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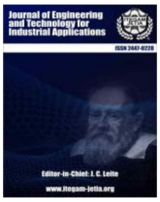

RESEARCH ARTICLE OPEN ACCESS

REVIEW OF TOWARD A CIRCULAR ECONOMY IN THE TIRE INDUSTRY: INTEGRATING LIFE CYCLE ASSESSMENTS AND RECYCLING INNOVATIONS

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ABSTRACT

The global tire industry generates approximately 1.5 billion end-of-life tires annually, amplifying waste, emissions, and health risks. This review synthesises contemporary life cycle assessment (LCA) evidence and recycling innovations, including pyrolysis, microwave devulcanization, and hybrid thermochemical routes, to map credible pathways toward circularity. We identified four persistent gaps: heterogeneous LCA methods and data silos, misaligned policy incentives, scalability and profitability limits of advanced recycling, and fragmented adoption of sustainable materials. To address these issues, we propose an integrated framework that couples standardised, sector-specific, and dynamic LCAs with modular, upgraded pyrolysis for high-value recovery (carbon black substitutes, oils, and steel), design-for-circularity (renewable elastomers and sensor-enabled tires), and enabling instruments (extended producer responsibility, differentiated subsidies, and carbon crediting). The framework establishes feedback loops between tire design and end-of-life performance, supports regionally deployable solutions, and prioritises the use of interoperable data platforms, pilot deployments, and policy realignment. Collectively, these measures can accelerate the tire sector's transition from linear to circular models while minimising environmental burdens across the production, use, and end-of-life stages.

I. BACKGROUND AND MOTIVATION

The global tire industry, with a market size exceeding $250 billion, is indispensable to modern mobility and poses a formidable environmental challenge. This is due to the excessive demand in the automotive industry for the use of vehicles such as cars, motorcycles, and heavy vehicles such as lorries and buses, as well as the development and aerospace sectors such as airplanes. According to previous studies, as living standards rise and the number of automobile owners increases each year, an increasing number of people choose transportation as their major mode of mobility. [1] Approximately 1.5 billion tires reach end-of-life annually, contributing to a growing stockpile of waste and associated environmental hazards, such as fires, leachate, and microplastics.

Furthermore, incorrect disposal procedures have turned the growing number of waste tires into a severe environmental issue, as they can contaminate the air and soil, spread dangerous diseases, and offer habitats for rats. Therefore, finding an environmentally appropriate approach to dispose of these old tires is critical. Recycling materials from old tires is increasingly regarded as a sustainable method for disposing of unwanted tires owing to its numerous benefits. Recycling old tires can reduce CO2 emissions by approximately 1523 tonnes per year, according to a life cycle study that examined the environmental effects of textile fibres salvaged from discarded tires. [2] However, owing to continuous innovations in tire design and material science, the industry struggles to transition from a linear to a circular model.

These due to break from the linear model, a creative process of systemic reconfiguration and flexibility is necessary. As a result of the technological revolution of the previous 200 years, the modern world is a complex system of interconnected parts surrounded by extensive stakeholder networks, rules, and incentive systems. These reasons make systemic sustainability change more challenging, both individually and in tandem with globalisation and shifting social expectations. The current unsustainable system has become stable due to the linear model's intrinsic lock-in inertia, which includes sunk costs in infrastructure, skills, and established economies of scale. As a result, transitioning to the circular model demands consideration of complex relationships and structural changes. Because of the significant initial investment, transitioning to an incentive structure based on long-term sustainability principles typically results in poor, short-term financial performance. Governments must play an important role in internalising the externalities associated with resource exploitation and waste disposal to change the current fiscal, accounting, and regulatory frameworks. [3]

Circular economy (CE) principles offer a conceptual and operational framework for reducing waste, extending product lifecycles, and recovering materials for reuse. However, the translation of CE concepts into measurable and scalable industry practices, particularly within the tire lifecycle, remains underdeveloped. Life cycle assessments (LCA) and advanced recycling technologies are essential instruments in this transition but are unevenly adopted across sectors and geographies. [4] This is because the implementation of a CE may have a disproportionate impact on certain groups or individuals, and there is a risk that it will exacerbate existing imbalances. The shift to a CE raises social challenges, such as income distribution, employment patterns, and the effectiveness of existing political structures. It has been claimed that CE will alter employment patterns across several industries, necessitating a shift in labour costs rather than material pricing. Furthermore, the transition to a CE may increase competition for resources, raising raw material costs and making acquisition more difficult for small businesses and low-income individuals. [5]

