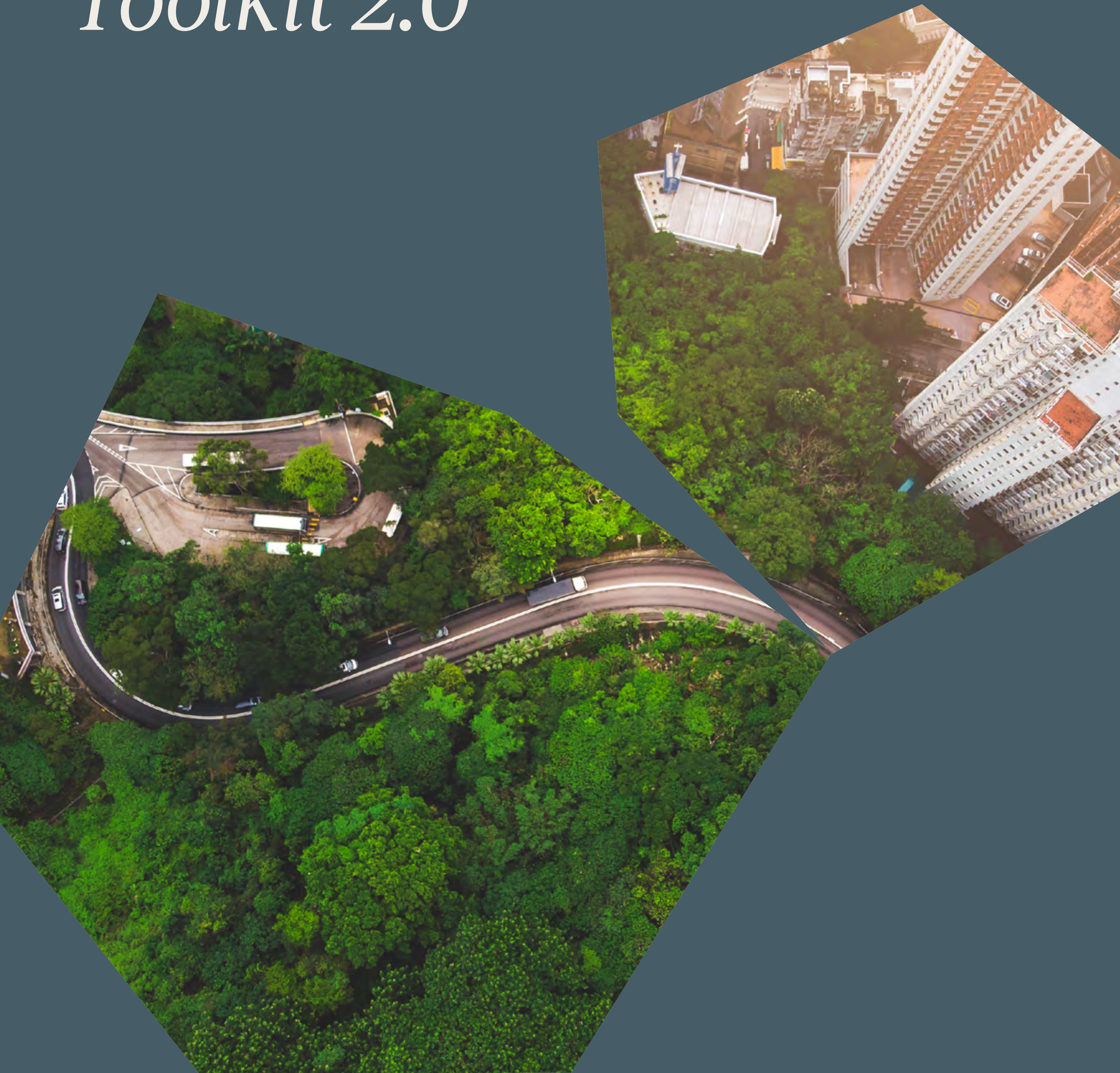
End-of-Life Tire *Toolkit 2.0*



World Business Council *for Sustainable Development*

Tire Industry *Project*

Table of contents

Figures

Tables

List of abbreviations

Abbreviation	Full Term
ATIC	Australian Tyre Industry Council
ATMA	Automotive Tyre Manufacturers' Association of India
BTMA	British Tyre Manufacturers' Association
CO_2	carbon dioxide
EES	environmental economic social
EIA	environmental impact assessment
ELT	end-of-life tire
EPR	extended producer responsibility
ESM	environmentally sound management
EU	European Union
FZOEU	Environmental Protection and Energy Efficiency Fund (Croatia)
GIS	geographic information system
ISO	International Organization for Standardization
KOTMA	Korea Tire Manufacturers' Association
KPI	key performance indicator
LCA	lifecycle assessment
MOE	Ministry of Environment (South Korea)

Abbreviation	Full Term
MSME	micro, small and medium enterprises
NGO	non-governmental organization(s)
NGT	National Green Tribunal (India)
OECD	Organization for Economic Co-operation and Development
PAHs	polycyclic aromatic hydrocarbons
PRO	producer responsibility organization
R&D	research and development
rCB	recovered carbon black
SDG	Sustainable Development Goal(s)
SME	small and medium-sized enterprises
TDF	tire-derived fuel
TIP	Tire Industry Project
TPO	tire pyrolysis oil
TRAC	Tire and Rubber Association of Canada
TTA	tire trade associations
WBCSD	World Business Council for Sustainable Development
WtE	waste-to-energy

Executive summary

Each year, more than one billion tires reach the end of their useful life, representing both a growing environmental challenge and a major opportunity to advance circularity. Despite progress in many regions, end-of-life tire (ELT) management systems around the world remain highly fragmented. Differences in policy frameworks, data transparency, collection efficiency, and recycling infrastructure continue to limit the recovery of valuable materials and the realization of circular economy potential.

To help address this complexity, the Tire Industry Project (TIP) was formed in 2005 by ten leading tire companies under the World Business Council for Sustainable Development (WBCSD), with a mission to anticipate, understand, and address global environmental, social, and governance (ESG) issues relevant to the tire industry and its value chain. As part of this mission, TIP has developed this product: the "End-of-Life Tire Management Toolkit 2.0".

Building on the first edition from 2021, this updated Toolkit reflects developments in global ELT management over recent years and integrates the latest knowledge, practical experience, and stakeholder feedback. It provides clear, action-oriented guidance to help policymakers, associations, manufacturers, and other value-chain actors design and improve ELT management schemes that are environmentally sound, economically viable, and socially responsible.

Toolkit 2.0 provides an overview of global approaches to ELT management — including extended producer responsibility (EPR), free-market, and tax-based models — and distills learnings from example countries and industries. It combines comparative analysis with real-world examples and practical guidance to support benchmarking, planning, and implementation. The updated version is designed with its core audience in mind, offering a more intuitive and practical format with harmonized terminology, step-by-step guidance, and "how-to" materials that help turn strategy into action.

Rather than prescribing a single model, the Toolkit 2.0 provides a flexible foundation that can be adapted to diverse local contexts and regulatory realities. It encourages collaboration, transparency, and data-driven decision-making among stakeholders who share a common ambition: to keep tires and materials in use for as long as possible, reduce waste, and minimize environmental impact.

This update represents the collective effort of many organizations and experts committed to advancing circularity in the tire sector. It reflects a shared belief that effective ELT management is both an environmental imperative and a source of long-term value creation. The Toolkit is intended as a living resource — one that will continue to evolve as new data, innovations, and partnerships emerge — and serves as an invitation for all stakeholders to collaborate, learn, and act together toward a more sustainable tire cycle.

Introduction to the Toolkit

Part I

1.1
Purpose and scope

This Toolkit's primary aim is to support WBCSD TIP in convening stakeholders toward more sustainable end-of-life tire management.[1]

To realize its ambition, TIP's work focuses on four areas of ELT:

- Defining and addressing ELT knowledge gaps
- Creating sustainable ELT management standards, methods, and data
- Driving policy and advocacy agendas on sustainable ELT management
- Building capabilities and awareness for sustainable ELT management

This TIP end-of-life tire (ELT) Toolkit 2.0, or simply "Toolkit", serves as a resource supporting all four working fields.

This Toolkit is a comprehensive, action-oriented guide for stakeholders across the global tire value chain to establish, enhance, and harmonize sustainable ELT management schemes. It builds on the foundation of the previous Toolkit, published in 2021 (Tire Industry Project, 2021). This updated version integrates new research, stakeholder feedback, and practical insights to address the evolving challenges and opportunities in ELT recovery, recycling, and circularity.

Compared to the previous version, this updated Toolkit:

- Strengthens the theoretical foundation with new frameworks and the latest developments in ELT management
- Places a stronger focus on stakeholder engagement and practitioner relevance
- Includes practical tools and templates to support system development and enhancement

This Toolkit's primary aim is to support WBCSD TIP in convening stakeholders toward more sustainable end-of-life tire management.

Given this, the Toolkit empowers stakeholders through:

- Clear pathways for navigating ELT management complexities
- Decision-making frameworks for different regulatory and market contexts
- Practical implementation steps aligned with environmental, health, and economic priorities
- Promotion of a shared understanding of ELT risks, recovery routes, and circular economy principles
- Being a catalyst for stakeholder engagement and policy advocacy

Through modular content, user-centric design, and practical templates, the Toolkit enables policymakers, associations and manufacturers, as well as other actors to co-create resilient, transparent, and effective ELT management schemes. The Toolkit is not just a reference document, but rather a strategic enabler for global collaboration, knowledge sharing, and capacity building in pursuit of a more sustainable tire industry.

The Toolkit has three overall objectives:

1. **Enable assessment and improvement of ELT management scheme:** Provide a clear framework to evaluate the maturity of ELT management scheme; identify strengths, gaps, and opportunities; and support the development of sustainable and impactful ELT strategies.
2. **Enable practical implementation:** Offer real-world examples and actionable recommendations to facilitate execution and guide users developing or improving ELT management schemes.
3. **Align with global sustainability goals:** Advance UN Sustainable Development Goals, particularly targets 8.4, 12.2, and 12.5 (United Nations Department of Economic and Social Affairs, 2015) by applying circular economy and environmentally sound management (ESM) principles that treat ELTs as valuable resources, not waste.

Disclaimer: While this Toolkit strives to offer clear and actionable insights, the guidance provided cannot fully account for the unique regulatory, economic, and infrastructural conditions of every market or individual use case. Users are encouraged to adapt the Toolkit's recommendations to their local context and consult with relevant stakeholders to ensure alignment with national policies and industry standards. To avoid doubt, the content of this Toolkit does not constitute legal advice. Users of this Toolkit are solely responsible for ensuring that any actions taken in reliance on its content comply with all applicable laws and regulations, including but not limited to competition laws.

[1]The scope of this Toolkit covers end-of-life tires manufactured by TIP member companies. TIP prioritizes actions within this scope based on materiality, potential impact, and local legal requirements, focusing on the most relevant opportunities to advance more sustainable ELT management.

1.2 Methodology and structure

Methodology of the Toolkit

The ELT Management Toolkit 2.0 was developed through a combination of research, expert input, and stakeholder consultation. It draws on both quantitative and qualitative analyses, integrating theoretical frameworks and practical insights developed by TIP ELT experts representing companies that together cover around 60% of the global tire market.

Real-world examples were informed by research and consultations with tire trade associations (TTAs), local authorities, and corporate ELT experts. The practical guidance in the Toolkit builds on this collective knowledge — translating research and theory into actionable tools, templates, and workflows.

This approach ensures that Toolkit 2.0 is both evidence-based and user-focused, bridging global knowledge with real implementation experience. While the methodology provides a comprehensive foundation, it must be tailored to individual needs to ensure relevance and effectiveness.

Structure of the Toolkit

This Toolkit is structured as step-by-step instructions to guide stakeholders through sustainable ELT management.

Part I – Introduction to the Toolkit: Outlines the Toolkit's purpose, ambition, and relevance in advancing circularity and sustainability in the tire value chain and introduces the Tire Industry Project. It also identifies three key user groups:

- Policymakers
- Associations
- Manufacturers

Part II – Research foundation: Presents comparative insights into system models (extended producer responsibility, free-market, and tax-based), along with ESM principles and ELT technologies.

Part III – Real-world examples: Showcase country-level ELT management schemes.

Part IV – Practical guidance: Translates research into action through templates and step-by-step guidance for:

- Assessing maturity levels
- Supporting decision-making
- Implementing and improving ELT management scheme

Part V – Conclusion: Summarizes key takeaways and provides an outlook on future developments.

Additional resources: Glossary, annexes, and ready-to-use templates to enhance clarity, usability, and customization.

1.3
Key stakeholder profiles and navigation guide

While the Toolkit offers structured guidance and practical tools, it does not aim to cover every scenario or provide exhaustive detail for all stakeholders. Instead, to ensure relevance, clarity, and usability across diverse contexts, it introduces three core audiences as representative profiles of key stakeholder groups that are pivotal to driving sustainable action.

The Toolkit is modular, so you can jump directly to the chapters that are most useful to your role. An easy guide will be shown after each key stakeholder profile.

Policymakers

Policymakers include government officials, regulators, and public authorities who are uniquely positioned as the architects of regulatory frameworks that govern tire lifecycle management. They are responsible for shaping environmental, waste, and circular economy policies related to tires and ELT.

Benefits

- Gain insights into the best global practices and ELT management schemes (e.g., EPR, tax systems, free-market models)
- Benchmark national systems and identify gaps in regulatory frameworks
- Develop policy instruments more easily to promote greater sustainable ELT recovery and circularity

Navigation guide

Policymakers

Understand the fundamentals → Design effective ELT schemes → Learn from global examples → Put policy into action

→ **Understand the fundamentals:** you can find definitions, risks of poor ELT management and the ELT management hierarchy in chapters **2.1.1 - 2.1.3**.

→ **Design effective ELT schemes:** familiarize yourself with the core ESM principles, socio-economic benefits, and regulatory frameworks and model comparisons in chapters **2.2.1 - 2.2.4, and 2.3**.

→ **Learn from global examples:** read these real-world examples from Brazil, EU countries, Japan, South Korea, and more in chapter **3.1**.

→ **Put policy into action:** use the practical tools and templates for ELT management for maturity assessments, drafting effective regulations, recovery route development, and set ELT data standards from chapters **4.1.1 - 4.1.3, and 4.1.5**.

→ START JOURNEY

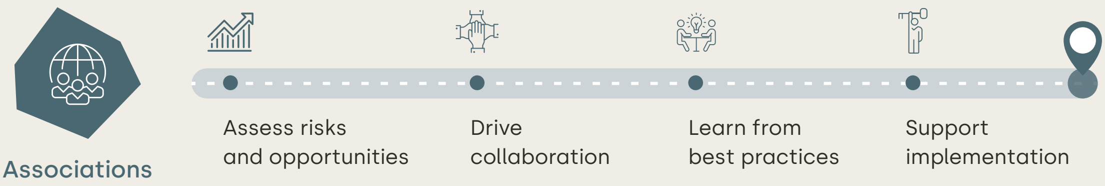
Associations (upstream & downstream)

Tire associations serve as the collective voice and networking hub for industry stakeholders, from production to recovery. This group includes industry associations, producer responsibility organizations (PROs), recycling networks, and trade bodies that operate across the tire value chain and are well-positioned to foster collaboration and standardize best practices across the industry.

Benefits

- Leverage strategies from the Toolkit to unify stakeholder efforts and advocate for industry-wide adoption of innovative solutions for ELT management
- Facilitate knowledge sharing and address policy adaptation complexities to improve industry practices as well as sustainability outcomes
- Benefit from examples and case studies that illustrate how associations can drive change through collaboration and advocacy

Navigation guide



→ **Assess risks and opportunities:** read about the challenges of weak ELT management and the role of the waste hierarchy in building a circular economy in chapters **2.1.2 - 2.1.3**.

