engineering proceedings

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Proceeding Paper

Circular Design as a Key Strategy to Cut Embodied Energy: A Digital AI Tool to Support Materials and Data Exchange for a Sustainable Built Environment †

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† Presented at the 1st International Online Conference on Designs (Designs 2026), 9–10 February 2026; Available online: https://sciforum.net/event/Designs2026.

Abstract

The NPRR research project "From waste to manufacturing" developed an AI-powered digital tool to support the transition towards a circular built environment in Italy. The tool integrates a web platform enabling data exchange about materials with recycled content between designers, manufacturers and waste recyclers, with a CAD plug-in for real-time sustainability assessment. As such, the tool fosters the use of recycled materials and allows a reduction in embodied energy. AI, trained through scenario-based learning and stakeholder participation, assists designers in sourcing recycled materials and processing data. With further training by LCA experts, it could interpret Environmental Product Declarations to guide material selection in line with international regulations.

Keywords: digital platform; circular design; AI-powered tool; embodied energy; recycled materials

1. Circular Materials as Solution to Lower the Embodied Energy in Buildings and Products

As the operational energy performance of buildings has improved substantially over recent decades—driven by progressively stringent low-energy and nearly zero-energy building (nZEB) standards—embodied energy (EE) has grown in relative significance within the total lifecycle energy balance of the built environment. EE encompasses all energy consumed across the full production chain of a material or product, from raw material extraction and manufacturing to transportation and installation (Figure 1). While operational energy savings have been achieved through envelope improvements and mechanical system efficiency, the energy embedded in building materials has increasingly come to represent a disproportionate share of lifecycle impacts. In the case of zero-energy buildings (ZEBs), where operational energy demand approaches zero, EE can account for the entirety of a building's lifetime energy use [1–3]. Furthermore, EE, in combination with embodied carbon, is now widely recognized as a key parameter in evaluating overall building performance in the context of climate change mitigation [4–6].

In this context, the choice of building materials emerges as a decisive lever for reducing the environmental impact of construction. A comparison between the EE of conventional virgin materials and their circular counterparts illustrates the scale of potential savings: for instance, the production of primary aluminum requires approximately 192 GJ/t of energy,

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Academic Editor: Surender Reddy Salkuti

Published: 28 May 2026

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compared to just 12.7 GJ/t for recycled aluminum, reflecting a reduction of over 93% [7]. In addition to recycled materials, reused components and natural-based materials offer further pathways toward decarbonization, aligning with the EU's climate targets and the broader transition to a circular construction economy. While there is great interest in the bioeconomy and new renewable materials, the use of recycled materials remains one of the key environmental strategies, including in European policies, as it allows an increase in the resource efficiency level of existing resources, also considering the expected demand growth in the coming years and the related growing pressure on raw materials, especially critical ones. However, in the Ecodesign Regulation (2024) [8], the EU Commission points out that current product design approaches often fall short in supporting sustainability across the entire lifecycle, resulting in premature replacements, excessive energy and resource consumption, underutilized opportunities for value retention, weak demand for secondary materials, and limited uptake of circular business models [8]. In fact, despite its recognized potential, the adoption of circular materials in the built environment, both in the construction and in the related value chains, remains constrained by a structural gap: the key obstacle, identified by the EU Commission, is the limited access to relevant information about products' sustainability, which is valid for both economic operators and consumers [8]. In fact, the absence of accessible, interoperable digital infrastructure to support the identification, exchange and traceability of secondary resources across supply chains limits the opportunities to select circular materials in the design phase.