I.1 STATE OF THE ART

Recent literature reflects the increasing momentum toward sustainability in the tire sector. Advances in LCA methodologies, including attributional and consequential models, allow for detailed comparisons of recycling, pyrolysis, retreading, and incineration pathways [6], [7]. For example, crumb rubber production, a widely used recycling method, performs moderately well in terms of environmental impact but is often constrained by market saturation and quality degradation issues. This is because tires consist of numerous finely developed elements, including treads, belts, inner liners, and sidewalls. When the performance characteristics of these parts are integrated, the resulting tires are strong, durable, dependable, and safe. These characteristics ensure the durability of the tyre materials and particles in the environment. Tires contain several chemicals and molecules, many of which are proprietary [8]. Tires are mostly constructed of rubber, with a framework consisting of textiles or metal mesh. Different tire brands, types, and components employ proprietary rubber formulas [9–13].

According to previous studies [12], tire rubber is typically composed of 40-60% synthetic and/or natural rubber, 20-25% fillers and reinforcing agents such as carbon black and silica, 12-15% process or extender oils, vulcanisation agents such as Zn and thiazoles, and additional additives such as preservatives and processing aids (5-10%). The ratio of natural to synthetic rubber in tires is approximately 50:50; trucks have more natural rubber, passenger cars have more synthetic rubber, and heavy-duty vehicles have little to no synthetic rubber [14]. Tires contain thousands of chemicals, including polycyclic aromatic hydrocarbons (PAHs), contaminants in manufacturing feedstocks, weathering or transformation products as tires age, and intentionally added chemicals such as N-(1,3-dimethylbutyl)-N′-phenyl-p-phenylenediamine (6PPD, DTXSID9025114; CAS 793-24-8) [15]. As a result, the chemical composition of the tyre wear particles varies.

Consequently, it is difficult to track and classify tire particles and tire-derived chemicals in environmental samples, anticipate the fate of tire microplastics, and assess their ecotoxicological impact. Research on the general and quantitative chemical composition of tyre rubber is still critically needed to produce new recycled types. Moreover, new materials research has led to the development of bio-based and smart elastomers, which may increase recyclability and reduce environmental burdens during use [16]. Simultaneously, integrated frameworks for tire lifecycle extension, such as predictive maintenance via AI and embedded tire sensors, suggest avenues for proactive waste minimisation. However, the systemic integration of these solutions remains rare. While a few smart city projects (e.g. in Europe and East Asia) incorporate tire recycling into urban sustainability plans, many regions still rely on landfilling or uncontrolled incineration [17], [18].

I.2 DEFINING THE RESEARCH GAP

The overarching gap lies in the absence of a unified operational framework that synthesises Life Cycle Assessment (LCA) results and innovative recycling methods into actionable circular business models. Several critical micro-gaps emerge within this broader challenge which are data silos and standardisation challenges in comparing LCA studies across tire types and regions [19]. In production and trading companies, life cycle evaluation can be used to address both general concerns and specific commodities issues. Waste management strategies, action plans, and design enhancements can be developed based on these findings and compared with those of other companies [20]. Environmentally friendly transportation must be designed using data from different sources. The increased use of cars has considerably influenced the natural environment. Multinational decision-makers must collaborate to change the current scenario [21].

To satisfy a specified vehicle tire recovery level, manufacturers and importers must follow regulations governing waste and product management constraints and deposit requirements. If they do not meet these conditions, they will face penalties [22]. Given the foregoing, the environment's ability to meet the demands of contemporary systems on natural resources is rapidly eroding. Concerns surrounding the assessment of the environmental impact of automotive tires must be addressed. A review of several studies on the environmental impact of commodities, such as vehicle tires, throughout their life cycle, shows that it is critical to identify specific sets of impacts and their sequence. Current and future costs should be considered. For example, a natural rubber tire has a different environmental impact than a regular automobile tire [23].

In addition, the insufficient scalability and profitability of newer pyrolysis-based systems despite their carbon offset potential [24]. The pyrolysis process can significantly benefit waste polymers that are typically difficult or impossible to recycle. This technique provides a realistic pyrolysis option for the economical and environmentally responsible reuse or disposal of these polymers, converting them into useful chemicals and fuels. Finally, pyrolysis can be beneficial to enterprises. However, in term of the scalability of system pyrolysis recycling is limited by the lack of usable space for expansion, scaling operations for viability, modularization, and quick turnaround time-speed to market. This is because the number of waste tires in this modernising environment has been a lot of increased significantly, and it is not sufficient to use the pyrolysis system.

