness, or the lack thereof, and community acceptance emerged as another major barrier, underlining the need for comprehensive educational efforts to promote understanding and engagement in circularity practices. Costs and investments associated with the adoption of CE initiatives represented a formidable challenge, emphasising the financial considerations with which stakeholders grapple [11,65].

While less frequently cited, barriers, such as coordination challenges, enforcement gaps, low administrative commitment, need for skilled staff, space constraints for waste separation, and material characterisation hurdles, also surfaced [63,65]. Importantly, respondents commented on the necessity of implementing incentives to facilitate the widespread adoption of CE principles in the construction sector, showcasing a collective call for proactive measures to overcome these barriers and unlock the full potential of circular initiatives [66].

MQ6: Proposing new circularity indicators and/or highlighting key existing ones

Participants were asked to propose indicators for evaluating the circularity of the built environment—that is, including new and existing ones, aiming to identify synergies between the indicators considered in both the RECONMATIC project and the CircularB COST Action. The responses yielded a comprehensive list of indicators reflecting the multifaceted nature of circularity in construction, thus proposing the list as follows:

- Waste production rate;
- Society involved (%);
- Reused content of materials (%; re-utilisation);
- Reused components (%);
- Reuse of elements—from demolition;
- CDW ratio as tonnes produced vs. recycled;
- Recycled content, as the minimum recycled content in new products;
- Secondary materials, as the level of using them and % of use;
- CDW as disposal volume;
- Product utility;
- Policy adoption;
- Carbon net zero buildings (%);
- Planning of and for deconstruction;
- Recycled aggregate used in public construction.

Notably, indicators, such as waste production rate and the CDW ratio, measuring the balance between waste generated and recycled, provide crucial insights into the overall sustainability of construction practices [67]. The focus on society's involvement underscores the social dimension of circular initiatives and emphasises the importance of community engagement [12]. Metrics relating to reused materials, elements, and components, along with the establishment of the minimum recycled content in new products, reflect the commitment to reducing reliance on virgin resources. Indicators, such as the use of secondary materials and the percentage of recycled aggregate in public construction projects, offer a tangible measure of the ecological footprint of the industry [68,69]. Furthermore, the emphasis on policy adoption and the percentage of carbon-neutral buildings highlights the

pivotal role of regulatory frameworks and environmental impacts in steering the construction sector towards circularity [70]. The inclusion of indicators related to deconstruction planning and product utility further enriches the evaluative landscape, illustrating the participants' holistic approach to gauging the success and impact of circular initiatives in the built environment [71]. However, a corporate social responsibility (CSR) indicator system was not mentioned or perceived by the business stakeholder groups in our study as a tool for sustainability performance in construction companies [72–74].

MQ7: Conclusions and future steps

The conclusions drawn by the participants collectively form a roadmap for advancing the implementation of CE initiatives and practices in the built environment. There was a unanimous call for heightened administration involvement, as identified previously, underscoring the pivotal role of governmental bodies in driving policy and regulatory frameworks conducive to circular practices. As reported by Senaratne et al. [75], the adoption of circularity frameworks and models seems to be a trend in CE adoption projects, including digital technologies such as blockchain. Embracing digitalisation emerged as a key opportunity, suggesting that leveraging technology can streamline processes and enhance efficiency in the construction sector and its transition to circularity, as indicated in Çetin et al. [76] and Senaratne et al. [75]. Participants expressed the need for more pilot cases that can serve as practical models for the successful implementation of circularity strategies, as well as the importance of global collaboration through knowledge transfer improvement, sharing the best practices and technical and economic performance on a broader scale [66]. Moreover, they emphasised the importance of raising awareness through the wide dissemination of the results of the projects in order to propagate the benefits of CE and encourage its application, as previously appointed by Zadeh et al. [77] on the use of sand substitute materials in the construction industry and its lack of stakeholder awareness. Other crucial steps for a holistic and impactful transition towards a circular built environment are universalising reuse through standardised policies and legislations, creating incentives and disincentives, evaluating the cost of carbon emissions, implementing material passports for new constructions, leveraging BIM, the need for circularity indicators and monitoring to quantify the benefits, and ensuring industry funding availability due to the perceived lack of economic resources [78]. In addition, the recent study by Senaratne et al. [75] highlighted the lack of CE promotion among stakeholder engagement strategies as a key urgent challenge to fostering effective collaboration. Zadeh et al. [77] emphasised the need for potential synergies between science and practice to create and increase awareness among construction industry stakeholders.

