Interreg Danube Region

Co-funded by the European Union

Circular DigiBuild

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Analysis "Cross-sectoral opportunities for CE solutions and innovations in construction and building"

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List of Abbreviations

AAGR - Average Annual Growth Rate
AI - Artificial Intelligence
BiH - Bosnia and Herzegovina
BIM - Building Information Modeling
CE - Circular Economy
CEFA - Circular Economy Forum Austria (organization)
C&D - Construction and Demolition
CDW - Construction and Demolition Waste
CO_2 - Carbon dioxide
CTU UCEEB - Czech technical university in Prague, University Centre for Energy Efficient Buildings
DGNB - Deutsche Gesellschaft für Nachhaltiges Bauen (German Sustainable Building Council)
EPA - Environmental Protection Agency
EPR - Extended Producer Responsibility
ESAP - Environmental Strategy and Action Plan
EU - European Union
FBiH - Federation of Bosnia and Herzegovina
GBC - Green Building Council
GDP - Gross Domestic Product
IoT - Internet of Things
IPA - Instrument for Pre-Accession Assistance
KfW - Kreditanstalt für Wiederaufbau ("Credit Institute for Reconstruction")
NCA - National Circularity Assessment
NCES - Romania's National Circular Economy Strategy
NGO - Non-Governmental Organization
PP - Project Partner
R&D - Research and Development
RTI - Research, Technology, and Innovation
RMSG - Regional Multi-Stakeholder Group
SEAP - Sustainable Energy Action Plan
SMEs - Small and Medium Enterprises
SRIP - Strategic Research and Innovation Partnership
UNDP - United Nations Development Programme
WLC - Whole Life Carbon
ZAG - Slovenian National Building and Civil Engineering Institute

Circular DigiBuild project

The Circular DigiBuild project is a forward-looking initiative designed to address the pressing challenges of sustainability within the construction and building sector, specifically targeting the Danube region. This innovative project seeks to harmonize the principles of the circular economy with cutting-edge digital technologies to revolutionize how resources are used and managed throughout the construction lifecycle. The construction industry is one of the most resource-intensive sectors, contributing significantly to waste generation and greenhouse gas emissions. Circular DigiBuild aims to tackle these issues head-on by promoting cleaner, smarter, and more efficient building practices. At its core, the project fosters transnational collaboration among various stakeholders, including industry leaders, academic institutions, and policymakers, to drive systemic change. It emphasizes the adoption of digital solutions such as big data analytics, artificial intelligence, blockchain, and the Internet of Things. These technologies are leveraged to improve resource efficiency, enhance waste management strategies, and ensure the sustainable use of materials across all phases of construction and demolition.

One of the project's key focuses is to identify barriers that hinder the integration of digital tools and circular economy principles in the construction industry. By addressing these obstacles, Circular DigiBuild aims to unlock new opportunities for innovation and sustainability. Pilot projects play a significant role in this initiative, demonstrating practical and scalable solutions for achieving cleaner construction practices and enhancing the circularity of materials. These pilots act as real-world examples that inspire change and encourage adoption across the region. Additionally, Circular DigiBuild seeks to develop strategic frameworks and action plans that support long-term sustainability goals. These plans are tailored to the unique needs of the Danube region, promoting knowledge sharing and capacity building among participating countries. By creating a cohesive innovation ecosystem, the project ensures that stakeholders are well-equipped to transition toward a more sustainable and resource-efficient future. Through its multidisciplinary approach, Circular DigiBuild is not just addressing environmental challenges but also contributing to economic resilience and regional cooperation. It envisions a future where the construction industry operates within a circular economy model, significantly reducing its ecological footprint while fostering technological advancement and innovation.

Introduction

The construction industry is a cornerstone of the European Union's (EU) economy, contributing approximately 9% of the Gross domestic product (GDP) and providing employment to 18 million individuals. A significant portion of this workforce is concentrated in the Danube region, underscoring the sector's vital role in the area's economic stability and development. Traditionally perceived as a low-tech domain, the construction industry is undergoing a paradigm shift. Emerging technologies and a growing emphasis on sustainability and energy efficiency are driving a transformative change. This transition necessitates the adoption of innovative materials, intelligent systems, and digital tools, alongside fostering robust collaborations across the value chain. These efforts aim to align the industry with the principles of the Circular Economy (CE), ensuring a more sustainable and resource-efficient approach to construction.

Despite its critical economic contribution, the construction sector in the Danube region remains one of the largest consumers of natural resources and a significant producer of waste and greenhouse gas emissions. The industry's fragmented nature and slow adoption of digital innovations pose additional challenges in transitioning toward circular construction practices, such as the reuse and recycling of materials. However, digital technologies such as big data analytics, artificial intelligence (AI), blockchain, building information modeling (BIM), digital passports, and the Internet of Things (IoT) hold immense potential to overcome these barriers. Combined with innovative business models, these tools offer transformative solutions to reimagine the construction process, enabling smarter and more sustainable practices.

To address these challenges and capitalize on emerging opportunities, this study provides a structured methodology for analyzing circular economy opportunities in the construction sector across the Danube region. The methodology integrates findings from existing studies, stakeholder consultations, and expert analyses, guided by a standardized template to ensure consistency and comparability across participating countries. By examining current practices, regulatory frameworks, and market dynamics, the study aims to equip stakeholders with actionable insights and foster a collaborative environment conducive to circularity in construction.

Scope of the Analysis

This analysis aims to explore and identify opportunities for implementing circular economy solutions and innovations in the construction and building sectors within the Danube region. By assessing relevant strategies, policies, and financial instruments, the study seeks to develop tailored recommendations suited to the unique contexts of each participating country. Through a comprehensive evaluation of national practices, regulatory frameworks, and market conditions, the analysis contributes to efforts aimed at:

- Enhancing resource efficiency.
- Promoting sustainable construction methodologies.
- Encouraging the adoption of circular design principles

The analysis also highlights the critical role of collaboration between stakeholders – governmental bodies, industry players, and academia – in driving the adoption of circular economy principles. By identifying specific opportunities, barriers, and drivers, it provides a roadmap for a more resource-conscious and environmentally sustainable construction sector.

Methodology

The data collection methodology employed for the study on cross-sectoral opportunities for CE solutions in the construction and building industry combines qualitative and quantitative techniques to ensure a comprehensive analysis. By integrating insights from document reviews and stakeholder consultations, the methodology aims to provide a robust foundation for understanding CE opportunities, regulatory conditions, market practices, and technological readiness in the Danube region.

Data Collection Approach

The data collection process is structured around two primary components:

Document Review

Each project partner (PP) conducts a systematic review of existing national and regional documents relevant to circular economy implementation in the construction and building sector. This review provides a baseline understanding of the regulatory, policy, market, and technological landscapes of each country and identifies existing CE strategies or frameworks influencing the construction sector.

The document review process includes:

- **Policy Papers and National Strategies**: To assess regulatory frameworks and strategic objectives.
- **Relevant Legislation**: To understand the legal context supporting or hindering CE practices.
- **Industry Reports and Analyses**: Insights from industry associations and consultancies highlighting market trends and challenges.
- **Academic Research and Case Studies**: To explore innovations, pilot projects, and CE applications in the building industry.
- **Regional and EU-level Policy Papers**: To ensure alignment with broader goals and strategies.

To maintain consistency, each PP utilizes a template to document their findings, ensuring comparable and coherent data across all participating countries.

Stakeholder Consultations

Stakeholder consultations complement the document review process by enriching and validating the gathered information through practical insights. These consultations engage a diverse range of stakeholders, including:

- Government officials and policymakers;
- Industry leaders, property developers, builders, and contractors;
- Architects and urban planners;
- Environmental Non-Profit Organizations (NGOs) and civil society organizations;
- Academia and research institutions.

By covering subjects from the quintuple helix model—government, industry, academia, civil society, and the natural environment—these consultations provide a multidimensional perspective on CE opportunities and challenges.

Each PP ensures comprehensive engagement with stakeholders to capture diverse viewpoints, covering both technical and non-technical aspects of circularity in construction.

Integration of Data

The data collected through document reviews and stakeholder consultations is synthesized to develop a holistic understanding of the state of CE in the Danube region's construction and building industry. The integration process involves:

1. **Validating Findings**: Cross-referencing document reviews with stakeholder input to ensure accuracy and relevance.
2. **Identifying Gaps**: Highlighting areas where additional research or intervention may be required.
3. **Building a Unified Framework**: Ensuring the collected data aligns with the study's objectives and contributes to actionable insights for advancing CE practices.

By combining these two complementary methodologies, the study ensures a robust and multidimensional approach to identifying opportunities and barriers to circular economy adoption in the Danube region's construction and building sector. This integrated methodology not only provides a detailed snapshot of current practices but also lays the groundwork for future innovation and collaboration in sustainable construction.

Chapter 1: Country and Regulatory Context

Section 1a: Country information

Austria

Austria's construction sector significantly impacts the economy and environment, consuming 14% of the nation's material footprint (33 tonnes per capita in 2017). It generates over 11.4 million tonnes of construction waste annually, alongside 41 million tonnes of excavated material. The sector is Austria's largest waste producer, with soil excavation increasing by 24% since 2015. Sustainability is a focus, with initiatives like the "City of Tomorrow" program promoting R&D for urban spaces, and a national Circular Economy Strategy aiming for climate neutrality by 2040. The adoption of digital technologies for circularity is growing but remains limited.

Slovenia

Construction investments represented 10.1% of GDP in 2022, supported by EU funding under the National Recovery and Resilience Plan. Residential property prices surged by 14.7%, yet construction permits fell by 6%. Labor shortages and high foreign labor reliance are prominent challenges, while public investments in transport and renewable energy infrastructure drive growth. Slovenia's construction market reached €13.2 billion in 2023, with an Average Annual Growth Rate (AAGR) of 2% expected from 2025 to 2028.

Montenegro

Montenegro's construction industry contributed 3.2% to GDP in 2023, focusing on transportation infrastructure and utilities. Sustainability efforts are emerging, underpinned by the National Strategy for Circular Transition to 2030, promoting waste reduction and material reuse. However, traditional practices dominate, and recycling infrastructure is underdeveloped. In 2023, construction waste decreased by 43.3%, reflecting reduced project activity. The sector faces challenges in modernizing its practices to align with EU directives.

Serbia

Serbia's construction industry is moderately sized, emphasizing infrastructure and residential projects. Urban areas are adopting modern techniques, while rural regions rely on traditional methods. Sustainability initiatives are in their early stages, focusing on energy-efficient buildings and recycling. EU integration drives regulatory alignment, but cost and policy gaps hinder comprehensive circular economy adoption.

Germany

Germany's construction industry is a European leader, contributing 5,4% (source statista) of GDP. Sustainability is a priority, with policies like the Building Energy Efficiency Act promoting energy efficiency. Circular economy approaches include voluntary resource passports for material reuse and advanced modular construction techniques. Challenges include an aging building stock requiring renovation and labor shortages. Government incentives, such as KfW loans, support green building projects and digitalization.

Bosnia and Herzegovina

Bosnia and Herzegovina (BiH)'s construction sector accounts for 4.33% of GDP (2022) and employs 8.3% of the workforce. Small and medium-sized enterprises (SME) dominance highlights small-scale operations, yet sustainability practices remain sporadic. The infrastructure for recycling construction waste is underdeveloped, with most waste directed to landfills. Initiatives like Wool-Line d.o.o. showcase emerging circular economy practices. Significant gaps in education and policy integration hinder the widespread adoption of sustainability.

Moldova

Moldova's construction market grew by 218% from 2013 to 2022, reaching €930 million and accounting for 6.5% of GDP. The focus remains on new buildings rather than renovations, particularly in the private and business sectors. Public sector projects lean towards renovations.

Hungary

Hungary's construction sector grew consistently until 2022, with post-pandemic challenges leading to a 5% decline in 2023. Price increases for materials (40% since 2022) and inefficiencies in outdated technologies pose significant issues. Circular economy practices are minimal, with slow adoption of advanced construction methods and industrialized products. Regional disparities in construction activity are notable, with Budapest performing better than other regions.

Croatia

Croatia's construction sector, accounting for 3–5% of GDP, is driven by post-earthquake reconstruction and EU funding. It generates 32% of the nation's waste, with downcycling dominating over high-quality recycling. Circular economy adoption is low (2.7% circular), hindered by stakeholder resistance. Government plans address waste management and sustainability but face cultural and practical barriers.

Czechia

The share of construction in GDP has ranged between 5% and 7% on a long term basis, rising slightly to 5.63% in 2022. The Czech construction industry is transitioning towards sustainability through initiatives like the Zero Carbon Roadmap and the adoption of life cycle assessments for

buildings. Challenges include fragmented financing, labour shortages, data gaps, and limited political commitment to EU targets. Timber construction and digital tools like BIM are gaining traction. Private sector efforts and EU-backed research projects drive gradual circular economy integration.

Romania

Romania's construction industry contributes 8.1% to GDP (2023) and shows strong growth driven by EU investments. The sector focuses on infrastructure, residential construction, and sustainable practices through frameworks like the Circular Economy Action Plan. Challenges include labor shortages, migration, and a lack of vocational training. EU Recovery and Resilience Plan funding supports infrastructure and energy-efficient projects, ensuring long-term sector growth.

Bulgaria

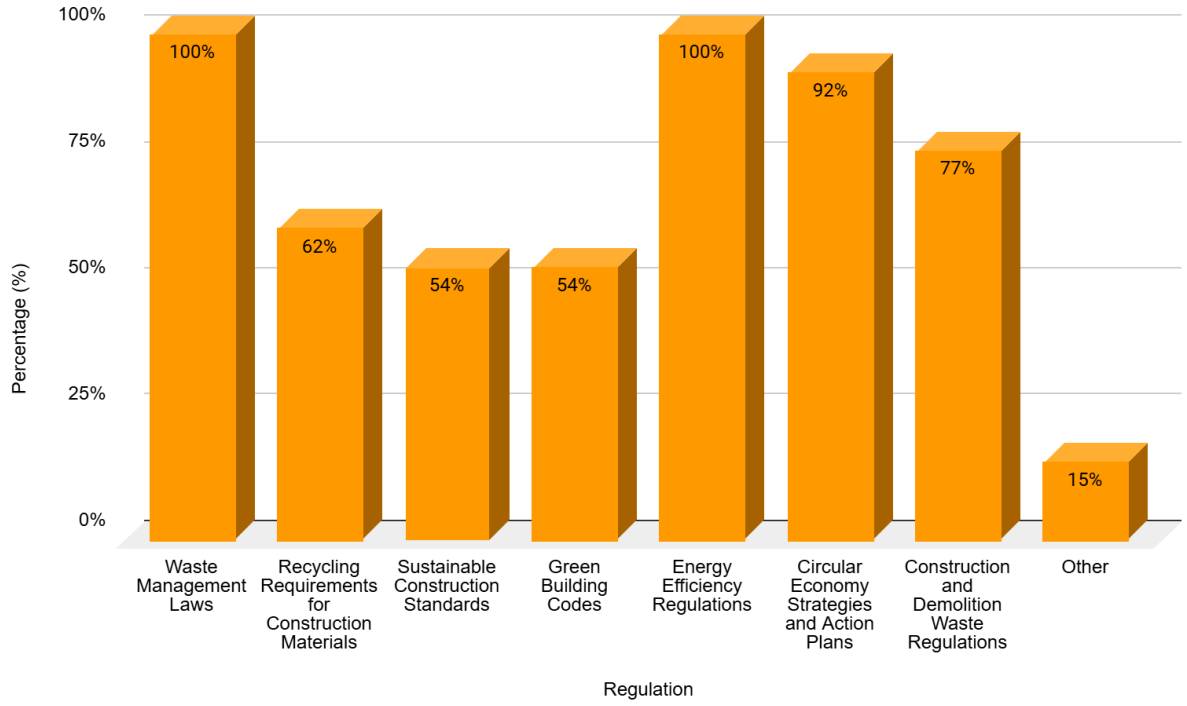
Bulgaria's construction sector, contributing around 10% of GDP, faces significant structural and sustainability challenges. Unlike Croatia, where EU funding drives post-earthquake reconstruction, or Czechia, which is advancing with sustainability roadmaps, Bulgaria struggles with low productivity growth, an aging workforce, and a lack of digitalization. Circular economy adoption remains limited, similar to Croatia, with ineffective waste management and downcycling dominating over high-quality recycling. While Romania leverages EU funding for infrastructure and energy-efficient projects, Bulgaria lags in integrating digital tools like BIM and adopting sustainable construction practices. Addressing these issues requires a coordinated approach, enhancing workforce training, improving digital adoption, and strengthening regulatory frameworks to support a circular construction economy.

Slovakia

Slovakia's construction sector, a crucial part of the economy, is gradually integrating circular economy principles. While no dedicated strategy exists for the sector, the "Closing the Loop" roadmap identifies construction as a priority. Slovakia aims to recycle 70% of construction and demolition waste by 2025, yet challenges persist in data transparency, legislative clarity, and economic incentives. Green public procurement targets a 70% adoption rate by 2030, though recycled content requirements are not yet mandated. Strengthening policy implementation, improving waste management, and fostering secondary raw materials use are key to advancing circularity in Slovakia's construction industry.

Section 1b: Regulatory framework

The first question of section 2 included the “check-all-that-implies” option about the type of regulations in place for each country. It included seven options that could be checked by each country: Waste Management Laws; Recycling Requirements for Construction Materials; Sustainable Construction Standards; Green Building Codes; Energy Efficiency Regulations; Circular Economy Strategies and Action Plans; Construction and Demolition Waste Regulations. Based on the answers provided, here is the distribution of implemented regulations and policies in each country:



Graph 1: Type of regulations in countries

The chart illustrates the distribution of regulation types adopted by countries in the Danube region, highlighting both common priorities and areas for further development. **Waste Management Laws and Energy Efficiency Regulations** are universally adopted, emphasizing their foundational importance in national policies across all surveyed countries.