The industrial sector still uses the old-school method of burying the remaining waste tires [25]. In addition, the fragmented adoption of sustainable materials is largely confined to research laboratories or niche commercial applications [26]. According to the European Tyre and Rubber Manufacturers' Association (ETRMA) statistics, the most commonly used technique among the various end-of-life tire recycling activities in 2018 was grinding or shredding used tires. This creates a significant challenge for researchers because it combines the material properties of one tire with another. The shredding process produces the so-called "chips," which are often used as alternative fuel (energy recovery). The ETRMA has released new, worrying numbers, revealing that 318 800 t of tires were wasted in 2018, a 12% rise over 2017. As evidenced by the statistics presented above, the disposal of worn tires is a major environmental concern that poses numerous challenges for researchers and corporate executives.

Thus, it is impossible to justify research on material recycling technologies for used tires [27]. Finally, Disjointed policy frameworks, where incentives for circular practices are either absent or misaligned with technical feasibility [28]. The existence of fragmented policy frameworks, where incentives for circular practices are either non-existent or not in line with technical feasibility, represents a major research gap in the tyre industry's efforts to advance a circular economy. Although the necessity of encouraging recycling, reuse, and resource efficiency in tire manufacturing and end-of-life management is becoming more widely acknowledged, current laws and policies sometimes fall short of offering cogent, helpful frameworks that are in line with what is both technically and financially feasible.

For example, subsidies or tax incentives might favour incineration over material recovery, even though, when considering life cycle assessments (LCA), the latter has a higher potential for environmental advantages. Furthermore, inconsistent policies across areas may stymie the development and deployment of novel recycling technologies by causing ambiguity and dispersion in market signals. These legislative misalignments might deter investment in sustainable design and enhanced recovery processes, as businesses may not see obvious benefits or returns under the present frameworks. Addressing this gap necessitates integrated policy approaches that not only incentivise circular innovations but are also informed by strong LCA data, ensuring that environmental objectives are achieved in ways that are both technically possible and commercially appealing [29].

I.3 OBJECTIVES OF THIS REVIEW

This study aims to map the transition of the tire industry toward circularity through an integrated review of life cycle assessments and recycling innovations. Specifically, the review will revealed about analyzes the strengths and limitations of LCA as a decision-making tool for tire recycling. In addition, the current and emerging recycling technologies, including pyrolysis, DE vulcanisation, and AI-enhanced separation, are evaluated. Second, identify the policy and industrial barriers that hinder circularity. Finally, a synthesised framework is proposed for advancing circular strategies in tire production, use, and end-of-life treatment.

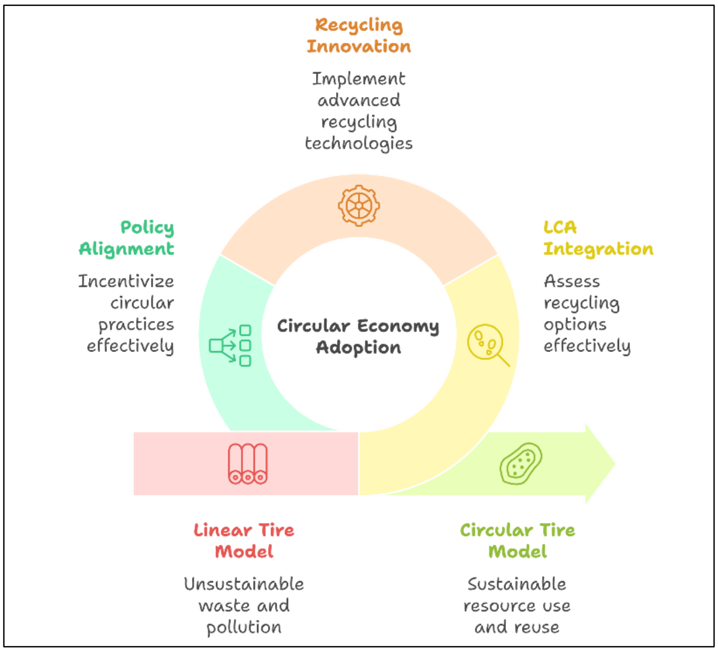

Figure 1: Transitioning to a Circular Tire Industry.
Source: Authors, (2026).

II. HYPOTHETICAL SOLUTIONS FOR SEVERAL POSSIBLE BEST METHODS TO CLOSE THE GAP

Researchers have estimated various viable but inconsistently implemented approaches for bridging the systemic and technological gaps in the circular transformation of the tyre industry. These initiatives are divided into four main areas: materials science, policy integration, LCA standardisation, and technical innovation. These are explained in detail in each category below.