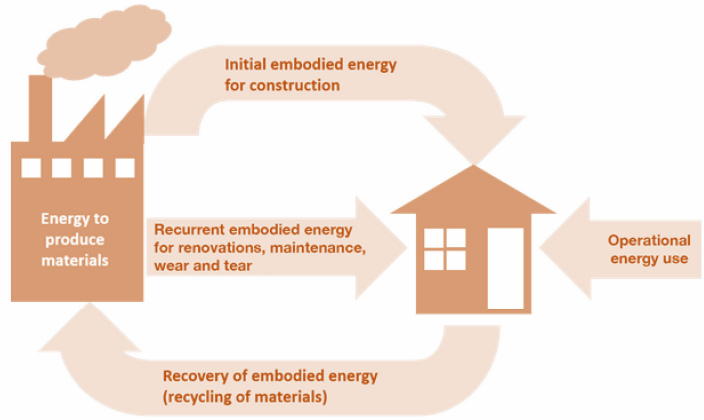


Figure 1. Embodied energy explained within a building's lifecycle. Source: Murray Hall, https://www.yourhome.gov.au/materials/embodied-energy (accessed on 1 February 2026).

Among the value chains connected to the built environment, this is particularly true for the furniture sector: beyond the heavy reliance on primary raw materials, the sector is characterized by energy-intensive processes—such as the polymerization of plastics—and the widespread application of adhesives, dyes and coatings, which generate volatile organic compounds (VOCs) and toxic substances, severely limiting the recyclability of many materials [9]. As a result, approximately 80–90% of furniture waste—whether pre- or post-consumer—ends up in landfill or is incinerated across the EU, with only 10% being recycled [10]. While both furniture and construction sectors share the fundamental goal of increasing the use of circular materials, they differ significantly in terms of scale, regulatory frameworks, supply chain structure, and material typologies: the construction sector deals with large volumes of materials governed by stringent building regulations and long lifecycles, whereas the furniture sector operates with shorter product lifecycles, a greater variety of materials and components, and a stronger influence of design-driven decision-making in material selection. However, the two sectors share the need to train

designers and professionals in the supply chain on circularity and sustainability related to their specific tasks: this could be facilitated by creating customized tools to promote knowledge and technical information tailored to the different stakeholders [11].

In this context, based on the increasing costs of raw materials and energy, and on the pressing need of relying on circularity in order to contribute to climate change mitigation and resource conservation, research is increasingly looking at digital technologies to support the upscaling of circular economy processes in the built environment, and artificial intelligence (AI) is increasingly being integrated into digital tools supporting circular design, driven by the need to process and interpret the growing volume and complexity of sustainability-related data—including lifecycle assessment results, environmental certifications, and recycled content documentation—that designers and manufacturers are required to handle. In fact, the role of AI in advancing the circular economy is becoming increasingly acknowledged, with its adoption across relevant applications growing at a steady pace [12]. In particular, industrial practitioners can be guided through the transition to the circular economy by means of AI-based decision support systems that help to prioritize circular design strategies [13]. AI-powered features such as automated data extraction, intelligent recommendation systems and natural language interfaces can significantly reduce the time and expertise needed to navigate this information, lowering the knowledge barrier for stakeholders with limited technical backgrounds and enabling more informed, data-driven material choices at the early stages of the design process. A relevant example in this sense is the Horizon EU Project SNUG (innovative methodology based in circular economy and artificial intelligence to foster the transition to sustainable and very-high-energy-performance buildings at a cost-optimal level), which combines AI simulations, an insulation material database, sustainable insulation solutions and smart materials and a digital building logbook to track performance over time [14].

In this scenario, if we look at the condition of Italian manufacturing industries (Figure 2), energy costs represent the primary challenge for companies of all sizes, both within industrial districts and elsewhere, but they particularly affect micro and small businesses, which constitute the very core of the Italian industrial landscape in both the construction and furniture sectors. It is therefore clear that it is not only necessary but also beneficial to work on reducing energy consumption in the production of materials, components and products, especially through the use of secondary materials, a strategy already adopted by 20% of companies [15].

