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From Linear to Circular: Strategies and Challenges in Eco-design and Product Innovation

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Abstract

Research on eco-design and product innovation within the framework of the circular economy (CE) has gained prominence as a response to rising environmental challenges, resource scarcity, and regulatory pressures. This growing field reflects a paradigm shift from traditional linear production models toward circular approaches that prioritize resource efficiency, waste reduction, and product life extension. By decoupling resource consumption from economic growth, CE principles offer significant potential to foster innovation and strengthen competitiveness.

Despite increasing scholarly and managerial interest, substantial knowledge gaps remain in operationalizing eco-design and circular product innovation across diverse industries. Existing studies frequently address material selection, modular design, and life cycle assessment (LCA); however, these elements are rarely integrated into coherent frameworks that systematically guide early stages of product development. Moreover, debates persist concerning the environmental trade-offs of advanced materials and manufacturing technologies, such as carbon fiber composites and additive manufacturing. Questions also arise regarding the scalability of circular business models and the role of digital tools in enabling material reuse and effective product lifecycle management. These unresolved issues risk undermining the efficiency of resource use and slowing the transition to sustainable production systems.

The purpose of this paper is to synthesize current knowledge on eco-design and product innovation in CE contexts, with a particular focus on design processes. It aims to identify effective strategies, highlight persistent challenges, and provide illustrative case studies. By offering an integrated perspective, this review contributes to bridging theoretical and practical gaps, supporting designers, manufacturers, and policymakers in advancing sustainable product innovation.

Keywords: Circular Economy, Design Process, Life Cycle Assessment, Sustainability, Sustainable Production