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# Optimising the Circular Economy for Construction and Demolition Waste Management in Europe: Best Practices, Innovations and Regulatory Avenues

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**Abstract:** This article explores the sustainable management of construction and demolition waste (CDW) as part of a circular economy in Europe. It provides an overview of current European practices, identifies the main challenges associated with collecting, sorting and recycling waste, and highlights the need to design buildings and construction that encourage the reuse of materials. The study also draws on best practice from internationally recognised examples such as Japan, Singapore, California, the Netherlands and China, which highlights the effectiveness of a combination of strict regulations, economic incentives and advanced recycling technologies. These international cases provide valuable lessons that can be adapted to the European context to improve the situation and fill gaps in policy, innovation and education. This article recommends targeted measures to strengthen circular practices, such as harmonising European standards, promoting eco-design principles in public procurement, investing in research and development (R&D) and establishing green administrative practices. By adopting these strategies, Europe can significantly improve the management of CDW, fostering a more resilient, sustainable and integrated circular economy.

**Keywords:** circular economy; construction and demolition waste (CDW); sustainable waste management; recycling building materials; environmental regulation; waste recovery; waste management policy; sorting and recycling technology

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## 1. Introduction

The circular economy is an innovative economic model that aims to minimise the use of resources and reduce the production of waste, while promoting the reuse, recycling and recovery of materials. In contrast to the traditional linear economy, which follows the "produce, consume and dispose" pattern, this model promises a more sustainable and environmentally friendly approach [1]. The transition to a circular economy is particularly relevant in the construction and demolition sector in Europe, where construction and demolition waste (CDW) accounts for around 37% of all waste produced, with an upward trend projected in the coming years [2]. This significant proportion demonstrates the substantial environmental impact of this sector, which is often considered to be one of the most polluting in Europe. The generation rates of CDW also vary considerably across Europe, ranging from just 1% to almost 90% of all waste generated depending on the country, reflecting major disparities in construction practices and national regulations [3].

In response to this problem, the European Union has stepped up its efforts by introducing new regulations, directives and targets to encourage Member States to further adopt the principles of the circular economy. Recent measures include, for instance, improving the recycling and reuse rate of CDW to 70%, reducing landfill waste and increasing the quality of recycled materials—initiatives that are part of the new European Green Deal Action Plan for the Circular Economy [4–6]. Other examples include the new taxonomy regulation aimed at directing investments towards sustainable activities and the newly adopted construction products regulation for clean and smart products [7–9]. Other recent initiatives by the European Commission Joint Research Centre on modular and reusable panels for buildings are also under assessment [10].

However, despite these advances, considerable challenges remain, particularly in terms of collection, sorting and design for circularity. CDW recovery rates vary widely between countries, from around 60% in Finland to almost 99% in the Netherlands, reflecting differences in national policies, the effectiveness of waste management systems and the commitment of local actors to the circular economy [2]. Recent studies indicate that many aspects of the circular economy value chain still require improvement to achieve optimal efficiency [11–15].

This study examines the current state of CDW management in Europe, highlights examples of best practices from around the world, including the Japanese and Singaporean models, and proposes concrete solutions for improving circularity in this sector. The aim is twofold: to assess the effectiveness of current practices in Europe and to propose specific measures to address existing gaps, thus to optimise the management of CDW. Ultimately, this article aims to demonstrate how, through combined regulations, technological innovation and economic incentives, Europe can become a world leader in the sustainable management of construction and demolition waste.

The methodology adopted to structure the path followed in this article is based on an analytical and comparative approach (developed in Figure 1), making it possible to link local European issues to proven global solutions. First, a contextual data analysis was carried out to identify the key challenges facing the management of CDW in Europe, such as disparities in recycling rates, gaps in standards and the fragmentation of practices in flow management. This was followed by an in-depth literature review, which provided an overview of existing policies and initiatives in Europe. Next, an international comparative analysis was conducted, based on case studies identified as best practices from regions that are leaders in the management of CDW (Japan, Singapore, California, the Netherlands and China), in order to extract lessons that can be applied to the European context. Finally, the solutions proposed in this article have been developed through a critical synthesis of the strengths and weaknesses of European practices, coupled with an adaptation of international best practices, thus guaranteeing, in principle, operational and strategic relevance for strengthening the circular economy in Europe.

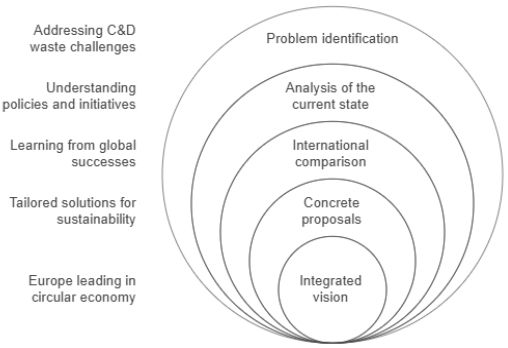



**Figure 1.** Methodology and analytical framework for this study.

## 2. Review of Policies, Initiatives and Best Practices for Managing Construction and Demolition Waste in Europe

The management of construction and demolition waste (CDW) has become a strategic priority for Europe, where the construction sector is both an economic mainstay and a major source of waste. In response to growing environmental pressures and sustainability requirements, the European Union has developed an ambitious regulatory framework to transform the way CDW is managed. EU policies aim not only to minimise the amount of waste sent to landfill but also to encourage innovation throughout the product lifecycle, notably in the sorting, recycling and reuse of construction materials. Different Member States, depending on their national contexts and capacities, have implemented these directives with varying results. As a result, Europe is becoming a hub of initiatives and good practices, offering valuable lessons on effective strategies for the sustainable management of CDW. However, CDW generation continues to increase over time, with a significant proportion still being diverted to landfill. According to Eurostat, the EU-wide recycling rate of CDW reached around 88% in 2020; yet, this figure is misleading, as a large share is downcycled into low-value uses (e.g., backfilling) rather than high-quality reuse.

The country cases selected in this section are not intended to be exhaustive. They have been chosen to illustrate a diversity of countries regulatory frameworks, policy maturity levels and geographical contexts across Europe. This approach aims to highlight representative best practices without claiming full coverage of all Member States.