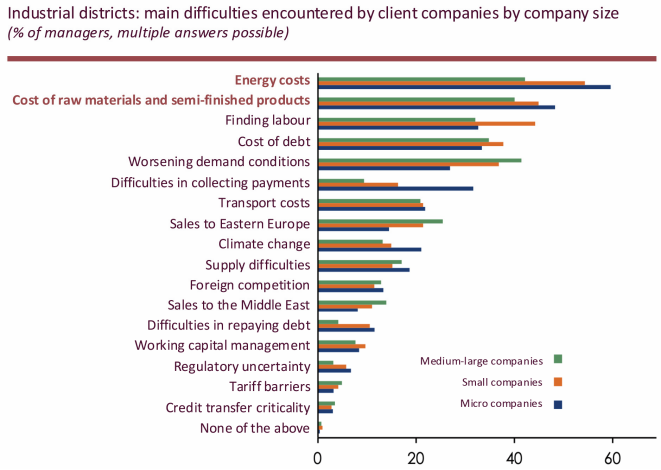


Figure 2. Main difficulties encountered by companies in Italian industrial districts, broken down by company size (micro, small, and medium–large), expressed as a percentage of managers surveyed (multiple answers possible). Energy costs and the cost of raw materials and semifinished products rank as the most widespread concerns across all company categories. Source: Intesa San Paolo survey (November–December 2023) [15].

https://doi.org/10.3390/engproc2026138008

In order to promote these strategies and support Italian manufacturing companies in the transition to circular production models, multi-stakeholder platforms can play a key role in promoting the engagement and collaboration of different actors who, based on shared values, are willing to work together to increase their knowledge and skill systems for collective progress [16].

In this process of change, multi-stakeholder digital platforms in particular can enable players involved in the various supply chains to access relevant information about circular materials, to help them tackle the main challenges including rising energy and raw material costs and the need to ensure energy- and resource-efficient solutions [16]. Addressing this gap, the present paper proposes a digital tool—informed by AI—designed to facilitate the exchange of materials and data among actors across the different value chains connected to the built environment, and in particular for the furniture industry and related supply chains. The tool is developed within a research framework that positions circular design not merely as an environmental aspiration, but as an operational strategy with a measurable impact on EE reduction at the material and product scale.

2. Research Aims

The NPRR research project "From waste to manufacturing: digital tools to establish virtuous cycles" aims to promote the use of circular materials in the Italian furniture industry, by enabling connections among different stakeholders in the value chain. The research's final goal is to create a digital tool fostering data exchange related to materials, enabling waste valorization into circular materials and products. The tool is open to include both materials and semifinished products, both for furniture production and for the fit-out and design of interior and exterior spaces. Although the tool has been specifically developed and oriented towards the Made-in-Italy furniture sector, its potential application extends beyond this domain, as the underlying logic and functionalities can be effectively adapted to support circular material exchange and sustainable design practices in the construction sector as well.

The AI-powered digital tool developed in the research integrates a web platform for circular materials—which enables data exchange between designers, manufacturers and waste recyclers—with a CAD plug-in that supports real-time sustainability assessment with the help of AI-enhanced features, focusing on the nexus between the recycled content in materials and the reduction in EE.

3. Methodology

Figure 3 illustrates the research methodology adopted for the development of a digital platform designed to facilitate the exchange of recycled and secondary materials within Italy's furniture and construction value chain. The framework is organized into five sequential phases, grouped under four overarching macro-stages: analysis, concept, development and divulgation.

The research started with Phase I "State of the art and stakeholder needs", an analytical phase aimed at mapping the existing context of circular material use in the Italian furniture and construction sectors. This stage involved analyzing recycled material databases, regulatory frameworks and material flows and reviewing current platforms, while simultaneously engaging key stakeholders—manufacturers, designers, consultants, contractors and waste operators belonging to the furniture sector or to companies and organizations with cross-cutting interests across the value chains of the built environment—to identify unmet needs, barriers to exchange and expectations for a digital solution. This evidence base ensured the tool is grounded in real sector dynamics. At this stage, it emerged that the tool could have cross-sectoral relevance spanning both the furniture and construction

industries, given that the information, certifications, and types of data to be mapped are common to materials applicable to both furniture and architectural contexts.