→ **Drive collaboration:** gain new ideas from the role and responsibilities of different stakeholders and strategies for effective engagement in chapter **2.2.1 and 2.2.2**.

→ **Learn from best practices:** refer to the ELT management scheme comparisons and case studies showing how associations engage, and which ELT management schemes have been applied in chapters **2.3.2 - 2.3.3**.

→ **Support implementation:** use the tools for awareness raising, risk assessment, and building partnerships across the value chain in chapters **4.1.2, 4.1.3, and 4.1.4**.

→ START JOURNEY

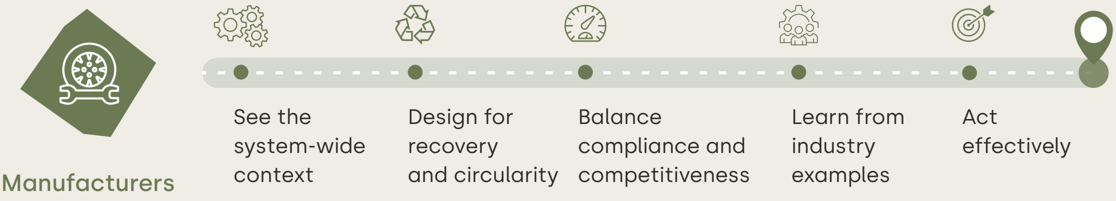
Manufacturers

Tire manufacturers are key to the design of tires, while tire manufacturers, importers and distributors, including retail/wholesalers, are the target audience for the information on ELT management schemes.

Benefits

- Understand how different ELT management schemes affect manufacturers' operational responsibilities and how to balance cost-effective production with sustainable innovation.
- Explore the implementation of additional circular design principles, recovery routes, and sustainable product strategies to extend tire lifecycles, facilitate recycling, reduce their environmental footprint, and maintain a competitive edge and profitability in complex markets.
- Adapt more easily to regulatory shifts, engaging with stakeholders and meeting consumer demands for more sustainable products, as well as contributing to industry-wide sustainability goals.

Navigation guide



→ **See the system-wide context:** Refer to the ELT hierarchy, a framework for understanding how ELT can be managed, in chapter **2.1.3**.

→ **Design for recovery and circularity:** Understand key aspects of lifetime extension, material recycling, and energy recovery in chapter **2.2.4**.

→ **Balance compliance and competitiveness:** Check how different frameworks affect producer responsibilities in chapters **2.3.2** and **2.3.3**.

→ **Learn from industry examples:** Learn from manufacturer-led initiatives like PROs in Italy and France in chapter **3.1**.

→ **Act effectively:** Get guidance on recovery routes, data monitoring, and research and development (R&D) support in chapters **4.1.4** and **4.1.5**.

→ START JOURNEY

Other Stakeholders

While the Toolkit is tailored to the three core audiences, it offers valuable insights and resources for a broader audience like recyclers, NGOs, researchers, investors etc.

Benefits

- **Recyclers and recovery operators** can use the Toolkit to understand policy trends, recovery route positioning, and opportunities for innovation.
- **Fleet operators and retailers** can explore how ELT management impacts procurement, logistics, and sustainability reporting.
- **Academics and researchers** can reference the Toolkit's structured data, maturity scales, and system comparisons for further study.
- **Civil society and non-governmental organizations (NGOs)** can use the Toolkit to advocate for responsible ELT practices and engage in dialogue with industry and government.
- **Investors and financial institutions** can use the Toolkit to understand ELT management benefits and challenges.

Navigation guide

→ **Recyclers:** Recovery technologies and pathways in chapters **2.2.4 and 4.1.4**.

→ **NGOs and civil society:** Socio-environmental benefits and awareness campaigns in chapters **2.2.3 and 4.1.3**.

→ **Academics and researchers:** Theory, data, and case comparisons in chapters **2 and 3.1**.

→ **Investors and financial institutions:** Economic models and long-term outlook in chapters **2.2 and 5.**

→ **Fleet operators and retailers:** Procurement, logistics, and sustainability reporting impacts in chapter **2.3**.

Research foundation

Part II

2.1 Global need for ELT management

2.1.1 Context and definition

Understand the fundamentals
2.1.1-2.1.3

← PREVIOUS
→ NEXT

Note: Click on the stakeholder icon to go back to key stakeholder profiles and navigation guide.

Tires and their uses

Tires play a crucial role in society. They are essential for the safe and efficient transport of people and goods and can enhance vehicle performance and comfort. Tire engineering is critical to ensure driving safety, endurance, and comfort. Tires are complex, component-rich, and innovative products that are designed to perform critical functions, including:

- Supporting vehicle weight
- Gripping the road to steer, accelerate, and brake
- Optimizing rolling resistance for energy efficiency
- Absorbing impacts and vibrations
- Resisting heat and speed
- Performing in wet and wintry weather
- Ensuring a long wear life

Like the vehicles they serve, tires wear down over time and must be replaced once they can no longer perform their intended functions safely and effectively. Tires at the end of life have ideally been fully utilized through proper maintenance over their lifetime, having carried the vehicle for a maximum distance in safe conditions before being dismounted (Tire Industry Project, 2019).

End-of-life tire (ELT)

When tires are no longer fit for use on a vehicle, they become waste to be managed. Tires that are still functional but removed prematurely for various reasons also become de facto waste. In this Toolkit, ELT refers to tires that no longer serve their original purpose on a vehicle, covering both cases (Tire Industry Project, 2019).

While ELT has a relatively high recycling rate in some regions, significant gaps remain in collection, recovery, and data availability. These gaps indicate that current systems are insufficient to manage ELT sustainably on a global scale, and more coordinated efforts are needed to track, process, and repurpose these materials efficiently.

The shift toward a circular economy is encouraging stakeholders to see ELT as a valuable resource for material reuse rather than mere waste. This change is driven by environmental, social, and economic considerations (Tire Industry Project, 2021).

- ELT management can reduce landfilling and illegal dumping.
- ELT can substitute limited natural resources in new products and industrial applications.
- ELT management supports employment throughout the value chain – from informal collectors to recycling plant technicians.
- ELT recovery can provide cost-effective, sustainable energy for various industries.

ELT management

The rising number of ELT indicates that dedicated management is needed. Therefore, this Toolkit also focuses on this aspect — defining ELT management as the collection, transport, and treatment of tires that can no longer serve their original purpose on a vehicle. The objective of ELT management is to recover material or energy from ELTs or to properly dispose of them to avoid negative impacts. ELT management contributes to the circular economy because ELT and their constituent materials offer valuable resources (Tire Industry Project, 2021).

30 million
metric tons

Each year, roughly one billion tires reach their end of life (Tire Industry Project, 2023), corresponding to an estimated ~30 million metric tons of ELT annually. These numbers highlight the scale of ELTs and the importance of finding sustainable ways to recover and reuse them.

2.1.2
The ELT Management Hierarchy – A circular economy tool

Understand the fundamentals
2.1.1-2.1.3
← PREVIOUS
→ NEXT

Assess risks and opportunities
2.1.2-2.1.3
← PREVIOUS
→ NEXT

TIP is committed to minimizing the environmental impact of tires throughout their entire lifecycle, from sourcing and manufacturing to their ELT management and supports three Sustainable Development Goals (SDGs) core targets (see Figure 1). More information about the commitment is available in the latest KPI report (Tire Industry Project, 2025).

Figure 1: SGD Core targets

TARGET 8-4
Improve resource efficiency in consumption and production

TARGET 12-2
Sustainable management and use of natural resources

TARGET 12-5
Substantially reduce waste generation

The circular economy

The circular economy is a systemic approach aimed at preserving the value of products, materials, and resources for as long as possible while minimizing waste and environmental impacts. Unlike the traditional linear economic model, the circular economy promotes the reuse, repair, refurbishment, and recycling of products and materials. By integrating circular principles into design, production, and use, innovative solutions are created that deliver both ecological and economic benefits.

The circular economy views end-of-life products such as tires not as waste, but as valuable resources for new applications and value chains. It supports the development of sustainable business models and encourages collaboration among industry, policymakers, and society. Implementing circular processes helps conserve natural resources, reduce emissions, and strengthen the resilience of value creation systems. International standards such as ISO 59004:2024 provide a common foundation for terminology, principles, and practical implementation of the circular economy (International Organization for Standardization, 2024). By defining the conditions for innovative ELT management solutions, the circular economy promotes responsible resource use throughout the entire tire lifecycle.

The waste hierarchy

TIP's approach to promote the circular economy and a more environmentally sound management of ELT is grounded in the leading policy framework worldwide for waste management: the "waste hierarchy." The concept is straightforward as it involves implementing measures in the following order of priority, at a societal, governmental, household, or individual level:

1. **Prevent:** Stop waste from being created in the first place.
2. **Minimize:** Reduce the amount and toxicity of waste generated.
3. **Reuse:** Extend the life of products or materials without major reprocessing.
4. **Recycle:** Convert waste materials into new products or materials.
5. **Recover in other ways:** Extract value from waste through energy recovery.
6. **Dispose:** Safely manage residual waste that cannot be prevented, minimized, reused, recycled, or recovered.

2.1.2 The ELT Management Hierarchy – A circular economy tool (continued)

The ELT management hierarchy

Based on its assessment of waste hierarchy principles, TIP developed the ELT management hierarchy in the Tire Life Cycle (see Figure 2), a framework adapted specifically to the case of ELT. It follows the same hierarchy of priorities and suggests actions specifically related to tire management. These actions span product design, product use, and end-of-life treatment.

Chapter 2.2 of this Toolkit explains how the ELT management hierarchy is derived from and follows the core principles of ESM.

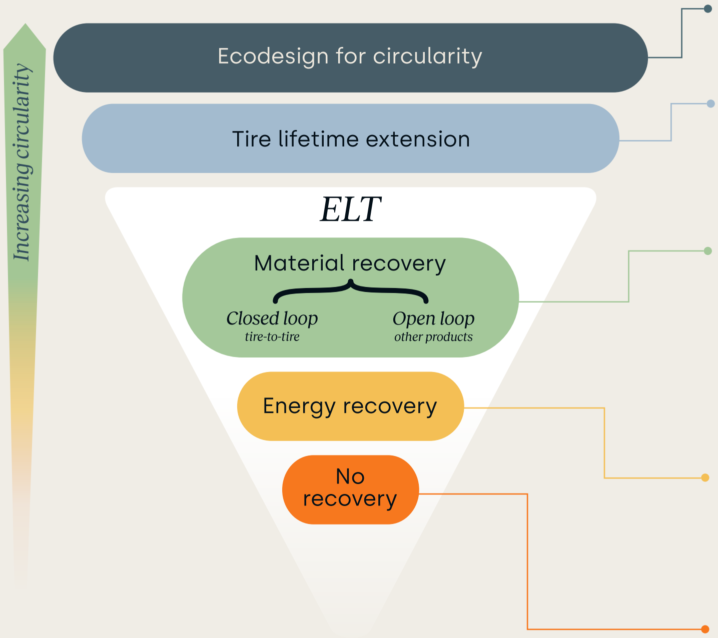
In general, circularity in the tire manufacturing industry is especially important for developing markets, where rapid economic growth and increasing vehicle use lead to higher tire consumption and waste generation. By adopting a circular economy approach, these markets can significantly reduce the environmental impact of tire disposal and resource extraction.

Implementing circularity principles starts with designing durable and recyclable tires in line with eco-design principles and establishing effective systems to extend the useful life of tires through maintenance, repair, and retreading. Eco-design principles provide a framework to set improvement goals for reducing environmental impacts across the life cycle of a product. This approach not only conserves valuable raw materials and reduces waste but also stimulates local economies by creating new business opportunities and jobs (Tire Industry Project, 2024). Once a tire becomes ELT, the highest priority is material recovery, with processes that enable closed loop recycling into new tires or open loop applications in other industries, ensuring resources remain in productive use.

If material recovery is not possible (typically when processing plants either do not exist or are too far away to be economically viable given the transport costs), the next priority is energy recovery, circularity encourages capturing heat or electricity efficiently from residual tire components while minimizing environmental impact. Finally, circularity principles call for minimizing landfilling and incineration without energy recovery.

End-of-life Tire (ELT) Management Hierarchy in the Tire Life Cycle

Figure 2: ELT Management Hierarchy in the Tire Life Cycle



Ecodesign for circularity
- Eco-design* for longevity and ability to repair, reuse & recycle

WASTE PREVENTION
Tire lifetime extension
- Maintenance & repair
- Regrooving & retreading tires design for multiple lives

WASTE TREATMENT
Material recovery
- Sorting, shredding, granulation, pelletizing, pulverization
- Devulcanization/regeneration/reclaim
- Pyrolysis, gasification, chemical recycling
- Cement kilns
- Civil engineering applications

WASTE TREATMENT
Energy recovery
- Cement kilns, combustion, electric arc furnace
- Pyrolysis, gasification

Other treatment and disposal
- Backfill, landfill
- Incineration

*In line with tire functional requirements and guiding principles set out in eco-design standards, for example ISO 14006:2020 Environmental management systems - Guideline for incorporating ecodesign

2.1.3 Risk associated with a lack of ELT management

Understand the fundamentals
2.1.1-2.1.3
← PREVIOUS
→ NEXT

Assess risks and opportunities
2.1.2-2.1.3
← PREVIOUS
→ NEXT

See the system-wide context
2.1.3
← PREVIOUS
→ NEXT

In the absence of ELT management, several key challenges arise that undermine both safety and sustainability:

- **Unregulated dumping:** Unmanaged tire piles can ignite and are extremely difficult to extinguish, creating persistent fire hazards. They also provide ideal breeding grounds for mosquitoes (Downard, et al., 2014), increasing the potential spread of mosquito-borne diseases. Mismanaged ELTs occupy valuable land and cause visible aesthetic damage, negatively affecting communities.
- **Unsafe reuse of ELT:** Without proper oversight, ELT may be reused illegally in contexts that fail to meet safety standards. This undermines regulatory compliance and puts users and communities at risk by allowing unsafe products back into circulation.
- **Ecological, social, and economic risks:** Without collective and standardized global management, the environmental, public health, and economic impacts of ELT mismanagement persist.
- **Economic and infrastructure costs:** A lack of ELT management can lead to substantial costs related to landfills, cleanup, remediation, and fire suppression (Tire Industry Project, 2021).
- **Loss of materials:** Mismanagement of ELT can lead to the loss of recoverable materials and missed opportunities to reuse them in new products or other applications, undermining resource efficiency and circular value creation (Tire Industry Project, 2021).

Collective efforts are needed to implement and standardize ELT management globally and comprehensively to minimize ecological, social, and economic risks, using circular economy as a guide.

2.2 Environmentally sound management (ESM) of ELT

Environmentally sound management is a fundamental concept of waste management established by the Basel Convention which defines ESM as:

> *"Taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes"*
>
> *(Basel Convention, 2014)*

This principle is widely recognized across international environmental law, such as in the Stockholm Convention, and is integrated into global environmental standards (e.g., ISO 14001, ISO 15270) and policy frameworks developed by organizations including the Organization for Economic Co-operation and Development (OECD) and the European Union (International Organization for Standardization, 2008; International Organization for Standardization, 2015; Basel Convention, n.d.; Stockholm Convention, n.d.).

In the context of ELT, ESM provides a holistic approach that guides practices in the responsible handling, use, and disposal of tires that no longer fulfill their original purpose on a vehicle. The aim is to minimize negative impacts on human health and the environment, emphasizing resource conservation and pollution reduction through a lifecycle perspective, often incorporating environmentally sound technologies.

Note: Click on the stakeholder icon to go back to key stakeholder profiles and navigation guide.