II.1 LIFE CYCLE ASSESSMENT (LCA) HARMONIZATION AND EXPANSION

LCA has become the cornerstone of environmental impact analysis; however, inconsistencies in methodologies and assumptions often limit comparability. A unified LCA framework tailored for the tire industry that accounts for regional, material, and use-phase variability could provide more actionable insights across the value chain. One proposed solution is a sector-specific LCA toolkit based on ISO 14040/44 but enriched with tire-specific inventory data, material degradation profiles, and recyclability indices [30]. Standardising LCA categories, such as global warming potential (GWP), acidification, and resource depletion, would foster comparability between tire brands and recycling strategies. Moreover, dynamic LCA models that integrate real-time data (e.g. wear sensors and GPS-based usage) could move the field beyond static cradle-to-grave snapshots toward adaptive cradle-to-cradle loops. Figure 2 shows an illustration of the LCA.

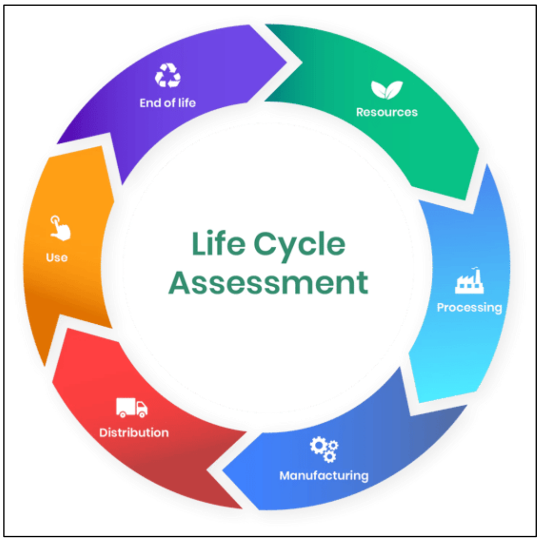

Figure 2: Life Cycle Assessment (LCA).
Source: [31].

II.2 ADVANCING TIRE RECYCLING TECHNOLOGIES

Pyrolysis, microwave devulcanization, and supercritical fluid extraction are increasingly recognised as next-generation recycling pathways. These technologies enable the recovery of high-value materials, such as carbon black, steel, and oil. Therefore, it is necessary to upgrade pyrolysis systems with continuous feed reactors, and gas cleaning units are being tested to improve the yield and reduce emissions [32]. The intention is to build a waste tyre (WT) pyrolysis and upgrading factory with an annual capacity of 100,000 tonnes, which will be allowed. Figure 3 depicts the pyrolysis of WT to produce high-value pyrolytic materials and the construction of new tires using M-CBp. Following the pre-stripping of the steel wire, the WTs were cracked in a revolving kiln to generate three-phase products. Subsequently, TPO and CBp were improved independently.

The pyrolytic gas served as the fuel for pyrolysis. The TPO components were separated into light, medium, and heavy oils based on their boiling points using a three-stage atmospheric and vacuum distillation tower set. The light and medium fractions completed sulphur removal to produce low-sulfur petrol and diesel. In terms of CBp, M-CBp created through various modification processes might be used to replace various proportions of commercial carbon black used in new tire production. Waste heat from pyrolytic gas combustion and TPO refining was recycled to generate steam (400 °C, 0.5 MPa) and low-quality steam (200 °C, 0.5 MPa) as byproducts of circulation.

In addition, microwave devulcanization allows for the selective cleavage of sulfur crosslinks, preserving the rubber backbone, which is a major advantage over mechanical shredding [33]. Devulcanization procedures vary according to the reaction mechanisms, which are physical, chemical, and biological. In the physical process, waste rubbers are devulcanized using external energies such as thermal, cryo, mechanical, microwave, or ultrasonic. To recuperate waste rubbers, a chemical process generates phenol sulphide and disulphides. Furthermore, in biotechnological processes, bacteria such as chemolithotrophic microorganisms and Nocardia species have been used to devulcanize scrap rubber. Among these approaches, microwave devulcanization has been extensively explored because of its high efficiency and superior control over the ultimate temperature, which plays an important role in devulcanization.

In addition, hybrid approaches that couple mechanical pre-processing with thermochemical recovery optimise throughput and energy efficiency. This type of process can be classified based on the target product, such as gas, liquid, or solid, the oxidation environment (partial or anaerobic), and the type of feedstock (wet or dry). Thermochemical conversion methods hold significant promise for producing renewable electricity through waste and coal co-combustion in power plants and for decentralised generation in underdeveloped nations. Additionally, using thermochemical processes to generate electricity from waste can contribute to meeting renewable portfolio standards in certain US states [34]. This type of transformative but underexplored option is modular recycling systems embedded within urban environments, allowing for decentralised, demand-responsive treatment, especially in smart cities pursuing circularity.