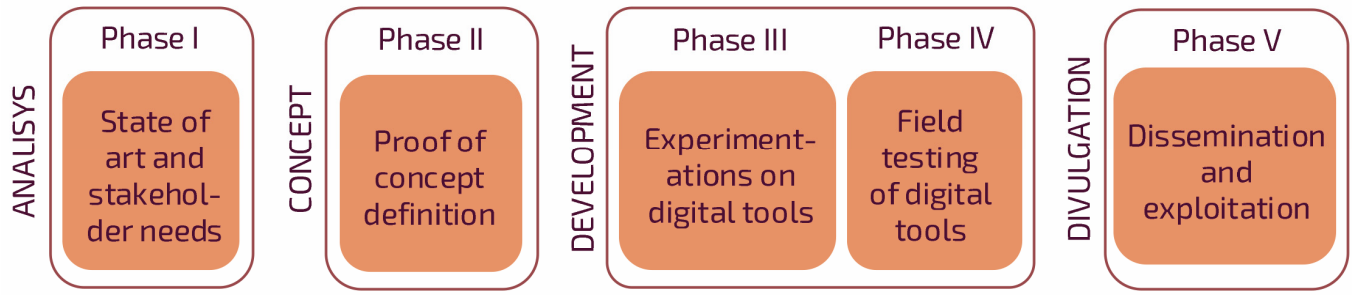


Figure 3. Research methodology articulated in five phases.

Drawing on the findings of Phase I, in Phase II "Proof of concept definition" the research transitioned into the conceptual design of the digital tool. This phase involved defining the functional architecture of the platform—its logic of material classification, matching mechanisms between supply and demand and the user interface requirements for different actors in the value chain. The proof of concept served as a testable blueprint that translates stakeholder needs into a concrete design proposition before full development begins.

In Phase III "Experimentations on digital tools", the development stage began with iterative experimentation. A prototype of the digital tool was built and tested internally, exploring different technological approaches to cataloging recycled materials, enabling traceability and supporting material-related information access by producers and potential buyers of secondary resources. This phase was iterative, allowing refinements based on technical performance and usability feedback. This activity included AI training.

The refined prototype was then deployed in Phase IV through field testing involving different types of stakeholders—material suppliers, design studios or consultants specialized in recycled material certification processes—to evaluate the tool's effectiveness in facilitating exchanges of recycled materials. Data gathered in this phase informed final adjustments to the platform.

The final phase (V, "Dissemination and exploitation") shifted focus from development to impact. The results, methodological insights and operational platform were disseminated to the broader community through publications and a final conference, involving trade associations of material producers and waste recovery operators, as well as foundations and companies interested in future collaboration with the research group to develop a management and business model aimed at making the digital tool fully operational.

Taken together, the methodology follows a research-through-design approach, moving from contextual analysis to conceptual proposition, technical development, empirical validation, and knowledge transfer.

4. Results

The results of the research presented in the following paragraphs focus on Phases I and III. A broader description of the full research results has been provided in other publications [17,18].

4.1. Recycled Materials Databases Analysis

Phase I of the research reviewed databases of certified furniture materials, components and products, including EU Ecolabel, the C2C certified products catalog [19], ReMade in Italy [20], Plastica Seconda Vita and EPDItaly, to map certified items using recycled materials.

In particular, the ReMade catalog of certified products was selected for an in-depth analysis of its database both for its national relevance and compliance with Italian national legislation (such as the Green Public Procurement Minimum Environmental Criteria for furniture and buildings), and for the indicators taken into consideration in the certification label. In addition to the percentage of recycled content, the label considers the reduction in energy consumption resulting from recycling (EE) and the reduction in climate-altering emissions resulting from recycling (embodied carbon), highlighting how the use of second-life materials can help to reduce energy consumption.

The database, consulted in March 2024, listed almost 200 furniture products from more than 15 companies, and 49% of the products listed contained more than 60% recycled or recovered material.

ReMade, as a platform showcasing certified circular materials, was also analyzed as a digital tool, observing the relationship between users and technicians during the data upload and download phases.

4.2. Digital Tools Comparison for Benchmarking

The next step within Phase I was the mapping of specific categories of digital tools selected for benchmarking purposes. The research examined different existing digital tools supporting circular material design and exchange, including Concular [21], Oogstkaart [22], RE-sign [23], WasteOutlet [24], WasteTrade [25], Rotor DC online shop [26] and Madaster [27]. Their comparative analysis was carried out in order to conceptualize the different types of platforms, depending on the characteristics of how the tool is used, the different figures that interact with the platform during the data input and output phases and the positioning of the tool within the broader lifecycle and product design cycle.