One of the European Union's current targets is to improve the recycling and reuse rate of construction and demolition waste (CDW) to 70% by weight, with a focus on reducing landfill waste and increasing the quality of recycled materials, which is in line with the new Circular Economy Action Plan (CEAP) introduced as part of the European Green Deal [4]. This initiative is part of the Waste Framework Directive 2008/98/EC [16], which aims to promote waste prevention and improve resource efficiency in Europe. Member countries are required to put in place waste management plans that include measures for the sorting and recycling of construction materials [6]. However, the implementation of these measures is uneven, and many Member States struggle to meet the 70% target with high-quality reuse.

CDW is also addressed in policies relating to critical raw materials, as it represents an important urban source for recovering critical, strategic and precious materials, such as copper, aluminium or niobium [17–21]. Construction and demolition waste also contains significant quantities of raw materials, such as steel, iron, aggregates and glass, which are essential for various industries. Recovering them from CDW not only helps to reduce the dependence on imports but also strengthens EU competitiveness and secures the supply of materials needed for European strategic sectors such as electronics, automotive and renewable energy. It also contributes to the decarbonisation roadmap highlighted within the European Clean Industrial Deal [22].

The implementation of CDW management policies varies considerably across Europe. For example, the Netherlands has developed a robust waste management infrastructure, with selective collection systems and advanced recycling facilities. The country has also introduced financial incentives to encourage businesses to adopt sustainable practices [12]. In Belgium, CDW management is also well regulated, with initiatives such as the certification of recycled materials and the creation of secondary market platforms for reused construction materials. On the other hand, countries such as Italy and Poland still face significant challenges in implementing these advanced policies due to fragmented regulations and a lack of appropriate infrastructure [13].

Across Europe, some countries are leading the way with innovative approaches and effective strategies to maximise recycling, reuse and waste reduction.

In the Netherlands, known for its advanced sorting systems and financial incentives, CDW management policy is one of the most advanced in Europe. The country has set up specialised sorting centres that enable recyclable materials to be effectively separated at building sites. In addition, financial and tax incentives are offered to companies that adopt sustainable construction practices. For example, the Dutch government subsidises projects using recycled materials and imposes strict recycling quotas [12].

In Belgium, recognised for its certification systems and reuse platforms, CDW management policy is well regulated and among the most structured in Europe. The country has developed several programmes and strategies to promote a circular economy [23,24], including a certification system for recycled building materials. This certification guarantees that the materials meet strict quality standards, enhancing their acceptance and use in new construction projects. In addition, the country has created online platforms where companies can buy and sell recycled materials, thereby facilitating their reuse [13].

In France, where regulations and training initiatives support the circular economy, CDW management policy is reinforced by strict measures and innovative practices. The country reinforces the management of CDW through strict regulations and initiatives supported by EPR schemes (Extended Producer Responsibility) [25]. This initiative requires producers to finance waste collection and recycling, encouraging companies to adopt sustainable design practices and minimise waste during the planning phase of construction projects. The country also encourages the creation of sorting centres at building sites and offers subsidies for construction projects that use recycled materials [25]. In addition, France has developed training programmes for construction workers to promote sustainable practices and efficient waste management [25]. Furthermore, the RE2020 regulation, introduced to improve the energy efficiency of buildings, also supports the use of greener materials by prioritising low-carbon construction products [26]. In principle, RE2020 could contribute to better end-of-life management by encouraging design practices that facilitate deconstruction, reuse and recycling.

## 3. Discussion: Challenges, Opportunities and Strategies for CDW Management

Despite the significant progress made in Europe in integrating the circular economy into the management of construction and demolition waste (CDW), a number of challenges persist throughout the value chain. These challenges are not only technical but also regulatory, economic and behavioural. They constitute major obstacles to the wider adoption of circular practices, but they also offer opportunities for future innovation and improvement.

### *3.1. Locks and Challenges in the Circular Economy Value Chain*

To achieve a true circular economy in CDW management, it is crucial to overcome existing shortcomings at every stage of the value chain. Key challenges include inefficiencies in waste collection and sorting, lack of design for circularity, lack of harmonised standards, insufficient economic incentives as well as the lack of awareness and training.

Inefficient collection and sorting of waste on construction sites remains a fundamental problem. Much recyclable material is often contaminated with other types of waste, reducing its quality and limiting its potential for reuse [12,27]. This leads to the degradation of recycled materials, affecting their acceptability for new construction projects. Improving selective collection, supported by stricter regulations, could significantly increase the purity of recovered materials. Practices such as sorting at the site and the use of specialised sorting centres are examples of approaches that can maximise the quality of recycled materials.

The lack of design for circularity is another major challenge. Buildings are often designed without consideration for the end-of-life of the materials used, which limits

the possibility of reusing or recycling these materials. To maximise the recyclability of materials, it is essential to incorporate eco-design principles, such as the use of modular and demountable materials [20,28]. In addition, designing for circularity should include strategies to minimise the contamination of materials during use, making them easier to recycle.

The lack of harmonised Europe-wide standards for the recycling of construction materials remains a significant obstacle. Differences in standards and quality output requirements limit the market acceptance of recycled materials and their integration into new projects. Updated, clear and uniform standards would help to guarantee the quality of recycled materials and stimulate demand for them. This could also facilitate cross-border trade in recycled materials, contributing to a more integrated circular economy in Europe [29].

Economic incentives play a crucial role in promoting circular practices, but they are often insufficient or poorly targeted. Subsidies for projects using recycled materials, taxes on virgin materials and tax credits for companies adopting sustainable practices are some examples of policies that could encourage a faster transition to a circular economy [25]. A better design of these incentives, tailored to the economic realities of different countries, could stimulate the wider adoption of recycling and reuse practices.

Finally, the lack of awareness and training among those involved in the construction sector represents a major barrier. Waste management operators are usually not aware of all of the materials incorporated in products, which reduces the likelihood of their recovery at the end of life. Knowledge sharing should thus be encouraged; it is also a pillar of the European Construction Sector Observatory [30]. Many professionals are not sufficiently informed about the benefits of the circular economy and modern techniques for recycling and reusing materials. Ongoing training programmes and awareness-raising campaigns are needed to fill this gap and encourage the wider adoption of circular practices [25]. These efforts should aim to integrate practical knowledge on the economic and environmental benefits of the sustainable management of CDW.

### *3.2. International Practices for Managing CDW: Relevant Examples from the Rest of the World*

As Europe continues to make progress in implementing the circular economy for the management of construction and demolition waste (CDW), it is instructive to consider best practices from other parts of the world that could be adapted or adopted in Europe. Countries such as Japan, Singapore, California, the Netherlands and China have developed particularly effective systems that overcome some of the challenges identified in Europe, including strict regulation, economic incentives and advanced technologies.