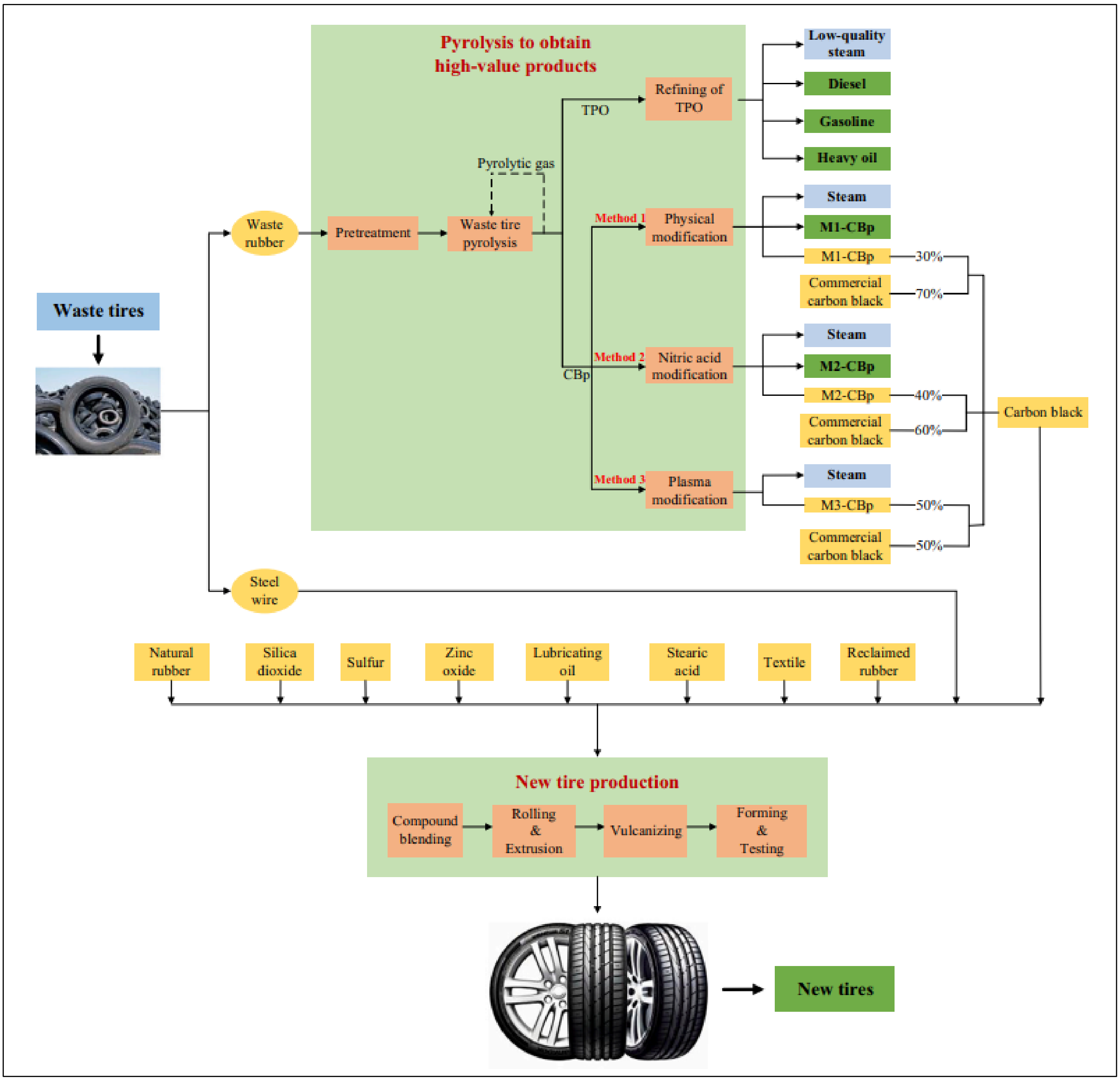

Figure 3: Flowchart of the closed loop of waste tire pyrolysis and new tire production.
Source: [32].

