CIRCULAR ECONOMY: A STUDY OF ECO-INDUSTRIAL PARK GOVERNANCE

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Abstract

The circular economy (CE) is a breakthrough solution for sustainable development, creating opportunities for economic, environmental, and social growth. However, there are still many obstacles to the implementation of CE practices in eco-industrial parks (EIPs) in Vietnam (Thúy et al., 2018; Dang, 2021). This research aims to find out barriers hindering developing linkage among companies for the exchange of finished products, components, waste materials, and energy inputs in the EIP (Le et al., 2024). This study employs the analytic hierarchy process (AHP) method to analyze primary data collected through interviews with CE specialists. The research identifies eight categories of barriers, encompassing 39 specific challenges faced by businesses in EIPs when adopting CE practices. Consumer awareness and commitment and government policies were identified as the most significant first-level barriers for businesses in EIPs to implement CE practices and leadership awareness, public awareness, and education of CE. The result analysis suggests solutions and recommendations for relevant stakeholders, including businesses, EIPs, and the government.

Keywords: Circular Economy, Circular Economy Model, Sustainable Development, Eco-Industrial Park

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1. INTRODUCTION

The world today is facing numerous challenges and instabilities after a long period of excessive focus on economic growth and extensive exploitation of natural resources essential for social development (Tran et al., 2022). Faced with these challenges, sustainable and environmentally friendly economic development has become the goal of many countries (Nguyen et al., 2021; H. A. Nguyen, 2021). In eco-industrial parks (EIPs), various businesses from different sectors coexist and interact, establishing symbiotic relationships. A portion of the input factors for production comes from other businesses within the industrial park. Additionally, some or all of the waste and by-products, instead of being disposed of or reused internally, are transferred to other businesses for recycling. This circular process continues, ensuring efficient use of input materials and effective utilization of waste. It provides input materials for other businesses, leading to cost savings, resource optimization, waste reduction, and thereby promoting the circular economy (CE).

The CE is based on the fundamental principle that "everything is an input for something else" or a closed-loop system. The natural environment provides the input resources for production. Production transforms these resources into products and services for consumption. During this process, waste is generated. This waste is either fed into another production cycle or returned to the natural environment (Pearce & Turner, 1990). The circular supply chain emphasizes environmental concerns throughout its operations, focusing on managing and regenerating resources in a closed-loop system, with the goal of minimizing waste generation (Murray et al., 2017; H. A. Nguyen, 2021; Pham &

Nguyen, 2021). The CE requires expanding the network of participants in the supply chain. In addition to the usual entities like suppliers, manufacturers, and customers, the circular supply chain also involves remanufacturers, waste collectors, and sorters, promoting horizontal collaboration between different industrial sectors (de Angelis et al., 2018; Guo et al.,2019; di Maria et al., 2022; Bimpizas-Pinis et al., 2021). This horizontal collaboration is facilitated by the fact that the output of one industry can serve as the input for another. In this regard, a comprehensive perspective of CE requires an ecosystem thinking method that includes all role-players, interactions, value, and supply chains totally in a living ecosystem (Goyal et al., 2021).

For developing economies like Vietnam, implementing a circular supply chain presents significant challenges. In reality, fully integrated CE models have not yet been developed in Vietnam (Mai & Lai, 2022; Hai et al., 2020; Binh et al., 2022). On a smaller scale, within Vietnam's industrial zones, the application of circular supply chain models by existing businesses is still quite limited (Stucki et al., 2019; Thanh et al., 2023), negatively impacting the environment both inside and outside these industrial zones (Massard et al., 2018). In this context, none of the previous studies have provided a satisfactory practical description on how enterprises in EIPs faced with factors influencing on promotion of CE model in their production activities. Previous studies in Vietnam on circular supply chains are limited in number and mainly focus on the barriers for businesses in promoting EIPs, with little research on promoting the CE within industrial zones. There is no research on the governance of CE in the EIPs. This research aims at finding the factors hindering the development of the CE model in enterprises in EIPs, then suggest some policy implications from business and government in order to promote CE model in EIPs in Vietnam.

This study utilizes the analytic hierarchy process (AHP) method to analyze primary data. The research identifies eight groups of barriers, comprising 39 specific barriers faced by businesses in EIPs when adopting CE practices. Among these, barriers related to consumers, government policies, and leadership are considered the most significant hindrances. The study provides solutions and recommendations for relevant stakeholders, including businesses, EIPs, and the government.

