Introduction to Special issue
The circular economy as a lever for decarbonization

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1. Background

The circular economy is not a novel topic. Almost a decade ago, Economics and Policy of Energy and the Environment devoted a special issue to the topic (EPEE n. 1-2, 2017), framing circularity primarily as a response to the inefficiencies of the linear "take-make-dispose" model. In more detail, in such a context circular economy was framed as a Porterian reading in which pollution and waste were understood as symptoms of economic inefficiency, and in which a series of centrifugal forces (i.e. information asymmetries, short-termism in business choices, price distortions, cultural habits, infrastructural gaps, technological bottlenecks and regulatory problems) were shown to systematically leak value out of would-be circular loops. That issue also offered early empirical evidence on how specific circular business models could begin to counter those centrifugal forces in individual sectors from Bocken et al. (2017) study of business-model experimentation in a large international clothing retailer, to Sarti et al. (2017) analysis of food-sharing platforms as a lever for food-waste prevention. Such a frame proposed by Iraldo et al. (2017) remains analytically valid, however, what has changed, in the years since, is the purpose attached to closing those loops. Alongside its initial rationale, reducing pressure on natural resources extraction and reducing the production of waste, the circular economy is today read, increasingly as a lever for decarbonization.

There are several reasons behind conceiving circular economy as a lever for decarbonization: extracting, processing and disposing of virgin materials is carbon-intensive, and any shift towards reuse, recovery and recycling might translate into avoided emissions along the value chain. Moreover, circular practices such as energy

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efficiency, adoption of renewable energy complement the decarbonization levers by acting where a substantial share of industrial emissions originates.

However, while resource efficiency and the circular economy are worldwide recognised as fundamental to reduce waste discharge and raw materials extraction, the extent to which they may also help pursue climate neutrality remains underemphasized, both from an economic and technological viewpoint, even though some evidence already emerges.

The Circularity Gap Report (Circle Economy, 2021) estimates that circular economy strategies could eliminate up to 22.8 Gt of CO_2 annually – approximately 39% of global emissions – by significantly reducing the use of virgin materials and the energy required for their extraction and processing. Well-designed material efficiency strategies may significantly reduce by 2050 life-cycle emissions in sectors such as the residential (up to 35% in G7 countries and 60% in China & India) and the automotive (40% and 35%, respectively) (IRP, 2020). Other approaches have added evidence in this respect. For instance, in the construction sector, one of the largest consumers of resources and energy, circular building techniques, such as modular prefabrication, enable the reuse of components and significantly reduce emissions associated with cement and steel production (Oladapo et al., 2024). In transportation, shared mobility services, such as car and bike sharing, can limit material consumption and the energy required for vehicle production, making a substantial contribution to decarbonization (Businge & Mazzoleni, 2023). Similarly, remanufacturing strategies can drastically cut both energy consumption and CO_2 emissions linked to the production of new components (Bressanelli & Saccani, 2025). This approach is also embedded in recent EU policy. The European Commission's Clean Industrial Deal (European Commission, 2025) recognizes circularity as a necessary condition for an affordable energy transition and for secure access to critical and strategic materials and connects it explicitly to the EU's intermediate 2040 climate target. In parallel, the European Environment Agency (EEA, 2026) has mapped the climate-mitigation potential of circular practices across the value chain, identifying waste management, construction, emission-intensive materials and agriculture as the sectors in which this potential is most concentrated.

The "centrifugal forces" framed in 2017 by Iraldo et al. (2017) are still at work; but their consequences are today seen and measured not only in terms of wasted resources, but also in foregone emission reductions. Overcoming those inertias is increasingly understood as a decarbonization lever, one whose relevance is acknowledged beyond the developed world, as the contributions to this special issue illustrate.

2. Structure of the special issue

The five papers collected here span aquaculture, agriculture, construction and energy. This diversity mirrors the cross-sectoral scope highlighted by EEA (2026) and demonstrates that the decarbonization potential of circular practices is not confined to any single industry, but emerges along the entire value chain, from primary production to energy-intensive manufacturing.