II.3 SUSTAINABLE AND CIRCULAR TIRE DESIGN

To achieve true circularity, tire design must anticipate end-of-life (EOL) processing. Several innovations show promise, such as dandelion rubber (Taraxacum kok-saghyz) and guayule as renewable elastomer sources, which reduce fossil dependency and potentially simplify devulcanization [35]. In addition, modular tire architectures that separate the tread from the carcase via mechanical fasteners could enable selective reuse and recycling. In addition, the provided sensor enabled smart tires to track wear and performance, potentially informing dynamic LCA models and enhancing product stewardship [16]. However, these solutions require compatibility with existing manufacturing lines and standardisation across different suppliers. This means that it is necessary to know each region and country that supplies the particular types of tires that match the environment.

II.4 POLICY, ECONOMIC INSTRUMENTS, AND INDUSTRIAL SYNERGIES

Public policy remains a significant bottleneck. Despite mandates in the EU and extended producer responsibility (EPR) laws in some countries, enforcement remains uneven. So to link with the policy and EPR laws. The proposed strategies include differentiated subsidies or tax incentives for tires that meet recyclability and life cycle performance thresholds. EPR frameworks internalise the cost of post-consumer waste and promote closed-loop models [36]. In addition, industrial symbiosis, where tire waste is co-processed with other industrial byproducts (e.g. in cement kilns), optimises material flows and emissions profiles [37]. Finally, emerging carbon credit markets could monetise the environmental benefits of high-efficiency tire recycling, providing additional incentives for early adopters [19].

II.5 INTEGRATIVE PLATFORMS AND CROSS-SECTORAL COLLABORATION

These can give the complexity of tire circularity; no single actor or intervention can succeed alone. Interdisciplinary platforms that bring together material scientists, LCA practitioners, policymakers, and industry stakeholders are essential. Emerging digital twins and collaborative LCA databases can catalyse such integration, enabling data transparency, interoperability, and benchmarking.

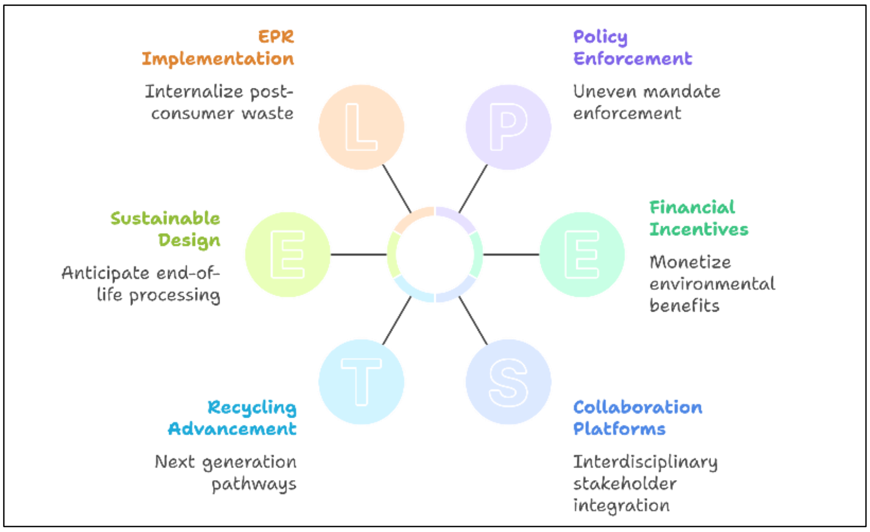

Figure 4: Tire Industry Circular Transformation.
Source: Authors, (2026).

III. THE BEST METHOD AMONG THEM AND HOW IT CAN CLOSE AND SOLVE THE GAP

Although numerous solutions have been proposed to address the linearity of the tire industry, not all offer equal potential in terms of scalability, system integration, and environmental efficacy. After a critical assessment of the approaches outlined in Chapter 2, one method emerges as the most promising: Integrated Life Cycle–Informed Modular Pyrolysis within a Circular Policy Framework. This hybrid strategy unifies real-time LCA modelling, advanced modular pyrolysis, and policy-supported circularity incentives to create a closed-loop system. This section defends its selection and details how it addresses the key structural and environmental gaps in the industry.

III.1 SUPERIOR MATERIAL RECOVERY

Among all the reviewed recycling technologies, advanced pyrolysis offers the broadest material recovery profile, yielding carbon black substitutes (CBp), oils, and steel. When enhanced with modular scalability and upgraded reactor design, pyrolysis provides both high throughput and regional flexibility [38]. Critically, pyrolysis does not require prior sorting by material type and can handle mixed, contaminated, or aged tires, which often overwhelm mechanical or devulcanization-based methods [33].