2.2.1 Core principles of ESM for ELT management

Design effective ELT schemes
2.2.1 - 2.2.4, 2.3
← PREVIOUS
→ NEXT

Drive collaboration
2.2.1, 2.2.2
← PREVIOUS
→ NEXT

ESM of ELT is grounded in the principles of the Basel Convention, including the "polluter pays" principle (European Commission, 2023) and the minimization of cross-border waste movement. Building on these foundations, this Toolkit introduces the ELT management hierarchy (see Figure 2) as a practical framework for applying ESM in a tire-specific context (Basel Convention, n.d.).

By following the hierarchy, users can ensure that all viable options for prevention, reuse, recovery, and recycling have been systematically considered before disposal, translating ESM principles into concrete implementation steps for the tire sector.

The core ESM principles are:

1. **Prevention and reduction:** Extend the lifespan of tires through design innovation, maintenance, and retreading.
2. **Material recovery:** Prioritize recycling to recover valuable materials like rubber, steel, and textiles.
3. **Waste-to-energy (WtE):** Use controlled methods to convert ELTs into energy while minimizing emissions.
4. **Minimized environmental impact:** Prevent pollution from improper disposal methods.
5. **Circular economy integration:** Promote the reuse of ELT-derived materials in manufacturing new products.

2.2.2 Key components for implementing the ESM principles

Design effective ELT schemes
2.2.1 - 2.2.4, 2.3
← PREVIOUS
→ NEXT

Drive collaboration
2.2.1, 2.2.2
← PREVIOUS
→ NEXT

Policy & regulatory frameworks

- ELT-specific legislation
- Robust management systems
- Permitting and licensing

Public awareness & participation

- Stakeholder collaboration
- Consumer education

Policy and regulatory frameworks

A comprehensive set of policies and regulations is essential for establishing accountability, ensuring compliance, and driving investment in sustainable solutions throughout the ELT value chain.

ELT-specific legislation provides a structured governance system by defining roles, responsibilities, and obligations for all stakeholders along the ELT value chain. It also regulates economic incentives and supports financial viability through taxes, fees, and other instruments, while ensuring environmental protection.
The specific mechanisms for incentives and environmental safeguards are discussed in more detail later in chapter 2.3.1.

Robust management systems result in coordinated ELT collection, recycling, and disposal while assigning clear responsibilities, setting performance targets, and outlining operational requirements to ensure effective implementation. Use these systems to complement the legal foundation of ELT management.

Permitting and licensing regulate collection points, transporting, and processing facilities to uphold environmental and safety standards. Apply these tools to ensure proper operational oversight (Basel Convention, n.d.).

Additionally, chapter 2.3.2 discusses several types of schemes (EPR, free-market, tax), which can be implemented together with the above-mentioned components to create a cohesive regulatory environment that supports the transition toward sustainable ELT management.

Public awareness and participation

Effective ELT management also relies on broad public engagement and collaboration among stakeholders. Building awareness, defining responsibilities, and promoting proper practices are key to ensuring the success of policy and regulatory measures.

Stakeholder collaboration brings together governments, industry, communities, and NGOs to ensure effective ELT management through clearly defined roles and responsibilities for manufacturers, importers, retailers, service providers, and processors. Under the EPR scheme, as one example, tire producers and importers are tasked with financing, overseeing collection, and recycling networks. Tire retailers and vehicle service centers are responsible for accepting used tires from consumers and managing them in accordance with ESM principles. Meanwhile, recycling and recovery facilities must operate in compliance with environmental permits and adhere to best practice standards, ensuring processor accountability throughout the value chain (Basel Convention, n.d.).

Consumer education engages individuals and stakeholders across the ELT value chain to increase awareness of proper tire maintenance, highlight environmental risks from improper/illegal disposal, and explain options for returning or recycling ELT (Basel Convention, n.d.).

2.2.2 Key components for implementing the ESM principles (continued)

ELT collection & transportation

- Centralized systems
- Regulatory compliance
- Consumer participation

ELT collection and transportation

Efficient collection and transportation systems are critical to ensure that ELT is properly recovered, safely handled, and reintroduced into circular value chains. A well-functioning logistics system minimizes environmental risks, prevents illegal dumping, and supports high recovery rates.

Centralized systems establish well-coordinated networks of collection points and logistics to close gaps in coverage and prevent illegal dumping or stockpiling.

Regulatory compliance ensures, through permitting requirements for the storage and transport of ELT, that all activities meet environmental and safety standards while preventing unauthorized dumping or open burning.

Consumer participation encourages individuals and businesses to return used tires to formal collection systems, improving recovery rates, and supporting the circular flow of materials (Basel Convention, n.d.).

2.2.3 Environmental and socio-economic benefits of ESM

Design effective ELT schemes
2.2.1 - 2.2.4, 2.3
← PREVIOUS
→ NEXT

Environmentally sound ELT management delivers a variety of interconnected environmental and socio-economic advantages, including:

- **Reducing pollution and health risks**: Proper collection, safe storage, and controlled processing prevent tire fires that emit toxic pollutants and eliminate illegal dumping and stockpiling that breed disease vectors such as mosquitoes and rodents (Downard, et al., 2014). This can result in reducing pollution and health risks.
- **Conserving natural resources and energy**: Recycling ELT recovers rubber, steel, and textiles, reducing demand for virgin materials and lowering energy consumption. This can result in conserving natural resources and energy.
- **Mitigating land use pressure and health risks**: Diverting ELT from landfills helps protect ecosystems, conserve valuable land, and lower the costs of environmental remediation, benefiting both the environment and public budgets (European Environment Agency, 2024). This can result in mitigating land use pressure and health risks.
- **Fostering economic development and employment**: Implementing ESM boosts industrial activity across the ELT value chain, improves infrastructure and funding allocation, and supports long-term investments in technology and market development. These factors collectively create diverse job opportunities and strengthen local and national economies (Tire Industry Project, 2021). This can result in fostering economic development and employment.
- **Enhancing community well-being and social equity**: Inclusive waste management initiatives of ELT management that formally integrate marginalized informal waste collectors and communities into municipal systems can enhance coordination across the entire ELT waste value chain. Such initiatives offer training, essential equipment, access to the formal ELT waste system, and support through social safety nets and fair payment mechanisms (United Nations Economic and Social Commission for Asia and the Pacific, 2021; Kain, Zapata, & Campos, 2021). This can result in enhancing community well-being and social equity.

2.2.4 Deep dive into the ELT Management Hierarchy

Design effective ELT schemes
2.2.1 - 2.2.4, 2.3
← PREVIOUS
→ NEXT

Design for recovery and circularity
2.2.4
← PREVIOUS
→ NEXT

Ecodesign for circularity

Applied to tires, the approach entails a focus on creating long-lasting tires with minimal material usage, incorporating a higher proportion of recycled or renewable raw materials, and reducing pollution risks through responsible chemical management of substances in the tire value chain. The principles extend the operational lifespan of tires, enhance their reparability, reusability, and recyclability while maintaining essential safety and driving performance standards.

Lifetime extension

Before a tire reaches the end of its service life and becomes waste to be managed, several approaches can enable a longer service life.

Preventive maintenance: Regular tire rotation and monitoring of inflation pressure help maintain even wear, improve safety, and extend the tire's useful life before major interventions are needed.

Repair: Minor damage such as punctures can sometimes be safely repaired by trained professionals to restore functionality without replacing the entire tire.

Regrooving: Removes additional rubber from the tread to deepen the grooves, restore grip, traction and extend the service life.

Retreading: Involves replacing the worn tread of a tire on a casing designed for multiple lives with a new tread layer by vulcanization[2], extending the tire's service life without the need for full replacement (Dabic-Miletic, Simic, & Karagoz, 2021).

[2]Vulcanization is a process of cross-linking rubber molecules chemically with organic or inorganic substance through heat and pressure. It makes rubber elastic. Devulcanization, which breaks these cross-links to restore processability, is described in the following content on chemical recycling.

2.2.4 Deep dive into the ELT Management Hierarchy (continued)

Benefits of lifetime extension

- **Resource conservation:** Preserving the original tire casing — over 80% of a tire's total weight (Nokian Tyres, 2024) — reduces raw material demand, energy use and greenhouse gas emissions compared to new tire production.
- **Local economic development:** Supports local manufacturing and creates jobs in tire service industries.
- **Waste and public health impact mitigation:** Reduces landfill pressure and tire stockpiles, which can otherwise become breeding grounds for disease vectors (Zertifizierte Altreifen Entsorger, n.d.).
- **Applications in heavy-duty transport:** Commonly adopted in commercial and heavy-duty vehicles — such as trucks and buses — where durability, load capacity, and cost-efficiency are essential (Hankook Tire, 2019; Woodrooffe, 2024; Zertifizierte Altreifen Entsorger, n.d.).

Challenges and limitations of lifetime extension: focus on retreading and regrooving

- **Specialized casings required:** Only casings designed for multiple lives can be retreaded. Quality and safety heavily depend on the service history of the tire, and casings must be thoroughly inspected and adhere to established manufacturing standards.
- **Process quality risks:** Poor-quality casings or substandard processes can reduce durability and increase safety risks, undermining market acceptance.
- **Suitability constraints:** Not all tires are suitable for retreading or regrooving; certain designs, damage types, or extensive wear can render casings unusable (Hankook Tire, 2019; Rubberman, 2025).

Despite the considerable environmental and socio-economic benefits of retreading and regrooving, advancing their practice requires embedding them in comprehensive industrial and circular economy policy or regulatory frameworks.

ELT Treatment Processes

Based on the core principles of ESM, effective ELT management prioritizes material recovery to maximize resource efficiency and minimize environmental externality. Translating these principles into practical methods is essential, given the variety of existing recovery routes. The diagram below, a framework developed by TIP, presents the main range of pathways known to date for recycling ELT, illustrating the most common ELT treatment processes as well as associated material and energy flows (see Figure 3).

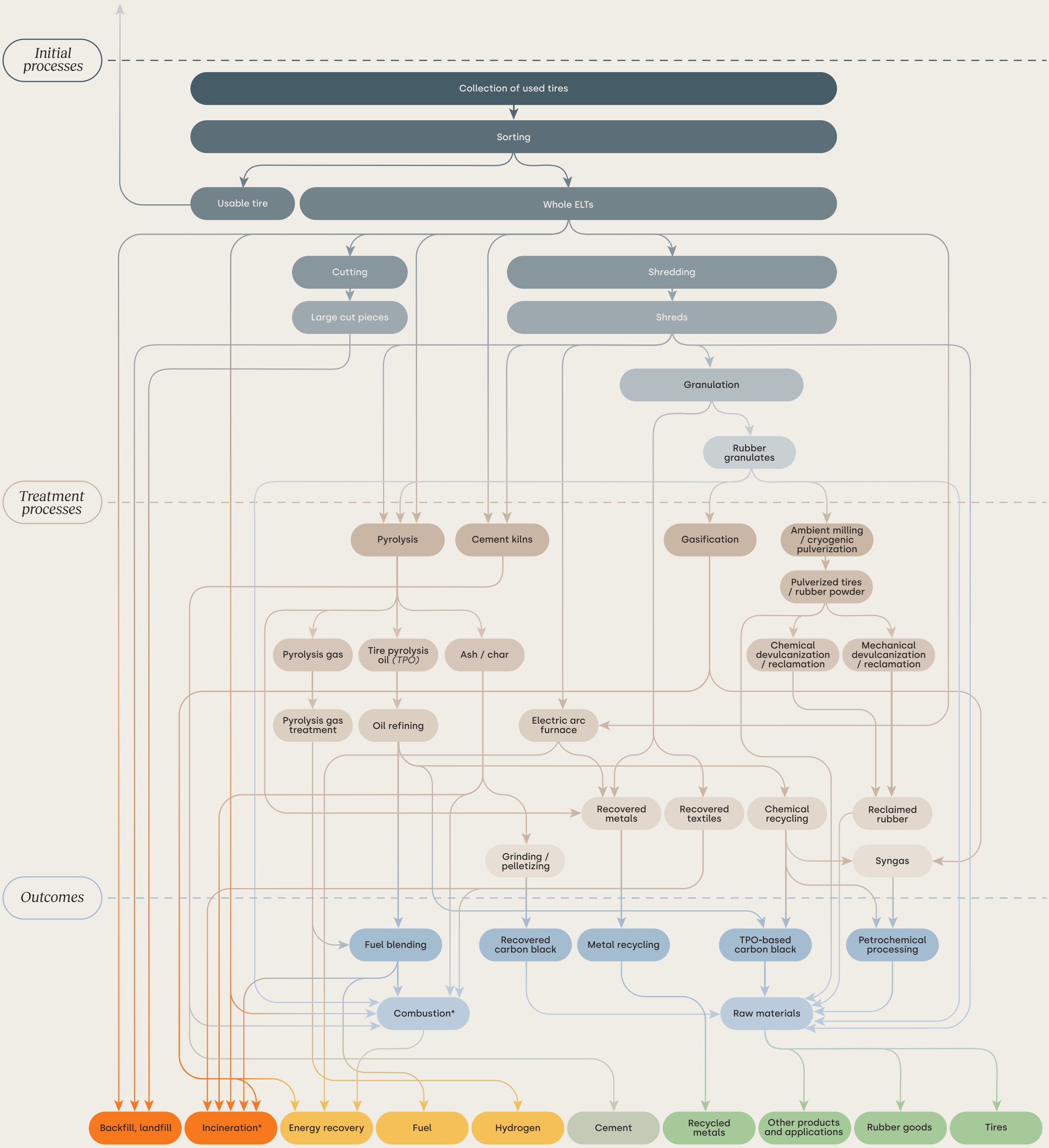
The key role of collection and sorting in promoting tire lifetime extension

When used tires are collected, any given mix will be characterized by varying levels of wear and/or damage. The crucial step following collection is to identify and sort out tires that might still be fit for use or that are candidates for repair, retreading and/or regrooving. Professional expertise is required to make decisions on which used tires can be channeled to repair shops or to the retreading industry. ELT management scheme (cf. Part III) can provide the necessary operational structure to carry out expert identification and arrange the reverse logistics to put used but still usable tires back into the economy and avoid them becoming waste to be treated. Point of attention: used tires sorted out for retreading may be considered a used article or a waste, depending on the jurisdiction (e.g., national, provincial). This distinction is important to be aware of: when tire casings have a regulatory status as waste, actors involved in the retreading value chain (e.g., transporters, retreading companies) could be required to comply with additional operating requirements.

Tire Recycling Ecosystem

End-of-life Tire (ELT) Treatment Processes and Related Material and Energy Flows

Figure 3: Tire Recycling Ecosystem



2.2.4 Deep dive into the ELT Management Hierarchy (continued)

Starting from the top, the diagram outlines the initial processes of collecting and sorting used tires, followed by various treatment processes.

The treatment flows end with the outcomes: secondary raw materials or energy recovery through combustion. The outcomes are color-coded according to ELT Management Hierarchy in the tire life cycle (see Figure 2). From left to right, the colors indicate the type of recovery.

GREEN "Material recovery"

GREEN YELLOW "Hybrid treatment"

YELLOW "Energy recovery"

ORANGE "No recovery"

The following chapter presents exemplary technologies that facilitate the application of the framework at each stage and color category.

GREEN

Material recovery – example technologies

Mechanical and Chemical Recycling

Once a tire reaches the end of its (extended) life, prioritizing material recovery is essential in managing ELT. Material recovery encompasses all treatment processes aimed at reclaiming materials from ELT for reuse, which can be broadly categorized into two main approaches:

- **Closed loop recycling** involves using ELT-derived secondary raw materials, such as rubber compounds, to manufacture components for new tires. Due to stringent tire performance and safety requirements, advanced recycling methods are necessary to produce high-quality secondary materials that meet these standards. Since current global production of such materials is limited, increasing capacity is a priority for stakeholders throughout the value chain to enhance circularity within the tire industry.
- **Open loop recycling** refers to the utilization of ELT-derived secondary raw materials for non-tire applications across various sectors, such as construction, public works, automotive components, and consumer goods. ELT can also be applied whole or in large cut pieces in civil engineering projects, where they offer structural benefits when safely incorporated into infrastructure. This form of recycling helps divert tires from waste streams and supports a variety of industries (International Organization for Standardization (ISO), 2024).