Japan is renowned for its recycling and recovery model in waste management, achieving remarkable results through a combination of rigorous standards, cutting-edge technologies and strategic planning. The country recycles more than 95% of its construction waste thanks to supporting policies and innovative technologies [29]. This success relies on a combination of stringent regulation and continuous innovation. Japan's Construction Materials Recycling Law, implemented in 2000, requires companies to recycle specific materials such as concrete, wood and asphalt. This legislation aims to ensure the separation of recoverable materials from the demolition phase, thereby improving the purity and quality of recycled materials [29].

To reinforce this policy, selective demolition methods, such as the "Kajima Cut and Take Down" technique [31], have been developed to allow buildings to be dismantled in stages while sorting the recoverable materials directly on-site (Figure 2). This approach reduces cross-contamination and maximises the recovery of high-quality materials, which can then be reused in new construction projects. However, despite its technical relevance, the

method remains costly, time-consuming and difficult to apply on a large scale. As a result, its deployment in Japan has been limited to a small number of demonstration projects.

In addition, facilities such as the Taisei Ecological Reproduction System (Tecorep) [32] efficiently transform construction waste into high-quality materials, demonstrating the importance of an integrated approach combining recycling and eco-design. The Japanese model also illustrates the importance of long-term planning and support for innovation to optimise CDW management. The government encourages the use of low-carbon-footprint materials and the development of advanced recycling technologies, creating an environment conducive to continuous innovation in the building sector.

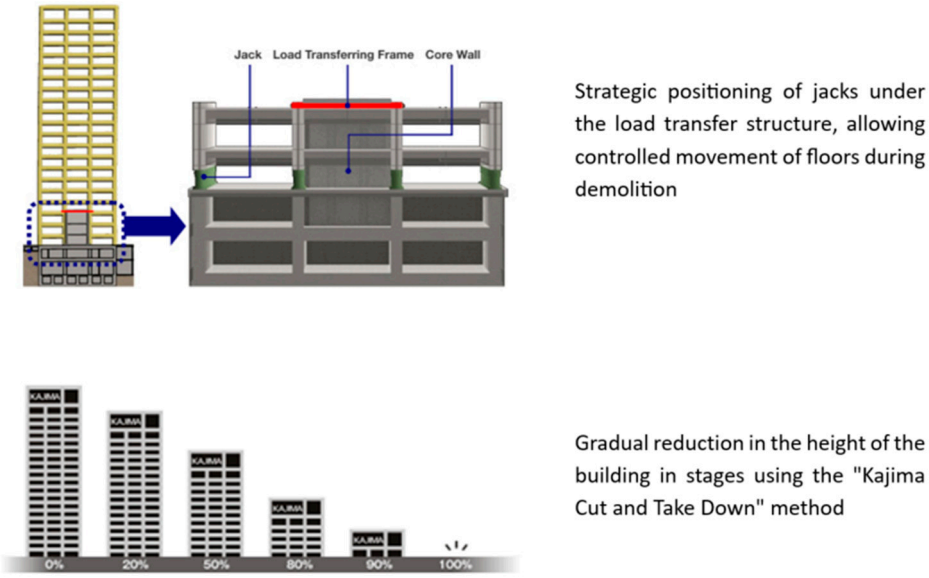



**Figure 2.** Illustration of the "Kajima Cut and Take Down" method for deconstructing buildings; figure extracted and adapted from [33].

Singapore, renowned for its strategic integration of regulations, economic incentives and advanced technologies, is a successful example of CDW management. This approach effectively combines strict regulations, targeted economic incentives and cutting-edge technologies to address waste management challenges [12]. The government has introduced stringent policies, such as the Green Mark Scheme, which rewards buildings that achieve high standards of sustainability and recycling [34–36]. Similar international frameworks, such as LEED (Leadership in Energy and Environmental Design, USA) and GSAS-CM (Global Sustainability Assessment System for Construction Management, Middle East), also include criteria relevant to CDW management. These frameworks promote the use of recycled materials, construction waste minimisation and design for disassembly, encouraging buildings to be more easily deconstructed and for materials to be reused or recovered at end-of-life.

For example, Table 1 provides an overview of the criteria and point allocation system under the Green Mark Scheme in Singapore, which rewards sustainable construction practices. Projects can earn up to three points if the materials used contain at least 30% recycled content by weight or volume, as highlighted in the table (see point c.(ii)) [37,38]. This system encourages the adoption of environmentally friendly materials and aligns with Singapore's broader goals of reducing waste and promoting a circular economy.

**Table 1.** Sustainable construction criteria and allocation of points in the Green Mark Scheme in Singapore, adapted from [36–38]. Each score on the right column corresponds to the mentioned practice on the left column. The use of recycled content in products is highlighted by light blue in the table.

| **Part 3–Environmental protection** | **Green Mark Points** |
| --- | --- |
| RB 3-1 Sustainable Construction:<br>The aim is to encourage the adoption of building designs, construction practices and materials that are environmentally friendly and sustainable. This can be as following: | |
| (a) More efficient concrete usage for building components. | 0.1 point for every percentage reduction in the prescribed Concrete Usage Index (CUI) limit for residential buildings.<br>(up to 4 points) |
| (b) Conservation of existing building structure. Applicable to existing structural elements or building envelope. | Extent of coverage: Conserve at least 50% of the existing structural elements or building envelope (by area)<br>2 points |
| (c) Use of sustainable materials and products in building construction such as: | |
| (i) Environmentally friendly products that are certified under the Singapore Green Labelling Scheme (SGLS). | 1 point for high Impact item<br>0.5 point for low impact item<br>(cap at 3 points) |
| (ii) Products with at least 30% recycled content by weight or volume (applicable only to non-structural elements). | 1 point for high Impact item<br>0.5 point for low impact item<br>(cap at 3 points) |
| Note (2): for products that are certified under SGLS and with at least 30% recycled contents, points can only be scored either from RB 3-1 (c)(i) or (c)(ii) | (up to 6 points) |

Construction companies must comply with waste management standards, and severe penalties are applied for non-compliance. In addition to these regulations, Singapore uses state-of-the-art technology to sort and recover waste. Facilities such as the Tuas South Incineration Plant effectively separate recyclable materials from waste, reducing the amount of waste sent to landfill [12]. Singapore is also investing in energy recovery technologies, converting non-recyclable waste into energy, thereby reducing reliance on landfill.