The high adoption rates for **Circular Economy Strategies and Action Plans in 12 countries** and **Construction and Demolition Waste Regulations in 10 countries** demonstrate a strong regional commitment to addressing critical waste-related challenges. Moderate adoption rates for **Recycling Requirements for Construction Materials in 8 countries**, **Green Building Codes**

in 7 countries, and **Sustainable Construction Standards in 7 countries** indicate a growing focus in these areas, although broader implementation is still needed.

Overall, the data showcases significant alignment on fundamental policies while revealing variability in sector-specific and advanced regulatory measures.

Key Themes Identified in CE Policies and Regulations

Analyzing CE-related regulations and policies in the Danube region reveals common themes among the countries studied. These themes underscore shared priorities and focus areas in circular economy practices. The identified themes are:

- Waste Management
- Energy Efficiency
- Recycling and Circular Economy
- Sustainable Construction
- Circular Economy Strategies
- Green Transition
- Public Procurement
- Innovation and Research

Country-Specific Policies and Practices

The table below summarizes how different countries address the identified themes in their policies and practices. This analysis highlights the specific regulations, strategies, and initiatives enacted by each country, providing a comparative view of their approaches to the circular economy.

Theme	Austria	Slovenia	Montenegro	Serbia	Germany	Bosnia and Herzegovina	Moldova	Hungary	Croatia	Czech Republic	Romania	Bulgaria	Slovakia
Waste Management	Waste Management Act 2002	Waste Regulation; Regulation on the Management of waste generated during Construction Works	Law on Waste Management	Waste Management Strategy 2020-2025, Waste Management Act; Action plan 2022-2024 for the implementation of the Waste Management Program in the Republic of Serbia for the period 2022-2031	Kreislaufwirtschaftsgesetz (Circular Economy Act); Extended Producer Responsibility (EPR) Packaging Act (Verpackungsgesetz) Battery Recycling Regulations	Regulation on construction waste management (93/19)	National Waste Management Strategy 2013	Government Decree: on detailed rules for the management of construction and demolition waste	Waste Management Plan 2023-2028; Ordinance on Construction Waste and Waste Containing Asbestos; Ordinance on Waste Management; Ordinance on Waste Landfills	Waste Management Plan; Strategic Framework 'Circular Czechia 2040'	Transposed EU Waste Framework Directives; Waste Management Legislation; Construction and Demolition Waste Management Plans	Waste Management Act (2014) Regulation on Construction Waste Management and on the Application of Recycled Construction Materials (2017)	Act No. 79/2015 Coll. on Waste and on Amendments and Additions to Certain Acts Act No. 230/2022 Coll. amending Act No. 79/2015 Coll. on Waste Regulation No 330/2018 Coll. on waste disposal fees Act No. 329/2018 Coll. on fees for waste disposal Decree No. 365/2015 Coll. on the Waste Catalogue Decree No. 371/2015 Coll. implementing provisions of the Waste Act Decree No. 373/2015 Coll. on extended producer responsibility
Energy Efficiency	Not explicitly mentioned	National Energy and Climate Plan	Not explicitly mentioned	Law on Energy Efficiency and and Rational Use of Energy	Building Energy Efficiency Act (GEG); Energieeinsparverordnung (EnEV)	Energy Efficiency Law (FBiH, RS); National Energy and Climate Plan 2030 (NECP)	Law on the energy performance of buildings nr. 282/2023	Not explicitly mentioned	National Energy Efficiency Action Plan 2022-2024; Energy Efficiency Law	National Energy and Climate Plan; Climate Protection Policy	Energy Performance of Buildings Directive (EPBD);	Energy Efficiency Law (2014)	Act No. 309/2009 Coll. on the Promotion of Renewable Energy Sources Act No. 321/2014 Coll. on Energy Efficiency Low-Carbon Development Strategy of the Slovak Republic until 2030 with a View to 2050 Integrated National Energy and Climate Plan 2021-2030 Act No. 555/2005 Coll. on the Energy Performance of Buildings Decree No. 364/2012 Coll. implementing Act No. 555/2005

													Decree of the Ministry of Economy No. 599/2009 on renewable energy sources Decree No 328/2005 Coll. of URSO on economic efficiency of heat systems
Recycling and Circular Economy	Recycling Building Materials Ordinance	Vision for Slovenia in 2050	National Strategy for Circular Transition to 2030 with Action Plan for 2023-2024;	Circular Economy Development Program	Mantelverordnung (Mineral Waste Ordinance)	No concrete policies; construction waste re-use acknowledged	The Green and Circular Economy Promotion Program 2024-2028	Not explicitly mentioned	Program for the development of circular management of space and buildings for the period 2021-2030	Draft technical standards for pre-demolition audits; Secondary Raw Materials Policy; Raw Materials Policy for Wood	Circular Economy Action Plan; National Circular Economy Strategy	Regulation on Construction Waste Management and on the Application of Recycled Construction Materials (2017) Waste Management Act (2014)	Waste prevention programme of the Slovak Republic for the years 2019-2025 Waste Management Programme of the Slovak Republic for 2021-2025 Recovery and Resilience Plan – Component 2: Building Renewal (Reform 3: Construction Waste Management Reform)

Sustainable Construction	ÖNORM B 3151; ÖNORM B 3140	Slovenian Industrial Strategy 2021-2030; Digital Slovenia 2030	Industrial Policy for 2024-2028 with Action plan; Rulebook handling construction waste	Draft Law on Construction Products	Baugesetzbuch (Building Code), DGNB Certification	Development Strategy for Construction Materials (FBiH); Law on Construction Products of the FBiH and RS; Law on Spatial Planning and Construction of RSand BD BiH; FBiH Building Renovation Strategy until 2050 and the RS Development Strategy of the Industry for 2021-2027	Not explicitly mentioned	Construction Products Regulation, CE Marking; Act C. of 2023 on Hungarian Architecture; Government Decree on the detailed rules for the design and installation of construction products in buildings	Green Infrastructure Development Programme in urban areas 2021 to 2030; Program for Circular Management of Space/Buildings 2021-2030; Building Law; Law on spatial planning and construction; National Building Renovation Plan	Concept for the Introduction of BIM in Public Administration; new law on BIM	Sustainable Construction Guidelines;	Sustainable Construction Standards	Act No. 555/2005 Coll. on the energy performance of buildings New Construction Law (Draft, 2025)
Circular Economy Strategies	Circular Economy Strategy	Roadmap for Circular Economy Transition	National Strategy for Circular Transition to 2030	Roadmap for Circular Economy	ProgRess Resource Efficiency Program and EU Circular Economy Action Plan Alignment	Draft Circular Economy Roadmap (not yet adopted)	The Green and Circular Economy Promotion Program 2024-2028	Circular Economy Strategy and Action Plan	Program for Circular Management of Space/Buildings; The Environmental Impact Assessment Regulation;	Strategic Framework 'Circular Czechia 2040'	National Circular Economy Strategy (NCES); Circular Economy Action Plan (CEAP)	Strategy for Transition to a Circular Economy (2022)	Vision and Sustainable Development Strategy of Slovakia up to 2030 Closing the Loop in the Slovak Republic – A roadmap towards circularity Strategy of the Environmental Policy of the Slovak Republic until 2030 Strategy for the Adaptation of the Slovak Republic to Climate Change Recovery and Resilience Plan Economic Policy Strategy

													of the Slovak Republic until 2030 (Proposal)
Green Transition	"City of Tomorrow" program; RTI initiative for CE	Slovenia's Development Strategy 2050; Smart Specialization Strategy S5; Long-term Climate Strategy 2050	National Strategy for Sustainable Development by 2030	Environmental Protection Act	Digital Product Passports according to EU regulation	Public Procurement Strategy indirectly supports green practices	Circular Economy Promotion Program; National Strategy for the Environment 2024-2030	Not explicitly mentioned	Integration of CE in National Climate and Energy Strategy; Law on the environmental protection; Regulation on the Environmental Permit	Climate Protection Policy	Promotes lifecycle thinking; CE in public procurement	National Strategy for Digital Transformation of the Bulgarian Construction Sector 2030 and Roadmap for its Implementation (2023)	Sustainability of construction works – Environmental product declarations (STN EN 15804)
Public Procurement	Not explicitly mentioned	Green Public Procurement	Not explicitly mentioned	Law on Public-Private Partnerships	Sustainable Public Procurement Circular Economy Procurement Practices	Public Procurement Strategy 2024-2028	Not explicitly mentioned	Not explicitly mentioned	Green procurement linked to Public Procurement Strategy	National Public Procurement Strategy; Sustainable Purchasing Action Plan	Sustainable Construction Guidelines for public authorities	Not explicitly mentioned	Not explicitly mentioned

Innovation and Research	"City of Tomorrow" program; RTI initiative	Not explicitly mentioned	Encourages CE-aligned innovation and investments	Not explicitly mentioned	Green Finance Policies	Support for SMEs in greening processes	Not explicitly mentioned	Not explicitly mentioned	Support for CE-aligned SME development	Unified methodology for GWP calculation; updates to CE strategies	Developed strategies for CE material use and lifecycle assessment	Strategy for Transition to a Circular Economy (2022) National Strategy for Digital Transformation of the Bulgarian Construction Sector 2030 and Roadmap for its Implementation (2023)	Act No. 230/2022 Coll., amending Act No. 79/2015 Coll. on waste Decree No. 344/2022 Coll. of the Ministry of Environment on construction and demolition waste Act No. 201/2022 Coll. on Construction

Table 1: Country-Specific Policies and Practices

Austria

Austria leads in circular economy practices, with a strong focus on waste management and recycling. Key regulations, such as the **Waste Management Act 2002** and the **Recycling Building Materials Ordinance**, promote sustainable construction and demolition practices. Comprehensive strategies like the **Circular Economy Strategy** and innovative initiatives, such as the **"City of Tomorrow" program**, further reinforce Austria's position as a leader in CE transitions.

Slovenia

Slovenia emphasizes a green transition through its **Development Strategy 2050** and **Smart Specialization Strategy**. These frameworks aim to integrate CE principles across industries, supported by the **National Energy and Climate Plan** and a roadmap for transitioning to a circular economy.

Montenegro

Montenegro's policies focus on waste reduction and sustainable resource use, guided by the **National Strategy for Circular Transition to 2030**. With an emphasis on eco-tourism and agriculture, the country is establishing a recycling infrastructure and aligning waste management practices with EU directives. Innovation and investment incentives are part of its long-term plan.

Serbia

Serbia's **Waste Management Strategy 2020-2025** and **Circular Economy Development Program** lay the foundation for its CE transition. The roadmap for a circular economy and action plans for waste management signal progress, but stronger sectoral implementation and enforcement are needed to advance further.

Germany

Germany stands out for its comprehensive CE frameworks, such as the **Kreislaufwirtschaftsgesetz (Circular Economy Act)** focusing on waste reduction and recycling and **Mantelverordnung**. The country excels in construction waste recycling, green building codes, and innovation, with initiatives like **Digital Product Passports** according to EU-regulation for marketing of construction products and green finance policies setting an example for the region.

Bosnia and Herzegovina

Governance fragmentation limits Bosnia and Herzegovina's CE progress. The **Draft Circular Economy Roadmap** and public procurement strategies demonstrate growing awareness, but harmonization across entities is necessary for effective implementation.

Moldova

Moldova focuses on energy efficiency through the **Energy Performance Law (2024)** and promotes CE principles via the **Green and Circular Economy Promotion Program 2024-2028**. While these initiatives reflect growing alignment with EU goals, comprehensive waste management and recycling policies remain underdeveloped.

Hungary

Hungary's CE efforts are driven by its **Circular Economy Strategy and Action Plan**. Regulations for construction and demolition waste and sustainable construction practices are in place, but broader integration across public procurement and innovation remains an area for growth.

Croatia

Croatia has made progress with its **Waste Management Plan 2023-2028** and **Program for Circular Management of Space and Buildings**. Energy efficiency regulations align with EU directives, and public procurement policies encourage sustainability. However, stronger enforcement and sectoral coordination are needed.

Czechia

The Czech Republic is advancing its CE transition through initiatives like the **Strategic Framework 'Circular Czechia 2040'** and the **National Public Procurement Strategy**. A focus on sustainable construction through BIM and pre-demolition audits highlights innovation, though inter-ministerial coordination is a challenge.

Romania

Romania's **National Circular Economy Strategy (NCES)** and **Circular Economy Action Plan** prioritize recycling, resource efficiency, and sustainable construction. Waste management aligns with EU directives, and public procurement emphasizes life cycle thinking. The country aims to achieve 70% recovery of construction and demolition waste, reflecting its commitment to CE goals.

Bulgaria

Bulgaria's **Waste Management Act (2014)** and **Regulation on Construction Waste Management (2017)** set the foundation for handling construction waste, promoting recycling, and minimizing environmental impact. The **Energy Efficiency Law (2014)** establishes policies to enhance energy performance in buildings, aligning with sustainability goals. The **Strategy for Transition to a Circular Economy (2022)** highlights construction as a priority sector, emphasizing resource efficiency, material reuse, and innovation-led digital solutions for circularity. However, Bulgaria currently lacks **specific incentives, tax breaks, or subsidies** for circular construction, relying on the **National Strategy for Digital Transformation of the Bulgarian Construction Sector 2030** to drive future advancements.

Slovakia

Slovakia's waste management framework is governed by **Act No. 79/2015 Coll. on Waste**, along with its amendments, setting regulations for disposal fees and extended producer responsibility (**Decree No. 373/2015 Coll.**). Energy efficiency is guided by **Act No. 309/2009 Coll. on Renewable Energy Sources** and **Act No. 555/2005 Coll. on Energy Performance of Buildings**, alongside the **Low-Carbon Development Strategy 2030**. The **Waste Management Programme 2021-2025** and **Recovery and Resilience Plan** target circular economy improvements, with a **70% recycling goal for construction waste by 2025**. The **New Construction Law (2025)** and **Decree No. 344/2022 Coll. on construction and demolition waste** reinforce sustainability measures, supporting **STN EN 15804 environmental product declarations**.

Comparative Analysis of Countries

The countries in the Danube region exhibit varying levels of progress in implementing circular economy (CE) policies. They can be classified into three categories: **Advanced Countries**, **Emerging Countries**, and **Countries in Early Stages of CE Implementation**.

Advanced Countries

Slovenia, Germany, and **Austria** are the most advanced in adopting CE policies. They have comprehensive frameworks, detailed regulations, and sectoral integration that set benchmarks for the region.

Emerging Countries

Countries like **Bulgaria, Slovakia, Croatia**, **Hungary, Romania,** and the **Czech Republic** are classified as emerging. They are making notable progress but face challenges in enforcement, cross-sectoral coordination, and infrastructure development.

Countries in the Early Stages

Montenegro, Serbia, **Bosnia and Herzegovina,** and **Moldova** are in the early stages of CE adoption. These countries are working on foundational frameworks and alignment with EU directives.

Slovenia, Germany, and Austria set the highest standards in CE policy development and implementation. Their focus on innovation and infrastructure investment distinguishes them as leaders. **Bulgaria, Slovakia, Croatia, Hungary, Romania, and the Czech Republic** are advancing with robust strategies and frameworks. However, gaps in enforcement, coordination, and infrastructure development hinder further progress. **Montenegro, Serbia, Bosnia and Herzegovina, and Moldova** focus on foundational policies but require significant efforts to build infrastructure, improve enforcement, and foster innovation.

Strengths and Gaps in CE Policies Across the Danube Region

The Danube region demonstrates a range of strengths and weaknesses in implementing circular economy (CE) policies. While some countries have made significant progress, others are still in the early stages, indicating uneven development across the region.

Strengths

The Danube region exhibits several strengths in its circular economy (CE) policies. Comprehensive national strategies are a hallmark of advanced and emerging countries, with Germany's ***Kreislaufwirtschaftsgesetz*** **(Circular Economy Act)** focusing on waste reduction and recycling and Austria's **Circular Economy Strategy** leading the way. Romania's ***NCES*** and the Czech Republic's ***Strategic Framework 'Circular Czechia 2040'*** reflect strong long-term planning. Slovakia's ***Vision and Sustainable Development Strategy 2030*** and ***Waste Management Programme 2021-2025*** also set ambitious goals for CE implementation, including increasing recycling rates and promoting reuse in the construction sector. Bulgaria, through its ***National Waste Management Plan 2021-2028***, aligns with EU directives and promotes waste prevention, separate collection, and landfill diversion.

Alignment with EU directives is another regional strength, as demonstrated by Croatia's ***Waste Management Plan 2023-2028***, Romania's transposition of **EU Waste Framework Directives**, and Bosnia and Herzegovina's ongoing harmonization efforts. Slovakia also excels in this area, with its ***Act No. 79/2015 Coll. on Waste*** ensuring compliance with EU standards, particularly in construction and demolition waste management. Bulgaria's waste and resource management laws, such as the ***Waste Management Act*** and its **Extended Producer Responsibility (EPR)** schemes, further reinforce EU alignment.

Sector-specific policies are well-developed in advanced countries, with Germany, Slovenia, and Austria excelling in construction waste management, energy efficiency, and sustainable building standards. Slovakia's ***Recovery and Resilience Plan*** emphasizes green building renovation and increasing circularity in construction waste. The Czech Republic showcases innovation in

construction through its adoption of BIM and pre-demolition audits. Public procurement is a strong tool for CE promotion, with Romania's ***Sustainable Construction Guidelines***, the Czech Republic's ***National Public Procurement Strategy***, and Slovakia's ***Low-Carbon Development Strategy 2030*** integrating sustainability criteria. Bulgaria has also begun integrating CE principles into public procurement, although enforcement remains a challenge.