The structure of this paper is as follows. Section 2 reviews the relevant literature. Section 3 shows the methodology that has been used to conduct empirical research in terms of research design and data processing. Then, the research results and discussion are presented in Section 4, and finally, in Section 5, we conclude with practical implications of the study, followed by limitations and directions for further research.

2. LITERATURE REVIEW

The transition from a linear economy towards a CE, based on reusing, repairing, refurbishing, and recycling existing materials and products, is one of the key priorities in pursuing sustainable development goals (SDGs), where governments play a fundamental role, with the support of digital technologies (Medaglia et al., 2024). The CE is based on an ideological agenda dominated by technical and economic accounts, which brings uncertain contributions to sustainability and depoliticizes sustainable growth (Corvellec et al., 2022). The CE was officially defined for the first time in the research work of Pearce and Turner (1990). According to this definition, CE is based on the fundamental principle that "everything is an input for something else" or a closed-loop system. The natural environment provides the input resources for production. Production transforms these resources into products and services for consumption, generating waste in the process. This waste can be directed into another production cycle or treated before being released into the natural environment.

The driving force behind the development of CE lies in its economic, environmental, and social benefits, which also contribute to sustainable development (Kumar et al., 2019; Rabbi & Amin, 2024). Businesses participating in the CE model reap several benefits. Firstly, they efficiently utilize resources and increase the use of renewable resources, helping reduce negative environmental impacts. Secondly, they enhance competitiveness in business and create positive outcomes for society. Thirdly, they save costs by maximizing resource utilization, simultaneously reducing the risk of raw material scarcity in production (Pham & Nguyen, 2021).

The CE model connects businesses, forming a closed-loop system that maximizes resource utilization and minimizes environmental emissions. It helps businesses and the economy achieve sustainable development (Wang et al., 2020; Dubey et al., 2019; Hasanbeigi & Price, 2015; Watanabe et al., 2019; Farooque et al., 2019; Lahane & Kant, 2021). This model improves the efficiency of activities and creates a competitive advantage (Geissdoerfer et al., 2018; Levering & Vos, 2019; Kumar et al., 2019; Lahane & Kant, 2021). The CE model is particularly concerned with environmental issues and enhances value creation by minimizing the use, maintenance, and restoration of natural resources (Geissdoerfer et al., 2018).

In recent decades, industrial parks in Vietnam have experienced significant growth in both form and quantity, making substantial contributions to the economy. However, they also face many limitations (Thanh et al., 2023). Since 1991, when the first industrial park was established, up until 2018, there were 324 industrial parks nationwide (Thúy et al., 2018). Industrial parks have played a leading role in economic development, driving the restructuring of the economy toward an increased share of industry and services, actively supporting the country's industrialization and modernization efforts. Additionally, industrial parks have significantly contributed to economic growth, improving living standards and people's incomes (Pham, 2011).

However, with such rapid industrialization, natural resources will gradually deplete in the near future, and environmental pollution will go beyond control due to inadequate treatment of industrial waste (T. N. Nguyen, 2021; Hai et al., 2020). Currently, industrial parks in Vietnam mostly operate in an open system, extracting resources from the environment for production and business activities, which are then returned to the environment as waste (Pham, 2011).

Studies like those by Massard et al. (2018) and Nylén et al. (2024) address the implementation and monitoring of EIPs, providing new approaches and measures to encourage the adoption of CE technologies. However, there is limited research on the barriers faced by circular businesses, especially

within industrial parks. Few studies have explored the obstacles encountered by businesses within industrial parks when deciding to adopt CE models.

Based on the literature review, this article proposes a research model consisting of eight primary barrier groups, including: 1) capital (*CL*), 2) human resources (*HR*), 3) leadership (*LP*), 4) business partnership (*BP*), 5) government policy (*GP*), 6) technology (*TC*), 7) socio-culture (*SI*), and 8) consumers (*CS*). The first and second-level barriers are presented in Tables 1 and 2.