III.2 INDUSTRIAL INTEGRATION POTENTIAL

The pyrolysis byproducts can reenter the supply chain, making this method uniquely compatible with circular manufacturing. Carbon black recovered via pyrolysis has shown near-commercial-grade performance when upgraded chemically or physically. This allows for partial substitution in new tire manufacturing, thereby reducing raw material demand and production emissions [26].

III.3 THE ROLE OF DYNAMIC, DIGITAL LCA

Static LCAs fail to capture the real-time variability in tire performance and end-of-life impacts. Embedding IoT sensors in tires and using cloud-based LCA platforms enable "living LCAs" that adjust impact predictions based on wear, driving behaviour, and regional recycling options. These LCAs are not only descriptive but also prescriptive; they can recommend optimal end-of-life treatment routes, for example, prioritising pyrolysis if a tire has high embedded energy or directing mechanical recovery if treads are intact. When integrated with digital twins, these models can simulate various circular scenarios, allowing manufacturers and policymakers to select strategies that minimise ecological and economic costs.

III.4 POLICY SCAFFOLDING AND INCENTIVIZATION

Even the most advanced technologies require policy scaffolding to thrive. Integrated modular pyrolysis succeeds when supported by differentiated recycling subsidies favoring high-yield, low-emission technologies. Besides that, EPR regulations that mandate material traceability and minimum recycled content in new tires [39] and digital certification of carbon savings, enabling manufacturers to monetize their environmental performance through carbon credits or product ecolabels [19]. Such measures close the economic loop and create systemic incentives to adopt and sustain circular practices across the tire lifecycle.

III.5 FEEDBACK LOOP BETWEEN MATERIAL DESIGN AND END-OF-LIFE PATHWAYS

The most critical function of this integrated strategy is that it enables a continuous feedback loop between tire design and end-of-life recovery. If a certain compound in a tire hinders pyrolysis efficiency, that information can be fed back into material R&D. If a modular pyrolysis unit reports higher yields from tires made with renewable elastomers (e.g. dandelion rubber), this can drive design innovation [35]. In this way, the system evolves organically, aligning product innovation with recyclability, market dynamics and environmental performance.

III.6 ANTICIPATED CHALLENGES AND COUNTERARGUMENTS

Despite its strengths, integrated modular pyrolysis faces challenges such as non-trivial energy input requirements that must be offset with renewable sources or recovered heat loops or public perception and investor uncertainty around pyrolysis persist, often due to legacy associations with incineration and digital infrastructure costs for LCA standardisation and sensor integration may limit adoption in low-resource contexts. These challenges are not insurmountable but must be acknowledged in any realistic deployment. Hybrid approaches, including phased rollouts, public-private partnerships, and open data sharing, can reduce systemic resistance and upfront costs.

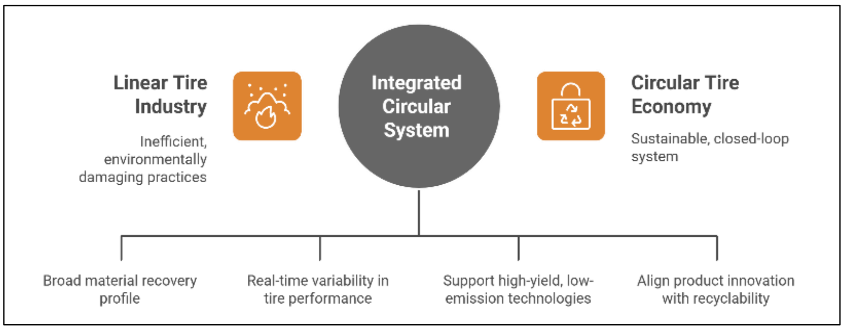

Figure 5: Closing the Tire Industry Gap.
Source: Authors, (2026).

IV. SUMMARY AND FUTURE DIRECTIONS

This review examines the intersection of life cycle assessments (LCA) and recycling innovations in guiding the tire industry's transition toward a circular economy. The investigation revealed the following core findings: current LCA frameworks offer critical environmental diagnostics but lack standardisation and real-time adaptability. A shift toward dynamic, digital LCAs is essential. Pyrolysis and its modular variants have emerged as the most promising recycling pathways for tires because of their capacity for material recovery, compatibility with mixed waste, and integration potential within existing supply chains.

Design for circularity, especially innovations in sustainable elastomers and sensor-enabled tires, can amplify both reuse and recovery potential but requires coordinated standardisation and investment. Finally, policy frameworks such as extended producer responsibility (EPR), subsidies for high-efficiency recycling, and carbon credit mechanisms are essential scaffolds that translate technical promises into systemic impacts. By integrating modular pyrolysis, digital LCAs, recyclable design, and supportive policy, a tire economy is envisioned that not only minimises waste but also transforms it into a valuable input for new cycles of production.