While the closed loop approach is more circular, it also currently faces technical limitations, particularly in meeting the demanding safety and performance criteria of new tires. In contrast, the open loop approach can accommodate ELT materials with fewer quality constraints, thereby providing immediate markets. Both approaches are therefore valuable depending on the situation. Over time, research and development, innovation, and tires with ecodesign principles are expected to enable higher-quality ELT-derived secondary raw materials suitable for closed loop reuse, gradually shifting the balance toward more circular tire production and consumption models (International Organization for Standardization (ISO 59004:2024).

Mechanical recycling

Among available recycling technologies[3], mechanical recycling is the most common method for processing ELT. It involves physically breaking down tires into constituent materials (e.g., rubber, steel, textile fibers) through processes like cutting or shredding, without altering the chemical structure of these materials.

A common mechanical method is granulation, which consists of shredding tires, removing steel and fibers, and grinding the rubber into crumb rubber of varying particle sizes. This crumb rubber is a versatile secondary raw material used in a variety of applications. For instance, granulated rubber is often used as performance infill in artificial turf or incorporated into industrial products (e.g., rubber-modified asphalt, molded rubber products), while non-granulated fractions can be recovered as recycled steel and textiles. Ambient milling and cryogenic pulverization are two main grinding techniques used in granulation to further reduce crumb rubber particle size for other applications (Recycling Europe, 2022).

Benefits of mechanical recycling

- **Lower embodied carbon:** Typically, lower greenhouse gas emission intensity of energy than virgin materials and thermochemical routes.
- **Waste mitigation:** Mechanical recycling reduces landfill pressure and tire stockpiles.
- **Local economic value:** Job creation in collection, processing, logistics, and manufacturing. support of the regional circular economy.
- **Resource conservation:** Lowers the environmental impacts associated with extracting raw materials (Tire Industry Project, 2021).

[3] In this context, the use of ELT in civil engineering applications is not classified as recycling. Processes that are considered recycling include: granulation; use of ELT in steel mills, foundries, dock fenders, or blasting mats; pyrolysis for metal and carbon black recovery; and the incorporation of inorganic ELT components into cement production.

2.2.4 Deep dive into the ELT Management Hierarchy (continued)

Challenges and limitations of mechanical recycling

- Energy demand: Shredding and grinding processes require electricity, while cryogenic systems add further energy consumption and costs associated with coolant use.
- Emissions and nuisances: Operations can generate airborne dust and particulates, noise pollution, and potential contamination from wastewater or runoff, as well as fire hazards (Chien, et al., 2003). Technical equipment is needed to mitigate the risk of emissions and nuisances.
- Health and safety: Workers may be exposed to dust, noise, and volatile organic compounds (VOCs), requiring strict housekeeping and the use of appropriate personal protective equipment (PPE) (Chien, et al., 2003). With appropriate technical equipment in place, facilities can reduce environmental impacts and mitigate health and safety risks.
- Technical limitations: mechanical processing alone cannot break sulfur cross-links, resulting in recycled rubber with inferior mechanical properties compared to virgin material and limiting its use to lower-value applications (Recycling Europe, 2022).

To manage operational risks and minimize environmental and health risks, adherence to ESM principles is essential during the treatment process. Preventive measures include robust air and dust control, wastewater management, fire prevention, occupational safety, and quality assurance.

To overcome the technical limitations of mechanical recycling, it is often combined with chemical recycling, which breaks down the rubber at the molecular level to enable higher-value material recovery and applications (Xiao, Pramanik, Basak, Prakash, & Shankar, 2022).

Chemical recycling

Chemical recycling methods aim to recover raw materials by chemically or thermally breaking down vulcanized rubber compounds, which are otherwise difficult to recycle mechanically. It encompasses processes such as pyrolysis and devulcanization. Ongoing research also explores biological approaches — using microbes, fungi, or enzymes — to biodegrade or partially depolymerize tire rubber, opening new possibilities for material recovery and innovation (Xiao, Pramanik, Basak, Prakash, & Shankar, 2022).

- **Pyrolysis** will be discussed in the hybrid section later.
- **Devulcanization** breaks the sulfur cross-links in vulcanized rubber[4], restoring its polymer processability and reversing the effects of vulcanization, allowing the recycled rubber to be converted into new products (Xiao, Pramanik, Basak, Prakash, & Shankar, 2022).

Benefits of chemical recycling

- **Versatility of processes:** Pyrolysis and devulcanization enable material recovery by producing reusable feedstocks and recovering polymers in a form suitable for further processing or incorporation into new products.
- **Circular economy contribution:** Reduces reliance on virgin materials, diverts ELT from landfills, and processes mixed or contaminated tire waste that mechanical recycling cannot efficiently handle.
- **Potential for higher-value recovery:** Offers the promise of producing materials with broader applications compared to lower-value outputs of mechanical methods.

Challenges and limitations of chemical recycling

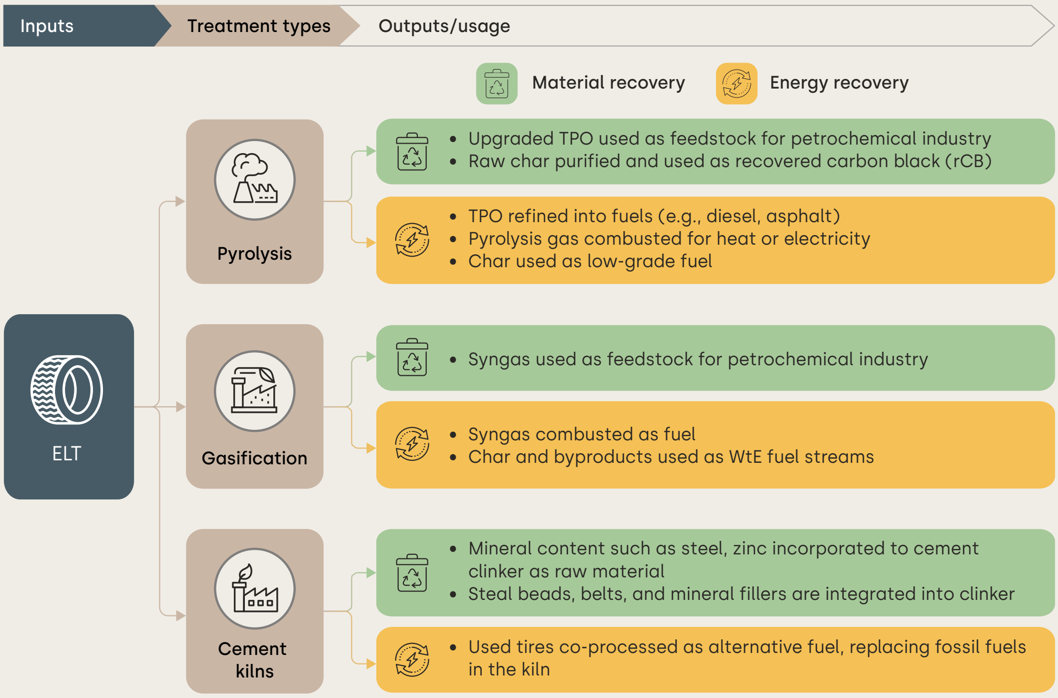
- **High cost and complexity:** Processes require substantial investment and advanced technology to operate effectively.
- **Operational difficulties:** Managing emissions, improving product yield, and scaling up to commercial levels remain key challenges.
- **Health and safety requirements:** Strict housekeeping and the use of appropriate PPE are necessary due to potential exposure to heat, fumes, and chemicals.
- **Long-term viability:** Many methods are still under development, with sustainability, economic feasibility, and environmental advantages yet to be conclusively demonstrated (Schwab, Nelson, & Mecking, 2024).

[4] Vulcanized rubber is a form of rubber which is strengthened and elastic through heating natural or synthetic rubber with sulfur. This chemical process (i.e., vulcanization) forms cross-links between the rubber's polymer molecules, making it more durable, resilient, and resistant to temperature changes and environmental stress.

2.2.4 Deep dive into the ELT Management Hierarchy (continued)

GREEN YELLOW

Hybrid treatment



Hybrid treatments, such as pyrolysis and gasification, combine both material recovery (chemical recycling) and energy recovery for ELT. Unlike traditional recycling methods that focus on either recovering materials or generating energy, hybrid treatments extract valuable chemicals, oils, and carbon-rich products while also producing heat or fuel. This section explains the concept of hybrid treatments in detail, discusses the technology specifics and outcomes of pyrolysis and gasification, and clarifies when these processes are considered chemical recycling versus energy recovery.

Pyrolysis is a versatile hybrid technology that thermally decomposes shredded or granulated tires, producing tire pyrolysis oil (TPO), char[5], pyrolysis gases, and recycled steel. These products can serve as feedstocks for chemical manufacturing, energy production, and materials processing (Xiao, Pramanik, Basak, Prakash, & Shankar, 2022).

- **Material recovery:** If the TPO is upgraded and used as a feedstock for chemical manufacturing (for example for producing new polymers, chemicals, or TPO-based carbon black) or if the raw char is purified and used as rCB, then the process constitutes chemical recycling and counts as material recovery (Infiniteria, n.d.; Huayin, n.d.).
- **Energy recovery:** TPO can be further processed into fuels such as diesel and asphalt, contributing to energy recovery. The pyrolysis gas produced is a combustible fuel that can be directly used to generate heat or electricity, either within the pyrolysis process or in external energy applications. If the TPO or pyrolysis gases are combusted to produce heat or power (either on-site in the reactor or externally), or if the char is used as a low-grade fuel, then the operation is energy recovery (Infiniteria, n.d.; Huayin, n.d.).

Gasification thermochemically converts ELT into syngas through partial oxidation at high temperatures.

- **Material recovery:** the resulting syngas can serve as a feedstock for advanced chemical recycling, enabling the production of chemicals and materials (Batuecas, Serrano, Horvat, & Abelha, 2023).
- **Energy recovery**: gasification converts waste tires into hydrogen-, carbon monoxide-, and light hydrocarbon-rich syngas, along with byproducts like CO_2 and char, which can be further used in petrochemical processing or as fuel, making it a promising WtE pathway (Wang, et al., 2025; Oboirien & North, 2017).

[5] Char is a valuable source of carbon black that, after appropriate treatment through grinding or pelletizing, can be converted into recovered carbon black (rCB) suitable for use in new tire production.

2.2.4 Deep dive into the ELT Management Hierarchy (continued)

Cement kilns treat ELT by co-processing them as alternative fuel and raw material.

- **Material recovery:** The mineral content, such as steel and zinc, is incorporated into the cement clinker as a raw material, which would otherwise become ash and require disposal. Steal beads, belts, and mineral fillers are integrated into clinker, reducing the need and consumption of raw material; zinc oxide integrated into clinker and provided concentration is controlled (ZKG International , n.d.).
- **Energy recovery:** The main goal of using ELT in cement kilns is to replace a portion of fossil fuels like coal, oil, or petroleum coke, which are traditionally used to heat the kiln. Using waste tires in cement kilns as an alternative fuel decreases the emission of nitrogen oxide, saves energy and environmental costs (Nakomcic-Smaragdakis, Cepic, Senk, Doric, & Radovanovic, 2016; Malekiha & Hajiahmad, 2015).

Benefits of hybrid treatment

- **Diversified recovery potential:** Pyrolysis and gasification can recover both valuable materials (e.g., recovered carbon black, syngas, pyrolysis oil) and energy (heat or electricity), maximizing the overall effectiveness of ELT treatment.
- **Reduction of landfill and fossil dependency:** These processes divert ELTs from landfills and substitute fossil feedstocks in petrochemical and energy systems, supporting circular economy and climate targets.
- **Compatibility with emerging circular value chains:** When outputs meet quality specifications, pyrolysis oil and syngas can be reintegrated into chemical and material loops (Han, et al., 2024a).

Challenges and limitations of hybrid treatment

- **Output quality and market acceptance:** Pyrolysis oil and rCB often face challenges such as impurities, variability in composition, and lack of standardized quality specifications, limiting their acceptance by refiners and tire manufacturers (Silva, et al., 2025).
- **Economic and energy balance constraints:** High capital and operational costs, complex gas cleaning systems, and limited economies of scale make many thermochemical plants financially marginal (Han, et al., 2024a).

YELLOW

Energy recovery – example technologies

When reuse or material recovery options are limited or economically infeasible, ELTs can be a valuable source for energy recovery through combustion. Waste tires have a calorific value ranging from 30- 40 MJ/kg, which exceeds that of coal and other solid fuels. This makes ELTs an attractive alternative fuel for industrial applications in cement kilns, pulp and paper mills, and power plants (Recycling Europe, 2022). Known as tire-derived fuel (TDF), this alternative fuel is also commonly used in electric arc furnaces to supplement energy needs. The co-combustion of ELTs with coal, for example, can improve boiler thermal efficiency and is also employed in processes to produce electricity, paper, lime, and steel (Pan, Jiang, Guo, Huang, & Pan, 2021).

The two technologies discussed in the hybrid chapter 2.4.2 — pyrolysis and gasification — have been introduced along with their applications for energy recovery.

Benefits of energy recovery

- **Fossil fuel displacement:** Reduces reliance on conventional fuels by partial substitution during combustion (Renew Tire Recycle, n.d.).
- **Waste mitigation:** Diverts significant volumes of tire waste from landfills.
- **Cost savings:** Lowers energy costs by converting waste into a usable energy resource (Renew Tire Recycle, n.d.).
- **Infrastructure compatibility:** Integrate easily with existing industrial systems using TDF (Renew Tire Recycle, n.d.).

Challenges and limitations of energy recovery

- **Pollutant emissions:** Thermochemical decomposition of ELT releases pollutants, such as particulate matter, greenhouse gases, hazardous air pollutants, and heavy metals (Okonkwo, Njan, Ejike, Nwodo, & Onwurah, 2018; Mentes, Tóth, Nagy, Muránszky, & Póliska, 2022) – with zinc being of particular concern, as it constitutes approximately 1% of a tire's weight (Councell, Duckenfield, Landa, & Callender, 2004)
- **High capital, operational costs, and technical complexity:** Requires significant investment, complex infrastructure, and advanced process control to clean and upgrade syngas for consistent quality.

2.2.4 Deep dive into the ELT Management Hierarchy (continued)

Effective emissions control and stringent regulatory compliance are essential to mitigate environmental and health impacts, particularly by addressing air quality issues related to particulate and toxic compound emissions. Although energy recovery can provide a lower-carbon alternative to fossil fuels, it ranks lower in the waste management hierarchy to increase material circularity because it consumes the tire as fuel, fully degrading its material content, which cannot be reclaimed or reused thereafter.

ORANGE

No recovery

Backfill, landfill

A disposal method involving the final depositing of solid waste at, below or above ground level at engineered disposal sites, excluding uncontrolled waste disposal such as open burning and dumping.

Incineration

A process that involves reducing combustible wastes, such as scrap tires, to inert residue through controlled high-temperature process. Incineration might lead to energy, but the purpose is not energy recovery but to eliminate/minimize waste.

Key risks:

- Long degradation times
- Fire hazards
- Breeding grounds for disease vectors such as mosquitoes

Typical drivers: lack of infrastructure, low regulatory pressure, storage overflow, weak or absent markets for ELT-derived materials

Landfilling and disposal

The least desirable route for managing ELT is landfilling, incineration (without energy recovery), and other forms of disposal without material or energy recovery. Tires disposed of in landfills pose significant environmental problems, including:

- Long degradation times
- Fire hazards
- Breeding grounds for disease vectors such as mosquitoes

Due to these risks and core principles of ESM, many jurisdictions restrict or ban tire disposal in landfills. For example, the EU Landfill Directive (specifically Council Directive 1999/31/EC) has been banning the landfilling of ELT since 2003 (Recycling Europe, 2022; European Parliament and Council, 1999).