Finally, innovation and research play a pivotal role in advanced countries, with Germany's ***Digital Product Passports*** and Austria's ***"City of Tomorrow"*** program driving CE advancements. Slovakia is making strides in innovation through incentives for renewable energy and energy-efficient buildings. Bulgaria has introduced pilot projects in circular construction but still lacks large-scale investment in CE research and innovation.

Gaps

Despite some strengths, significant gaps still exist across the region. Many emerging and early-stage countries face challenges with policy enforcement. For instance, Montenegro and Croatia need stronger mechanisms to monitor and enforce waste management regulations. In Bosnia and Herzegovina, governance fragmentation hinders implementation across its different entities. Moldova also struggles with enforcing its circular economy (CE) strategies. Bulgaria, while aligned with EU directives, faces major enforcement gaps, especially in landfill diversion and separate waste collection, which remain below EU targets. Slovakia, though more advanced, still struggles with illegal waste disposal and insufficient monitoring of construction waste recycling.

Another critical gap is the inadequate recycling and waste management infrastructure. Both Serbia and Moldova lack sufficient facilities for recycling construction and demolition waste, while Montenegro requires significant investment in its recycling systems overall. Bulgaria also faces infrastructure deficits, particularly in the processing of secondary raw materials and the development of industrial symbiosis models. Slovakia, while making progress, needs further investment in advanced recycling technologies and waste-to-energy solutions to close the loop on material recovery.

Additionally, inter-ministerial coordination remains a recurring issue. The Czech Republic illustrates this challenge, as better alignment across ministries is necessary to fully realize its CE strategies. Similarly, Bulgaria's CE implementation suffers from weak coordination between environmental, economic, and industrial policies, leading to delays in execution. Slovakia, although progressing, faces challenges in cross-sectoral collaboration, particularly in integrating CE principles into broader economic development plans.

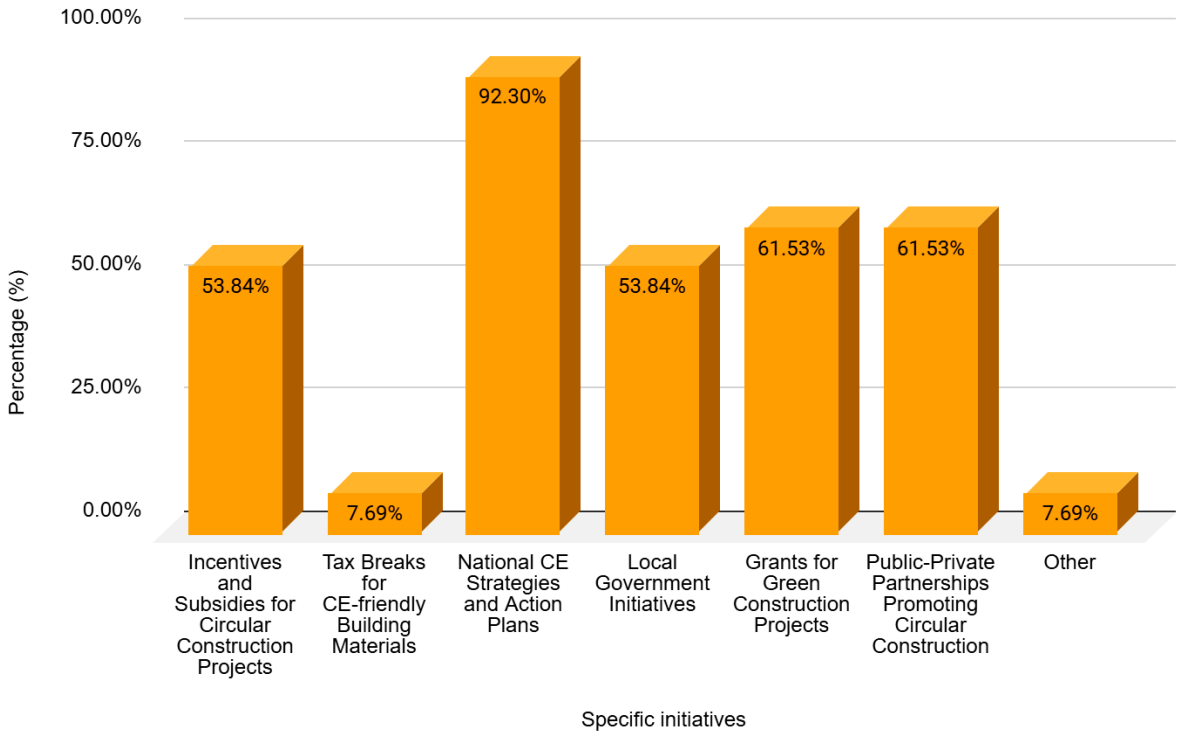
These gaps emphasize the need for stronger enforcement mechanisms, improved infrastructure, and enhanced collaboration to ensure more cohesive and effective CE policies in the Danube region.

Opportunities for Improvement

The Danube region has a significant opportunity to harmonize circular economy (CE) policies and address existing gaps through targeted actions. Strengthening enforcement mechanisms in emerging and early-stage countries, such as Montenegro, Bosnia and Herzegovina, and Moldova, would enhance the effective implementation of current regulations. Investment in recycling and waste management infrastructure is critical, particularly for Serbia, Montenegro, and Moldova, to ensure compliance with EU directives and facilitate circular practices. Slovakia and Bulgaria, while making good progress in integrating CE principles, could benefit from further investments in infrastructure, especially for construction and demolition waste management, and strengthening enforcement to support their growing regulatory frameworks. Improving inter-ministerial coordination, as illustrated by the Czech Republic's challenges, could enhance the integration of CE principles across various sectors in all countries, including Bulgaria and Slovakia, where coordination remains crucial for the successful implementation of CE strategies.

The region would benefit from a shared framework for public procurement, drawing on best practices from advanced countries like Slovenia, Germany, and Austria. Slovakia's efforts in aligning with EU standards on sustainable construction and waste management can be complemented by enhanced public procurement policies focused on sustainability. Additionally, fostering innovation through collaborative research initiatives, especially involving emerging countries such as Romania, Croatia, and Bulgaria, could expedite the adoption of CE strategies and bridge gaps in sector-specific implementation, particularly in waste recycling, sustainable building practices, and the adoption of green technologies.

Overall, the Danube region demonstrates considerable progress in adopting circular economy practices, with advanced countries like Slovenia, Germany, and Austria setting benchmarks for regulatory frameworks, innovation, and enforcement. Emerging countries, including Romania, the Czech Republic, Croatia, Slovakia, and Bulgaria, show strong alignment with EU goals through the adoption of strategies and planned reforms in public procurement and waste management. However, gaps in enforcement, infrastructure, and coordination remain, particularly among early-stage countries like Montenegro, Serbia, and Moldova. A cohesive approach to harmonizing policies, strengthening enforcement, and fostering innovation will be essential for advancing the region's CE objectives. By integrating advanced practices with collaborative regional efforts, the Danube region can position itself as a leader in sustainable development and the transition to a circular economy.



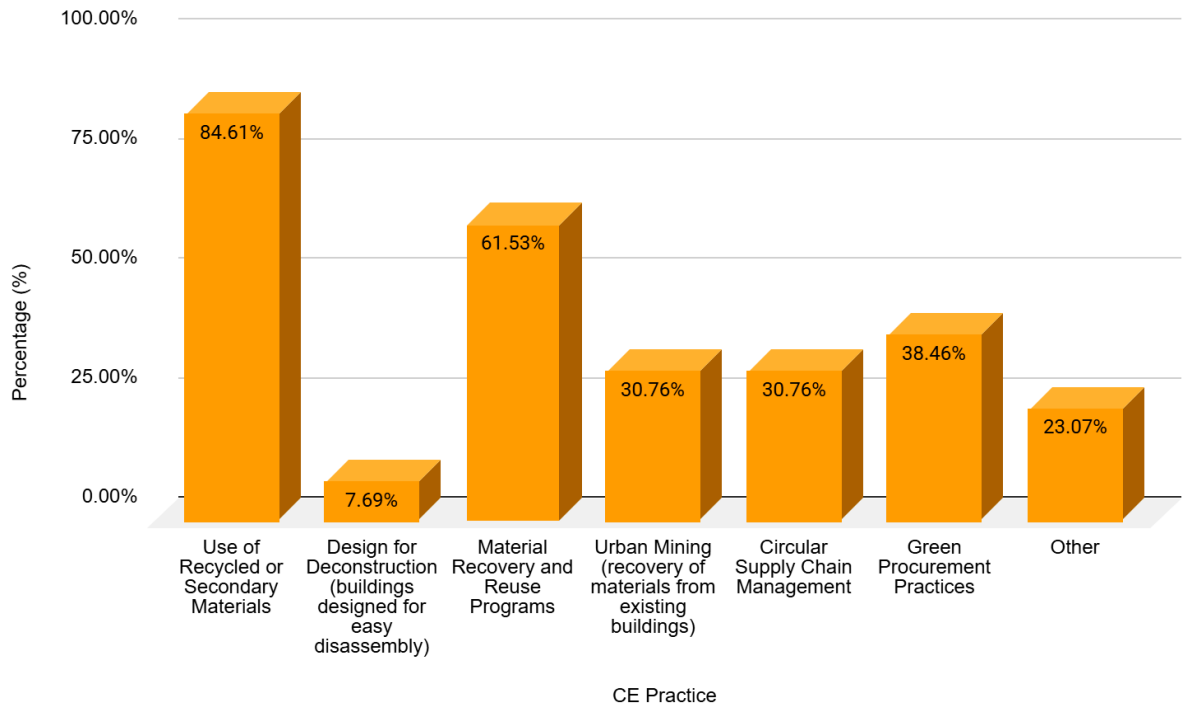
Graph 2 - Countries' specific initiatives

The data reveals that **National CE Strategies and Action Plans** are the most widely adopted initiatives in the Danube region, with **12 countries** implementing them, highlighting their importance as a cornerstone of circular economy policies. **Grants for Green Construction Projects** follow with adoption among **8 countries**, reflecting strong support for financial incentives to promote sustainable practices. **Incentives and Subsidies for Circular Construction Projects** are implemented by **7 countries** and **Public-Private Partnerships Promoting Circular Construction** are implemented by **8 countries**, signaling a growing recognition of the need for collaborative and financial mechanisms to foster CE-friendly construction. **Local Government Initiatives** are present in **7 countries**, emphasizing the role of municipalities in driving localized CE efforts. However, **Tax Breaks for CE-friendly Building Materials** have a limited presence, with only **1 country** adopting them, indicating untapped potential for fiscal incentives to encourage sustainable material use.

In addition to the predefined options, one country reported "other" initiatives that further support circular economy (CE) practices in the construction sector. Notably, the **Czech Republic** stands out for its involvement in **international research projects** such as **Circular DigiBuild**, **BUS-GoCircular**, **CirCon4Climate**, **INDICATE**, **ReBuilt**, and **RECONMATIC**. These projects focus on developing training materials, digital tools, and methodologies for circular procurement and construction, underscoring the country's commitment to integrating CE principles through innovation and cross-border collaboration. In addition to the Czech Republic, it is important to

note that nearly every surveyed country participates in international research projects, particularly highlighting Germany, Austria, and Slovenia.

Section 1c: Market conditions



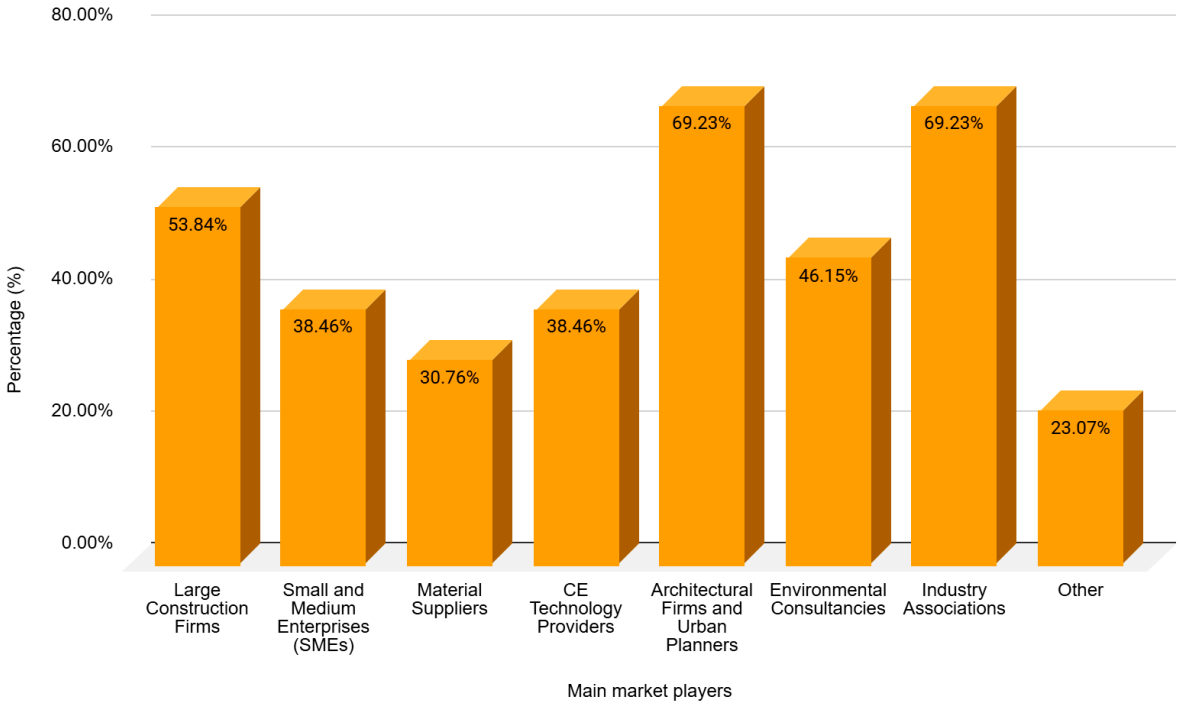
Graph 3 - Most commonly adopted CE practices

The most commonly adopted CE practice across the Danube region is the **Use of Recycled or Secondary Materials**, with **11 out of 13** surveyed countries reporting its implementation. **Material Recovery and Reuse Programs** follow with adoption in **8 countries**, highlighting a growing focus on reclaiming materials from construction and demolition activities. **Urban Mining** and **Circular Supply Chain Management** with **4 countries** each**,** are also gaining traction, reflecting efforts to optimize resource use and integrate circularity into building material flows. **Green Procurement Practices** are similarly adopted by **5 countries**, emphasizing the importance of sustainable purchasing in construction. However, **Design for Deconstruction**, where buildings are designed for easy disassembly, is the least adopted practice in only **1 country**, indicating room for further development in this innovative area.

The "other" responses highlight innovative and localized approaches to circular economy practices in the building sector, showcasing efforts tailored to specific national contexts. In **Montenegro**, construction companies reuse "scraped" asphalt by mixing it with oil for road reconstruction projects, such as those on the PG-DG road and in Kolašin smaller road works.

Small contractors also repurpose demolition rubble, including stone and concrete, as foundation fill for new housing. These practices demonstrate practical applications of circular principles in resource-limited contexts. **Austria and Germany** stand out with advanced initiatives, including its leadership in sustainable building technologies like passive houses and energy-efficient designs. In Germany, the use of BIM is mandatory, for example, in the construction of federal buildings. Austria has adopted **Building Information Modeling (BIM)** to improve construction planning and management while ensuring precision and efficiency. Austria's **Recycling Building Materials Ordinance** mandates waste separation during construction and demolition, ensuring compliance with recycling goals, while its commitment to doubling energy-efficient renovations over the next decade reflects alignment with the European Green Deal. **Romania** emphasizes the integration of energy-efficient designs in compliance with EU directives, aiming to enhance building sustainability and embed CE principles into construction projects. These diverse practices illustrate how countries are finding unique ways to advance CE goals in the building sector, leveraging innovation, regulation, and localized solutions.

While the region is making progress in fundamental CE practices like recycling and material recovery, there is significant potential to expand innovative approaches like design for deconstruction and urban mining in the Danube region, which could accelerate the transition to a more sustainable and circular construction sector.



Graph 4: Main market players

The analysis reveals that **Industry Associations** are the main market players in most of the surveyed countries, **9 of them**, highlighting their significant role in fostering collaboration,

advocating for best practices, and driving the adoption of circular economy principles across the construction and building sector. **Large Construction Firms** are identified in **7 countries**, while **Architectural Firms and Urban Planners** are frequently identified stakeholders in the circular economy, with **8 of countries** acknowledging their roles. This highlights their pivotal role in implementing CE principles through large-scale projects and urban development. **Small and Medium Enterprises (SMEs) and CE Technology Providers** were recognized by **5 countries**, emphasizing their growing importance in facilitating innovation and localized CE efforts. Meanwhile, **Material Suppliers** were selected by **4 countries**, reflecting their moderate but crucial role in providing sustainable materials for CE practices.

Research institutions and universities, highlighted by **Slovenia** and **Austria**, play a pivotal role in advancing CE technologies and methodologies, fostering innovation, and training the next generation of professionals in sustainable building practices. For instance, Austria's research-driven initiatives support the integration of CE principles into construction projects through technological advancements and knowledge-sharing. **Governmental institutions**, mentioned by **Moldova** and **Austria**, are crucial for establishing policies, offering financial incentives, and ensuring compliance with CE practices. Their involvement underscores the importance of regulatory and financial frameworks in facilitating the transition to a circular economy.

In **Germany**, the **Deutsche Gesellschaft für Nachhaltiges Bauen (DGNB)** stands out as a key industry association promoting CE adoption. The DGNB develops certification systems for sustainable construction, providing benchmarks for best practices and motivating stakeholders to adhere to CE standards. Such organizations play a vital role in uniting diverse stakeholders and fostering collaboration. Additionally, Slovenia noted the importance of **research institutions**, which, in collaboration with consultancies and SMEs, create solutions tailored to local contexts.