For example, Concular has a system based on an AI-driven platform that matches buyers' demand for construction material with suppliers' circular materials in order to disrupt the construction industry by developing a circular process for material flow. Material demands from construction projects can be uploaded onto the platform by a counselor, while circular materials from demolition projects can be recorded using a digital material passport.

This process was carried out in order to identify the requirements for the new tool and define the model, selecting the most relevant and pertinent features for the purposes of the project from the various tools analyzed.

4.3. Tool Development and AI Training

Based on the analysis of different operational models, it was possible to design the structure of the digital tool, understanding its role within the material and data flows related to the circular project. The tool was therefore configured as a manufacturer-to-designer platform and plug-in software, connected to the production phases of materials and components in the Italian furniture industry, but also directly connected to the design cycle as the first moment in which to evaluate and intervene with the product in order to reduce its energy and environmental impacts.

As mentioned, the tool consists of a web platform for the exchange of circular, second-life or natural-based materials and components, and a software plug-in for CAD, specifically Rhinoceros, which was only conceptualized and is still under development. The correlation between the two parts and the real-time updating of the project based on the materials chosen for the project is the core of the tool and is supported by AI.

Figure 4 illustrates, through a flow diagram, the role of AI within the data flows enabled by the digital tool developed in the research. Through the consultation of Environmental Product Declarations, Material Certifications and Material Passports, the platform

returns information on available materials covering not only their physical characteristics, but also the processes linked to the lifecycle and circularity level of the material or semifinished product. In the context of the design process, the tool therefore enables an understanding of the environmental impacts related to the materials used, thanks to its connection with CAD software and the support provided by AI in the extraction and interpretation of complex, multi-layered data linked to the certificates and documentation associated with the materials. The three main functions performed by AI within the tool are described below.