Nonetheless, in some regions or circumstances where recovery infrastructure is insufficient or unavailable, disposal remains an unfortunate utilized route. Minimizing these disposal methods is critical because they permanently terminate the material flow, preventing any possibility of resource recovery or circular use. Effective strategies to reduce ELT sent to landfills or non-recoverable incineration include:

- Strong regulatory enforcement
- Improved tire collection and sorting systems
- Incentives to promote the development and adoption of recycling and energy recovery technologies (Narra, Agboka, Narra, & Nelles, 2025).

2.3 ELT management scheme

2.3.1 Background on schemes and regulations

Design effective ELT schemes
2.2.1 - 2.2.4, 2.3

← PREVIOUS
→ NEXT

Note: Click on the stakeholder icon to go back to key stakeholder profiles and navigation guide.

Objectives of successful ELT management scheme

An ELT management scheme is a set of laws, rules, and standards that assign responsibility, funding, and controls to ensure used tires are collected, handled, and recovered safely and efficiently. They operationalize regulatory requirements across the tire value chain, enabling recycling, energy recovery, and circular use of materials.

A successful ELT management scheme emphasizes:

- **Establishing a coherent system:** Guarantee universal, convenient collection alongside safe storage and transport across the entire value chain.
- **Prioritizing value-preserving options:** Following the waste hierarchy, keep reusable tires in the economy, practice material recycling over energy recovery, while minimizing or prohibiting landfilling.
- **Safeguarding health and the environment:** Implement fire-prevention measures, emissions controls, and chemical safety requirements.
- **Supporting durable end markets:** Cultivate reliable demand for ELT-derived materials via quality specifications and procurement levers.
- **Ensuring transparency and accountability:** Deploy robust tracking and enforcement mechanisms to deter free-riding and illegal dumping, while supporting continuous performance improvement.

Key components of ELT regulation

ELT management scheme consists of a number of regulations, setting mandatory standards, restrictions, and obligations such as landfill bans, safety protocols, and recycling targets. They provide the foundation upon which ELT management schemes are designed and implemented, ensuring that all activities are compliant while promoting environmental, economic, and social benefits. Many countries have established dedicated targets for ELT recovery and recycling.

Key aspects commonly addressed in ELT regulations include:

- **Waste hierarchy and responsibility:** A legal framework that defines the roles and obligations of tire producers, collectors, and treatment operations in managing ELT.
- **Technical standards:** Safety and emissions controls, alongside specifications for recycled materials to ensure safe storage and effective processing.
- **Market restrictions:** Restrictions on landfill use, bans on open burning, and controls on hazardous substances like polycyclic aromatic hydrocarbon (PAHs) and microplastics. For example, the EU's REACH Regulation (Registration, Evaluation, Authorisation and Restriction of Chemicals) ensures a high level of protection for human health and the environment with respect to chemical use, which is relevant to ELT chemical recycling.

Benefits of effective regulation

- **Market correction:** Effective regulation is a necessary condition for successful ELT management as it corrects inherent market failures associated with bulky, low- or variable-value wastes that are costly to manage safely. In the absence of enforceable rules, illegal dumping and stockpiling can proliferate as private actors externalize fire, vector, runoff, and air-emission risks.
- **Financing and accountability:** Regulation can help establish stable funding mechanisms for ELT management, ensuring universal coverage, including remote or low-density regions, creating accountability for stakeholders, and deterring unsafe practices.

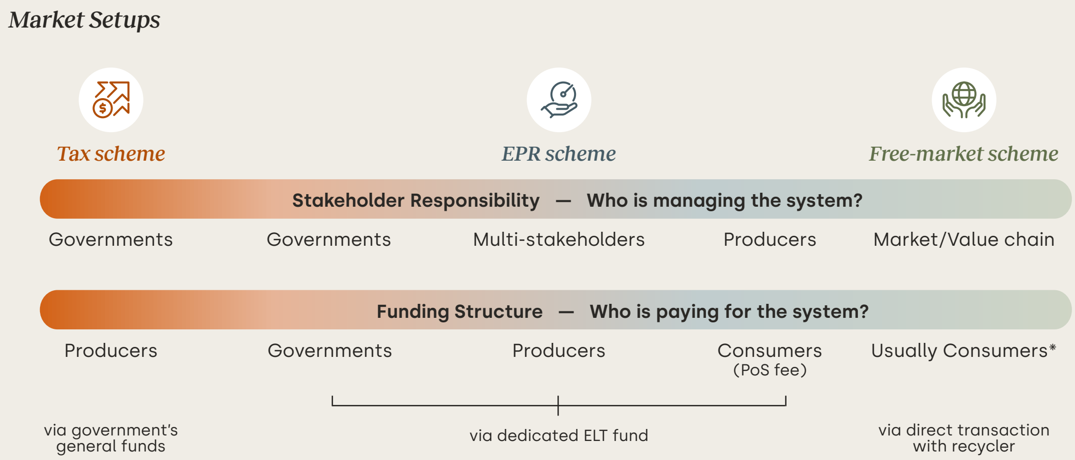
Well-designed regulatory frameworks ultimately support the circular management of ELT by encouraging higher-value reuse and recycling, promoting safer storage and treatment, and facilitating market development for recovered materials. By combining enforceable standards, technical requirements, and reporting obligations, regulation helps improve system efficiency, data transparency, and the long-term sustainability of ELT management.

2.3.2 Overview of various schemes and their principles

Learn from best practices
2.3.2, 2.3.3
← PREVIOUS
→ NEXT

Balance compliance and competitiveness
2.3.2, 2.3.3
← PREVIOUS
→ NEXT

ELT management schemes are commonly organized under three models with distinct trade-offs. Each has separate ways to finance operations, organize collection and recycling, and deliver environmental outcomes.



EPR scheme

Extended producer responsibility is a widely adopted policy instrument for establishing ELT management. Its central premise is to integrate the full cost of collection and environmentally sound treatment into the price of tires, thereby assigning operational and financial obligations to producers, including manufacturers and importers (OECD, 2016).

Key Features

1. Obligations are typically fulfilled through PROs, helping to ensure transparent cost accounting and competitive tendering.
2. EPR schemes are outcome-oriented, setting clear performance requirements such as convenient nationwide take-back with collection and recovery rate targets, as well as safe storage and transport capability. These requirements guide the selection of technologies without mandating specific technical solutions.
3. Landfilling is minimized or banned, supported by robust data traceability through mandatory reporting obligations.
4. EPR schemes operate through authorized collectors and recyclers, which are vetted and approved to ensure compliance with environmental, safety, and quality standards, providing accountability throughout the value chain.

Free-market scheme

The free-market scheme relies on decentralized, price-driven coordination among private actors instead of centralized stewardship and producer-financed obligations. Retailers and vehicle dismantlers form contracts with independent collectors and transporters, supplying processors on commercial terms (Tire Industry Project, 2010)

Key Features

1. Financed by service charges paid by waste generators and revenues from ELT-derived outputs, recyclers, and collectors, rather than by mandated eco-fees.
2. Performance depends on robust end markets; competition can drive cost efficiency, innovation, and rapid reallocation of flows.
3. Jurisdictions often introduce "free-market plus" measures: landfill and storage controls, digital manifests, standardized reporting, and demand-side enablers like public procurement.

Tax scheme

In the tax scheme, a publicly levied charge on tire sales is collected at the point of purchase, directed to fund collection, transport, and environmentally sound treatment. Unlike EPR schemes, this model centralizes stewardship within a public authority, which aggregates revenues and procures services through competitive contracting (Tire Industry Project, 2010).

Key Features

1. Offers administrative simplicity and quick mobilization of predictable, territory-wide financing.
2. Effective for funding non-commercial tasks, such as stockpile abatement and rural service subsidies.

2.3.3 Comparison of challenges and benefits

Learn from best practices
2.3.2, 2.3.3
← PREVIOUS
→ NEXT

Balance compliance and competitiveness
2.3.2, 2.3.3
← PREVIOUS
→ NEXT

Table 1: Comparison of three ELT management schemes

Model	Benefits	Challenges
EPR schemes have proven effective in creating structured, accountable frameworks for ELT management, ensuring that producers play a central role in financing and overseeing collection and recycling. When well implemented, EPR promotes transparency, consistent data reporting, and continuous performance improvement across the value chain. However, implementation effectiveness varies between countries. Differences in governance, enforcement, and stakeholder coordination can affect system efficiency and cost distribution, highlighting the importance of clear regulation, robust oversight, and stakeholder collaboration to achieve intended circularity outcomes.	**Stable financing and strong accountability** The primary advantages of EPR are stable financing, since costs are built into tire prices, and strong accountability, which tends to maximize recycling and reduce illegal dumping.	**Regulation and oversight** Key challenges include ensuring robust regulation and oversight to maintain cost transparency and operational efficiency. Free riders — actors who participate in the market but do not contribute financially — can undermine system performance, particularly in regions with a small number of manufacturers or high import shares. Specific regulatory measures, such as mandatory registration and enforcement mechanisms, are needed to mitigate these risks.
Free-market schemes rely on decentralized decision-making coordinated by price signals. Tire retailers or garages pay independent haulers, who then sell tire derived materials such as rubber or fuel to recyclers or cement kilns.	**Innovation and efficiency** This market-driven approach can spur innovation and cost efficiency when profitable end use markets exist, for example crumb rubber products and energy recovery.	**Service coverage and market volatility** The scheme can lead to uneven service coverage and vulnerability to market swings. If the price of recycled rubber falls or remote areas are not profitable, tires may go uncollected, increasing the risk of stockpiling or environmental impacts. To address these risks, free-market plus variants add rules such as landfill bans, tracking systems, and cleanup funds to ensure basic nationwide service and environmental safeguards while preserving competition.
Tax-based schemes finance ELT management through a government-imposed levy or recycling fee applied to the sale of new tires. The collected funds are managed by a public authority, which contracts waste management companies to collect and recycle end-of-life tires. This approach is particularly suitable for markets with many small or diverse producers, where centralized administration can ensure consistent collection and treatment.	**Predictable funding and responsive oversight** This approach provides predictable, dedicated funding and universal collection, and authorities can quickly address problems such as abandoned tire piles or rural service gaps that the private market might overlook. Its key strength is administrative simplicity and the ability to cover tasks that are not profitable, for example cleanup of old dump sites.	**Bureaucratic inefficiencies and innovation limitations** Its drawbacks include potential bureaucratic inefficiency and a lack of direct incentives for industry innovation since producers pass the tax on to consumers and are less involved in operations.

In summary, EPR assigns environmental responsibility to industry, the free-market model harnesses competition but needs oversight to prevent service gaps, and the tax-based model guarantees stable funding but depends on effective public management. Many regions combine elements of these approaches to balance efficiency, cost, and environmental reliability.

Real-world examples

Part III

3.1
Example: country-level ELT management scheme

Learn from global examples
3.1

← PREVIOUS
→ NEXT

Learn from industry examples:
3.1

← PREVIOUS
→ NEXT

Note: Click on the stakeholder icon to go back to key stakeholder profiles and navigation guide.

ELT management sits at the intersection of environmental protection, public safety, and circular economy markets. Globally, diverse models have been implemented by regulators and industry to ensure tires are collected, treated, and returned to value. This chapter examines nine selected countries, covering EPR, free-market, and tax systems, illustrating a variety of regulatory approaches and system maturities. The case studies provide insights into successful strategies and common challenges, supporting informed decision-making and effective ELT management practices.

Each deep dive outlines the country's governance and financing model, recovery routes and technical capacity, and the strength of end-markets. It also assesses economic and sustainability impacts and highlights the distinctive features that make each system stand out.

Countries were selected to represent a spread of different ELT management schemes across the globe and based on the quality and completeness of data from the TIP ELT Data Collection Project. Within the project, the TIP ELT Task Force identified metrics to track over time to assess the industry's progress toward sustainable ELT management. The full dataset and methodology will be published next year.

Brazil

Scheme Type: EPR Scheme | Start: 2010

Most impactful measure:

- **2010** PNRS (National Solid Waste Policy) foundation
- **2012** Strong IBAMA enforcement combined with industry-run national collection (RECICLANIP)
- **2023** Full implementation for tires

Italy

Scheme Type: EPR Scheme | Start: 2006

Most impactful measure:

- **2006** Legal base
- **2011** Establishment of Ecopneus consortium, enabling national coordination
- **2020** System efficiency improvements

India

Scheme Type: EPR Scheme | Start: 2016

Most impactful measure:

- **2016** EPR foundation - Hazardous & Other Wastes Rules
- **2022** Launch of the CPCB EPR certificate system, enabling traceability and compliance
- **2025** Circular action plan rollout

France

Scheme Type: EPR Scheme | Start: 2002

Most impactful measure:

- **2002** Tire EPR established; Introduction of free point-of-sale take-back
- **2015** Strengthened framework
- **2020** AGEC Law expands obligations

South Korea

Scheme Type: EPR Scheme | Start: 1992

Most impactful measure:

- **1992** Producer Deposit-Refund System
- **2003** Full tire EPR obligations
- **2005** Introduction of KECO's Allbaro digital tracking system, enabling real-time compliance and traceability

Japan

Scheme Type: Free-market Scheme | Start: 2000

Most impactful measure:

- **2000** Basic Act on Establishing a Sound Material-Cycle Society
- **2002** ELV Act
- **2005** JATMA anti-dumping program

Germany

Scheme Type: Free-market Scheme | Start: 2002

Most impactful measure:

- **2002** ELV Directive
- **2010s** Deployment of eANV electronic tracking, strengthening enforcement and compliance
- **2012** KrWG modernized framework

Croatia

Scheme Type: Tax-based Scheme | Start: 2004

Most impactful measure:

- **2004** ZOEU state-managed scheme launched - centralization of financing and contracting
- **2013** Sustainable Waste Management Act
- **2016** Waste Tires Ordinance

New Zealand

Scheme Type: Tax-based Scheme | Start: 2020

Most impactful measure:

- **2020** Tires designated a priority product
- **2023** Regulations
- **2024** Launch of Tyrewise national digital tracking & stewardship, creating full end-to-end traceability

3.1.1 Brazil

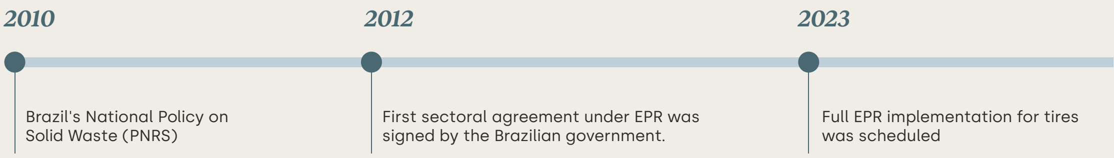
EPR scheme

Brazil's ELT management scheme is a mature, EPR-based reverse-logistics[6] scheme under the National Solid Waste Policy (Law 12.305/2010), which mandates reverse logistics, the waste hierarchy, and shared responsibility.

In Brazil, disposal-company reports filed with the Federal Technical Registry (FTR) indicate that the most frequently declared end-of-life tire (ELT) destination activities were co-processing, granulation, and lamination[7]. Other pathways, such as shale industrialization and rubber regeneration, appear in much smaller volumes (Thives , Ghisi, & Thives Júnior, 2022).

Manufacturers and importers are required to finance and ensure collection and environmentally sound destination proportional to market placement. Enforcement is led by IBAMA (the Brazilian Institute of Environment and Renewable Natural Resources) with support from state/municipal agencies and public prosecutors. The framework aligns with OECD principles and applies Basel controls to discourage exports and favor domestic recovery. Industry runs nationwide collection networks and contracts with recyclers and cement kilns (Valentini & Pegoretti, 2022). IBAMA, as the government's environmental authority, monitors the targets established by CONAMA, the National Environment Council, and publishes reports on the country's tire recycling rate. The system is managed collectively by the tire industry through programs, for example, RECICLANIP, a NGO. It brings together 12 tire manufacturers and handles all technical and operational aspects of tire recovery and monitoring for these manufacturers.