4. Discussion and Conclusions

This study provides a comprehensive overview of the survey methods employed and the resulting findings obtained as part of the CircularB COST Action stakeholder activities. It sheds light on the various aspects of the research process and highlights the key insights gained from the survey activities. The primary objective was to assess stakeholders' perspectives on multiple aspects associated with key CE strategies within the building sector and the built environment. The survey activities comprised three distinct types. Firstly, an online survey centred around cost–benefit analysis was employed to gain insights into CE strategies. Secondly, an in-person, semi-guided survey with three sections was conducted during CircularB WS1P2. This survey covered socio-demographic parameters, the ranking of 19 key CE strategies, and an evaluation of their importance and adoption levels. Thirdly, an interactive round table discussion was conducted among stakeholders using the Six Thinking Hats® method. This discussion served as a dynamic platform for exploring diverse perspectives on critical CE strategies.

In conclusion, the comprehensive analysis of the information and data in this study provided key insights into the costs and benefits, adoption and implementation, as well as challenges and opportunities associated with CE strategies in the construction sector. Regarding the financial implications of CE strategies, stakeholders predominantly expressed

neutral sentiments, largely due to the absence of pilot cases demonstrating the long-term benefits juxtaposed with the immediate costs of most CE strategies. Consequently, more experience, additional pilot projects, and in-depth case studies are requisite to enable stakeholders to formulate more decisive opinions on the cost–benefit relationships of CE strategies. However, the timeframe required for these cases to yield conclusive results poses a significant hindrance. While the majority of stakeholders recognised the importance of integrating CE strategies throughout the building lifecycle, a significant gap emerged in their perspectives on the adoption of strategies at the end-of-life and planning and design stages. Furthermore, stakeholders emphasised specific concerns about the systemic approach to CE, calling for multi-dimensional support encompassing technical, legal, economic, and environmental aspects. To address these concerns, the study findings underscored the necessity of bridging the gap between theory and practice by actively motivating industry stakeholders to participate in the transition to CE. However, this gap is exacerbated by various obstacles to CE implementation, including a lack of supportive legislation and policies, insufficiently explained high costs associated with CE implementation compared to conventional strategies, and a dearth of clear guidelines, tools and practical examples to foster expertise in and knowledge of the best practices for CE strategies. Future steps to enhance CE implementation in the sector therefore necessitate increased engagement of policymakers and governments, the adoption of digital tools and technologies, illustrative case studies showcasing the technical and economic viability of CE solutions, heightened awareness and education, and the establishment of standards and incentives.

In essence, this study provides valuable insights into the challenges and opportunities inherent in implementing CE strategies within the construction sector. By addressing the barriers identified, the industry can move towards a more sustainable and circular approach to building design, construction, operation, and end-of-life management, contributing significantly to a more sustainable future for the planet. A shortened list of key points summarising our conclusions is as follows:

1. While stakeholders acknowledged the importance of integrating CE strategies, gaps emerged in adoption at the end-of-life and planning and design stages, requiring multi-dimensional support.
2. Obstacles to CE implementation include a lack of supportive legislation, high implementation costs, and an absence of clear guidelines and tools.
3. Recommendations include increased engagement of policymakers, the adoption of digital tools, illustrative case studies, heightened awareness, and the establishment of standards and incentives.
4. Further research is needed to broaden stakeholder representation, refine ranking methodologies, and develop multi-criteria models to evaluate building circularity performance.
5. Circular practices encompass technical and process factors necessitating a systemic view and close collaboration between stakeholders.
6. The recommendations also extend to augmenting sentiment analysis studies of CE-related terms in diverse contexts for a more comprehensive understanding.

Additional research is essential to gain a more comprehensive understanding of stakeholders' perspectives on various aspects of CE within the built environment. This can be achieved by augmenting the sample size and diversifying the respondents in the survey, ensuring a broader representation of countries where limited or insufficient responses were initially received. The methodology employed in this study to rank and prioritise key CE strategies in the second survey warrants further refinement through an exhaustive literature review, taking into account stakeholders' input on crucial strategies that may have been overlooked in the initial survey. Consequently, the ranking and prioritisation can be transformed into a multi-criteria model that encompasses technical, economic, environmental, and social dimensions. Such a model would significantly contribute to an overarching evaluation of circularity performance in buildings, offering a more holistic perspective on their sustainability. However, it is crucial to note that circularity evaluation should extend beyond the material and technical aspects. It must also include process

factors influenced by stakeholders' engagement and adopt a systemic view that encompasses all value chain factors and influencers over the lifecycle. Circular practices are not solely about the technicalities of materials, but also about the efficiency of processes, which is amplified by the circularity of feedback systems and close collaboration between transdisciplinary stakeholders.

Finally, in a broader sense, it is recommended to augment sentiment analysis studies of terms, such as “CE”, “sustainability”, and other environmentally related terms, in text corpora. Existing studies have yielded conflicting results, indicating the need for a more comprehensive understanding of the sentiment surrounding these terms in diverse contexts.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/buildings14040935/s1>, File S1: Workshop survey part.

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