Country-Specific Analysis of CE Market Leaders in the Building Sector

Slovenia

Slovenia showcases strong leadership in CE initiatives through collaborations such as the **Strategic Development and Innovation Partnership – Networks for Transition to a Circular Economy (SRIP – Circular Economy)** and **SRIP PSiDL** for smart buildings and wood chains. These partnerships unite businesses, research institutions, and government bodies to enhance material circularity, develop closed material loops, and foster public-private collaborations. Specific companies like **GIC Gradnje** are driving digital transformation in construction, while the **Slovenian National Building and Civil Engineering Institute** plays a key role in research, certification, and technical assessments. Other notable contributors include the **Slovenian Association for Sustainable Construction**, which promotes green building standards, and **Innorenew CoE**, an institute focusing on renewable materials and sustainable building

innovation. Together, these organizations position Slovenia as a hub for circular construction innovation.

Montenegro

Montenegro is gradually adopting CE principles, driven by key players such as **Bemax**, which integrates recycled asphalt in road construction, and **Eurozox**, which runs a take-back program for unused construction materials. While companies like **Zetagradnja** emphasize ecological standards, the lack of official verification limits their impact. Notable initiatives include individual contractors repurposing demolition waste for foundational work and NGOs like **Gradionica**, which advocate for sustainable urban development. The **Chamber of Economy of Montenegro** and **UNDP** lead strategic efforts such as the **Roadmap Towards the Circular Economy** and the establishment of the **CE Hub** to integrate CE principles across sectors. While progress is evident, the scale of implementation remains limited, indicating a need for more structured enforcement and innovation.

Serbia

In Serbia, governmental organizations like the **Ministry of Environmental Protection** and the **Ministry of Economy** play central roles in shaping CE policies. NGOs such as the **Balkan Green Foundation** and **Ko Gradi Grad** promote sustainability and citizen-led housing initiatives, incorporating CE principles. Academic institutions, particularly the **University of Belgrade**, contribute through research and education on sustainable development. International organizations like the **UNDP** and the **EU** provide support for green economy transitions. While there is a solid foundation of stakeholders, the practical implementation of CE practices remains in its early stages, requiring greater collaboration and private sector involvement.

Bosnia and Herzegovina

Key players in Bosnia and Herzegovina include **Heidelberg Materials Cement** and **Lukavac Cement**, which are pioneering industrial symbiosis by utilizing waste products like slag and ash in cement production. These companies also adopt alternative fuels and engage in innovative initiatives such as CO_2 reuse in collaboration with the **Sisecam Soda Lukavac Factory** and the **Technological Faculty in Tuzla**. These initiatives demonstrate advanced CE practices, but the country still lacks widespread adoption across sectors, highlighting the need for greater private-sector engagement and public awareness.

Germany

Germany leads in CE innovation through platforms like **Madaster**, which creates material passports for buildings to track and reuse materials effectively. Companies such as **Kewazo** and **Concular** use robotics and digital resource passports to enhance circularity in construction processes. These initiatives reflect Germany's focus on integrating digital tools and automation into CE practices. Additionally, organizations like the **Deutsche Gesellschaft für Nachhaltiges**

Bauen (DGNB) certify sustainable buildings and set benchmarks for CE standards. Germany's combination of technology, strong regulatory support, and collaboration among stakeholders positions it as a global leader in circular construction.

Republic of Moldova

In Moldova, companies like **Lafarge SA** contribute by recycling concrete and producing eco-friendly materials. NGOs like **Green City Lab** and **E-Circular** play critical roles in raising public awareness and promoting CE practices through conferences and educational initiatives. However, Moldova's efforts remain concentrated on select projects and lack broader industry participation, emphasizing the need for scaled implementation and greater private sector involvement.

Hungary

Hungary's key players include **Holcim Magyarország Ltd.**, which uses construction and household waste in cement production, and **CeMBeton**, which supports CE innovation through collaboration with national and international bodies. Organizations like the **KÖVET Association for a Sustainable Economy** and **ÖKO Trade Ltd.** provide environmental consultancy and corporate governance programs. While these initiatives demonstrate a commitment to sustainability, expanding CE practices to include more comprehensive recycling and waste recovery systems could strengthen Hungary's position in the region.

Austria

Austria's leadership in CE adoption is driven by organizations like the **Circular Economy Forum Austria (CEFA)**, which connects stakeholders to promote CE principles. The **BauKarussell** specializes in reuse-oriented demolition, while the **Austrian Association for Recycling of Building Materials** represents most of the CDW recovery industry. The **City of Vienna** sets guidelines for CDW reduction and recycling, and government bodies like the **Federal Ministry for Climate Action** develop national strategies and host summits. Austria's integration of technology, regulation, and multi-stakeholder collaboration solidifies its position as a CE leader.

Croatia

Croatia's **Green Building Council (GBC)** is the primary organization promoting sustainable construction and green energy practices. By fostering education and networking among stakeholders, GBC Croatia supports the transition to a circular economy. While this highlights a focused effort on sustainability, broader engagement with technology providers and material suppliers could enhance the adoption of CE practices in Croatia.

Czechia

Czechia showcases innovation through companies like **Skanska**, which implements circular supply chain management, urban mining, and material recovery in projects like the **Mercury building**. Suppliers like **Saint Gobain** and **Tarkett** offer recycled materials, while architectural studios emphasize sustainable designs. The **CTU UCEEB** plays a vital role in research and education, operating platforms like "Let's Recycle Buildings" to promote best practices in CDW recycling. These initiatives position the Czech Republic as an emerging leader in CE innovation.

Romania

In Romania, companies like **LanaTerm** produce eco-friendly insulation, and **Bricked** specializes in restoring vintage bricks, promoting reuse. **Wienerberger Romania** reduces CO_2 emissions through high-efficiency brick production, while **TeraPlast Group** incorporates recycled materials into new products. These practices, supported by a strong focus on energy efficiency, highlight Romania's potential to advance CE adoption in construction.

The Danube region features a diverse ecosystem of organizations leading CE adoption, ranging from global leaders like Germany and Austria to emerging innovators such as the Czech Republic and Romania. Advanced countries leverage technology, research, and regulatory frameworks to drive progress while emerging countries focus on integrating sustainable practices into local industries. However, countries like Montenegro and Moldova face challenges in scaling initiatives and fostering broader industry participation. Greater regional collaboration and knowledge sharing could further accelerate the transition to a circular economy across all countries in the region.

Bulgaria

Glavbolgarstroy is the largest construction group in Bulgaria and one of the biggest in Southeastern Europe. Specializing in infrastructure, residential, commercial, and industrial projects, the company places a strong emphasis on sustainable development. They collaborate with universities and research organizations on innovative solutions such as the mobile installation for producing high-class recycled construction materials and the prototype of a pulse generator crusher within the *MOBICCON-PRO project*. This energy-efficient crusher produces finer materials, improving the quality of recycled products. Glavbolgarstroy is also working with prestigious universities like **Darmstadt University and Delft University of Technology** on developing an ultra-light insulation material. The product, currently in the testing phase, is expected to offer higher insulation capacity and energy efficiency, marking a significant step in sustainable construction.

Slovakia

CYRKL is a key player in promoting circular economy practices in Slovakia, focusing on waste management solutions that optimize resource use through its digital marketplace. ***INCIEN*** contributes to the circular economy by offering expertise, advocacy, and educational programs aimed at integrating sustainable practices into organizations, while promoting policies that reduce waste and encourage material reuse. ***Circular Slovakia***, a national public-private platform, advocates for the transition to a circular economy, emphasizing collaboration across industries, including construction, to reduce environmental impacts. ***Slovak Passive House Institute (iEPD)*** promotes energy-efficient building techniques and sustainable construction practices, particularly through passive house standards, which align with circular economy goals by reducing energy consumption and utilizing sustainable materials.

We Build in Timber advocates for timber use in construction, supporting its life cycle through sustainable forestry and material reuse, contributing to circular economy goals. ***Slovak Green Building Council (SK GBC)*** leads initiatives in promoting green building practices, certification systems, and low-carbon, recyclable materials in the construction sector. The ***Slovak Chamber of Architects*** plays a significant role in fostering quality architecture and responsible building culture, promoting environmentally harmonious designs through its annual architecture awards. The ***Institute for Urban Development (IUR)*** emphasizes sustainable urban planning by encouraging the reuse of materials and reducing waste in city-building projects, integrating circular economy principles into urban development.

The ***Ministry of the Environment*** *of the Slovak Republic* sets the legislative framework for environmental policy, waste management, and construction demolition waste management, while the ***Ministry of Transport and Construction*** provides crucial support for sustainable public infrastructure projects and the restoration of historic buildings. The ***Metropolitan Institute of Bratislava*** works on enhancing public spaces and improving resilience to climate change through projects in architecture and spatial planning. The ***Slovak University of Technology*** *in Bratislava* is the leading institution in technical education and research related to architecture, urban planning, and construction, with key faculties driving innovation in the sector.

Gaps and Challenges in CE Leadership

The Danube region exhibits a diverse landscape for circular economy (CE) leadership, with both significant advances and persistent gaps. Large companies like ***Skanska*** in the Czech Republic, ***Wienerberger*** *Romania*, and ***Holcim Magyarország Ltd.*** lead the charge due to their resources and capacity. However, smaller firms and SMEs, especially in countries like *Montenegro*, *Moldova*, and even *Bulgaria*, face barriers such as limited access to funding, technology, and knowledge-sharing platforms, slowing the broader adoption of CE practices. In *Slovakia*, while there are strong advocacy groups like ***Cyrkl*** **and** ***Circular Slovakia***, the challenge remains to ensure these groups' messages and solutions effectively reach all parts of the construction industry, including smaller contractors. Even in large firms, there are issues around transparency

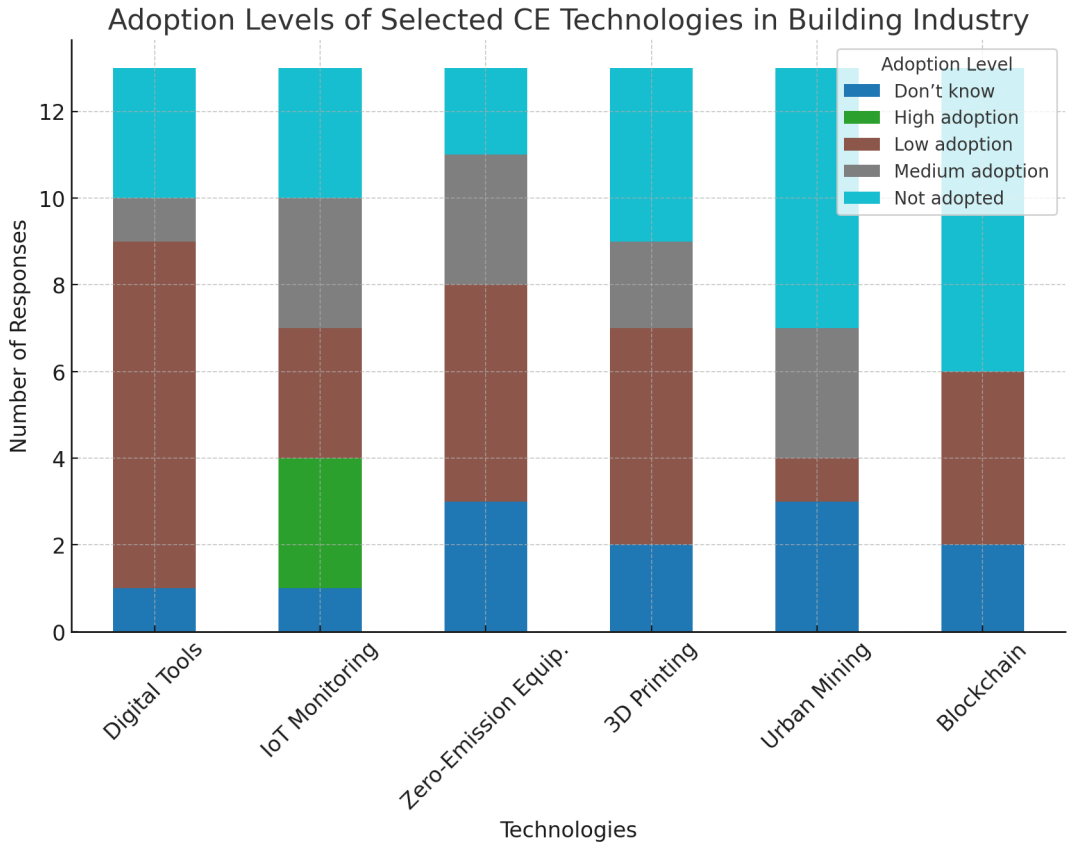
in implementing circular practices, as seen in *Montenegro's Bemax*, which uses recycled materials without openly promoting their use due to concerns about quality perception. Fragmented engagement by government bodies and research institutions is another hurdle, with countries like *Bulgaria* facing a lack of widespread collaboration between industry associations and public authorities. Research institutions in countries like *Austria* and *Slovakia* are more prominent, but knowledge transfer and innovation diffusion remain inconsistent across the region. These gaps underscore the need for improved collaboration between firms, associations, governments, and research entities to ensure that CE adoption is scaled and harmonized across the Danube region.

Opportunities for Advancement

Despite these challenges, the Danube region holds significant opportunities for advancing CE practices through enhanced collaboration and innovation. Large firms, such as ***Glavbolgarstroy*** in *Bulgaria* and *Skanska* in the *Czech Republic*, have the potential to leverage their resources to form public-private partnerships, supporting SMEs in adopting circular economy practices. Initiatives such as *Austria's* ***BauKarussell*** and *Romania's* ***TeraPlast Group*** could serve as models for similar collaborative projects in countries like *Slovakia*, where organizations like ***INCIEN*** **and** ***Circular Slovakia*** can help bridge the knowledge and resource gap for smaller companies. Expanding research and innovation hubs like *Slovenia's* ***SRIP – Circular Economy*** and *Czech Republic's* ***CTU UCEEB*** can foster cross-sectoral partnerships, enabling small and medium-sized firms in *Bulgaria* and *Slovakia* to access cutting-edge technologies and best practices. Transparency and education campaigns are vital, with programs like ***Montenegro's CE Hub*** and *Austria's* ***recycling guidelines*** serving as good examples of addressing public skepticism about recycled materials. In *Slovakia*, promoting initiatives like *Slovak* ***Passive House Institute*** can further support the acceptance of sustainable building materials and energy-efficient practices. Regional cooperation through shared knowledge platforms, such as *Germany's material passport systems* and *Czech Republic's* ***urban mining practices***, would be crucial for accelerating the harmonization of CE practices, ensuring inclusive and sustainable growth across the Danube region, with a focus on overcoming regional disparities and fostering stronger cross-border partnerships.

Chapter 2: Technological Readiness and Economic Impacts

Section 2a: Technological readiness



Graph 5: Technological readiness

General Observations

The adoption of CE technologies across countries in the Danube region is marked by low levels of implementation across most categories. Many technologies are either minimally adopted or absent, particularly advanced tools like 3D printing, blockchain for supply chain transparency, and urban mining technologies. These findings point to a widespread lag in integrating cutting-edge

solutions within the building industry. Furthermore, there is no consistent "high adoption" reported for any technology, underscoring the significant potential for growth and improvement across the region. While some countries report early-stage exploration of CE-related digital tools and energy-efficient methods, overall adoption remains fragmented and inconsistent.

Key Findings by Technology

Digital tools for resource tracking and management, such as material passports, are generally at low adoption levels, with occasional medium adoption noted. This emphasizes the need for broader integration of digital solutions that enhance resource transparency. Similarly, circular design software, which includes lifecycle assessment tools, is either not adopte d or at low levels, reflecting a notable gap in optimizing building designs for circularity. Advanced construction methods, such as 3D printing with recycled materials, remain underutilized, with most respondents categorizing these technologies as being in their infancy or absent altogether.

Technologies like IoT-based building monitoring systems display slightly better adoption rates, with some countries reporting medium levels. This suggests that IoT holds promise as a transformative tool for investment and capacity building. Conversely, blockchain solutions for supply chain transparency are largely "not adopted," revealing a missed opportunity to improve material traceability in the sector. Urban mining technologies, which are critical for recovering materials from older structures, are also mostly absent, signaling a lack of focus on sustainable resource recovery. In some cases, there is interest in repurposing demolition waste, though this is not yet systematically implemented.

Zero-emission construction equipment presents mixed adoption levels. Some countries report medium adoption, indicating early-stage exploration of these tools.However, in some areas, the focus appears to be more on low-carbon construction materials rather than the equipment itself. Circular economy platforms, like digital marketplaces for secondary materials, are predominantly at low adoption levels, reflecting the underdevelopment of digital infrastructure for material reuse. Construction robotics, another area of innovation, is evenly divided between low adoption and no adoption, pointing to limited use of automation. Water recycling technologies show balanced adoption levels between low and medium, signaling gradual progress in sustainable water practices. Nanotechnology-based solutions, such as self-healing concrete, are mostly not adopted, highlighting a lack of integration of cutting-edge material innovations.