IV.1 CONTRIBUTIONS TO THE FIELD

This study contributes to the growing dialogue on circularity in the tire industry by offering a synthesised roadmap that integrates technological, environmental, and policy dimensions. Unlike earlier studies that focused on isolated solutions, this study presents a comprehensive framework in which LCA acts as the analytical engine, pyrolysis as the material recovery mechanism, and policy as the market enabler. Furthermore, by acknowledging the nuances and trade-offs in each domain, this study provides a balanced and realistic foundation for both academic enquiry and industrial action.

IV.2 RESEARCH LIMITATIONS

This study has several limitations. First, comparative LCA data across geographies are inconsistent, which restricts generalisability. Second, while pyrolysis holds immense potential, much of the data are based on pilot-scale or regional deployments, limiting insights into global scalability. Third, social dimensions, such as labour conditions in recycling sectors or public acceptance of new materials, are underexplored in this review but are vital to the circular transition.

IV.3 FUTURE RESEARCH DIRECTIONS

To close the remaining gaps and deepen the operational feasibility of circular tire systems, future studies should prioritise real-world pilot projects combining IoT-enhanced tires, dynamic LCAs, and localised pyrolysis units in both urban and rural contexts. Cross-sector LCA platforms enable data sharing among tire manufacturers, recyclers, and policymakers. Materials science research has focused on easily recoverable compounds and alternative fillers (e.g. lignin and silica) to replace carbon black. Policy modelling to simulate the environmental and economic impacts of various EPR designs, recycling credits, and trade regulations. Additionally, a critical frontier will be the integration of behavioural sciences into the circular economy model to understand how consumer use patterns, industry incentives, and regulatory cultures influence the success or failure of recycling strategies.

IV.4 FINAL REFLECTIONS

The transformation of the tire industry from a predominantly linear model to a circular one is not purely a technical challenge. It is a systems problem interlacing materials science, environmental modelling, economics, and governance. The convergence of modular and scalable technologies with smart and transparent analytics is the key to accelerating this transition. However, most crucially, it demands collaboration across silos. Manufacturers must align with regulators, researchers with recyclers, and policymakers with data scientists. Only through such integrative action can the vision of a zero-waste, resource-efficient tire industry become a tangible reality.

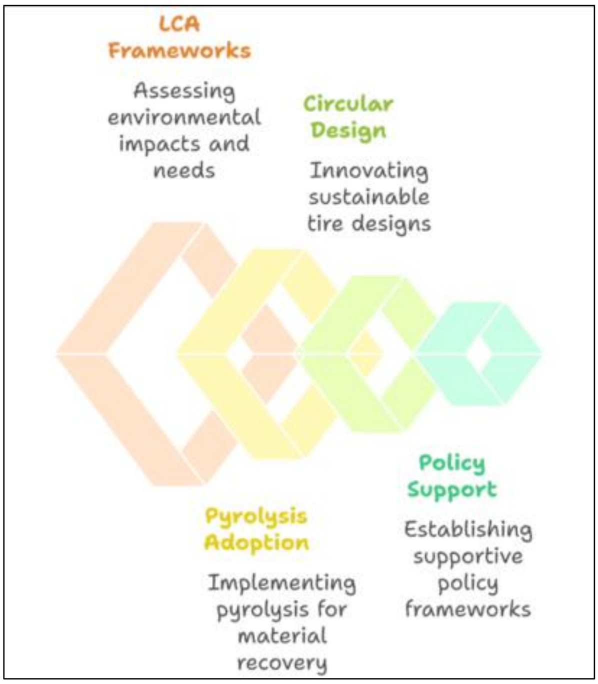

Figure 6: Transition to Circular Tire Economy.
Source: Authors, (2026).

V. AUTHOR'S CONTRIBUTION

Conceptualization: Ahmad Zaki Abadi.
Methodology: Ahmad Zaki Abadi.
Investigation: Ahmad Zaki Abadi.
Discussion of results: Ahmad Zaki Abadi.
Writing – Original Draft: Ahmad Zaki Abadi.
Writing – Review and Editing: Mohd Nizar Mhd Razali, Ahmad Shahir Jamaludin and Muhammad Amirul Azwan Azmi.
Supervision: Siti Nadiah Binti Mohd Saffe.
Approval of the final text: Ahmad Shahir Jamaludin and Siti Nadiah Binti Mohd Saffe.

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