Overarching Timeline



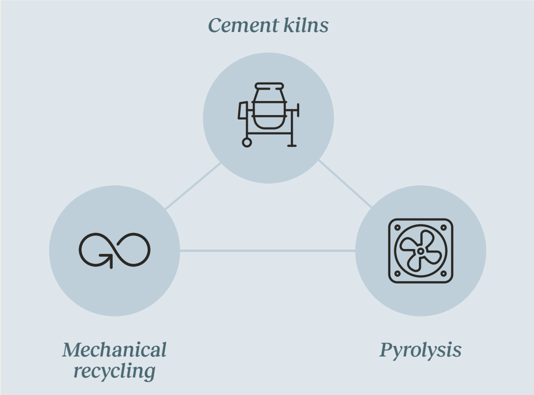
2010: Brazil's National Policy on Solid Waste (PNRS) introduced the concept of EPR, mandating that producers and importers are responsible for the lifecycle of their products, including waste management (Bolsa Verde do Rio de Janeiro (BVRio), n.d.).

2012: The first sectoral agreement under EPR was signed by the Brazilian government, targeting automotive lubricant plastic packages. This agreement requires manufacturers and retailers to implement take-back programs for these specific products (Trentinella, 2014).

2023: Full EPR implementation for tires was scheduled by the Brazilian government to commence, with producers required to comply with the reverse logistics system and meet specified recycling targets (Xavier & Mofati, 2025).

Recovery routes and technical capacity

The recovery routes in Brazil combine mature energy recovery and material recycling, supported by a growing infrastructure for processing ELT. Overall, technology maturity is high for co-processing and mechanical recycling, medium for asphalt rubber scale-up, and emerging for pyrolysis and advanced material recovery (Buttlar & Rath, 2021).



- **Cement plants** have invested in feeding systems, emission controls, and pre-processing to meet environmental permits.
- **Material recycling** produces crumb rubber for rubberized asphalt, molded products, playground and sports surfaces, and acoustic insulation.
- **Pyrolysis** exists in technical research and pilot plants. Larger-scale adoption of pyrolysis as a primary waste management route faces hurdles (De Oliveira Neto, et al., 2019).

[6] According to Brazilian legislation, reverse logistics is defined as the set of activities and processes aimed at collecting, transporting, and properly disposing of products and materials after consumer use, with the goal of reusing, recycling, or disposing of them in an environmentally friendly way (Fidalgo & Marcilio, 2024).

[7] Lamination in this context refers to the reuse of whole or cut tire layers as protective or structural materials in industrial applications (e.g., flooring, barriers, or coverings). Shale industrialization involves the co-processing of shredded tires as an auxiliary fuel or carbon source in shale oil production, hence its classification among tire-related recovery processes.

Economic, environmental and sustainability impacts

Economic impacts

Brazil's ELT management sector has become a sizeable circular-economy niche.

- Jobs are supported by industry players across collection, transport, pre-processing, processing, and application markets.
- Revenue is generated for market players from gate fees[8] for collection and processing, and from sales of these related goods (De Oliveira Neto, et al., 2019; Pereira, dos Santos de Sousa Teodósio, & Viegas da Costa, 2025)

Investments are driving upgrades, including kiln feeding systems, emissions monitoring, expanded granulation capacity near metropolitan centers, and pilots in pyrolysis and devulcanization for higher-value outputs.

Social impacts

Brazil's formal ELT reverse-logistics network has improved public health and community safety and professionalized collection, while gaps remain in integrating informal actors and overseeing smaller processors.

- Informal collectors are integrated by larger players via cooperatives and fair contracts to improve income stability and safety. Large facilities comply, ensuring safe operations.
- It also diminishes the negative impacts of informal recycling, reducing child labor, and improving the conditions of work, occupational health and safety, and uncontrolled pollution (Machin, Travieso Pedroso, & Andrade de Carvalho Jr., 2016)

Environmental impacts

Brazil's EPR-driven ELT management scheme has sharply reduced dumping and open burning of discarded tires, effectively ended whole-tire landfilling, and is delivering climate and biodiversity gains by preventing these hazards and advancing resource efficiency and circularity (e.g., through material recycling), while addressing residual risks.

- Fewer open dumps and burns mitigate vector-borne disease and local pollution.
- Material recycling displaces virgin inputs; ELT in cement cut Scope 1 CO_2 emissions; better collection/processing avoids methane and black carbon.
- Illegal piles are cleared by value chain players near sensitive areas, reducing environmental harm.
- Concerns persist over crumb-rubber micro-particles and the need for strict pyrolysis emissions controls (Oliveira, Arantes de Oliveira, & Fonseca, 2021; Padilla, Díaz, & Anzules, 2025; Machin, Travieso Pedroso, & Andrade de Carvalho Jr., 2016).

Why Brazil stands out in ELT management

Brazil stands out for its large-scale, industry-led national EPR reverse logistics program with strong enforcement and nationwide reach, supporting the sorting out of tire casings to the retreading industry, and resilient ELT recovery pathways anchored by permitted cement coprocessing and expanding uses of ELT-derived materials in multiple applications.

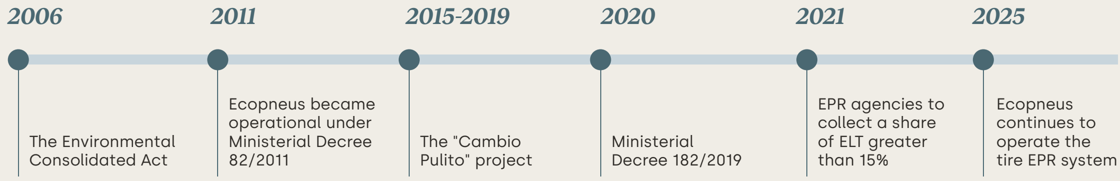
[8]In ELT management, a "gate fee" is a charge paid by a tire collector to a processing facility for each tire it receives for processing.auxiliary fuel or carbon source in shale oil production, hence its classification among tire-related recovery processes.

3.1.2 Italy

EPR scheme

Italy's ELT management scheme is a European benchmark: a clear EPR framework that requires producers and importers to fund collection and treatment through a point-of-sale eco-contribution, with robust enforcement by the Ministry of Environment and Energy Security and support from regional and provincial permitting authorities. The system aligns with EU law — including the Waste Framework Directive, the waste hierarchy, and landfill bans — which governs transboundary movements under the EU Waste Shipment Regulation and Basel Convention, and shapes downstream markets through the 2020 end-of-waste criteria for vulcanized rubber granulate/powder and EU chemical regulations (European Tyre and Rubber Manufacturing Association, 2024). Ecopneus and Ecotyre, non-profit consortia, are the primary operational bodies responsible for managing ELT collection and recovery on behalf of their member producers. They use monthly planning to meet regulatory targets and track collections (EcoTyre, n.d.).

Overarching Timeline



2006: The Environmental Consolidated Act (Legislative Decree No. 152) established the legal framework for waste management, including provisions for EPR.

2011: Ecopneus, a non-profit consortium, became operational under Ministerial Decree 82/2011 to manage the collection and recovery of ELT, covering approximately 60% of the national market share.

2015–2019: The "Cambio Pulito" project enhanced transparency and efficiency in tire recycling through collaboration between EPR agencies, trade groups, and environmental organizations.

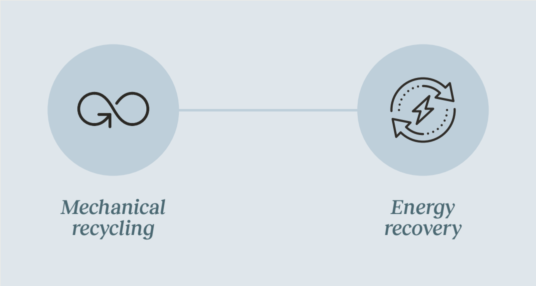
2020: Ministerial Decree 182/2019 introduced improvements to enhance the efficiency and effectiveness of tire recycling processes.

2021: A directive from the Ministry of Ecological Transition required EPR agencies to collect a share of ELT greater than 15% relative to their legal targets, with the possibility of an increase to 20%.

2025: Ecopneus continues to operate the tire EPR system, ensuring compliance with regulations and supporting Italy's circular economy for ELT.

Recovery routes and technical capacity

On the ground, the technology portfolio is diverse and well established.



- **Mechanical shredding and granulation** at ambient temperature is the main route, producing rubber granulate and powder as well as recovered steel (Ecopneus, n.d.).
- **Energy recovery** in cement kilns is a stable outlet and is integrated by the EU into a regulated industry under the EU emissions trading system (Vilella & Arribas, n.d.)

Economic, environmental and sustainability impacts

Economic impacts

Economically, the sector is a stable circular value chain.

- The eco-contribution finances collection and primary treatment, while sales of rubber products, recovered steel, and alternative fuel to cement kilns support operators further downstream.
- Investment has been steadying in shredding and granulation capacity, logistics and traceability, and quality control. New capital is flowing to rubberized asphalt capability and to pilot projects in devulcanization and pyrolysis.
- Market trends point toward higher-value material uses, a progressive tightening of demand for loose infill due to microplastics policy, and continuing use of energy recovery as a balancing outlet (Ecopneus, 2023; European Climate, Infrastructure and Environment Executive Agency, 2023)

Social impacts

Socially, the system relies on formal, registered operators, and labor conditions are governed by national occupational health and safety law.

- Preventing fire hazards: Accumulated scrap tires pose a risk of fires, which can endanger nearby communities and disrupt local life.
- Protecting public health and the environment: Fires release large amounts of smoke, toxic metals, and hydrocarbons, contaminating soil and groundwater, and creating long-term health risks for society (Hashamfirooz, et al., 2025).

Environmental impacts

Environmental performance is broadly positive.

- The majority of ELT are diverted to material recycling, and a complementary share goes to energy recovery.
- Regulated plants control dust, noise, and emissions.
- However, stockpiles can still ignite with severe local impacts, and illegal dumping persists in some hotspots (Ecopneus, 2023; Salvadori, n.d.)

Why Italy stands out in ELT management

Italy is worth a closer look because it combines a long-standing legal framework, disciplined oversight, and active market development with real-world lessons about trade-offs. It does especially well in nationwide service coverage, in building markets for recycled rubber through end-of-waste criteria and partnerships with road authorities, and in public communication led by consortia. The system is mature, but there is room for improvement in eliminating illegal dumping and stockpiles, accelerating the shift from energy recovery to higher value material recycling, and reducing microplastic leakage from open applications.

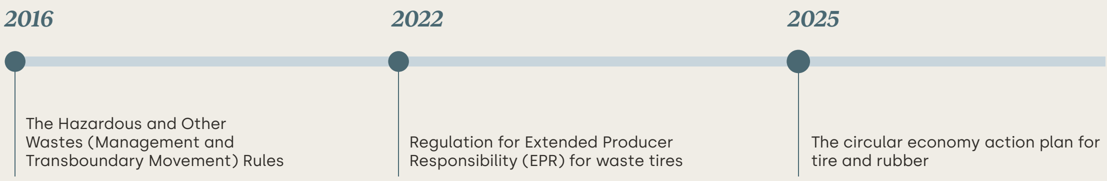
3.1.3 India

EPR scheme

India's ELT management scheme, part of a broader shift toward EPR and stricter waste oversight, is anchored in the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. The tire EPR framework assigns obligations to producers and importers, with registry and certification enforced by the Central Pollution Control Boards. The National Green Tribunal has driven closures and upgrades of non-compliant units, particularly pyrolysis facilities. India aligns with Basel controls and EU-style EPR principles while adapting technologies and implementation to local conditions (Khan, Shyamal, & Kazmi, 2024).

Primarily, the Central Pollution Control Board (CPCB) tracks and monitors the management of ELT via a centralized monitoring online portal. All producers, importers, and waste tire recyclers must register on the CPCB portal and obtain authorization. This creates a traceable network of all entities involved in the ELT supply chain (Sundaram, 2025). However, India lacks precise official data on ELT: according to Automotive Tyre Manufacturers' Association (ATMA), India's tire recycling industry is highly unorganized, and the data is fragmented. The subcategorization of ELT arisings is only an estimate based on research and inputs by recyclers, and informal re-use further complicates accounting, which overlaps with the "recovery hybrid" category.

Overarching Timeline



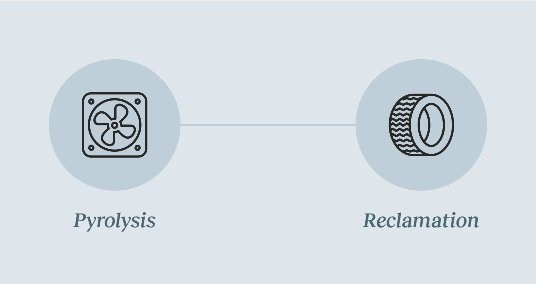
2016: The Hazardous and Other Wastes (Management and Transboundary Movement) Rules were introduced, laying the groundwork for EPR in India, including provisions for tire waste management.

2022: Regulation for Extended Producer Responsibility (EPR) for waste tires came into effect, aiming to streamline operations for producers and recyclers in compliance with the new EPR regime.

2025: The circular economy action plan for tire and rubber is being implemented, with the management of waste tires regulated under the Hazardous and Other Wastes (Management and Transboundary Movement) Amendment Rules, 2022. These rules are designed to promote a circular economy through EPR principles.

Recovery routes and technical capacity

ELT management in India spans the spectrum from sorting out casings for the well-developed retreading industry to ELT material recovery and energy recovery, with varying levels of technological maturity and environmental performance.



- **Pyrolysis oil or char**, which are only used as fuel and not as raw material for the manufacturing of new tires (Weibold, 2022).
- **Reclamation** involves processing ELT rubber to restore partial plasticity for use in secondary rubber applications.

Economic, environmental and sustainability impacts

Economic impacts

EPR adoption into the future is expected to improve collection efficiency and stabilize demand for verified environmentally sound recycling, catalyzing digital tracking, and performance-linked financing.

- Jobs are created across collections, aggregation, transport, processing, and downstream applications.
- Market value is driven by recovered outputs, but prices fluctuate due to varying input quality, tightening regulations, and strict buyer specifications.
- Increasing investment in the development and innovation of shredding technology and pyrolysis technologies (Kharrati, 2025).

Environmental impacts

India's ELT management exhibits a mixed environmental profile, with high-performance options coexisting with pollution risks.

- Co-processing in cement kilns and well-controlled mechanical recycling delivers comparatively strong outcomes – displacing fossil fuels and virgin materials, lowering lifecycle emissions, and aligning with industrial decarbonization strategies.
- Poorly managed pyrolysis can emit hazardous pollutants and generate problematic residues, posing local air quality and community health risks.
- Open dumping and uncontrolled storage create fire hazards, vector breeding, and localized biodiversity risks, particularly near water bodies and peri-urban settlements (Molla, et al., 2023; Baidya, Ghosh, & Parlikar, 2017; Klean Industries, 2025).

Social impacts

Heavy reliance on informal labor and uneven safety standards in the ELT management scheme creates social and health risks, but EPR-linked formalization and traceability can improve worker protection, community safety, and gender inclusion.

The ELT management scheme relies heavily on an informal workforce for collection and pre-processing – precarious employment, limited protective equipment, and exposure to hazardous conditions.

- A greater awareness level in society is more conducive to adopting and implementing any subsequent recycling framework (Molla, et al., 2023).
- Resilient communities: Effective waste management practices contribute to more resilient and sustainable local communities, as seen in the development of recycling sectors in regions like Uttar Pradesh and Haryana (Kaur, 2024).