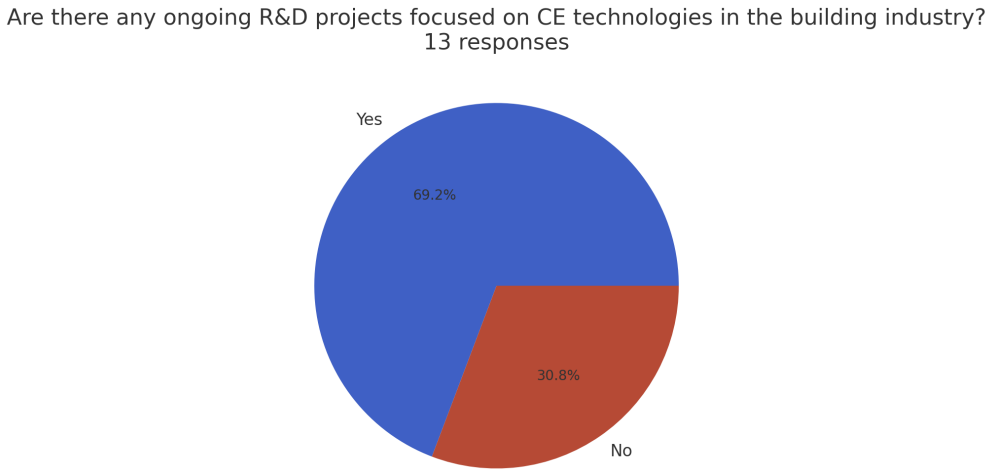
Opportunities for Improvement

To address these challenges, the region should focus on increasing the adoption of digital tools like IoT, blockchain, and digital material passports, which can significantly enhance circular practices. Promoting pilot projects and showcasing successful implementations of CE technologies can build trust and encourage broader adoption. Training programs and awareness campaigns targeting technologies like circular design software, 3D printing, and robotics are crucial to bridging the knowledge gap.In areas where awareness of CE remains low, targeted

educational initiatives and industry partnerships could help accelerate adoption. Governments can play a pivotal role by aligning policies, supporting R&D, and providing financial incentives to reduce the high costs associated with advanced technologies.

Similarities and Differences Between Countries

Despite shared challenges, such as the low adoption of advanced CE technologies like 3D printing and blockchain, some countries demonstrate incremental progress in specific areas. For instance, IoT-based monitoring systems and water recycling technologies show medium adoption in certain nations, reflecting efforts to integrate these solutions into their construction practices. Additionally, the level of exploration of zero-emission construction equipment and digital tools for resource tracking varies, influenced by differences in national priorities, regulatory frameworks, and market readiness. While all countries face common barriers, some have prioritized specific CE technologies over others, highlighting varied approaches to circularity within the region.



Graph 6: R&D projects fostering CE technologies in the building industry

The analysis of responses to the question about ongoing R&D projects focused on CE technologies in the building industry, as illustrated in the chart, indicates 9 countries confirmed active R&D initiatives. This demonstrates a strong focus on innovation and the development of sustainable practices within the sector. However, only 4 countries reported no such projects, reflecting gaps in research activities across certain regions or stakeholders. These findings emphasize the need for more inclusive collaboration and targeted support to ensure that R&D efforts are evenly distributed and effectively drive the adoption of CE technologies in the building industry across the Danube region.

The analysis of responses to ongoing R&D initiatives in CE technologies highlights a diverse range of projects across countries in the Danube region. These initiatives emphasize innovation, resource efficiency, and sustainability in the building industry. Below are the significant projects and their focus areas:

1. **RECONMATIC**
    - **Institutions Involved**: Czech Technical University in Prague (CTU), Aristotle University of Thessaloniki, Munich University of Applied Sciences, and others.
    - **Focus Area**: Life-cycle construction and demolition (C&D) waste management. This project integrates automation and digital tools to minimize waste and improve communication among stakeholders, advancing the construction sector towards a zero-waste industry by 2050.
2. **ReBuilt**
    - **Institutions Involved**: Slovenian National Building and Civil Engineering Institute (ZAG) and 13 partners from Italy, Austria, Slovenia, Czech Republic, Croatia, Hungary, Slovakia, Poland and Germany.
    - **Focus Area**: Development of circular and digital construction strategies and educational resources related to green labeling, end-of-waste criteria, and green public procurement.
3. **Circon4Climate**
    - **Institutions Involved**: ITB, Innowo (Poland), ZAG (Slovenia), IÖR (Germany), and CTU UCEEB (Czech Republic).
    - **Focus Area**: Circular construction practices to combat climate change and improve resource security by promoting secondary material use and circular procurement.
4. **TISMIC**
    - **Institutions Involved**: ETH Zürich, Graz University of Technology, and UCEEB.
    - **Focus Area**: Development of pre-demolition audit tools and deconstruction databases to forecast secondary material availability for construction projects.
5. **Built by Nature (BbN)**
    - **Institutions Involved**: INCIEN (Czech Republic).
    - **Focus Area**: Promotion of multi-story timber buildings to encourage renewable material use and eco-friendly construction inspired by Dutch practices.
6. **CircBoost**
    - **Institutions Involved**: Universitat Politècnica de Catalunya, HafenCity University, Serbia Green Building Council, and others.
    - **Focus Area**: Large-scale pilot projects to demonstrate circular solutions in demolition, waste processing, and material reuse.
7. **LIFE ClimArchiBase**
    - **Institutions Involved**: Passive House Centre, Rethink Architecture Institute, Czech Green Building Council, and the Partnership Foundation.
    - **Focus Area**: Raising awareness about climate-neutral buildings through digital platforms, interactive design guides, and training programs.

8. **European Climate Foundation (ECF Buildings Programme)**
    - **Institutions Involved**: INCIEN (Czech Republic).
    - **Focus Area**: Whole Life Carbon (WLC) measurement and reduction, supported by international best practices and recommendations for policy implementation.
9. **CIRCULARIO**
    - **Institutions Involved**: Romanian government, industry, and academia.
    - **Focus Area**: Supporting Romania's transition to a circular economy, with construction as a key sector, focusing on scaling sustainable practices nationwide.
10. **Transilvania University of Brașov's Research Institute**
    - **Institutions Involved**: Multidisciplinary research centers in Romania.
    - **Focus Area**: Research on sustainable building materials and energy-efficient construction methods.
11. **INDICATE**
    - **Institutions Involved**: Chance for Buildings, Czech Green Building Council, CTU UCEEB.
    - **Focus Area**: Developing case studies of lifecycle carbon emissions in buildings (LCA) and proposing national strategies and a calculation methodology for measuring and reducing whole life carbon in construction.

12. **Slovak Circular Construction Research Initiative**

- **Institutions Involved:** Slovak University of Technology in Bratislava, Institute of Civil Engineering and Architecture SAS, Ministry of the Environment of the Slovak Republic.
- **Focus Area:** Focused on the use of recycled materials in concrete production, low-carbon cement innovations, and carbon capture technologies to reduce environmental impact. The initiative supports research aimed at increasing sustainability in Slovakia's construction sector while fostering a circular economy.

13. Bulgaria's Digital and Circular Construction Initiative

- **Institutions Involved:** Glavbolgarstroy, Darmstadt University, Delft University of Technology, National Digital Innovation Hub for Construction.
- **Focus Area:** This initiative aligns with Bulgaria's National Strategy for Digital Transformation in Construction. It emphasizes research into ultra-light insulation materials with enhanced thermal efficiency, mobile recycling units for processing construction and demolition waste, and integrating digital tools to enhance circular economy adoption in the sector.

These initiatives reflect a strong emphasis on collaboration among universities, private companies, and governmental institutions, highlighting the critical role of research and development in advancing circular economy practices in the building industry. By focusing on innovative solutions such as lifecycle carbon measurement, digital tools for waste management,

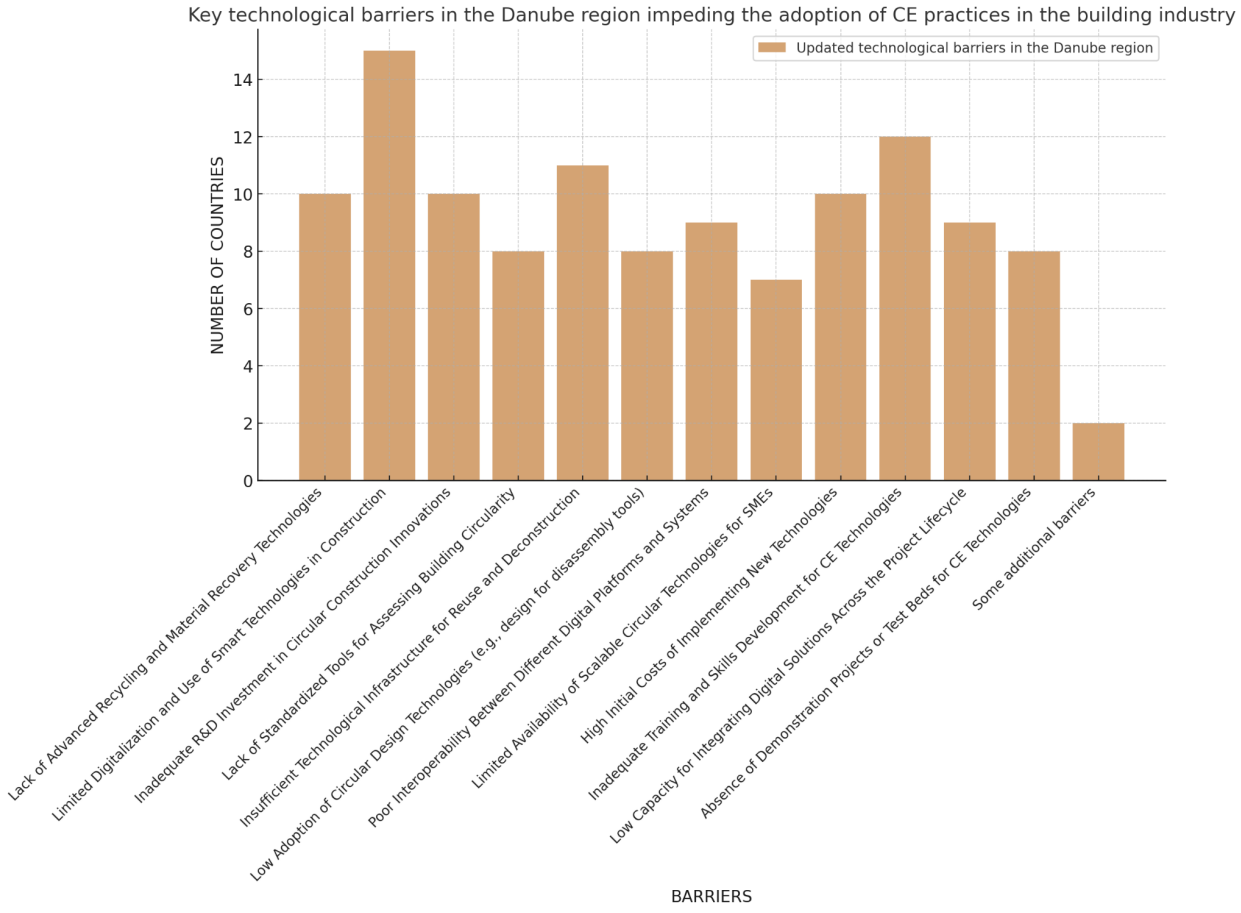
circular procurement strategies, and sustainable construction materials, these projects demonstrate how targeted R&D efforts can address the sector's most pressing challenges, including resource inefficiency, environmental degradation, and carbon emissions.

Furthermore, the diverse scope of these projects—ranging from local initiatives like Romania's CIRCULARIO to large-scale EU-funded endeavors such as CircBoost—illustrates the potential for both national and transnational efforts to contribute meaningfully to the circular transition. This integration of localized focus with broader, cross-border collaboration is a key strength, as it allows regions to tailor solutions to their unique circumstances while benefiting from shared knowledge, innovation, and expertise.

The impact of these projects extends beyond technical advancements. They also play a vital role in shaping policies, raising awareness, and building capacity among stakeholders across the value chain. Programs like LIFE ClimArchiBase, which emphasize training and educational outreach, underline the importance of equipping industry professionals, policymakers, and the public with the tools and knowledge necessary to support and accelerate the adoption of circular practices.

However, despite these successes, the data also highlights disparities in R&D efforts across countries. While some regions exhibit strong engagement with circular economy initiatives, others lag behind due to limited resources, lack of institutional support, or fragmented policy frameworks. Although most countries are engaged in some level of research, certain regions require enhanced regional cooperation and additional funding to ensure broader participation in circular innovation. Addressing these gaps will require enhanced regional cooperation, increased funding, and supportive policies to create a cohesive and inclusive strategy for circular innovation in construction.

In conclusion, the breadth and depth of R&D initiatives across the Danube region showcase the immense potential of circular economy solutions to transform the construction sector. These projects not only drive technological and material innovation but also foster systemic change by aligning environmental, economic, and social objectives. To fully realize this potential, stakeholders must continue to prioritize collaboration, invest in scaling successful pilot projects, and harmonize regulations and strategies across borders. By doing so, the Danube region can position itself as a leader in sustainable and circular construction practices, setting a precedent for other regions to follow in addressing global environmental challenges.



Graph 7: Technological barriers

This question provides a comprehensive overview of the main technological barriers to CE adoption in the building industry. These barriers reflect financial, infrastructural, technological, and regulatory challenges that hinder progress toward circularity.

Key Findings

1. **High Costs of Advanced Circular Technologies**: Highlighted by **11 countries**, this is the most frequently mentioned barrier. The significant financial burden of adopting advanced technologies, such as modular construction systems and digital material tracking, limits widespread implementation. This was also echoed in the data colected, where respondents pointed out that costs remain a deterrent, particularly for smaller firms.
2. **Poor Integration of Digital Tools**: Almost all respondents (**10**) identified poor integration of digital tools, such as BIM and

IoT, as a key barrier. Both data sources underline how fragmented or incompatible digital systems obstruct effective communication, data sharing, and decision-making within the construction value chain.

3. **Lack of Infrastructure for Recycling and Reuse**: With **10 countries** emphasizing this challenge, it is evident that inadequate recycling and material reuse infrastructure is a pervasive issue. The Excel responses also indicate that many countries lack facilities for processing and reusing secondary materials, creating structural gaps in the adoption of circular practices.
4. **Limited Access to CE Technologies**: Also mentioned by **10 countries**, limited access to cutting-edge CE technologies such as smart demolition tools or circular design software was a common theme. In the Excel data, stakeholders noted that these tools are often unavailable or financially inaccessible, especially for SMEs.
5. **Weak Linkages Between Stakeholders**: Another barrier cited by **8 countries** is the weak collaboration between technology providers, construction firms, and policymakers. The Excel responses expand on this, highlighting the need for better partnerships to align technological innovations with industry needs and regulatory frameworks.
6. **Inadequate Data and Interoperability**: As mentioned by **8 countries**, the lack of data availability for circular design and the incompatibility of digital systems present significant challenges. The Excel data complements this by pointing out that these gaps hinder lifecycle analyses and other data-driven decisions essential for CE practices.
7. **Low R&D Investment and Skilled Workforce Shortages**: Both barriers were highlighted by **8 countries**, reflecting systemic underinvestment in innovation and a lack of trained professionals capable of integrating CE technologies into the construction lifecycle. Excel responses also call for increased funding and training programs to bridge these gaps.
8. **Lack of Pilot Projects and Demonstration Facilities**: Identified by **8 countries**, this barrier is further detailed in the Excel data, where stakeholders stress that pilot projects are essential to showcase the practicality and benefits of CE technologies, building confidence among industry players.
9. **Insufficient Testing and Certification Facilities**: With **5 countries** mentioning this barrier, there is a clear need for facilities that can validate and certify the use of secondary materials and new technologies. This issue also appears in the Excel data, where respondents point to the absence of mechanisms to ensure trust and compliance.
10. **Regulatory Restrictions on New Technologies**: Highlighted by **5 countries**, outdated or inconsistent regulations create significant hurdles for implementing innovative CE solutions. The Excel responses further emphasize the need for harmonized policies that encourage innovation.
11. **Public Awareness and Incentives**: Although mentioned by only **1 country**, this barrier remains critical. Limited public

awareness and inadequate incentives for CE technologies were also flagged in the responses, suggesting the need for campaigns and financial support to stimulate adoption.

Conclusion

The interconnected challenges of adopting CE technologies – high costs, inadequate infrastructure, fragmented digital systems, and regulatory barriers – demand a coordinated and multi-pronged approach. Addressing these issues requires increased investment in infrastructure and R&D, development of pilot projects, and stronger collaboration among stakeholders to align objectives and streamline technology integration. Workforce training programs are essential to address skill shortages, while policy reform and regulatory alignment can create an enabling environment for innovation. Incentives, both financial and market-based, along with public awareness campaigns, will drive adoption and demand for circular practices. By tackling these barriers collectively, the construction sector can transition toward a sustainable and circular economy, setting a benchmark for innovation and environmental responsibility.

The additional comments provide valuable insights into ongoing initiatives, challenges, and potential solutions related to the adoption of CE practices in the building industry. They highlight a range of efforts to address technological barriers, foster innovation, and improve resource management. These insights reinforce the necessity of **regional cooperation, investment in training, and infrastructure development** to support the widespread adoption of CE practices.

Key Initiatives Supporting CE Adoption

1. **Waste Exchange Platform**:
   The development of a waste exchange platform, supported by the EU through the IPA project, aims to strengthen the secondary raw material market. By connecting providers and users of secondary raw materials, this initiative creates a transparent marketplace for waste streams. Businesses will define technical criteria for utilizing these materials, ensuring they meet industry standards. This platform addresses the lack of infrastructure for recycling and reuse while improving efficiency in waste collection and recovery. Additionally, several countries have implemented local government initiatives and public-private partnerships to enhance material reuse and support CE-friendly market regulations.
2. **Collaboration for Innovation in Construction**:
   The partnership between the Association of Innovators of Bosnia and Herzegovina and Rekaz Company emphasizes innovation in the construction sector. This collaboration supports startups and entrepreneurs, showcasing advancements at events like Real Expo. By connecting innovators with investors and partners, the initiative fosters technological development and the adoption of CE practices.

3. **INTERA Technology Park Mostar**: This project under the Interreg Danube program focuses on accelerating the transfer of research, technology, and innovation (RTI) in materials science. By fostering collaboration between SMEs and research entities, and establishing Know-how Community hubs, this initiative aims to enhance innovation in materials and material technologies, addressing barriers related to R&D and the adoption of advanced CE technologies.
4. **BAMB Project (Buildings As Material Banks)**: This EU Horizon 2020 project introduced tools like Materials Passports and Reversible Building Design to support circularity in construction. These approaches were tested in pilot projects and supported by new business models and policy recommendations. This project exemplifies how practical tools and models can facilitate CE adoption.