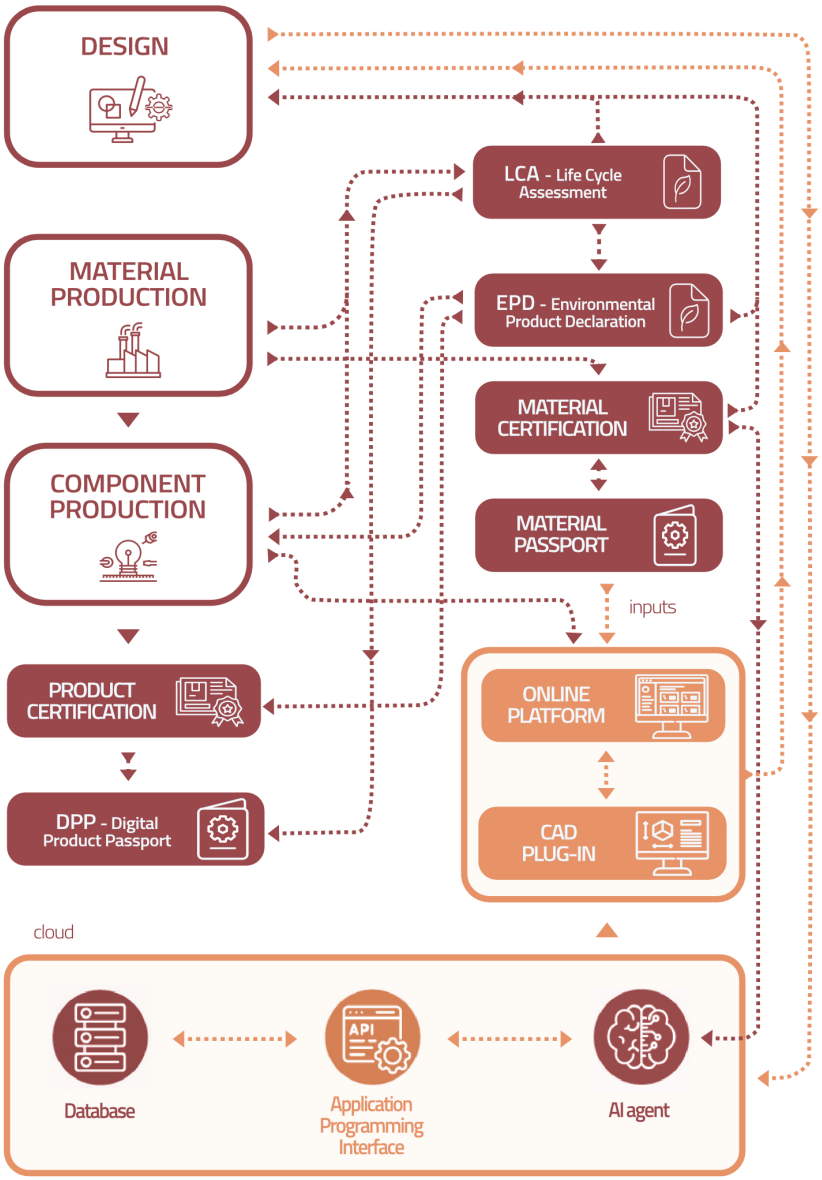


Figure 4. Flow diagram highlighting the role of AI within the data flows allowed by the digital tool developed in the research. The orange color represents the positioning of the tool in the materials data management flow/process, which is more broadly represented by the color red.

The first function of AI within the tool is in the data upload. AI can support the manufacturers and material producers in entering data relating to materials present on the platform, through the reading and interpretation of technical data sheets and environmental certifications and subsequent critical extrapolation of the information required by the system. By continuing training, with the support of LCA experts, artificial intelligence could interpret complex documents such as EPD certifications, extracting the

information needed to guide sustainable and circular design towards a reduction in the energy and carbon incorporated into products, as increasingly required by national and international regulations.

The second function involving AI is the material search: AI, trained through scenario-based learning with stakeholder participation during platform use, can offer support in searching for materials available on the platform, by understanding the designer's needs through conversation with the chatbot assistant, and then quickly comparing the available alternatives.

The third function of AI is in the comparison of scenarios: its integration with the software plug-in provides feedback to the designer concerning crucial positive and negative aspects for each design scenario, based on the characteristics and peculiarities of the chosen material.

Therefore, overall, AI supports designers in researching and sourcing recycled/reused materials, as well as in data processing.

Through real-time feedback, designers can understand the consequences of their design choices in terms of environmental and energy impact. With the support of AI, they can then review certain choices and steer the project towards a more sustainable and circular model.

A testing phase was conducted with the stakeholders involved in the initial phase of the project through interviews, in order to understand whether the prototype developed met the needs identified. Thanks to the iterative research testing of the tool, users gave positive feedback overall. While acknowledging its limitations due to ongoing development, users appreciated the platform navigation experience and AI support, emphasizing how the data entry support function significantly speeds up the process of interfacing with the tool.

5. Discussion and Conclusions

In the transition towards a more circular built environment at all levels of design, digital support tools are needed to ensure an effective material-related data exchange in order to enable a reduction in embodied energy in both products and buildings. The research results show how AI can provide effective support within digital tools oriented to support designers towards circular material choices. As experimented with during the testing phase of the digital tool prototype, by continuing training with the support of LCA experts, AI could interpret complex documents such as Environmental Product Declarations, extracting the information needed to guide design towards the selection of circular, low-embodied-energy materials and products as increasingly required by international regulations.

Currently, the MICS Project plans to release the prototype of the digital tool within an open-source platform [28] including the full portfolio of digital tools developed with the Extended Partnership research projects. However, the exploitation strategy by the research group addresses how the tool can be scaled, maintained and integrated into existing circular economy ecosystems in Italy, ensuring continuity beyond the research project. Moreover, the tool holds significant potential for application in the construction sector as well. This broader applicability was actively highlighted by the stakeholders who participated in the research and tested the tool at different stages of its development, providing direct evidence of its relevance beyond the furniture industry.