The Netherlands stands out as a pioneer in the circular economy and eco-design, adopting an integrated approach to CDW management with ambitious policies to achieve a circular economy by 2050 [39,40]. The country actively promotes the use of advanced sorting centres, and financial incentives have been introduced to promote source separation and the use of recycled materials [39]. In addition, the concept of 'circular hubs', where companies collaborate to exchange materials and resources, is being actively promoted [39]. These hubs enhance stakeholder collaboration and facilitate the circular economy by encouraging material reuse.

The Netherlands also supports circular design and procurement strategies, which are guided by measurement tools such as the Environmental Cost Indicator (ECI) and the Dutch National Environmental Database. These tools help to assess environmental impacts and promote circular products [41]. Furthermore, the Building Circularity Index (BCI) provides an innovative method to measure the circularity of buildings, encouraging eco-design and waste reduction at the source [40]. Table 2 provides a comparative overview of these tools, highlighting their objectives, applications and data requirements.

**Table 2.** Comparison of measurement tools for the circular economy in the Netherlands.

| Measurement Tool | Objective | Application | Types of Data/Indicators Used |
| --- | --- | --- | --- |
| Environmental Cost Indicator (ECI) | Assessing the environmental impact of construction materials and products. | Used by companies and local authorities to compare the environmental impact of materials and to choose more sustainable solutions. | $CO_2$ emissions, energy consumption, the use of resources, the impact on biodiversity and external environmental costs. |
| Dutch National Environmental Database | Providing a standardised database of the environmental impacts of construction materials. | Used for sustainable building design and calculating the environmental impact of construction projects. | Lifecycle inventory (LCI) data, product profiles, greenhouse gas emissions and raw materials consumption. |
| Building Circularity Index (BCI) | Measuring the circularity of buildings and promoting eco-design and waste reduction. | Used by architects, engineers and urban planners to assess the circularity of a building and plan more sustainable constructions. | Proportion of materials reused/recycled, the lifespan of materials, the adaptability of structures and the potential for dismantling. |

To further drive sustainable practices, the Netherlands has implemented taxes on virgin materials, incentivising the use of recycled alternatives and fostering innovation in construction [40]. Innovations such as material passports make it easier to track materials throughout their lifecycle, supporting reuse and recycling [41]. Pilot projects like the Green House in Utrecht, a demountable circular catering pavilion, exemplify the practical application of circular construction. Additionally, technologies such as SmartCrusher, which recovers sand, gravel and cement from concrete, highlight the potential for advanced recycling techniques in the building sector [41].

California illustrates how a mix of federal regulations and local incentives can create a robust framework for CDW management. California legislation requires construction projects to meet certain recycling standards, notably under the California Green Building Standards Code [42], which mandates that 65% of construction waste be recycled or diverted from landfill since 2010.

In addition to CALGreen's statewide mandate, local governments have introduced complementary initiatives to further encourage recycling and material reuse. Cities such as San Francisco and Los Angeles have established municipal programmes that promote the reuse of materials recovered from construction sites and offer economic incentives to contractors who comply with recycling guidelines.

The Californian government's green procurement policies, which impose sustainable building standards for municipal projects, are also driving change in the private sector. As shown in Figure 3, municipal recycling programmes in San Francisco and Los Angeles set ambitious targets for material reuse and incentivise contractors who meet these guidelines. These policies encourage private developers to adopt similar standards, such as LEED (Leadership in Energy and Environmental Design) certification, thereby expanding the market for sustainable building materials and practices [43].