3. RESEARCH METHODOLOGY

After collecting and analyzing data from both domestic and international research studies, as well as consulting opinions from experts, the research has developed a hierarchical model of barriers faced by businesses within EIPs when implementing CE models (Tables 1 and 2). Other research methodology can be applied to deal with the research topic, i.e., questionnaires for businesses to collect data of barriers hindering CE implementation, however CE is a new concept of economic model that is difficult for even experienced businesses to understand in order to explain and answer academic questionnaires, thus interview experts and managers is more suitable to do research.

The study involved interviewing 30 experts and managers in the field of CE in Vietnam. The interviews were conducted through multiple rounds. In each round, each expert evaluated the opinions of other experts and continued to participate in subsequent rounds. The research employed the AHP model, developed and introduced by professor Saaty (1983), to assist in multi-criteria decision-making.

When applying this method, the decision-maker selects the most suitable decision based on the analysis of the impact level of various criteria. It involves analyzing the responsiveness of different options and, ultimately, finding the best solution that aligns well with the criteria and aspects significantly influencing the decision.

4. RESULTS AND DISCUSSION: IMPACT LEVELS OF THE BARRIERS

The research results on the barriers to implementing CE for businesses within EIPs are presented in the following Table 1.

Table 1. The weight of first-level barriers in decreasing order of significance

No.	*Code*	*First-level barriers*	*Weight*
1	*CS*	Consumers	0.16
2	*GP*	Government policy	0.15
3	*CL*	Capital	0.14
4	*LP*	Leadership	0.13
5	*BP*	Business partnership	0.12
6	*SI*	Socio-culture	0.11
7	*HR*	Human resources	0.10
8	*TC*	Technology	0.09

Source: Authors' elaboration.

Table 2. Weight of second-level barriers in decreasing order of significance

No.	*Code*	*Second-level barriers*	*Weight*
1	*LP2*	Leadership has not yet fully recognized the role and trends of the CE in the 4.0 economy.	0.37
2	*SI1*	The public is not yet aware of the role of the CE.	0.36
3	*SI3*	Educational and promotional efforts on the CE have not been given sufficient attention.	0.34
4	*LP3*	Leaders are not determined to build businesses under the CE model.	0.33
5	*TC3*	The TC applied in the CE model is complex and challenging to businesses in Vietnam.	0.296
6	*LP1*	Leadership has not adapted to the CE model.	0.290
7	*SI2*	Businesses are accustomed to the traditional production model.	0.285
8	*CS3*	Consumers have not yet familiarized themselves with the CE.	0.281
9	*CS4*	Consumers do not have the demand to purchase circular products yet.	0.277
10	*CL1*	Lack of initial investment CL to implement circular manufacturing projects.	0.2758
11	*HR1*	Lack of experienced LP with knowledge in operating circular production process.	0.2751
12	*CS1*	Consumers still have concerns about products that are recycled, reused, or refurbished.	0.25
13	*TC4*	Lack of regulations for evaluating and controlling the quality of technologies.	0.246
14	*CL2*	Lack of investment CL to sustain circular production and business.	0.244
15	*GP1*	The legal system and regulations related to the CE are not yet available.	0.243
16	*TC1*	Lack of TC for optimizing resource utilization.	0.23
17	*TC2*	Lack of TC compatible with the CE model.	0.22
18	*CL5*	Lack of financial capacity to anticipate and address arising issues when implementing circular manufacturing.	0.20
19	*GP5*	Circular economy-related regulations lack of encouragement and stability.	0.19
20	*CS2*	Consumers are not interested in circular products yet.	0.18
21	*BP3*	Partners do not share information.	0.179
22	*HR2*	Lack of skilled staff to perform tasks for circular production process.	0.178
23	*GP2*	Regulations are unclear and do not facilitate circular manufacturing.	0.171
24	*BP2*	Partners are not transparent and well-informed to manage product exchanges and waste.	0.16
25	*CL4*	Businesses find it difficult to achieve the goal of CL recovery.	0.153
26	*BP1*	Partners do not cooperate to reinforce the circular production.	0.151
27	*GP3*	Lack of government regulations to promote the CE.	0.148
28	*HR6*	Businesses lack regular training programs for employees of circular business.	0.146
29	*HR3*	Employees lack awareness of the environment and the benefits of circular production.	0.143
30	*BP4*	Partners lack of knowledge to manage circular business.	0.1378
31	*HR4*	Employees are not adapting to the working of circular production.	0.1376
32	*GP6*	The regulations of EIPs do not facilitate circular manufacture.	0.133
33	*BP5*	Lack of businesses to connect and exchange products and waste materials.	0.1204
34	*CL3*	Lack of financial capacity for marketing circular products.	0.1201
35	*HR5*	Employees are not aware of the development trend of the CE.	0.118
36	*GP4*	The government has not issued evaluation criteria and support for circular businesses.	0.111
37	*BP6*	Lack of collection centers and waste exchange facilities within EIPs.	0.09
38	*BP8*	Lack of reverse logistics system.	0.08
39	*BP7*	Lack of suppliers for raw materials.	0.06