Challenges and Barriers Highlighted

1. **Technological Barriers**: Many comments emphasize recurring challenges such as high costs of advanced circular technologies, insufficient infrastructure for recycling and reuse, and fragmented digital systems. These barriers align with previously identified issues and underscore the need for strategic investments in technology and infrastructure. Several countries also indicate a lack of large-scale incentives or regulatory frameworks to encourage businesses to invest in CE-related technologies.
2. **Shortage of Skilled Workers**: The lack of trained professionals capable of integrating CE technologies into construction practices remains a significant hurdle. Investment in reskilling and educational initiatives is critical to addressing this gap. In response, some EU-funded projects and training programs are being developed to improve workforce readiness in circular construction.
3. **Material Certification and Market Gaps**: There is a lack of sufficient recycled materials for certain applications, such as roof tiles, where only 30% recycled content is achievable. Additionally, a gray market thrives for dismantled materials, creating issues with certification and compliance. Establishing clear standards and supporting legitimate reuse through proper certification processes will be essential. Some countries have launched pilot projects to explore circular procurement strategies, but full market adoption remains a challenge.
4. **Awareness and Engagement**: The adoption of CE practices often suffers from a "lukewarm approach," where rules and regulations are not taken seriously until they become mandatory. Large companies are expected to lead the way in adopting CE practices, similar to how the automotive industry addressed environmental standards.
5. **BIM Adoption**: The growing adoption of BIM, supported by national frameworks and legislation, highlights progress in digital transformation. However, further integration of BIM into CE practices will require sustained support and alignment with other digital tools.

6. **Interconnected Barriers**: Several comments stress that the barriers to CE adoption are interconnected. Insufficient infrastructure, limited technology access, high costs, and a shortage of skilled workers all reinforce each other. Addressing one barrier often supports progress in others. National CE strategies and EU-backed research projects aim to tackle these interconnected challenges by promoting policy alignment and industry collaboration.

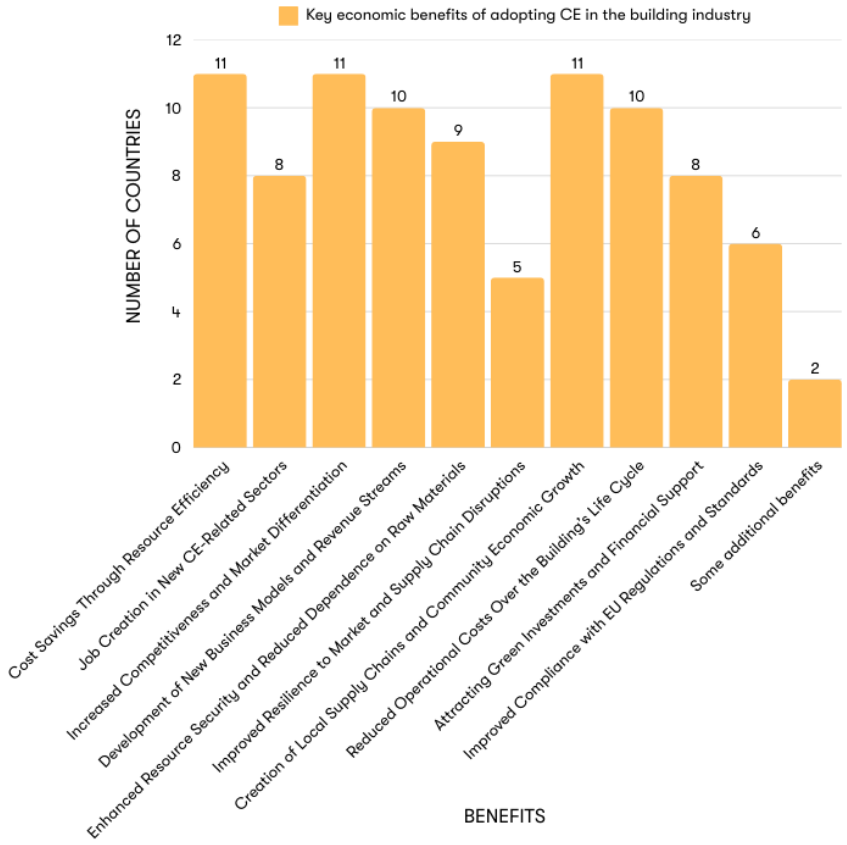
Key Recommendations

- **Expand Collaborative Platforms**: Initiatives like the waste exchange platform and INTERA's Know-how hubs should be scaled up to foster broader collaboration and efficient resource management. Additionally, increasing investment in public-private partnerships and regional research projects could enhance market engagement.
- **Enhance Infrastructure and Certification Processes**: Developing robust systems for recycling, reuse, and certification of secondary materials will help bridge gaps in material availability and compliance.
- **Strengthen R&D and Innovation**: Supporting projects like BAMB and INTERA can drive technological advancements and practical tools for CE adoption. National and EU research funds should be leveraged to scale pilot projects into industry-wide solutions.
- **Raise Awareness and Strengthen Regulations**: Clear enforcement of CE-related rules and active engagement with industry leaders will encourage compliance and innovation. Public campaigns can also increase awareness of CE benefits.
- **Invest in Workforce Development**: Reskilling programs tailored to CE technologies and practices will address the shortage of skilled professionals. Several countries are already implementing education initiatives to improve the technical capacity of the construction sector workforce.

These initiatives and challenges underscore the need for an integrated approach to CE adoption in the building sector. By fostering collaboration, investing in infrastructure and innovation, and addressing workforce gaps, the construction industry can overcome its barriers and accelerate the transition to a circular economy. Such efforts will not only enhance resource efficiency but also create a more sustainable and competitive sector.

Section 2b: Economic and Environmental Impact

This section analyzes the economic and environmental advantages of integrating CE principles into the building industries of 13 countries within the Danube region. The findings highlight the dual importance of CE, positioning it not only as an imperative for environmental sustainability but also as a strategic economic paradigm for transforming and modernizing the building industry across the region.



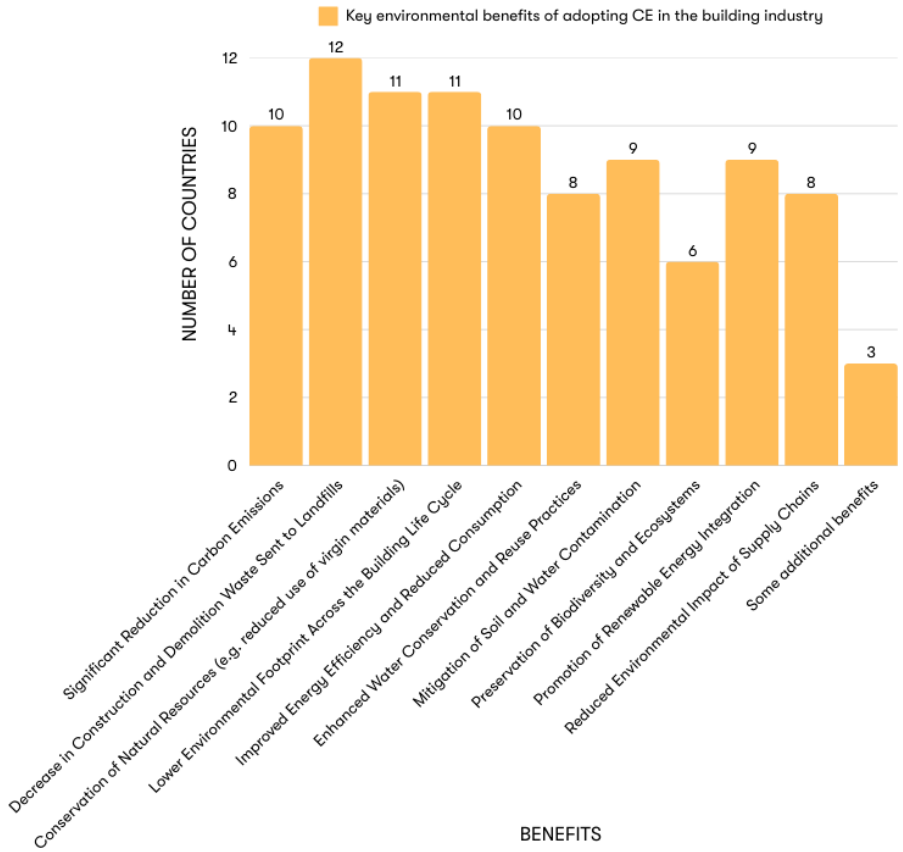
Graph 8: Key economic benefits of adopting CE in the building industry

Insights from industry partners highlight **enhanced market competitiveness** as the most prominent economic benefit of adopting CE practices in the building industry, with 84.62% (11 out of 13 countries) of respondents identifying it as a key advantage. This competitive edge stems from the ability of construction firms to differentiate themselves through sustainable practices, aligning with market trends and consumer demand for environmentally responsible solutions. The adoption of CE principles enables companies to strengthen their market position by leveling innovative approaches, such as resource-efficient designs and the integration of secondary materials, appealing to both clients and industry stakeholders. This option's near-universal significance across the surveyed regions underscores its critical role in driving CE adoption.

Regarding market competitiveness, 11 out of 13 countries (84.62%) identified **cost savings through resource efficiency** as an important factor. Since CE focuses on utilizing materials designed to have extended lifespans, be easily repairable, recyclable, or reusable, such circular designs can offset the higher costs of recycled materials. Additionally, reducing dependency on primary raw materials helps save expenses in the long term and enhances companies' resilience to price fluctuations in the raw materials market.

In addition to enhancing competitiveness, CE practices also **support job creation**, with 61.54% (8 out of 13 countries) of respondents identifying it as an economic benefit within their region. This is largely driven by the expansion of secondary industries, including recycling, material recovery, and deconstruction, which create diverse employment opportunities. Other significant economic benefits include the **development of new business models and revenue streams** (with 76.92% of respondents, 10 out of 13 countries, selecting this option as a relevant economic benefit) and **attracting green investments and financial support** (69.23% of respondents, thus 9 out of 13 countries). Circular business models, such as leasing, sharing platforms, or modular construction, create opportunities for generating revenue in the building sector while reducing resource consumption. Furthermore, the **creation of local supply chains and community economic growth** was prioritized as a relevant advantage by 84.62% of respondents, 11 out of 13 countries. Establishing local supply chains within the circular economy closely aligns with the concept of industrial symbiosis. This approach allows the waste of one company to serve as raw material for another, reducing the need for new resources and enhancing competitiveness. Furthermore, creating local supply chains boosts economic development, supports job creation, and increases resilience to economic and environmental crises. Additionally, **reduced operational costs over a building's lifecycle**, noted by 76.92% of respondents, also 10 out of 13 countries, highlight the long-term financial efficiencies achievable through CE practices.

The least commonly identified economic benefits include **improved compliance with EU regulations and standards** and **improved resilience to market and supply chain disruptions**, noted by 46.15% of respondents (equal to 6 out of 13 countries) and noted by 38.46% of respondents (equal to 5 out of 13 countries), respectively. These lower recognition rates suggest that these benefits may be perceived as less directly impactful compared to more tangible advantages such as competitiveness, job creation, and cost savings. These findings highlight the prioritization of market and resource-oriented benefits, while regulatory and resilience aspects remain less prominently acknowledged.



Graph 9: Key environmental benefits of adopting CE in the building industry

The implementation of CE practices in the building industry brings in not only significant economic benefits but also substantial environmental advantages, emphasizing the transformative potential of circular strategies both within the Danube region and on a global scale. From the perspective of CE principles - elimination of waste and pollution, maintaining materials/products at the highest possible quality level, and regeneration of nature - these offer comprehensive solutions. By prioritizing the reuse of materials and minimizing demolition waste in the construction sector, CE practices promote efficient and sustainable resource utilization, thereby reducing reliance on virgin raw materials. These practices align closely with global sustainability objectives and play a pivotal role in mitigating the environmental impact of construction activities, contributing to the creation of a more sustainable and resilient built environment.

The most prominent environmental advantage identified was a **decrease in construction and demolition waste sent to landfills**, selected by 92.31% of respondents (also 12 out of 13 countries). This benefit reflects the widespread acknowledgment of CE's ability to reduce waste and optimize resource flows in construction. The construction sector was the third-largest producer of waste in 2022. Most of this waste came from two divisions: Engineering Construction

(nearly 49%) and Building Construction (over 30%) (State of the Environment Report, 2022). Circular economy helps reduce such waste through material reuse, recycling, and selective demolition, which carefully dismantles buildings and sorts usable materials for further use. Following this, **lower environmental footprint across the building life cycle** was highlighted by 84.62% of respondents, 11 out of 13 countries, emphasizing the comprehensive sustainability improvements achievable through CE practices. CE approaches consider the entire lifecycle of buildings to minimize environmental impact, reducing the use of primary resources at the beginning and preventing waste generation at the end. CE focuses on optimizing the entire process—from design and construction to operation and building disposal. Similarly, **improved energy efficiency and reduced consumption** (76.92%, 10 out of 13 countries) and **conservation of natural resources** (84.62%, 11 out of 13 countries) were recognized as key benefits. A report by the Ellen MacArthur Foundation, Completing the Picture: How the Circular Economy Tackles Climate Change, shows that applying circular strategies to four key industrial materials—cement, steel, plastics, and aluminum, which are also critical in construction—could help reduce emissions by 40% by 2050.

Several other benefits were acknowledged by a majority of respondents, though with slightly less frequency. These include **enhanced water conservation and reuse practices** (61.54%, 8 out of 13 countries) and **mitigation of soil and water contamination** (69.23%, 9 out of 13 countries), both of which address critical environmental concerns associated with construction activities. **Significant reduction in carbon emissions** (76.92%, 10 out of 13 countries) was another frequently cited advantage, highlighting CE's role in contributing to climate change mitigation. According to a UNEP report, the building sector contributes approximately 16% of global CO_2 emissions, specifically from operational emissions related to building energy consumption. When including embodied emissions from the production and use of construction materials, the sector's total contribution rises to 37%. Implementing CE in construction can significantly reduce these carbon emissions. CE practices promote material recycling and the use of local resources, eliminating the need for energy-intensive production and transport of new materials. This shift toward sustainable practices reduces not only operational emissions but also embodied emissions from construction materials, which is key to mitigating climate change and protecting the environment. Furthermore, **promotion of renewable energy integration**, recognized by 69.23% of respondents, equal to 9 out of 13 countries, underscores the potential for CE to support cleaner energy systems in the construction sector.

Preservation of biodiversity and ecosystems and **reduced environmental impact of supply chains** were each noted by 46.15% of respondents (6 out of 13 countries) and by 61.54% of respondents (8 out of 13 countries), respectively. These benefits are critical in certain settings, particularly in projects that intersect with sensitive ecological zones or involve complex supply chains. Lower selection rate of preservation of biodiversity and ecosystems suggest that these advantages may be perceived as secondary or context-dependent compared to broader benefits such as waste reduction and resource efficiency. CE prioritizes the use of local resources, supporting local suppliers and simultaneously strengthening the local economy.

In addition to the widely recognized economic and environmental benefits of CE practices mentioned above, some participating countries have highlighted unique advantages that further emphasize the transformative potential of CE. **Montenegro**, for example, underscores the economic and environmental benefits of CE in addressing its specific regional challenges. The reduction of coastal and marine pollution, a critical issue in this tourism-dependent nation, is achieved by minimizing construction waste and pollutants. Additionally, CE practices enhance climate resilience by improving resource efficiency and mitigating risks from coastal erosion and extreme weather events. Environmental benefits such as designing for durability, adaptability, and reuse extend the lifespan of buildings, increasing asset value for investors and property owners. Reduced waste management costs also alleviate financial pressures on municipalities and private firms. Furthermore, CE in construction supports sustainable tourism in Montenegro.

Germany highlights the long-term sustainability gains of CE practices, particularly in urban settings where enhancing public health and safety is a priority. The integration of digital solutions for resource management exemplifies the country's emphasis on innovation and technology development within the construction sector. Germany also stresses the importance of fostering collaboration across all sectors of the Quadruple Helix—Industry, Academia, Government, and Civil Society. Effective CE implementation depends on these partnerships to drive innovation, share knowledge, and align regulatory frameworks with sustainability objectives. Specifically, closer cooperation between the private sector and academia is crucial for accelerating the development of new technologies and business models, while government incentives and clear policies help mitigate financial barriers. Engaging civil society through education and awareness campaigns is essential for cultivating a cultural shift toward circular consumption and production.

The Ministry of the Environment of the **Slovak Republic** highlights the importance of transitioning from a linear to a circular economy, particularly in the construction sector, as a key step toward achieving sustainability and fulfilling the commitments of the Paris Agreement on Climate Change. Recognizing the sector's significant potential to reduce primary raw material use and increase recycled material adoption, the Ministry emphasizes the need for improved construction and demolition waste management and stronger incentives for circular design. The gradual implementation of CE goals is already driving positive change, with benefits such as reducing material consumption, minimizing waste, enhancing safety in hazardous waste handling, and lowering emissions of harmful substances into the environment.