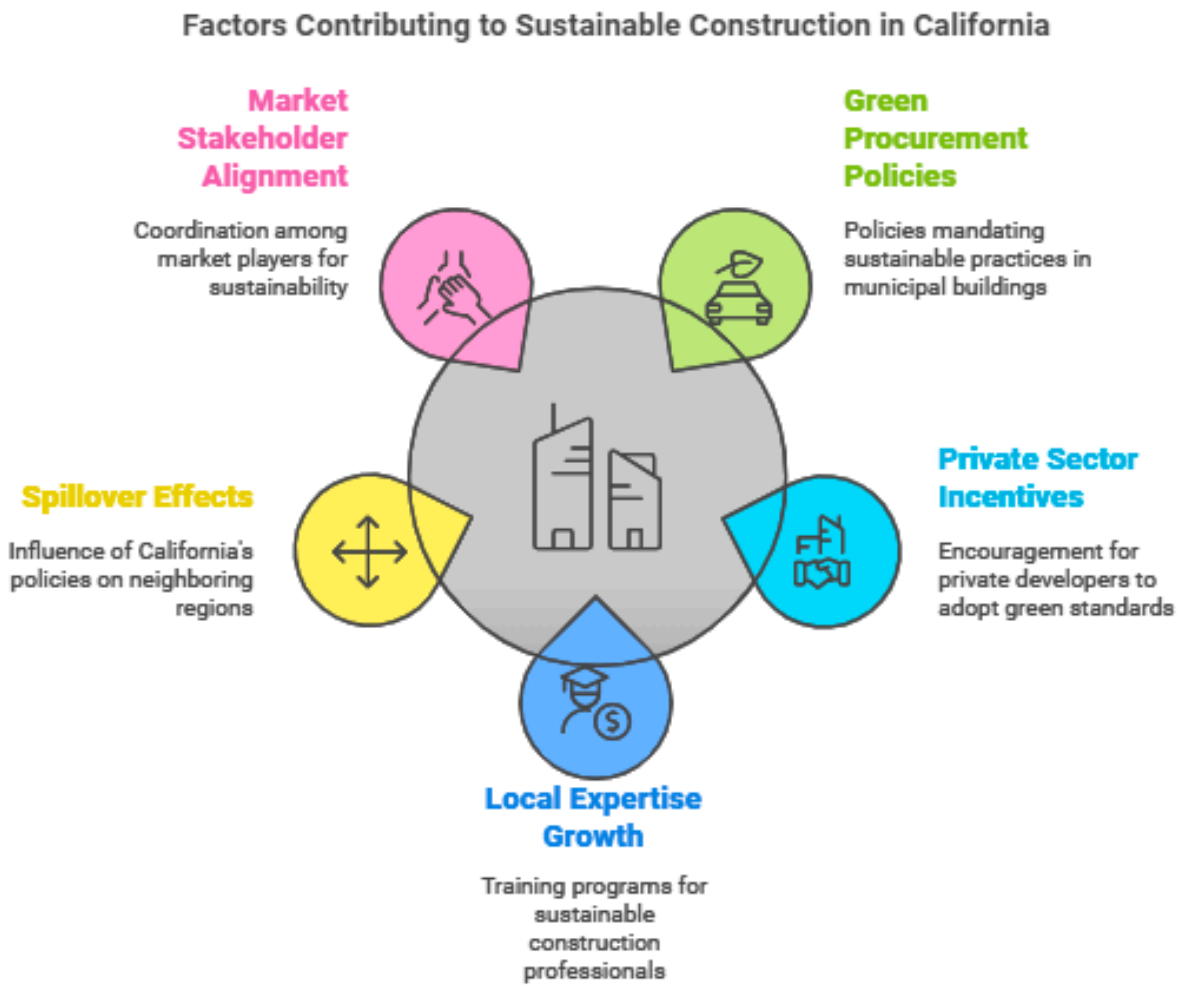



**Figure 3.** Impact of green building policies in California on the reuse of materials and economic incentives.

Furthermore, these initiatives are fostering the development of local expertise in sustainable construction. For instance, the number of Leadership in Energy and Environmental Design Accredited Professionals (LEED APs) has increased significantly in local markets, as developers align with green building standards [43]. California's policies also have a regional impact, influencing private sector practices and LEED AP certifications in neighbouring cities. This ripple effect demonstrates how well-designed local policies can influence the broader adoption of sustainable practices, thereby extending their benefits beyond state boundaries.

China demonstrates the challenges and opportunities of scaling up CDW management in the context of rapid urbanisation. As one of the largest producers of construction and demolition waste (CDW) in the world, it has historically faced significant challenges in its management, including economic feasibility and the implementation of effective recycling practices [44]. Since 2015, China has intensified its efforts by introducing a national policy encouraging CDW recycling, with a particular focus on Zero-Waste City Demonstration Zones [45–47]. These initiatives aim to integrate waste management practices into urban development plans by promoting source separation, the recycling of construction materials and energy recovery from waste.

As part of its 14th Five-Year Plan (2021–2025), China has expanded its "zero-waste cities" pilot programme to include 113 cities and 8 special areas. This programme focuses on reducing solid waste at the source, thus achieving full recycling, and ensuring safe waste management to reduce pollution and carbon emissions while promoting green and

sustainable urban development [46]. The government has introduced a 'zero-waste city indicator system' to assess progress and provide guidance, enabling cities to adapt their strategies to local conditions [46].

Figure 4 illustrates the chronology of the key steps and initiatives taken by China to strengthen CDW management and achieve zero-waste goals. These steps include the launch of initial research, the development of policies and the implementation of pilot and demonstration projects.

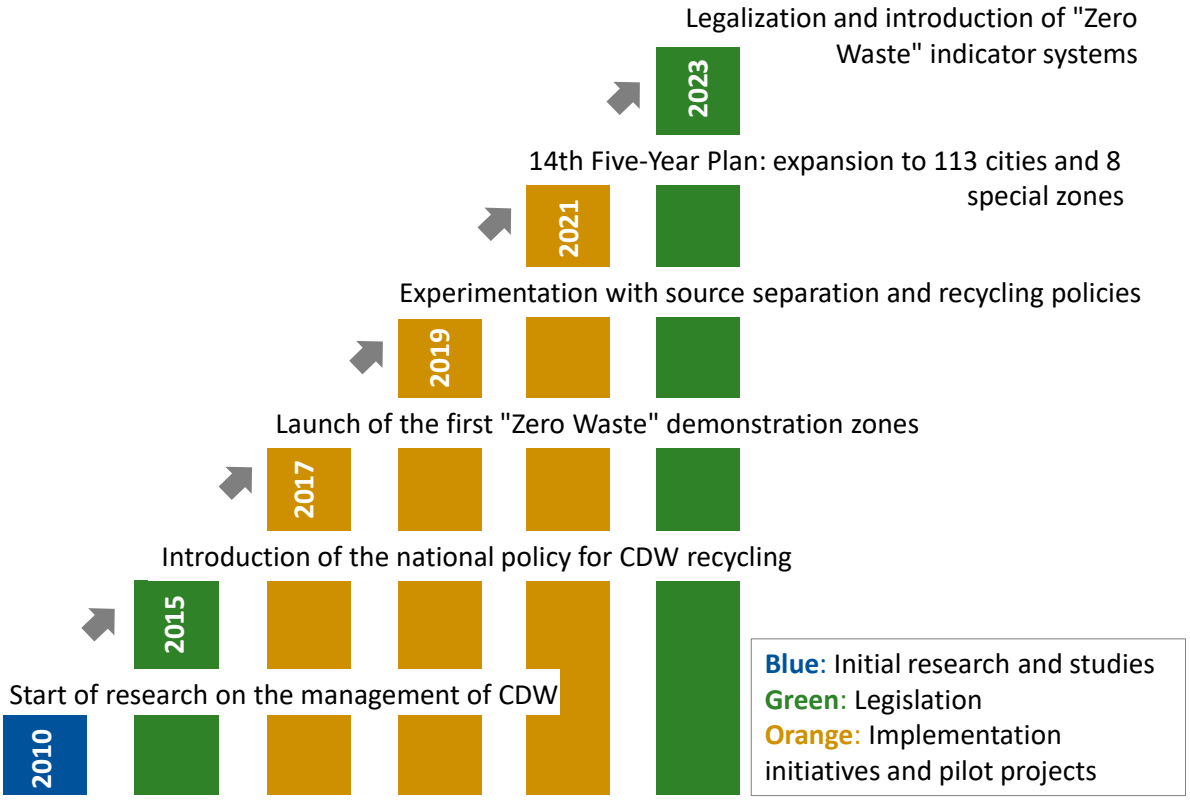



**Figure 4.** Chronology of China's initiatives and policies for the management of construction and demolition waste (CDW) and the "zero-waste" objective.

Technologies such as concrete recycling and steel waste treatment are being actively encouraged by the government, with subsidies and incentives for companies adopting these practices. In addition, the programme initiated a legalisation process in 2021, introducing laws and regulations that require local governments to integrate solid waste management into economic development and environmental protection plans [46]. However, scaling up remains a significant challenge due to heterogeneous local capacities, a lack of awareness and the need for better coordination to synergistically "reduce pollution and carbon emissions" [46].