Source: Authors' elaboration.

The barrier of lack of CS awareness and commitment was identified as the most significant barrier for businesses in EIPs to implement CE practices, with a weight of 16%. The majority of Vietnamese CS are not conscious of, and not willing to pay for, circular products due to a lack of understanding about the indirect benefits to the community, such as resource conservation and social cost reduction.

Additionally, GP was identified as a major hindrance, accounting for 15% of the total weight. GPs play a crucial role in encouraging businesses to adopt CE models. On the other hand, barriers of HR (10%) and TC (9%) were perceived as having lower levels of obstruction.

At the level of sub-factors (level 2), barriers associated with LP awareness and commitment (*LP2*) were considered the most significant, contributing to 37% of the total weight. If LP fails to recognize the role and trends of CE in the 4.0 industrial revolution, it can create substantial challenges in implementing CE models. Chowdhury et al. (2022) have also shown that awareness and commitment from LP play a crucial role in implementing CE models. Their research demonstrated that organisational LP will facilitate developing the culture and innovation capability to adopt circular economic practices through a 'hub and spoke' strategy for enhancing sustainable performance among the small and medium enterprises (SMEs) in Vietnam.

The next barriers with relatively high obstruction levels for businesses in the EIP when implementing the CE model include: 1) citizens are not aware of the role of the CE (*SI1*); 2) education and awareness campaigns about the CE are not given adequate attention (*SI3*); 3) lack of support and commitment from top LP (*LP3*); 4) complex and challenging implementation of TC in the CE model in Vietnam (*TC3*); 5) CS have not researched the CE (*CS3*); 6) CS do not have the demand to purchase circular products (*CS4*); and 7) initial lack of investment CL to implement projects according to the CE model (*CL1*).

The group of barriers with the lowest obstruction levels, according to the calculated weights, includes: 1) employees are not aware of the CE development trends (*HR5*); 2) the government has not issued evaluation criteria and support for businesses to implement the CE model (*GP4*); 3) lack of waste collection and exchange centers in the EIP (*BP6*); 4) lack of reverse logistics systems (*BP8*); and 5) lack of raw material suppliers (*BP7*). These barriers, although ranked low in terms of obstruction, still require attention and efforts from businesses in EIPs to overcome in order to successfully implement the CE model.

In Vietnam, the pilot implementation of the EIP model is currently taking place in three EIPs: 1) Khanh Phu EIP (Ninh Binh Province), 2) Hoa Khanh EIP (Da Nang City), and 3) Tra Noc EIP (Can Tho City). Within an EIP, the interactions between businesses have shifted from independent activities in different sectors to forming collaborative partnerships. This collaboration is evident in the way waste and by-products generated by one business become input materials for other businesses within the EIP. The goal is to minimize emissions into the environment and maximize the utilization of resources. Consequently, the CE model contributes positively to achieving the objectives of the EIP by optimizing resource utilization and reducing negative environmental impacts. Businesses implementing the CE model need to consider these interactions with other businesses and organizations within the same EIP. The solutions and recommendations provided in the research aim to contribute to reducing the obstacles with the highest level of obstruction. Johansson and Henriksson (2020) emphasized that it was time for producers and the state to reclaim the idea of circularity and to create "a closed, material loop limited in size and space, based on the principle of fair distribution of resources" (p. 154).

5. CONCLUSION

Based on these results, it is recommended to enhance education and awareness among CS regarding the benefits of CE. Moreover, there is a need for increased support and incentives from the government to help businesses overcome these barriers and implement CE practices effectively.