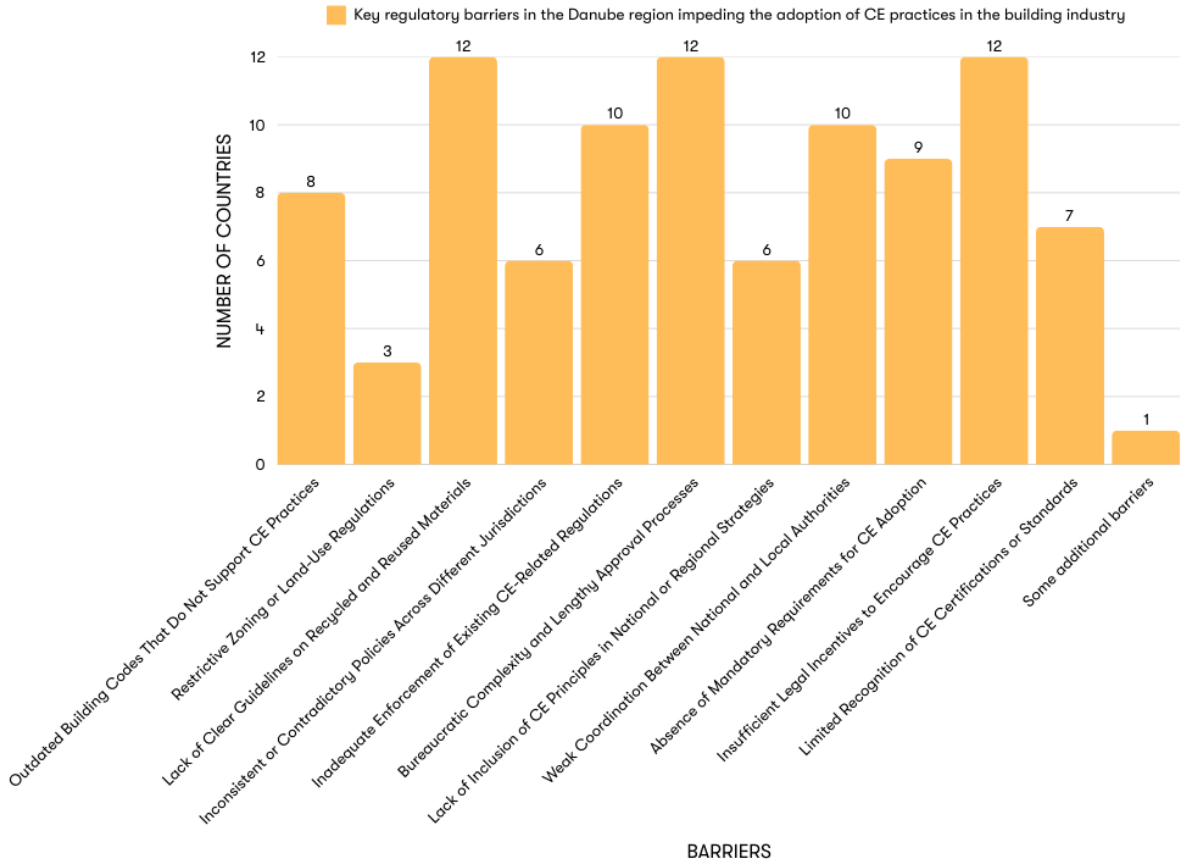
In **Bulgaria**, CE is a key component of the country's vision for digitalization in construction. The integration of digital technologies is seen as essential for tackling major sectoral challenges, including labor shortages, competitiveness, resource and energy efficiency, and productivity. Given the construction sector's role in the national economy, its digital transformation is not only important for growth but also serves a broader, long-term purpose, supporting European and national policies on sustainability, climate neutrality, and CE. By harnessing digitalization and improved management of the built environment, Bulgaria aims to cultivate a green, digital, and resource-efficient construction ecosystem, while also addressing demographic changes, workforce development, and education in the sector.

Conclusively, these findings indicate that while certain economic and environmental benefits are widely acknowledged within the Danube region, others reflect region-specific priorities and contexts, highlighting the diverse environmental and economic challenges and opportunities within the Danube region.

Chapter 3: Challenges, Opportunities, and Best Practices

Section 3a: Challenges and barriers

This section analyzes the challenges and barriers of integrating CE principles into the building industries of 13 countries within the Danube region. The survey findings identify a diverse range of regulatory, market, and technological barriers—spanning policy gaps, consumer behavior, cost structures, material availability, value chain dynamics, digitalization, infrastructure, and skills development—that collectively challenge the adoption and effective implementation of CE principles.



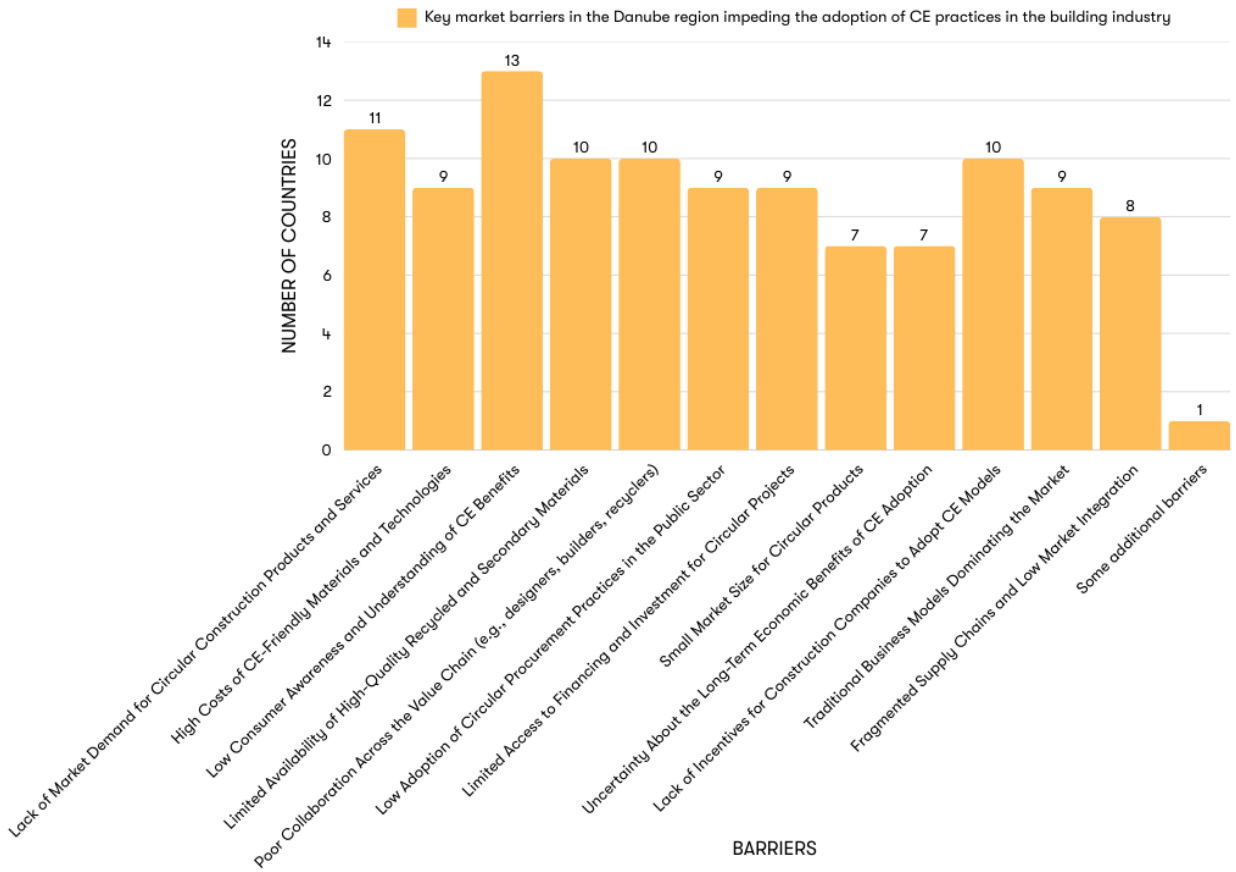
Graph 10: Key regulatory barriers in the Danube region impeding the adoption of CE practices in the building industry

Outdated building codes that do not support CE practices are a significant concern. More than half of the respondents (61.54%, 8 out of 13 countries) indicated this as a barrier in terms of their national policy context. Similarly, **restrictive zoning or land-use regulations** impede the flexibility required to adopt CE practices, making sustainable solutions harder to implement. However, these do not seem to be as big of a challenge, with only 23.08% of respondents (3 out of 13 countries) specifying this as an issue.

The **absence of clear guidelines for using recycled or reused materials** poses a notable challenge with 92.31% of respondents (12 out of 13 countries) experiencing this barrier on their national level. Additionally, **inconsistent or contradictory policies across jurisdictions** create confusion and hinder the uniform application of CE principles for 46.15% of respondents (6 out of 13 countries). This inconsistency likely complicates efforts for businesses and local authorities aiming to comply with CE-related measures.

Inadequate enforcement of existing CE-related regulations and **bureaucratic complexity, including lengthy approval processes**, emerge as barriers. Each one of these regulatory barriers was noted by 10 out of 13 countries (76.92%) and 12 out of 13 countries (92.31%), respectively. Such inefficiencies discourage the proactive adoption of sustainable practices by increasing costs and delays. The **lack of inclusion of CE principles in national or regional strategies** reflects a lack of prioritization at higher policy levels for 46.15% of respondents (6 out of 13 countries).

Weak coordination between national and local authorities further exacerbates this issue, with authorities failing to align their efforts to promote CE effectively in 76.92% (10 out of 13 countries) of the cases. The **absence of mandatory requirements for CE adoption** and **insufficient legal incentives** are clear obstacles. Without compelling frameworks or financial rewards, stakeholders lack motivation to transition to CE models. Each one of these regulatory barriers was noted by 9 out of 13 countries (69.23%) and 7 out of 13 countries (53.85%), respectively. Additionally, the **limited recognition of CE certifications or standards** undermines efforts to reward and legitimize CE-compliant projects, which was agreed by 7 out of 13 countries (53.85%).



Graph 11: Key market barriers in the Danube region impeding the adoption of CE practices in the building industry

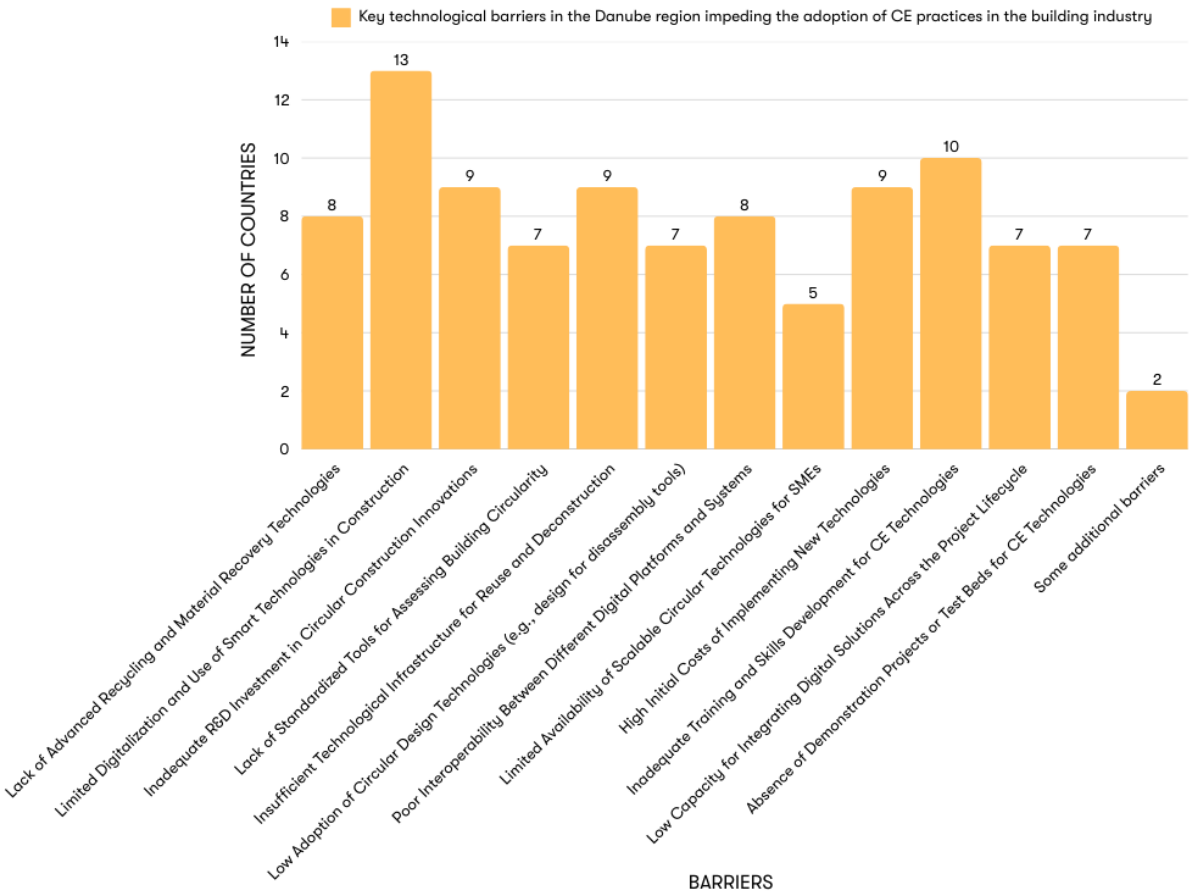
The most significant barrier, identified by all respondents (100%, 13 out of 13 countries), is **low consumer awareness and understanding of the benefits of CE practices**. The **lack of market demand for circular construction products and services** was similarly recognized as a major challenge by 84.62% of respondents, 11 out of 13 countries. This limited market demand highlights a disconnect between CE innovations and consumer or industry readiness to embrace them. The insufficient demand is further compounded by **high costs associated with CE-friendly materials and technologies**, as reported by 69.23% of respondents (9 out of 13 countries), which limits their accessibility and adoption.

Additionally, the **limited availability of high-quality recycled and secondary materials** remains a prevalent issue, with 76.92% of respondents (10 out of 13 countries) identifying it as a barrier. This shortage impedes the implementation of CE practices, as stakeholders struggle to source materials that meet the necessary quality standards for construction. **Poor collaboration across the value chain**, also highlighted by 76.92% of respondents (10 out of 13 countries), reflects the challenges in fostering coordinated efforts among designers, builders, recyclers, and

other key actors. This fragmentation weakens the integrated approaches required for a successful transition to CE models. Furthermore, the **lack of incentives for construction companies to adopt CE practices**, cited by 76.92% of respondents (10 out of 13 countries), underscores the need for stronger regulatory or financial frameworks to motivate industry stakeholders toward circular practices.

Uncertainty about the long-term economic benefits of CE adoption present additional challenges, with 53.85% of respondents (7 out of 13 countries) pointing to low adoption of circular procurement practices in the public sector, limited access to financing for circular projects, and the dominance of traditional business models as significant obstacles. Similarly, **small market size for circular products** was identified as a market barrier by the same number of respondents, highlighting ongoing concerns about the feasibility and profitability of transitioning to CE. These factors suggest a systemic rigidity in both market structures and institutional support, which restricts innovation and the broader adoption of CE principles. **Fragmented supply chains and low market integration**, noted by 61.54% of respondents (8 out of 13 countries), further intensify these challenges by creating inefficiencies that hinder the seamless implementation of circular practices.

Additionally, one respondent (7.69%) suggested a **lack of skilled labor for implementing CE practices, inadequate support for startups in CE Sectors, cultural resistance to change, and lack of local market data for CE investments**, signalling a targeted need for capacity-building efforts in specific regions.



Graph 12: Key technological barriers in the Danube region impeding the adoption of CE practices in the building industry

The most universally cited barrier is the **limited digitalization and use of smart technologies in construction**, with 100% of respondents (13 out of 13 countries) identifying this as a significant challenge. This lack of digital integration reflects a fundamental gap in the sector's capacity to leverage advanced tools, such as BIM or IoT-based systems, to support circular practices. Closely related to this is the **inadequate training and skills development for CE technologies**, noted by 76.92% of respondents (10 out of 13 countries). This barrier underscores the pressing need for capacity-building initiatives to equip the workforce with the technical expertise necessary to operate and implement these emerging technologies effectively.

Several other critical barriers, each identified by 61.54% of respondents (8 out of 13 countries), include **high initial costs of implementing new technologies**, **inadequate R&D investment in circular construction innovations**, and **insufficient technological infrastructure for reuse and deconstruction**. These challenges point to structural limitations in both technological availability and financial accessibility. For instance, the high costs associated with adopting innovative technologies disincentivize investment, particularly for smaller firms, while inadequate

infrastructure slows down the scalability of sustainable practices such as modular construction or selective demolition.

Additional barriers reflect challenges in coordination, interoperability, and the practical application of circular technologies. For instance, **poor interoperability between different digital platforms and systems** (61.54%, 8 out of 13 countries) and **low adoption of circular design technologies**, such as design-for-disassembly tools (also selected by 53.85%, 7 out of 13 countries), reveal obstacles to integrating digital solutions across the project lifecycle. Similarly, the **absence of demonstration projects or test beds for CE technologies** (53.85%, 7 out of 13 countries) and **low capacity for integrating digital solutions across projects** (53.85%, 7 out of 13 countries) highlight the need for practical frameworks and experimental spaces to showcase the feasibility of CE practices.