### *3.3. Potential Inputs for European CDW Management*

In order to further clarify the relevance of international benchmarks for Europe, a comparative synthesis of the case studies is proposed in Table 3. This table highlights the main strengths and weaknesses observed in each country's approach—Japan, Singapore, California, the Netherlands and China—with a specific focus on regulatory frameworks, economic incentives, technological tools and governance models.

**Table 3.** Comparative synthesis of international case studies: strengths, weaknesses and transferable elements for EU CE implementation.

| Country | Strengths | Weaknesses | Transferable Elements for the CE in EU |
|---|---|---|---|
| Japan | Rigorous national regulation, high recycling rates, selective demolition, integration of innovation | High costs of selective demolition, not easily scalable | Selective deconstruction, legal obligations for material separation |
| Singapore | Certification schemes (Green Mark), advanced technologies, penalties for non-compliance | Dependence on incineration, limited space for sorting | Incentive systems, integration of sustainability in building codes |
| California | Mix of federal and local policies, green procurement spillovers, widespread LEED certification | Disparities between municipalities, moderate recycling targets | Local empowerment, green procurement, spillover strategies |
| Netherlands | Circular hubs, material passports, advanced tools (ECI and BCI), fiscal incentives | High upfront investment required, complex tracking | Digital tools, inter-company collaboration, national CE roadmap |
| China | Ambitious top-down policy (zero-waste cities), scaling strategies, subsidies | Regional disparities, lack of enforcement in some areas | National indicator frameworks adaptable at the local level |

The comparative perspective allows for the identification of key transferable elements that could inspire the design of a more coherent and effective strategy for implementing circular economy principles in the European construction and demolition sector. These include, for example, selective deconstruction protocols, digital tools for material tracking, incentive-based certification systems or integrated governance frameworks that combine national coordination with local adaptability.

This structured comparison supports the formulation of shared and scalable practices, which can help to bridge current disparities between EU Member States and contribute to the harmonisation of CDW management approaches across Europe.

### *3.4. Opportunities for Improving the Management of CDW in Europe*

The challenges and lessons learned from international practices offer a number of concrete opportunities for improving the management of construction and demolition waste (CDW) in Europe. This section summarises some key areas for improvement.

- Harmonisation of standards and regulations: Europe could work to harmonise CDW management and use standards across its Member States while allowing for local adaptations. The introduction of Europe-wide guidelines, similar to the EU omnibus or the forthcoming Circular Economy Act, or similar to those in California and Japan, combined with local adaptations to meet the specific needs of each region, could enhance the effectiveness of CDW management policies.
- Strengthening economic incentives: Policies, such as subsidies for projects using recycled materials, taxes on virgin materials or tax credits for businesses adopting sustainable practices, are essential to encourage a faster transition to a circular economy. Europe could benefit from Singapore's approach by developing certification and reward schemes for sustainable buildings, which would encourage businesses to adopt circular practices.
- Supporting innovation and developing advanced sorting and recycling technologies: Europe could invest more in advanced sorting and recycling technologies, such as

those used in Japan and Singapore. Targeted investments in selective demolition technologies, such as the "Kajima Cut and Take Down" method, and automated sorting centres could improve the purity of recycled materials and increase the recycling rates.

- Promoting eco-design and design for deconstruction: Incorporating eco-design principles, such as the use of modular and demountable materials, into building regulations could maximise the recyclability of materials. In Europe, the Building Circularity Index (BCI) concept used in the Netherlands could be adopted to assess the circularity of construction projects and encourage design for deconstruction.
- Raising awareness, knowledge sharing and providing training: Europe could step up its efforts to raise awareness and provide training for professionals in the construction sector. Inspired by the educational programmes set up in California and the Netherlands, Europe could develop continuous training programmes and awareness campaigns to promote sustainable CDW management practices. This could also be supported by enhanced knowledge sharing between all actors in the value chain to promote better management of materials throughout their lifecycles.
- Developing public–private partnerships: Partnerships between the public and private sectors, such as the circular hubs in the Netherlands, could be encouraged to foster innovation and efficiency in the management of CDW. These collaborations can lead to the better use of resources, the sharing of best practices and the optimisation of recycling and reuse processes.

The diagram elaborated in Figure 5 summarises these opportunities for improvement by highlighting the potential inter-relationships between the different strategies. For example, the harmonisation of standards and regulations can strengthen economic incentives by facilitating the implementation of common policies at the European level. Similarly, the development of advanced sorting and recycling technologies can support eco-design efforts and design for deconstruction, enabling the better management of materials throughout the lifecycle of buildings.

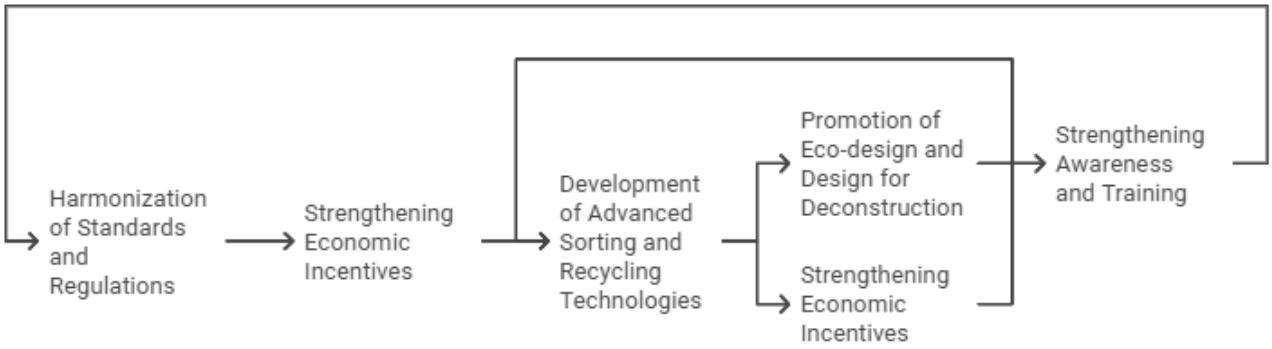



**Figure 5.** Sequential and interconnected strategies to improve the management of construction and demolition waste (CDW) in Europe.