For businesses, they play a pivotal role in enhancing the CE by adopting practices that reduce waste, increase resource efficiency, and promote the reuse, recycling, and regeneration of materials. It is essential to focus on CS, developing producers for the CS group who are willing to pay for products from circular production. Businesses need to actively participate in programs to promote and advertise products and economic zones operating under the CE model. Secondly, businesses should develop a supply chain in order to collaborate closely with suppliers to optimize the use of raw materials and reduce excess inventory. They should collaborate with suppliers to ensure resource-efficient and waste-reducing practices throughout the supply chain through working with suppliers to design and implement circular strategies, such as using by-products as inputs, reducing packaging waste, or transitioning to reusable packaging systems. Thirdly, businesses are willing to collaborate with domestic and international enterprises to seek experienced partners who can implement the CE model. This collaboration is aimed at providing support in terms of TC and finance, as well as learning from the operational experiences of the CE model. Fourthly, exploring decentralized or local production models that reduce transportation emissions and waste associated with long-distance shipping. Fifthly, implementing lean manufacturing processes to minimize resource use and waste. This could involve optimizing production processes to reduce material waste, water, and energy consumption through adopting zero-waste-to-landfill goals by improving internal recycling, repurposing waste streams, or collaborating with other companies for industrial symbiosis and developing closed-loop systems where waste from the production process is captured, processed, and fed back into the manufacturing cycle as raw material. Additionally, businesses need to implement responsible sourcing practices, favoring suppliers with sustainable and eco-friendly certifications. And businesses should explore local sourcing options to minimize the environmental impact of transportation. By adopting these strategies, businesses can reduce waste, conserve resources, and transition to more sustainable, circular models of production and consumption. This not only benefits the environment but also improves profitability, resilience, and customer loyalty.

EIPs currently play a significant role in supporting businesses with infrastructure, technical aspects, and providing comprehensive shared services. However, businesses under the CE model need more than that in finding suitable partners and creating conditions for these partners to be strategically located for organizing management and connections among businesses. These businesses also require an industrial park designed specifically to foster circular manufacturing among various businesses by several key strategies to ensure the park operates in a closed-loop system, where resources are reused, recycled, and optimized. Firstly, setting up an industrial symbiosis platform or marketplace where businesses can exchange excess materials or by-products, facilitating material reuse within the park. Secondly, developing centralized waste collection and recycling infrastructure within the park to handle solid waste, wastewater, and industrial by-products. This can include facilities for material recovery, composting, or reprocessing. It is necessary to invest in waste-to-energy plants to convert non-recyclable waste into energy that can be used within the park, further reducing reliance on external energy sources. Facilities for the safe treatment and disposal of hazardous waste generated by industries within the park should be established in order to ensure compliance with environmental regulations. Thirdly, ensure that new buildings and infrastructure within the park are designed with sustainability in mind. This includes using eco-friendly construction materials, incorporating green roofs, and ensuring buildings are energy-efficient. Additionally, encouraging companies to shift from selling products to offering services, such as leasing or maintenance agreements, where they retain ownership of products and ensure their longevity and recyclability. By implementing these strategies, EIPs can foster an environment that supports CE principles, reduces environmental impacts, and improves resource efficiency while also creating economic and social value for businesses and surrounding communities.

For the government agency, enhancing the CE in EIPs in Vietnam requires a combination of policy, infrastructure, and business incentives that foster sustainable practices and resource efficiency. This approach not only reduces waste and environmental impacts but also boosts resource efficiency and long-term economic sustainability. Firstly, the government should clarify the objectives and strategies for circular economic development. This clarification would enable the issuance of regulations aimed at promoting CE in a comprehensive and practical manner. It's important to learn from other countries' conversion processes and apply them appropriately to Vietnam. This approach would help shorten the implementation time and reduce frequent regulatory changes, which can lead to uncertainty in business decisions. Secondly, the policies should encourage and further promote the participation of businesses in the circular production process. Leadership-related barriers rank third in terms of obstruction, following barriers of CS and government policies, in the mean while the lack of vision among top LP is identified as the most significant hindrance, thus, there is a need to enhance businesses' awareness of environmental issues and trends in environmentally friendly production and consumption. Thirdly, it is necessary to develop training programs for businesses regarding future business trends as well as the long-term benefits that the CE model can bring to businesses. Through these programs, there can be a shift in the mindset and orientation of LP. Furthermore, public awareness campaigns about sustainable and environmentally friendly production models should be conducted, highlighting the economic, social, and environmental benefits for the general population. Fourthly, holding training program of circular economic promotion in order to educate CS about the benefits of CE practices and responsible consumption; encourage CS to participate in product recycling and reuse programs. Fifthly, promote partnerships between the government, private sector, and academia to develop CE projects, especially in waste management, water reuse, and energy recovery. Collaborative platforms for companies, local governments, and civil society to collaborate on CE initiatives and share best practices are necessary.