Several region-specific issues were also highlighted. **Montenegro**, for example, faces a shortage of advanced machinery and equipment for sustainable construction practices, such as modular building and selective demolition, as well as the absence of standardized systems to monitor the use and quality of recycled materials. This lack of transparency prevents confidence in the reliability of secondary materials. **Romania** similarly noted the limited integration of IoT and real-time monitoring, insufficient technological transfer from research to practice, and a lack of localized data for material circularity, which collectively impede the translation of theoretical advancements into practical applications. In **Germany**, the lack of alignment between federal, state, and municipal regulations creates regulatory fragmentation, complicating efforts to standardize CE practices. Industry resistance to adopting new approaches, coupled with skepticism about the reliability of recycled materials, further slows progress. Technical challenges related to retrofitting existing buildings and limited financial support for such projects exacerbate these issues. Additionally, a significant gap in education and awareness among industry professionals limits the widespread adoption of CE practices, emphasizing the need for targeted capacity-building initiatives. In **Moldova**, the construction sector's engagement with CE remains in its nascent stages, with numerous barriers reported. Similarly, the **Czech Republic** highlighted a range of challenges, including knowledge gaps among private builders, public investors, and building managers, as well as insufficient expertise in sustainable building design and decarbonization. Educational and awareness barriers were also noted, such as the limited inclusion of CE topics in educational programs and inadequate public communication. Administrative challenges, including the failure to incorporate emissions performance into public procurement and a lack of strategic renovation efforts for government-owned buildings, further hinder progress. Strategic and organizational barriers, such as the absence of a national construction sector strategy and limited ministerial capacities, also contribute to the slow adoption of CE practices. In **Slovakia**, the Ministry of the Environment recognizes the challenges associated with the implementation of Decree No. 344/2022 Coll. on construction and demolition waste. The current provisions present practical difficulties, necessitating broader discussions and the active involvement of diverse stakeholders. Furthermore, a key issue identified is the lack of a standardized pre-demolition audit process. Such audits are essential for determining the presence and volume of hazardous substances before demolition, ensuring their proper removal.

However, Slovakia currently lacks certified auditors or qualified professionals for this task, leaving it to designers in collaboration with experts from various fields. To address these challenges, the Ministry is actively developing a methodological manual on the management of construction and demolition waste, providing developers and builders with clear legal and procedural guidance. Additionally, the Ministry is preparing a roadmap and educational publications to further support the sector's transition towards circularity and sustainability. Lastly, **Bulgaria**, despite its commitment to digitalization in construction, as demonstrated by the approval of a National Strategy for Digitalization, continues to face significant barriers that hinder progress in this area. The country serves as an example where persistent regulatory, financial, and structural challenges still impede the effective implementation of circular and digital practices in the construction sector. To align with leading EU trends, there is an urgent need for targeted policy interventions and increased funding measures that would facilitate the adoption of innovative technologies, enhance sectoral efficiency, and accelerate the transition toward a more sustainable and digitalized built environment.

Section 3b: Best practices and opportunities

Case Studies

1. **Energy2POG – Hybrid Energy Concept (Austria)**: This project focuses on implementing a hybrid energy concept within residential and commercial buildings. It incorporates renewable energy systems, advanced insulation materials, and smart building technologies to achieve high energy efficiency and resource optimization. The initiative demonstrates a scalable approach to integrating CE principles in energy-efficient construction.
2. **B2GreenHub Initiative (Slovenia)**: The B2GreenHub initiative supports businesses in aligning with the EU's Corporate Sustainability Reporting Directive (CSRD) and other green regulations, emphasizing circular economy principles. It acts as a comprehensive ecosystem, transforming regulatory challenges into growth opportunities through access to over 50 testing facilities, 200+ technological solutions, and a digital platform with case studies and cost analyses. With backing from 100+ EU institutions and 150+ experts, the hub fosters sustainable transitions and business innovation.
3. **Implementation of Circular Construction Practices (Montenegro)**: Montenegro's CE initiative integrates circular construction practices in public housing projects. The focus is on modular construction, biobased materials, and deconstruction strategies to ensure resource recovery. The project highlights the importance of regulatory support and cross-sectoral collaboration.
4. **Digital Resource Passport (Germany)**: This initiative by concular and DGNB provides digital resource passports to improve material traceability and transparency in the construction supply chain. The passports

allow for better planning, deconstruction, and reuse of building components, supporting waste reduction and CE innovation.

5. **BREEAM Certification Standards (United Kingdom)**: The BREEAM certification promotes sustainability in construction through lifecycle assessments and resource-efficient building designs. Projects certified under BREEAM demonstrate significant reductions in embodied carbon and operational energy usage.
6. **Holcim's Circular Economy Concept (Hungary)**: Holcim developed a circular economy framework that reuses construction waste as raw materials for new products. The initiative integrates recycling technologies with sustainable business models, setting an example for closed-loop material usage.
7. **Series of Completed Sustainable Housing Projects (Romania)**: Several housing projects demonstrate sustainable construction techniques, including the use of prefabricated modules, energy-efficient designs, and renewable materials. These projects reduce resource consumption and increase building lifespan.
8. **Skanska Mercury Project (Czech Republic)**: Skanska implemented CE principles by conducting a pre-demolition audit of a brownfield development site, selective demolition and optimizing deconstruction, recycling and reusing materials and building components, and incorporating modular construction elements. The project serves as an early benchmark for sustainable commercial building practices.
9. **EFdeN Signature (Romania)**: A solar-powered, sustainable housing model that integrates passive building designs, renewable materials, and water recycling systems. EFdeN Signature illustrates the potential for energy-self-sufficient housing aligned with CE principles.
10. **MOBICCON-PRO (Bulgaria):**

    This Horizon project focuses on recovering resources from construction and demolition waste. It implements innovative circular solutions such as mobile recycling installations, advanced demolition techniques, and new construction materials with recycled content. The project also aims to validate sustainable business models for waste management and circular construction practices.

11. **Slovak Circular Construction Innovation Hub (Slovakia)**

    This initiative promotes circular construction by developing sustainable building materials and fostering collaboration between research institutions and industry players. It focuses on recycling concrete and low-carbon cement production, supporting the broader integration of CE principles in the construction sector.

Insights and Common Themes

- **Technological Integration**: Many projects leverage smart technologies such as digital resource passports, IoT sensors, and modular systems to streamline circular practices.

- **Material Circularity**: Several initiatives prioritize recycling and reuse, focusing on secondary materials, urban mining, and innovative biobased solutions.
- **Collaboration**: Cross-sectoral partnerships, involving governments, private firms, and research institutions, are central to the success of these initiatives.
- **Regulatory and Certification Support**: Standards such as LEED and BREEAM and public support for pilot projects play a vital role in encouraging sustainable practices.

Conclusion

These case studies underscore the importance of integrating CE principles through innovative technologies, material circularity, and collaborative frameworks. They offer replicable models for fostering sustainability in the building sector across the Danube region and beyond.

Additional Case Studies

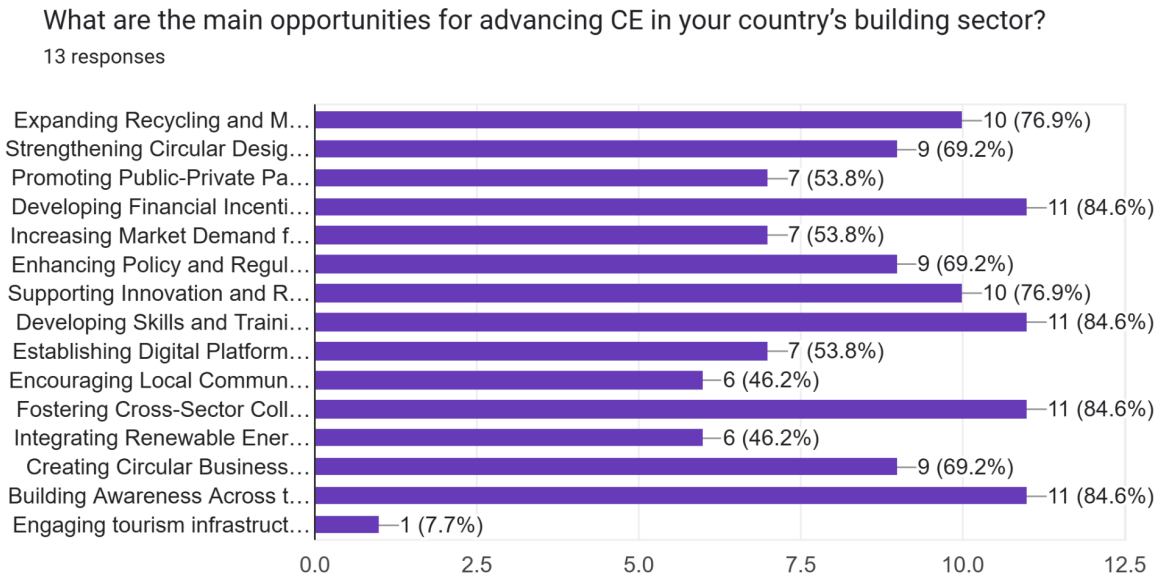
1. **BauKarussell Project (Austria)**:
    - **Description**: This initiative focuses on the reuse and recycling of construction materials during demolition projects. It emphasizes the role of social enterprises in managing materials, providing job opportunities for marginalized groups, and reducing waste.
    - **Impact**: BauKarussell has become a model for inclusive circular practices, creating economic and environmental benefits.
2. **Chamber of Economy Initiative (Montenegro)**:
    - **Description**: A program aimed at fostering circular economy practices within the construction sector. This initiative connects stakeholders, promotes the reuse of construction materials, and supports the adoption of eco-friendly technologies.
    - **Impact**: Enhanced collaboration and greater awareness of circular practices across the value chain.
3. **Madaster Platform (Germany, foundation in The Netherlands)**:
    - **Description**: Madaster is a digital platform designed to create "material passports" for buildings. It allows for detailed tracking of materials used in construction to facilitate recycling and reuse during renovations or deconstruction.
    - **Impact**: Promotes transparency in material usage and encourages sustainable practices in construction projects.
4. **Krivaja Homes (Bosnia and Herzegovina)**:
    - **Description**: This project features low-energy and passive housing designs using renewable materials. The focus is on modular prefabrication, ensuring faster construction and minimal environmental impact.
    - **Impact**: Demonstrates the scalability of energy-efficient housing solutions in a CE framework.
5. **Adam Rujbr Architects (Czechia)**:

- **Description**: This architectural firm integrates circular principles by utilizing recycled materials and emphasizing sustainable designs and renovation over new construction. Their projects often incorporate urban mining and closed-loop material systems.
- **Impact**: Sets a benchmark for integrating CE principles in architectural practices.

6. **Bricked Initiative (Poland)**:
   - **Description**: Focuses on the production of bricks made from recycled construction and demolition waste. This initiative demonstrates the potential for transforming waste into high-value products.
   - **Impact**: Encourages material circularity while reducing dependency on virgin resources.

Observations

- **Material Tracking and Reuse**: Platforms like Madaster and projects such as BauKarussell emphasize the importance of tracking materials to promote reuse and reduce waste.
- **Collaboration**: Many initiatives are driven by partnerships between private firms, local governments, and community organizations.
- **Energy Efficiency**: Case studies such as Krivaja Homes highlight the role of energy-efficient designs in circular construction.
- **Social Impact**: Projects like BauKarussell also demonstrate how CE practices can contribute to social inclusion by creating employment opportunities.



Graph 13: Main opportunities for CE advancement

Analysis of Opportunities for Advancing CE in the Building Sector

The opportunities for advancing CE in the building sector demonstrate a diverse and multifaceted approach across countries. A significant emphasis is placed on expanding recycling and material recovery infrastructure, which was highlighted by 81.8% of respondents. This indicates a broad recognition of the need to develop systems for reusing and recycling construction and demolition waste, which currently remains underutilized in many regions. Such infrastructure improvements are critical to fostering material circularity and reducing reliance on virgin resources.

Strengthening circular design practices was identified as another key opportunity, with 69.2% of respondents emphasizing its importance. Circular design involves embedding lifecycle thinking into the early stages of building planning, ensuring efficient material use, and facilitating reuse at the end of the building's life. This approach aligns with the growing push for sustainable and resource-efficient construction techniques.

Financial incentives also emerged as a top priority, with **11 countries** identifying them as essential for advancing CE practices. Subsidies, tax relief, and grants are seen as powerful tools for encouraging the adoption of CE technologies, particularly in regions where cost barriers remain a challenge. Supporting innovation and R&D in circular technologies was another critical area, cited by **10 countries**. Investment in research and development is viewed as a pathway to creating new materials, systems, and technologies that align with CE principles.

In addition, developing skills and training programs (**11 countries)** and fostering cross-sector collaboration (**11 countries)** were highlighted as key enablers of CE adoption. Building capacity through education is necessary to equip workers with the skills needed to implement CE initiatives, while cross-sector partnerships can create synergies and promote a more integrated approach to sustainability.

Interestingly, several respondents pointed to the importance of promoting public-private partnerships (**7 countries**) and enhancing policy and regulatory support (**9 countries**) to drive systemic changes. These measures are seen as foundational for creating an environment conducive to CE adoption, particularly in regions where regulations and governance structures are not yet fully aligned with sustainability goals.

The integration of renewable energy and resource efficiency was highlighted by **6 countries** of respondents as a complementary opportunity to CE practices. Energy efficiency not only reduces the carbon footprint of buildings but also enhances their lifecycle performance, making it a natural fit within the broader framework of circular construction.

Building awareness across the value chain was another widely recognized opportunity, with 84.6% of respondents underscoring its importance. Raising awareness among stakeholders, from policymakers and developers to consumers, is essential for fostering a culture of sustainability and encouraging the adoption of CE practices.

Insights

- **Context-Specific Relevance**: The comments emphasize the importance of tailoring CE strategies to specific national contexts. While some opportunities may be universally applicable, others might hold less relevance depending on local conditions and policy environments.
- **Policy and Fiscal Environment**: The example of tax exemptions in the Czech Republic highlights how fiscal policies can indirectly influence the adoption of CE practices. The planned removal of these tax breaks points to the need for alternative financial incentives to sustain momentum in CE adoption.
- **Funding and Reform Dependency**: Romania's delays in accessing EU funds underline the critical role of financial and institutional readiness in advancing CE opportunities. Timely reforms and access to funding are essential for scaling CE practices across the region.
- **Technological and Infrastructure Barriers**: Technological barriers such as high costs of advanced CE technologies, inadequate data for circular design, and fragmented digital systems hinder Germany's progress. R&D projects like Concular Digital Resource Passports and Kewazo's robotics for scaffolding showcase potential solutions. However, the need for broader infrastructure development, pilot projects, and testing facilities is critical to addressing infrastructure and knowledge gaps that limit the widespread implementation of CE.

Conclusion

The analysis uncovers a diverse array of opportunities to advance circular economy (CE) adoption in the construction and building sector across the Danube region. While the shared priorities of reducing construction and demolition waste, improving resource efficiency, and fostering innovation are evident, the specific pathways and readiness levels vary significantly among countries due to differences in regulatory, technological, and market landscapes.

A key opportunity lies in scaling public-private partnerships to pool resources, expertise, and innovation capacity. Austria’s BauKarussell, which not only recycles construction materials but also creates social employment opportunities, exemplifies the multi-dimensional benefits of such initiatives. Similarly, Romania’s TeraPlast Group demonstrates the potential of advanced recycling technologies to transform waste into high-value materials. Scaling such models across the region could help small and medium enterprises (SMEs) overcome barriers to adopting CE practices, making them pivotal players in the transition to circularity.

Innovation hubs such as Slovenia's SRIP – Circular Economy and the Czech Republic's CTU UCEEB provide critical platforms for fostering collaboration between academia, industry, and government. These hubs drive advancements in technologies like modular construction systems, life cycle assessment tools, and material tracking mechanisms. For instance, the Czech Republic's urban mining projects leverage Building Information Modeling (BIM) to optimize the reuse of construction materials, showcasing a scalable solution that could inspire similar initiatives across the Danube region.

Recycling and material recovery infrastructure remain a foundational area of focus, especially in countries like Montenegro and Moldova, where CE frameworks are less developed. Investments in processing facilities for construction and demolition waste are essential to close resource loops and reduce dependency on virgin materials. The success of Austria's comprehensive recycling guidelines and Germany's material passport systems offers a blueprint for these countries to enhance material circularity and transparency.

Education and awareness initiatives are crucial to building public trust in CE practices and fostering a cultural shift toward sustainability. Montenegro's CE Hub serves as a prime example of how targeted communication campaigns can dispel misconceptions about recycled materials and encourage their acceptance. Worker training programs in Hungary and the Czech Republic further highlight the importance of equipping the workforce with the skills necessary to implement advanced CE technologies, ensuring that local industries remain competitive in a rapidly evolving market.

Digital technologies offer transformative potential to accelerate CE adoption. The integration of Internet of Things (IoT) technologies, digital material passports, and lifecycle monitoring systems facilitates efficient tracking and optimization of resources. Germany's adoption of digital material passports, for example, ensures the traceability of material properties, simplifying their reuse and recycling at the end of a building's lifecycle. Expanding such digital solutions throughout the region could create more robust and data-driven approaches to CE.

Financial incentives, including subsidies, grants, and tax exemptions, are vital for overcoming economic barriers to CE adoption. EU funding, in particular, plays a pivotal role in enabling infrastructure modernization, supporting R&D, and incentivizing private sector participation. However, as seen in Romania, delays in implementing necessary reforms can jeopardize access to critical funding, underscoring the need for streamlined governance and timely policy alignment.

Moreover, fostering regional cooperation is essential to harmonizing CE practices across the Danube region. Shared knowledge platforms, cross-border pilot projects, and collaborative initiatives such as material exchanges and urban mining practices provide scalable solutions that can address disparities in readiness and capacity among countries. These collaborative efforts can create a unified framework for CE implementation, ensuring that no country lags in the transition toward circularity.

An important consideration is the dynamic and adaptive nature of CE frameworks. As markets evolve, policies must remain flexible to integrate emerging innovations, address new challenges, and capitalize on unforeseen opportunities. For example, while community-led initiatives may currently seem less relevant in certain contexts, such as the Czech Republic, they may gain significance as local engagement becomes a more integral part of the CE transition over time.

Ultimately, the path to a circular construction sector requires tailored strategies that align with each country's regulatory frameworks, technological capabilities, and market dynamics. By leveraging their unique strengths, fostering inclusive collaboration, and addressing regional disparities, the Danube region can accelerate its transition to a sustainable and resilient circular economy. This collective effort not only enhances environmental sustainability but also strengthens social and economic resilience, paving the way for long-term regional growth.

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