The process begins with regulatory harmonisation, which plays a fundamental and transversal role across all stages. It then progresses through the activation of economic levers, technological investment and design innovation, culminating in knowledge dissemination and capacity-building. The feedback loop between training, awareness-raising and the earlier stages highlights the iterative nature of these strategies, as well as the importance of stakeholder engagement and policy adjustments throughout the implementation process.

### *3.5. Practical Measures to Strengthen the Circular Economy of CDW in Europe*

To complement the opportunities identified for construction and demolition waste (CDW) management in Europe, a number of practical measures and additional initiatives

can be implemented to address the specific challenges. Building on proven approaches and innovations tailored to European realities, these measures aim to optimise waste collection and sorting, promote sustainable design strategies, encourage technological innovation and strengthen administrative and regulatory coordination. By integrating these strategies, Europe can maximise material reuse, reduce the ecological footprint of construction and support the transition to a more circular and resilient economy.

For an overview of these measures, Figure 6 illustrates an integrated process for strengthening the circular economy of CDW in Europe. Although this figure is presented in a circular format, the measures illustrated are not intended to follow a strict chronological sequence. Depending on the national or regional context, they can be implemented in parallel, iteratively or in different orders.

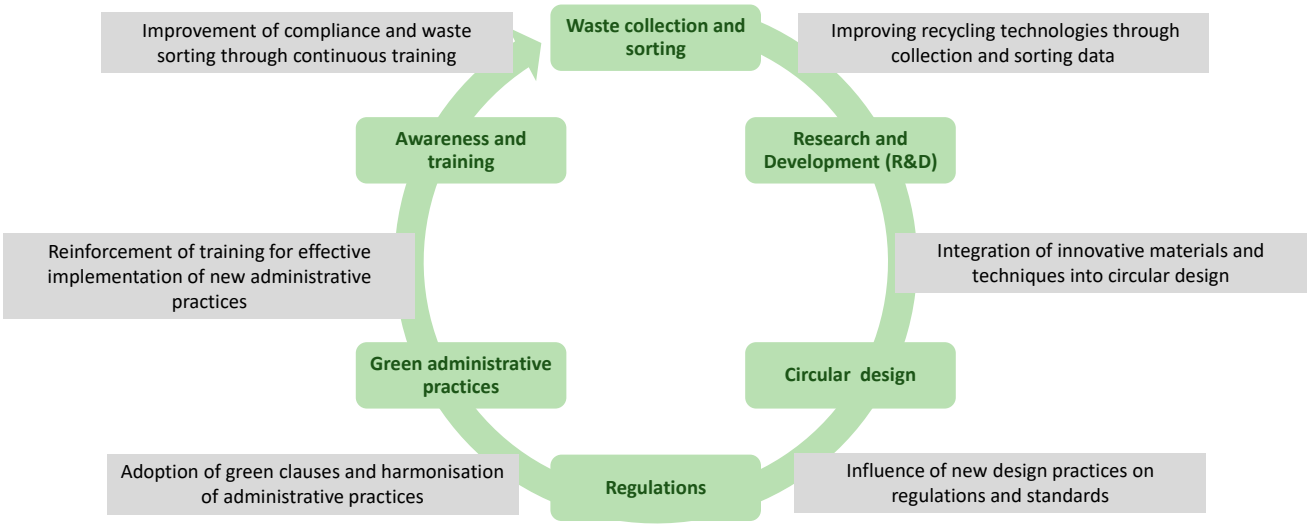



**Figure 6.** Integrated and non-sequential processes for strengthening the circular economy of CDW in Europe. The circular layout is used for visual clarity and does not imply a fixed implementation order.

#### 3.5.1. Improving Waste Collection and Sorting

Efficient collection and the rigorous sorting of construction and demolition waste (CDW) are essential to guarantee the purity of recycled materials and maximise their reuse. However, the contamination of recyclable materials remains a major obstacle to effective recycling.

- Obligation to sort at source: Construction companies should be required to sort waste directly on-site, separating materials such as concrete, wood and metal [12]. This measure should be supported by frequent inspections and penalties for companies that fail to comply with these obligations.
- Specialised sorting centres: Develop dedicated infrastructure for sorting centres to efficiently process collected waste and ensure the accurate separation of recyclable materials. These centres could be equipped with advanced sorting technologies, such as the automated systems used in Japan and Singapore.

#### 3.5.2. Encouraging Circular Design Through Public Procurement

Incorporating eco-design principles into public procurement is crucial to achieving a truly circular economy.

- Incorporating circular design standards: Public tenders should include eco-design requirements, such as the use of recyclable materials, building modularity and ease of dismantling [28]. This approach could draw inspiration from practices in Singapore

and the Netherlands, which integrate eco-design into their regulations to encourage sustainable construction.

- Supporting innovation in sustainable design: Companies that develop innovative solutions for sustainable design and material reuse should be rewarded through grants, subsidies and tax credits.

#### 3.5.3. Investing in Research and Development (R&D)

Technological innovation and research are essential to improve the recycling and recovery processes for construction and demolition waste (CDW).

- Increased funding for research into new technologies: Greater investment is needed in the development of sorting, recycling and recovery technologies for construction materials, including critical and strategic raw materials, in partnership with universities and research centres [29]. Selective demolition technologies, such as the "Kajima Cut and Take Down" method used in Japan, should be prioritised to optimise material recovery and reduce waste.
- Development of new materials: Encourage the creation of innovative construction materials designed to be more easily recyclable or reusable, thereby reducing the dependence on virgin materials. Substitutes for traditional materials, such as recycled concretes or bio-sourced composites, should be actively supported through economic incentives, such as subsidies or tax credits [28].
- European innovation projects and scientific contributions: Several European research and innovation initiatives aim to accelerate progress in the recycling of construction and demolition waste (CDW). For instance, the ICEBERG Project [48,49], funded by Horizon 2020, contributes to this effort by developing technological solutions to enhance sorting and material recovery. Other projects also support a similar aim, such as [50–52]. In parallel, scientific research is increasingly focusing on advanced processing methods, the design for reuse, material traceability and quality control tools. These ongoing efforts, both experimental and theoretical, help to bridge the gap between technological innovation, regulatory frameworks and industry practices [53–56].

#### 3.5.4. Strengthening Regulation and Harmonising Standards

To achieve a true circular economy in the management of construction and demolition waste (CDW) in Europe, it is crucial to establish effective regulations at every level of the value chain. The following highlights some regulatory frameworks that need to be strengthened.