Although one limit of the research is the fact that the software plug-in remains in the embryonic prototype stage, this component of the tool was met with enthusiasm by the stakeholders involved in the testing phase. Therefore, the research perspectives include the full development of this part of the digital tool.

https://doi.org/10.3390/engproc2026138008

Furthermore, continuing the research, through collaboration with external certification bodies, will enable the development of a comprehensive and effective AI-based tool to reduce the impacts of the furniture sector in terms of embodied carbon and embodied energy.

Author Contributions: Within the Research Group, the authors—based on their specific disciplinary competencies: carried out the analysis of the materials' databases, of the existing digital tools, and of environmental indicators and regulatory context; contributed to the tool development by defining needs and contents relatively to materials' circularity. Conceptualization, S.B. and P.A.; methodology, S.B. and P.A.; investigation, P.A. and G.R.; writing—original draft preparation, P.A. and G.R.; writing—review and editing, S.B. and P.A.; visualization, G.R.; supervision, S.B. All authors have read and agreed to the published version of the manuscript.

Funding: This contribution is the product of a study carried out within the MICS (Made in Italy—Circular and Sustainable) Extended Partnership and received funding from the European Union Next-GenerationEU (Piano Nazionale di Ripresa e Resilienza (PNRR)—Missione 4 Componente 2, Investimento 1.3—D.D. 1551.11-10-2022, PE00000004). This manuscript reflects only the authors' views and opinions; neither the European Union nor the European Commission can be considered responsible for them.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Acknowledgments: The research presented in this paper was developed by the Research Group of Sapienza University of Rome (IT) who developed the Project "From waste to manufacturing: digital tools to establish virtuous cycles": P.I. Lorenzo Imbesi, Serena Baiani, Sabrina Lucibello, Emanuele Panizzi, Paola Altamura, Viktor Malakuczi, Luca D'Elia, Carmen Rotondi, Mariia Ershova, Gabriele Rossini, Alessandro Aiuti.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. Guidetti, E.; Ferrara, M. Embodied energy in existing buildings as a tool for sustainable intervention on urban heritage. *Sustain. Cities Soc.* **2023**, *88*, 104284. [CrossRef]
2. Chastasa, P.; Theodosioua, T.; Bikasa, D.; Kontoleona, K. Embodied energy and nearly zero energy buildings: A review in residential buildings. *Procedia Environ. Sci.* **2017**, *38*, 554–561. [CrossRef]
3. Ferrara, M.; Lisciandrello, C.; Messina, A.; Berta, M.; Zhang, Y.; Fabrizio, E. Optimizing the transition between design and operation of ZEBs: Lessons learnt from the Solar Decathlon China 2018 SCUTxPoliTo prototype. *Energy Build.* **2020**, *213*, 109824. [CrossRef]
4. Lützkendorf, T.; Foliente, G.; Balouktsi, M.; Wiberg, A.H. Net-zero buildings: Incorporating embodied impacts. *Build. Res. Inf.* **2015**, *43*, 62–81. [CrossRef]
5. Ferrara, M.; Fabrizio, E.; Virgone, J.; Filippi, M. Appraising the effect of the primary systems on the cost optimal design of NZEB: A case study in two different climates. *Energy Procedia* **2015**, *78*, 2028–2033. [CrossRef]
6. Blengini, G.A.; Di Carlo, T. The changing role of life cycle phases, subsystems and materials in the LCA of low energy buildings. *Energy Build.* **2010**, *42*, 869–880. [CrossRef]
7. CRAS S.r.l. *Ecological Footprint. Un Approfondimento Sull'impronta Ecologica Dell'edilizia Residenziale in Italia*; Papageno: Palermo, Italy, 2004.
8. European Commission. Regulation (EU) 2024/1781 of the European Parliament and of the Council of 13 June 2024 Establishing a Framework for the Setting of Ecodesign Requirements for Sustainable Products. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02024R1781-20240628 (accessed on 15 January 2026).
9. Azizi, M.; Mohebbi, N.; De Felice, F. Evaluation of sustainable development of wooden furniture industry using multi criteria decision making method. *Agric. Agric. Sci. Procedia* **2016**, *8*, 387–394. [CrossRef]
10. EEB. Circular Economy Opportunities in the Furniture Sector. 2017; p. 55. Available online: https://eeb.org/wp-content/uploads/2019/05/Report-on-the-Circular-Economy-in-the-Furniture-Sector.pdf (accessed on 15 January 2026).