Developing the economy in a circular direction is an urgent goal given the depletion of resources and environmental pollution. To achieve this objective, close collaboration among businesses, EIPs, and the government is crucial. This research has identified systematic barriers in the development of the CE model for businesses within EIPs. The research findings will contribute positively to promoting the implementation of the CE model for businesses within EIPs. To do better on the promotion of circular manufacturing, it is essential to do quantitative research in a larger scale in various EIPs to find out what businesses, CS, and EIPs need to enhance circular manufacturing. It is also essential to research on how to enhance sustainability, resource efficiency, and collaboration among businesses within these industrial zones, evaluate the effectiveness of existing policies and regulatory frameworks for promoting CE practices in EIPs. Especially investigating innovative business models that can support CE implementation in EIPs, such as closed-loop production, industrial symbiosis, and sharing platforms.

The transition towards CE has become an imperative due to the increasing depletion of natural resources and escalating environmental challenges associated with industrial production. EIPs play a crucial role in facilitating this transition by promoting resource efficiency, waste reduction, and industrial symbiosis. However, despite growing recognition of CE as a sustainable development model, its implementation within EIPs remains constrained by various systemic barriers, including regulatory inconsistencies, financial limitations, and technological gaps. While existing studies have explored CE adoption in different contexts, research on its practical application in EIPs — particularly in developing economies such as Vietnam — remains limited in scope, scale, and methodological rigor.

Current research on CE implementation in EIPs has several limitations. First, many studies rely on qualitative case studies or conceptual frameworks, which, while valuable, lack the empirical generalizability needed to inform large-scale policy interventions. Second, there is a scarcity of comprehensive assessments examining the economic viability of CE models within industrial parks, particularly regarding cost-benefit analyses and return on investment for businesses. Third, existing studies often focus on individual CE strategies, such as waste reduction or resource efficiency, without considering the systemic

interdependencies among businesses, regulatory agencies, and market forces. These gaps highlight the need for more robust, interdisciplinary research to develop actionable strategies for scaling CE practices in EIPs.

To address these limitations, future research should prioritize large-scale quantitative studies across multiple EIPs to assess the specific needs of businesses, industrial zones, and key stakeholders in fostering circular manufacturing. Such studies would provide empirical evidence on the drivers and challenges of CE implementation, enabling policymakers and industry leaders to develop targeted interventions. Additionally, further investigations should focus on strategies to enhance sustainability, resource efficiency, and inter-business collaboration within EIPs. Evaluating the effectiveness of existing policies and regulatory frameworks is also essential to identify institutional gaps and develop more robust mechanisms to support CE initiatives.

Moreover, innovative business models that facilitate CE adoption warrant further exploration. Research should examine closed-loop production systems, industrial symbiosis, and digital sharing platforms, which have the potential to optimize resource utilization and minimize waste generation. Additionally, financial mechanisms and incentive structures — such as green financing, carbon credit schemes, and tax incentives — should be studied to determine their role in enhancing the economic feasibility and scalability of CE practices within EIPs.

Another critical research area is the application of digital transformation and smart technologies, including big data analytics, blockchain, and artificial intelligence, in circular industrial systems. These technologies can improve resource tracking, optimize supply chain efficiency, and facilitate waste reduction. Furthermore, understanding consumer behavior and market demand for circular products is essential for developing effective business strategies that promote the commercialization of CE innovations. Comparative analyses of successful CE models in other countries could also yield valuable insights into best practices and their applicability in the Vietnamese context.

Given the increasing urgency of sustainable industrial development, there is a pressing need for interdisciplinary research that integrates technological, economic, and policy perspectives to advance CE implementation in EIPs. Addressing these research gaps will generate evidence-based insights that inform policymakers, industry leaders, and researchers, ultimately accelerating the transition toward a sustainable and circular industrial economy.

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