(a) Legislation level: harmonisation of regulations

Towards a circular economy omnibus: To be potentially explored under the forthcoming EU Circular Economy Act under the EU Competitiveness Compass [57], which would provide a clear long-term circularity roadmap aligned with the omnibus on sustainability [58].

Harmonised European policy files: Implement European regulations requiring the recycling of certain construction materials, inspired by Japan's Construction Materials Recycling law [29]. Such legislation should include recycling quotas for materials such as concrete, wood and asphalt, while allowing for adaptation to local contexts.

Waste prevention strategy: Develop a European strategy for waste prevention, with incentives to reduce waste at the source, such as promoting design for deconstruction [28].

(b) Product level: quality standards and certification

Quality standards for recycled materials: Establish an EU-wide certification scheme for recycled building materials, ensuring they meet strict quality standards [13]. This system could also include eco-labels to help guide consumers and businesses in their purchasing decisions [25].

Environmental Product Declarations (EPDs): In line with the revision of the Construction Products Regulation (CPR), the adoption of Environmental Product Declarations (EPDs) with mandatory carbon footprint indicators is expected to become a standard requirement across the European Union. Integrating these obligations into public procurement and market access policies would serve as a concrete lever to promote the use of low-carbon construction materials and help align national practices with the EU's decarbonisation goals.

Several European countries have already developed national certification systems that integrate environmental performance and resource efficiency. Notable examples include BREEAM (Building Research Establishment Environmental Assessment Method, UK), DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen, Germany) and HQE (Haute Qualité Environnementale, France). These schemes promote sustainable construction through criteria such as energy efficiency, the use of low-impact materials and lifecycle performance. However, the inclusion of specific criteria on construction and demolition waste (CDW) management remains uneven. Strengthening the integration of CDW-related indicators—such as the reuse potential, material traceability or design for deconstruction—within these frameworks could support a more coherent alignment between voluntary certification schemes and European circular economy objectives.

(c) Administrative level: green administrative practices

Mandatory green clauses in calls for tenders and public procurement: Introduce mandatory circularity clauses in public tenders for construction projects, prioritising companies using recycled materials and sustainable practices [25].

Training and awareness-raising: Establish mandatory or standardised continuing education modules on circular economy principles and sustainable construction practices for public project managers, architects and contractors. These modules should be integrated into national professional certification schemes and updated regularly in line with EU regulatory developments and technological innovations. In line with initiatives already launched in some Member States [12], awareness campaigns targeting private stakeholders and SMEs can further accelerate the voluntary adoption of circular practices across the sector.

To complete this analysis, Table 4 provides a detailed overview of practical measures to improve CDW management in Europe. The table identifies concrete actions to be implemented, along with the main stakeholders involved, in order to clarify responsibilities and highlight key levers for action.

**Table 4.** Practical measures and complementary initiatives for a circular economy for CDW.

| Category | Practical Measures | Examples of Actions | Stakeholders Involved |
| --- | --- | --- | --- |
| Waste Collection and Sorting | Improving waste collection and sorting on construction sites | Obligation to sort at source and the development of specialised sorting centres | Construction companies, waste operators and local authorities |
| Circular Design | Incorporating eco-design criteria into public procurement contracts | Circular design standards in calls for tender and support for innovation in sustainable design | Public procurers, architects and design offices |

**Table 4.** *Cont.*

| Category | Practical Measures | Examples of Actions | Stakeholders Involved |
| --- | --- | --- | --- |
| Research and Development (R&D) | Investing in recycling technologies and developing new materials | R&D funding for recycling and the development of recyclable and bio-sourced materials | Research institutions, private firms and innovation agencies |
| Regulations | Establishing regulatory frameworks at the European level | Harmonised guidelines for the recycling of construction materials and waste prevention strategies | European Commission, national ministries and regulators |
| Green Administrative Practices | Introduce environmental clauses in public tenders and ongoing training programmes | Green clauses in calls for tender and training programmes for public project management | Public authorities, procurement officers and training bodies |

## 4. Conclusions

The transition towards a circular economy in the management of construction and demolition waste (CDW) in Europe is essential to meeting current and future environmental challenges. Despite significant progress, much remains to be done to achieve full circularity. European initiatives reflect a growing commitment to circular principles, but persistent disparities in waste collection and sorting, circular building design and recycled material quality underscore the need for more consistent and effective approaches.

Global leaders such as Japan, Singapore, California, the Netherlands and China have demonstrated that a combination of strict regulations, advanced technologies and economic incentives can significantly reduce construction waste and improve the quality of recycled materials. Drawing from these examples, Europe must enhance its efforts to optimise waste management, integrate circular design principles, establish harmonised standards and implement effective economic incentives. Awareness-raising and training for sector professionals remain critical to fostering wider adoption of circular practices.

Achieving these goals will require robust legislation at the political level, the establishment of product standards, the development of alternative materials and the promotion of green practices in public procurement. An integrated and harmonised European approach will be pivotal to the success of these initiatives.

To achieve a true circular economy in the CDW sector, Europe must continue to draw inspiration from global best practices while adapting its policies and regulations to local contexts. Investments in research and development, combined with proactive legislation and targeted economic incentives, can accelerate this transition. Collaboration between governments, businesses and citizens is essential to achieving these ambitious goals.

Although challenges remain, the opportunities for the sustainable and efficient management of CDW in Europe are considerable. By adopting an integrated approach and leveraging technological innovations and global best practices, Europe has the potential to become a world leader in the circular economy for buildings and construction.

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## Abbreviations

The following abbreviations are used in this manuscript:

| | |
|---|---|
| BCI | Building Circularity Index |
| BREEAM | Building Research Establishment Environmental Assessment Method |
| CALGreen | California Green Building Standards Code |
| CDW | Construction and Demolition Waste |
| CEAP | Circular Economy Action Plan |
| CPR | Construction Products Regulation |
| CUI | Concrete Usage Index |
| ECI | Environmental Cost Indicator |
| EPD | Environmental Product Declaration |
| EPR | Extended Producer Responsibility |
| EU | European Union |
| GSAS-CM | Global Sustainability Assessment System for Construction Management |
| HQE label | Haute Qualité Environnementale (High Environmental Quality) Label |
| LCA | LCA |
| LCI | Lifecycle Inventory |
| LEED (AP) | Leadership in Energy and Environmental Design (Accredited Professionals) |
| R&D | Research and Development |
| SGLS | Singapore Green Labelling Scheme |

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