11. Cecconello, M.A. Circular Economy Solutions and Strategies for the Furniture Sector in the European Union. *DIID* **2022**, *78*, 10. [CrossRef]
12. Miroslav, D.; Glatschke, M. Challenges and opportunities of artificial intelligence and machine learning in circular economy. In Proceedings of the 63rd ERSA Congress, Terceira Island, Azores, Portugal, 26–30 August 2024.
13. Agrawal, R.; Wankhede, V.A.; Kumar, A.; Luthra, S.; Majumdar, A.; Kazancoglu, Y. An exploratory state-of-the-art review of artificial intelligence applications in circular economy using structural topic modeling. *Oper. Manag. Res.* **2022**, *15*, 609–626. [CrossRef]
14. Horizon Europe. Innovative Methodology Based in Circular Economy and Artificial Intelligence to Foster the Transition to Sustainable and Very High eNergy Performance bUildinGs at a Cost Optimal Level. Available online: https://cordis.europa.eu/project/id/101123150 (accessed on 15 January 2026).
15. Intesa Sanpaolo, Direzione Studi e Ricerche. Economia e Finanza dei Distretti Industriali. Rapporto Annuale–n.16. March 2024. Available online: https://group.intesasanpaolo.com/content/dam/portalgroup/repository-documenti/research/it/economia-e-finanza-dei-distretti/2024/Economia%20e%20finanza%20distretti%20industriali%20nr%2016._finale.pdf (accessed on 15 January 2026).
16. Altamura, P.; Baiani, S.; Ceruti, F.; Cutaia, L. Collaborative platforms supporting circularity in the built environment. Identifying strategic actions and replicable good practices. *Detritus* **2024**, *28*, 5–18. [CrossRef]
17. Rossini, G.; Altamura, P.; Baiani, S. Digital platforms for circular design. A comparative study, towards a tool for Made in Italy. In *Proceeding of the 6th International Conference "Recycling. Innovative Scenarios in Design and Research Culture"*; Baratta, A.F.L., Calcagnini, L., Magarò, A., Eds.; Forma Edizioni: Florence, Italy, 2025; pp. 148–163. Available online: https://www.conferencerecycling.com/index.php/it/# (accessed on 15 January 2026).
18. Imbesi, L.; Lucibello, S.; Panizzi, E.; Baiani, S.; Malakuczi, V.; Altamura, P.; D'Elia, L.; Rotondi, C.; Ershova, M.; Rossini, G.; et al. Design-driven Sustainable Manufacturing: Enabling Multi-Stakeholder Knowledge Exchange for Circular Furniture Production. *DIID* **2026**, 70–87. [CrossRef]
19. C2C Certified Products. Available online: https://c2ccertified.org/certified-products (accessed on 15 January 2026).
20. Catalogo ReMade. Certified Products Catalogue. Available online: https://www.remadeinitaly.it/catalogo-remade-prodotti/ (accessed on 15 January 2026).
21. Concular. Available online: https://concular.de/ (accessed on 15 January 2026).
22. Oogstkaart. Available online: https://knowledgeplatform.gtb-lab.com/project/oogstkaart/ (accessed on 15 January 2026).
23. RE-sign. Available online: https://re-sign.it (accessed on 15 January 2026).
24. WasteOutlet. Available online: https://impactindex.startupguide.com/startups/waste-outlet (accessed on 15 January 2026).
25. WasteTrade. Available online: https://www.wastetrade.com/ (accessed on 15 January 2026).
26. Madaster. Available online: https://madaster.com/platform/ (accessed on 15 January 2026).
27. RotorDC Shop. Available online: https://rotordc.com/shop (accessed on 15 January 2026).
28. Resource. Available online: https://resource.mics.tech/about/portfolio (accessed on 15 January 2026).

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