In more detail, Miceli et al. (2026) focus on agri-food waste and by-products technologies to reduce carbon footprint of the agri-food sector while boosting sustainable bioeconomy and bioenergy production. Anaerobic digestion generates biomethane and biogas from livestock waste, crop residues and agro-industrial by-products, contributing to renewable energy as well as reducing landfilling. Technical potential is remarkable, up to 10 billion cubic meters of biogas per year in Europe. Compost and organic fertilizers indirectly reduce greenhouse emissions by enhancing soil carbon sequestration, soil carbon content, and ecosystem resilience. Biochar production may achieve sequestration capacity greater than 40% over 100 years. Biomaterials represent another sustainable option for decarbonization, by replacing fossil-based plastics for packaging. 3D food printing allows reducing food transport, representing around 20% of food system total emissions and enhancing food customization, safety, traceability and nutritional values. Biorefineries allow producing biofuels from biomasses, being one of most recognized ways to reduce emissions in the transport sector, once again coupled with the reduction in agri-food waste disposal. Digital traceability, based on new technologies such as Internet of Things and Blockchain, can deliver benefits all the whole value chain, by preventing food waste, transport emissions as well as transparency for customers. One more channel of positive interaction between agri-food system overall efficiency and greenhouse emissions reduction is through the education of entrepreneurs and workforce, thanks to higher orientation towards innovation and increased capabilities.

Nguyen (2026) analyzes the orientation of Vietnam farmers towards the introduction of circular principles in their own activities, applying the KAP (Knowledge-Attitude-Practice) model. Almost four hundred farmers were involved in a self-assessment survey, aiming to highlight the knowledge and the relevance of circular economy practices such as reusing agricultural by-products, treating livestock waste for biogas or organic fertilizer, implementing crop rotation and recycling water for irrigation. Then, farmers were asked about policy and behavioral opportunities and challenges for adoption of circularity. Interestingly, younger, less experienced and small-scale farmers result more sensitive to introduce circular economy practices, recognizing the advantages of new technologies rather than the perceived risks from the required initial investments, thereby supporting the need for targeted policy instruments.

Carollo et al. (2026) provide evidence about the benefits of selective demolition in the building sector from both environmental and economic viewpoints. Construction and demolition waste represent a large share of inorganic waste that can be normally landfilled, even though still with a high potential intrinsic value. Through a questionnaire-based environmental Life Cycle Costing analysis applied on 7 case studies in the Lombardy region (Italy), authors show the extent at which costs from demolition activities may be reduced by recovering materials and selling resulting recycled aggregate to the market. In turn, this implies reducing extraction of raw materials such as concrete, carbon intensive processing of material such as cement and steel, and landfilling of inert, metal and other waste categories. The study sketches and implements a methodology with a wide application potential, allowing increasing awareness on economic and ecologic advantages of sustainable value chain management.

The contribution from Fricano et al. (2026) explores the potential of recycling bivalve mollusk shells as a pathway to decarbonization through industrial symbiosis. Drawing on the MATSHELL project, the authors show that mussel shells (usually discarded as waste) can yield high-purity calcium carbonate ($CaCO_3$) suitable both for high-value industrial applications (nutraceuticals, pharmaceuticals, construction) and as a regenerable sorbent for CO_2 capture via the calcium looping (CaL) process. The authors propose a localized industrial symbiosis model linking coastal aquaculture with emission-intensive sectors (cement, steel), validated through a SWOT analysis based on interviews with experts and stakeholders. The authors draw on the lessons of previous research to further support that successful symbiotic networks require not only technical feasibility but also cooperative governance, geographic proximity between symbiotic nodes and appropriate coordination mechanisms. In this context, the paper directly addresses the special issue theme by showing how circular practices in aquaculture can tangibly contribute to CO_2 emission reductions in industrial processes.

The contribution from Dua at al. (2026) explores the factors influencing circular economy adoption in the oil and gas sector across the MENA region, employing a quantitative approach based on structural equation modeling on a sample of 230 industry workers. Results identify three key antecedents – organizational inclination, external pressures, and innovation – and demonstrate that innovation plays a crucial mediating role between internal/external drivers and the actual adoption of circular practices. External pressures (regulation, stakeholder expectations) positively influence both innovation and CE adoption, yet do not significantly amplify the effect of organizational inclination. This paper contributes to the special issue by positioning the circular transition within the energy sector as a strategic lever for decarbonization. Given that this industry accounts for a substantial share of global emissions, deciphering the organizational and institutional mechanisms that enable or impede the adoption of circular practices is critical to accelerating the reduction of its carbon footprint.

3. Closing remarks

The five contributions collected in this issue, taken together, offer a concrete illustration of how circular economy practices can translate into decarbonization outcomes in different sectors, scales and geographies. A common denominator across all the collected works is indeed the emphasis that circularity operates on the material side of the economy to support decarbonization strategies. At the same time, the evidence gathered here confirms that the transition is far from automatic as its speed depends on the interplay of technological maturity, organizational capabilities, enabling regulation and the behavioral orientation of producers and consumers. This special issue corroborates the importance of viewing the circular economy as a lever for decarbonization, but much remains to be done. Future works, for instance, might help in sharpening the methodologies used to quantify the climate benefits of circular practices or help in designing the policy mix that can turn their potential into actual emission reductions.

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