Why India stands out in ELT management

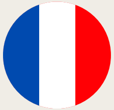
India stands out for its scale and the Ministry of Micro, Small & Medium Enterprises (MSME) -driven innovation alongside an assertive EPR rollout that brings digital tracking and performance-based compliance to a complex, distributed market, leveraging a vast cement sector for high-integrity energy recovery.

Besides, India's EPR framework mandates that producers, importers, and brand owners ensure the environmentally sound management of waste tires. A pivotal component of this system is the EPR certificate, which quantifies the recycling obligations fulfilled by registered recyclers. It uniquely assigns technology-specific weighting factors to recycling methods, ensuring certificates reflect environmental impact and resource recovery efficiency.

Despite uneven technology and demand shocks, tighter controls, traceability, and Basel-aligned oversight position India to show how large emerging economies can align circular ambitions with practical enforcement and market realities.

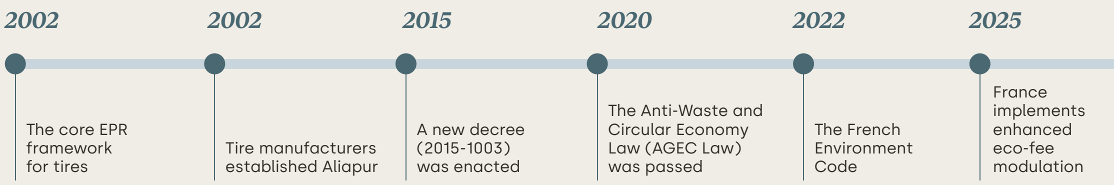
3.1.4
France

EPR scheme



France's ELT management scheme is a mature EPR system; an EU-aligned model built on producer responsibility, free point-of-sale take-back, and diversified recovery routes. The Environmental Code mandates obligations for producers, importers, and distributors, fulfilled through approved eco-organizations or individual systems. The regime aligns with EU law, including the Waste Framework Directive, the Landfill Directive (landfilling of most tires banned), and the Waste Shipment Regulation implementing Basel (European Tyre and Rubber Manufacturing Association, 2024). The monitoring and tracking of the ELT management primarily through the non-profit organization Aliapur, which operates as the central hub for France's ELT tracking system, including data collection and reporting, digital tracking via Aliabase, and monitoring compliance (Aliapur, n.d.).

Overarching Timeline



2002: The core EPR framework for tires was established by the earlier Decree No. 2002-1563, which was enacted in late 2002 and was later incorporated into the French Environmental Code

2002: Tire manufacturers, including Bridgestone, Michelin, and Goodyear, established Aliapur, a non-profit organization responsible for managing the collection and recycling of end-of-life tires (ELTs) in France.

2015: A new decree (2015-1003) was enacted to update and strengthen the regulatory framework for tire recycling, aiming to improve the efficiency and environmental performance of the system.

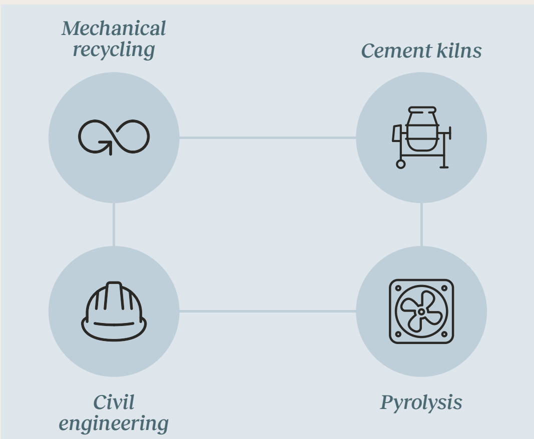
2020: The Anti-Waste and Circular Economy Law (AGEC Law) was passed, reinforcing the EPR scheme and introducing new obligations, including stricter recycling targets and extended producer responsibilities.

2022: The French Environment Code mandated that every new tire sold in France must be recycled at the end of its life.

2025: France implements enhanced eco-fee modulation under the EPR system, adjusting producer fees based on environmental performance with new criteria and stronger bonus/penalty mechanisms for sectors such as packaging and electrical and electronic equipment (EEE) but also for tires.

Recovery routes and technical capacity

Operationally, the system is well structured. Consumers hand back used tires at retail and fitting points at no charge, an intuitive service that raises return rates. Eco-organizations[9] contract a nationwide network of collectors and processors and report performance to the authorities. On the technology side, France relies on fully commercial solutions for the bulk of its flows:



- **Mechanical processing** to recover steel and produce chips, granulation, and powder is widely available, and feeds markets in molded goods and asphalt modification.
- **Cement kilns** provide a stable outlet for energy recovery with modern emission controls.
- **Civil engineering** uses such as drainage and embankments exist but are niche and project-based.
- **Pyrolysis** is moving from pilot to early commercial stages with several projects advancing, and devulcanization remains limited to small-scale operations.

[9] An Eco-organization can be understood as a non-profit organization designated by the French Ministry of the Environment to manage the collection, recycling, and recovery of specific waste streams under the EPR framework. These organizations are responsible for implementing and overseeing the recycling systems for various product categories, such as textiles, packaging, and electronics. They operate under a public service delegation model and ensure that producers comply with their obligations to reduce the environmental impact of their products at the end of their life cycle (TUEV Sued, 2022).

Economic, environmental and sustainability impacts

Economic impacts

The economic performance of the system is underpinned by the producer funded eco fee that stabilizes revenues across commodity cycles and supports long-term contracts:

- The most resilient economics are still found and in well-developed granulation processes.
- Investment continues in process upgrades and digital traceability, while new capital is flowing into pyrolysis and devulcanization (Ernst & Young, 2016; Murphy, 2025).

Environmental impacts

Environmental performance is strong by European standards:

- Landfilling is essentially eliminated, storage is regulated to reduce fire risk, and industrial plants operate under permits that reflect the best available techniques (Lilley, 2024).
- Material recycling displaces virgin elastomers, steel and bitumen, and energy recovery substitutes for fossil fuels in cement kilns.

Social impacts

Social impacts are comparatively professionally managed:

- Communities benefit from strict storage rules and traceability, though they still bear occasional nuisance from traffic or noise and the rare incident of a tire fire.

Why France stands out in ELT management

France, where tires were among the earliest producer responsibility streams to be regulated, does several things particularly well. It ensures universal access to take back, it enforces obligations consistently across the value chain, and it keeps a balanced portfolio of recovery routes that can absorb fluctuations in individual markets. It also provides clear strategic framing by treating tires as a resource within a circular economy, which maintains political will and public support. Today, the most dynamic debate in the press and civil society is about microplastics from tire wear and synthetic turf – a reminder that even a mature system must continue to evolve.

3.1.5 South Korea

EPR scheme

South Korea's ELT management scheme is a mature, centralized EPR regime. Under the Act on the Promotion of Saving and Recycling of Resources, tire producers/importers must meet collection and recycling targets and report results. The Ministry of Environment sets policy and compliance; the Korea Environment Corporation (KECO) manages registration, verification, and settlements; local governments enforce under the Resource Recycling Act. Korea follows OECD EPR and Basel/OECD rules on transboundary waste. The model mirrors leading EU national schemes. Ministry of Environment (South Korea) (MOE)/K-eco and Korea Tire Manufacturers' Association (KOTMA) publish annual performance data (Valentini & Pegoretti, 2022). KECO also oversees the EPR system, with the KOTMA collaborating with the government to fulfill recycling obligations (Lee, 2024). KECO operates the "Allbaro" system; a comprehensive, real-time platform that manages the flow of waste (Korea Environment Corporation, n.d.).

Overarching Timeline

1992 – South Korea introduced the Producer Deposit-Refund System (PDR)

2003 – The mandatory recycling responsibilities for tire manufacturers and importers

2005 – The Korea Environment Corporation (KECO) was designated as the central agency

2006 – Specific regulations for tire recycling were introduced

2015 – The government updated the EPR regulations

1992: South Korea introduced the Producer Deposit-Refund System (PDR) under the Law for Promotion of Resources Saving and Recycling of Resources (LRSR). This system required producers to pay a deposit for their products, refundable upon return for recycling. Tires were included in this scheme.

2003: The mandatory recycling responsibilities for tire manufacturers and importers, along with the full implementation of EPR for tires, have been in effect since January 1, 2003.

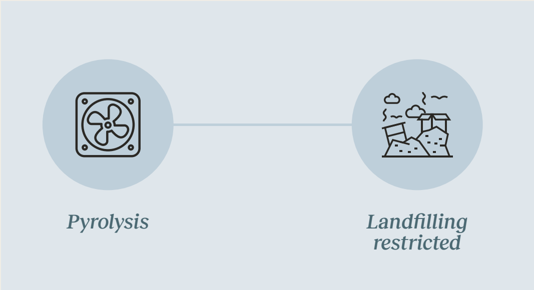
2005: The Korea Environment Corporation (KECO) was designated as the central agency to oversee the EPR system, including tire recycling. KECO's responsibilities included setting recycling targets, monitoring compliance, and enforcing regulations.

2006: Specific regulations for tire recycling were introduced, including mandatory collection and recycling rates for producers and importers of tires.

2015: The government updated the EPR regulations to include more detailed guidelines for tire recycling, aiming to improve efficiency and increase recycling rates.

Recovery routes and technical capacity

ELT management supports the sorting out of casings, mainly truck and bus, for the retreading industry, while ELT recovery routes balance material and energy pathways, with longstanding industrial infrastructure:



- **Pyrolysis facilities** operate at small-to-medium scale and are expanding.
- **Landfilling of whole tires is restricted** and not a routine endpoint.

Economic, environmental and sustainability impacts

Economic impacts

The ELT management scheme underpins a national market of meaningful scale:

- Thousands of direct and indirect jobs are supported across collection, processing, compliance, equipment supply, and services.
- Revenues derive from EPR-funded collection and recycling fees, complemented by sales of recovered products.
- Investment is strongest in emissions and fire-safety upgrades at existing recyclers, incremental improvements in alternative-fuel systems at cement plants, and selective expansion of pyrolysis capacity (Kim, 2012; Korea Herald, 2024).

Environmental impacts

The environmental profile of this system reflects both the benefits of high recovery and the challenges of industrial processing:

- Air emissions from authorized plants are regulated through permits with continuous or periodic monitoring under the Clean Air Conservation Act. (Clean Air Conservation Act, 1990).
- Ash and trace metals are largely immobilized in clinker during co-processing.
- Mechanical operations must manage dust, odor, stormwater, and the nontrivial risk of stockpile fires.

Social impacts

South Korea's ELT chain is almost entirely formal. The EPR framework ties collection, transport, and treatment to licensing, manifests, and financial settlements, leaving little room for informal operators:

- worker health and safety is governed by the Industrial Safety and Health Act and related chemical and fire codes.
- for communities, the main concerns are odor, noise, truck traffic, perceived air-emission risks around cement and thermal facilities, and low-probability but high-consequence fires (Lee, 2024; Han, et al., 2024b).

Why South Korea stands out in ELT management

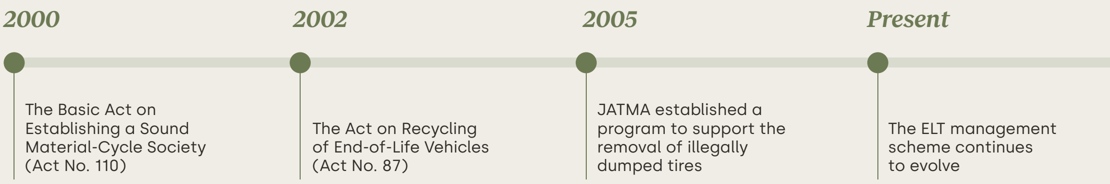
South Korea stands out for a long-standing, tightly enforced ELT EPR regime aligned with Basel/OECD, minimal informal sector, and strong industrial capacity (notably cement) that sustains high recovery while steering a shift toward higher-value material and chemical circularity.

3.1.6 Japan

Free-market scheme

Japan's ELT management scheme is a mature, predominantly market-driven regime embedded in a stringent environmental governance framework. Under the Waste Management and Public Cleansing Act, waste tires are classified as general waste (non-industrial waste) and industrial waste (waste generated through business activities). The Ministry of the Environment oversees national policy and enforces the Basel Convention domestically. Japan has no tire-specific EPR statute, instead, generators (dealers, garages, dismantlers, fleets) contract with licensed operators (The Japan Automobile Tyre Manufacturers Association, Inc., n.d.). Japan's system for tracking and monitoring ELT management is primarily coordinated by the Japan Automobile Tire Manufacturers Association (JATMA), an association formed by several tire producers, in collaboration with the government, including annual surveys, public reporting, and tracking the effective utilization rate.

Overarching Timeline



2000: The Basic Act on Establishing a Sound Material-Cycle Society (Act No. 110) was enacted, laying the foundation for a circular economy in Japan, including principles for the reduction, reuse, recycling, and proper disposal of waste in general, and it can be interpreted that ELTs are included within this scope.

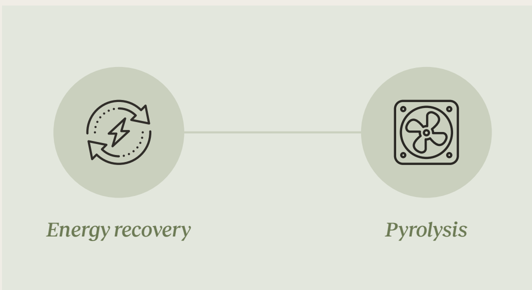
2002: The Act on Recycling of End-of-Life Vehicles (Act No. 87) was introduced, indirectly affecting ELT management by promoting the recovery and recycling of tires from scrapped vehicles.

2005: JATMA established a program to support the removal of illegally dumped tires (The Japan Automobile Tyre Manufacturers Association, Inc., n.d.).

Present: The ELT management scheme continues to evolve, focusing on material recovery, energy recovery, and circular economy principles.

Recovery routes and technical capacity

ELT management supports the sorting out of casings, mainly truck and bus, for the retreading industry, and is characterized by diversified ELT recovery pathways dominated by energy recovery.



- **ELTs are used for energy recovery in paper mills, chemical plants, cement plants, etc.** This is supported by nationwide collection logistics and stable demand.
- **Chemical recycling**: advancing from pilot to early commercial scale is pyrolysis producing oil, gas, and rCB, often in partnership with tire and chemical companies working to qualify rCB and upgrade pyrolysis oil for petrochemical use (The Japan Automobile Tyre Manufacturers Association, Inc., n.d.).

Economic, environmental and sustainability impacts

Economic impacts

The amount of effectively utilized ELT in 2024 was 692,000 tons, with an effective utilization rate of 99.6% (The Japan Automobile Tyre Manufacturers Association, Inc., n.d.). Generator-paid collection fees and downstream product and fuel revenues together imply a market size of several tens of billions of yen annually (The Japan Automobile Tyre Manufacturers Association, Inc., n.d.; Quantum Leap Corp, 2025).

It supports thousands of jobs across collection, transport, shredding, and industrial applications with additional indirect employment in equipment and services (Klean Industries, n.d.).

Environmental impacts

Environmental performance benefits from Japan's permitting stringency, process controls, and traceability. Biodiversity impacts are limited because handling occurs in controlled facilities and engineered works, with the main vulnerabilities arising from any illegal dumping or fires.

- Cement kilns operate at high temperatures and long residence times with modern air-pollution controls and monitoring,
- Mechanical recycling facilities primarily face dust, noise, and stormwater management challenges, addressed through enclosures, filtration, and site controls.
- Tire stockpile fires, a major environmental hazard globally, are comparatively uncommon due to storage regulations and fire codes (The Japan Automobile Tyre Manufacturers Association, Inc., n.d.).

Social impacts

Social impacts are favorable, as Japan's licensed system generally excludes informal ELT activities.

- occupational health and safety are governed by the Industrial Safety and Health Act.
- community health concerns are concentrated around industrial areas, where traffic, noise, and dust are intense (United Nations Environment Programme, n.d.).
- emissions from kilns or pyrolysis are managed through strict permitting and regulated.

Why Japan stands out in ELT management

Japan stands out globally in ELT management due to its innovative approach, combining several key strengths:

- High capture and utilization rate: Achieved without a tire-specific EPR law.
- Robust enforcement and traceability: Employs a manifest system to ensure stringent oversight.
- Acceptance of "effective utilization": Recognizes thermal recovery alongside material recycling, offering a comprehensive waste management strategy.

Japan's pragmatic, high-functioning ELT regime not only sets a benchmark for environmental and economic outcomes but also demonstrates adaptability in pursuing advanced sustainability goals.

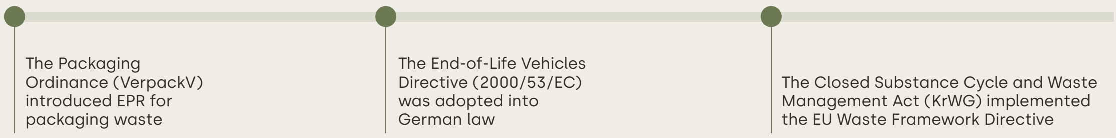
3.1.7 Germany

Free-market scheme

Germany couples EU-level environmental standards with a free-market ELT model that still delivers high recovery and low incident rates, making it a benchmark given its large economy, tire market, and advanced cement sector. A clear legal backbone plus devolved enforcement by authorities (registering collectors/dealers, inspections, permits, and shipment policing with customs/police) makes the system genuinely powerful without a tire-specific eco-fee or take-back mandate (European Tyre and Rubber Manufacturing Association, 2024).

Germany's system for tracking and monitoring the progress of ELT management relies on a combination of legislative framework (the closed substance cycle waste management law – Kreislaufwirtschaftsgesetz–KrWG), market self-regulation, and electronic waste management verification systems (elektronische Nachweisverfahren – eANV) (Environment, Climate, Energy and Agriculture Authority, n.d.).

Overarching Timeline



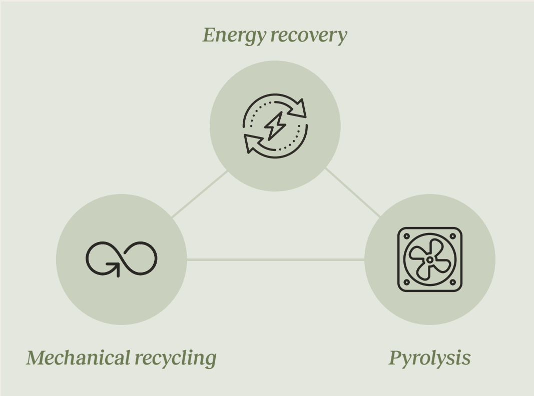
1991: The Packaging Ordinance (VerpackV) introduced EPR for packaging waste, laying the groundwork for producer responsibility in other streams, including tires (Bünemann, Brinkmann, Dr. Löhle, & Bartnik, 2020).

2002: The End-of-Life Vehicles Directive (2000/53/EC) was adopted into German law, requiring manufacturers to ensure recycling of vehicle components, including tires (Umwelt Bundesamt, 2014).

2012: The Closed Substance Cycle and Waste Management Act (KrWG) implemented the EU Waste Framework Directive, providing a comprehensive legal framework for ELT and promoting circular economy principles.

Recovery routes and technical capacity

Operationally, the system is mature and diversified:



- **Energy recovery has high maturity** and extensive capacity in advanced cement kilns under strict permits and emissions controls
- **Material recovery also has high maturity** with large granulation capacity (chips, granulate, powder) and steel recovery.
- **Pyrolysis/devulcanization is in the mid-maturity**; a small number of permitted pyrolysis plants/pilots producing tire-derived oil and recovered carbon black with variable quality; devulcanization mainly R&D/pilot (Secretariat of the Pacific Regional Environment Programme (SPREP), 2022; New Life, 2022; Shetkar, 2023).

Economic, environmental and sustainability impacts

Economic impacts

Germany's ELT management scheme delivers strong economic outcomes, with competitive collection and processing, diversified revenue streams, and steady investment in capacity and quality.

- A wide network of SMEs is involved in collection, logistics, trading, granulation, and services, with linkages to cement and rubber product manufacturing that sustain regional jobs and productivity.
- The collection network supports the channeling of casings and second-hand tires to the retreading services sector and export markets, respectively.
- ELT-related revenues are generated from tire-derived fuel contracts with cement kilns, sales of rubber granulate/powder and molded products, recovered steel, retreading services, and limited part-worn exports
- Investment continues in ongoing upgrades in plant efficiency and emissions control and growing interest in pyrolysis/rCB and devulcanization pilots, and traceability (Shetkar, 2023; Global Recycling, 2025).

Environmental impacts

Environmental performance reflects rigorous controls:

- Stockpile fires are uncommon because storage limits fire prevention planning, and stormwater and leachate management are obligatory and enforced.
- Emissions from co-processing and processing plants remain under European industrial limits for particulates, nitrogen oxides, sulfur dioxide and metals.
- Salient challenge has been microplastic loss from crumb rubber infill on synthetic sports fields (Shetkar, 2023; Donnelly, 2025).

Social impacts

Socially, Germany's ELT chain is formal and comparatively safe:

- Workers operate under robust occupational safety law and certification regimes, with personal protective equipment, training, ventilation, and fire protection.
- Many sites have works councils and collective agreements.
- Community impacts are traffic, noise and occasional odors or dust near facilities, and permitting conditions are designed to manage these (Wagner, et al., 2022; Arbeitsschutzgesetz (ArbSchG), n.d.).

Why Germany stands out in ELT management

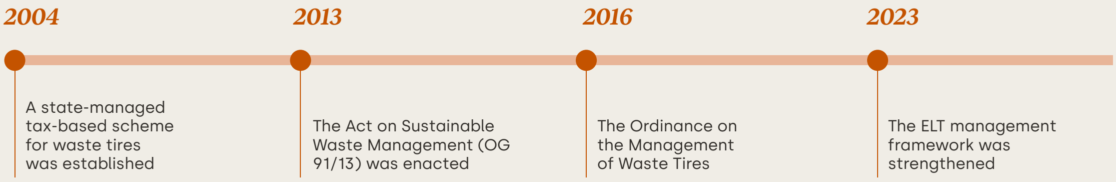
Germany's market-based ELT regime shows that high recovery and compliance are achievable without tire-specific producer responsibility when a clear legal framework, capable devolved enforcement, and mature infrastructure are in place. However, performance is constrained by reliance on energy recovery, early- to mid-stage advanced recycling, and uneven enforcement, and limited data transparency.

3.1.8 Croatia

Tax-based scheme

Despite its small size, Croatia operates a state-managed ELT tax-based scheme as a service model that provides regulatory stability but limits market adaptability and innovation. The Environmental Protection and Energy Efficiency Fund (FZOEU) administer producer-funded contracts, manages data, and stabilizes finances under policies from the Ministry of Economy and Sustainable Development, with enforcement by the State Inspectorate. The framework is tightly aligned with EU law with cross-border movements under the EU Waste Shipment Regulation (European Tyre and Rubber Manufacturing Association, 2024). Croatia monitors ELT management progress through National Waste Management Plan, which sets objectives and measures for waste management, via reporting obligations to the European Commission and oversight by the Ministry of Economy and Sustainable Development.

Overarching Timeline



2004: A state-managed tax-based scheme for waste tires was established, with the Environmental Protection and Energy Efficiency Fund (FZOEU) responsible for administering producer-funded contracts. The system functions as a tax-style mechanism, with mandatory fees from producers financing collection, recycling, and administration (European Commission, n.d.).

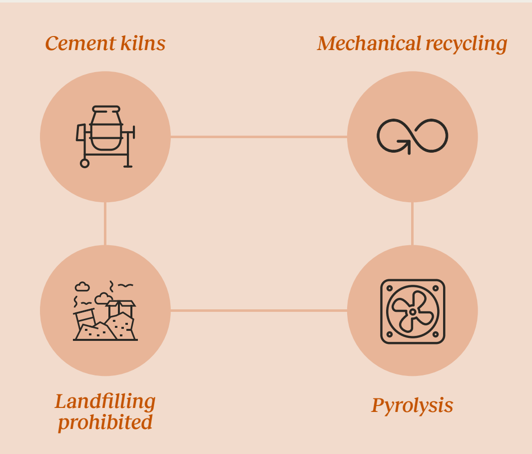
2013: The Act on Sustainable Waste Management (OG 91/13) was enacted, providing the legal framework for ELT management (Croatian Parliament, 2013).

2016: The Ordinance on the Management of Waste Tires (N° 113/16) was introduced, detailing procedures for collection, transport, treatment, reporting, and defining the responsibilities of producers and waste holders (Barišić, Zvonarić, Netinger Grubeša, & Šurdonja, 2021).

2023: The ELT management framework was strengthened to ensure compliance with the EU Waste Shipment Regulation, regulating cross-border movements of tires and ensuring that all producer-funded operations adhere to EU environmental standards (Directorate-General for Environment, 2023).

Recovery routes and technical capacity

ELT management supports the sorting of truck and bus casings for the retreading industry, while ELT recovery is characterized by well-developed infrastructure across the country:



- **Energy recovery via co-processing in cement kilns** remains a preferred method, replacing traditional fuels.
- **Mechanical recycling to chips, crumb rubber, and powders with steel recovery is also well established**, contributing to a steady supply of materials for industrial applications.
- **Pyrolysis and devulcanization are still in their nascent stages**, operating at small or pilot scales.
- **Landfilling is effectively prohibited** (Environmental Protection and Energy Efficiency Fund, n.d.).

Economic, environmental and sustainability impacts

Economic impacts

At an economic level, Croatia handles approximately twenty thousand tons of ELT per year, supporting a stable value chain. Revenues come from FZOEU fees and sales of recycled materials.

Environmental impacts

Croatia's ELT management scheme shows broadly positive environmental performance, with high capture and strict controls, alignment with EU climate/circular goals, and some residual risks that can be further mitigated.

- Permitted plants operate under emission limits with storage and fire-prevention measures.
- Favorable life-cycle results for material recycling.
- Cement co-processing substitutes fossil fuels but retains process emissions (Tire Retread & Repair Information Bureau, n.d.; Da Silva, Vitor Chaves S. G. Francisco, & Oliveira Lopes, 2017; World Bank Group, 2021).

Social impacts

Croatia's formal EPR architecture leaves little room for an informal ELT sector:

- Workplace safety is managed within structured systems typically in larger sites.
- Public awareness of ELT management scheme is moderate, with media and NGOs occasionally highlighting issues like illegal dumping or air quality near cement plants (World Bank Group, 2023).

Why Croatia stands out in ELT management

Croatia provides a valuable blueprint for countries aiming to develop compliant and effective ELT management scheme. By balancing regulatory alignment, economic viability, and environmental responsibility, Croatia offers actionable insights into how state-driven frameworks can operate successfully within a broader international context. While the state-driven approach benefits compliance and stability, it may reduce incentives for private sector involvement and innovation, particularly in emerging technologies. There are opportunities for introducing market competition and technological innovation, emphasizing the need for a dynamic strategy that adapts to emerging challenges and opportunities.

3.1.9 New Zealand

Tax-based scheme

New Zealand's ELT management scheme, enabled by the Waste Minimization Act 2008, uses regulated product stewardship: the Ministry for the Environment sets policy and oversees the scheme, local authorities enforce bylaws/consents, and the Environmental Protection Authority and Customs manage transboundary flows, aligning with EPR principles and Basel obligations and featuring mandatory stewardship, cost internalization, and performance targets similar to EU/North American models (Tyrewise, 2024). A mandatory, regulated product stewardship scheme, Tyrewise, is the primary mechanism for tracking and monitoring ELT management progress via digital tracking system and compliance monitoring.

Overarching Timeline

2012-2013
The Tyrewise project was launched with funding from the Waste Minimization Fund

2020
Tires were officially declared a priority product under the Waste Minimization Act 2008

2022
Auto Stewardship New Zealand (ASNZ) received government funding to run the Tyrewise Implementation Project

2023
The Waste Minimization (Tires) Regulations 2023 were passed

2024
The regulations entered into force, with Tyrewise becoming fully operational

2012-2013: The Tyrewise project was launched with funding from the Waste Minimization Fund, engaging stakeholders and developing a business plan for a regulated product stewardship scheme (Speirs, 2012).

2020: Tires were officially declared a priority product under the Waste Minimization Act 2008, making a regulated product stewardship scheme mandatory (New Zealand Government, 2020).

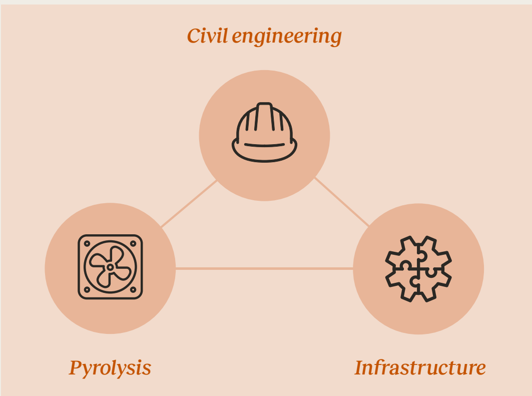
2022: Auto Stewardship New Zealand (ASNZ) received government funding to run the Tyrewise Implementation Project, preparing the scheme's infrastructure, contracts, and data systems.

2023: The Waste Minimization (Tires) Regulations 2023 were passed, establishing legal obligations for producers, fees, registration, and scheme administration.

2024: The regulations entered into force on 1 March 2024, with Tyrewise becoming fully operational from 1 September 2024.

Recovery routes and technical capacity

The regulated stewardship model supports the sorting of truck and bus casings for the retreading industry, while ELT recovery pathways have consolidated around mature, domestically available technologies:



- **Civil engineering applications** provide additional outlets where performance and environmental safeguards are robust.
- **Emerging thermal technologies** such as pyrolysis are present at pilot to early commercial scale.
- **Infrastructure availability has improved through a collector network**, standardized logistics, and digital tracking from point of sale to end-use (Tyrewise, 2020).

Economic, environmental and sustainability impacts

Economic impacts

The regulated product-stewardship fee stabilizes financing for collection and recovery, enabling investment in plant upgrades, emissions controls, and logistics, and shifting the sector from sporadic, price-sensitive outlets to predictable, contract-based services:

- Job creation has been supported across collection, sorting, transport, processing, compliance, and data management, with the employment footprint extending into regional communities where facilities are sited.
- Investor interest is evident in new capacity for crumbing, emissions abatement at kilns, and trials of advanced recovery.
- The overarching trend is a transition from fragmented, often informal disposal practices to a professionalized, service-funded circular system with more resilient demand for ELT-derived outputs (Speirs, 2025; Ministry for the Environment, 2024)

Environmental impacts

New Zealand's regulated stewardship is reducing dumping and stockpiles while directing ELT into controlled energy and material recovery with safeguards that deliver climate and biodiversity benefits:

- Controlled use of tire-derived fuel in cement offers lifecycle greenhouse gas benefits relative to coal, aiding the sector's alignment with national climate goals and the decarbonization pathway of process industries.
- Material recovery via crumb rubber extends pavement life and can lower maintenance-related emissions.
- Environmental management plans and resource consent conditions mitigate local pollution risks, and stewardship tracking reduces leakage into sensitive environments (Tyrewise, 2020; Palermo, et al., 2020).

Social impacts

New Zealand's ELT management operates largely within the formal economy, with limited involvement of informal pickers or processors:

- the Health and Safety at Work Act 2015 and sector-specific codes of practice underpin labor conditions, training, and safety standards in collection and processing.
- reduced dumping and fewer stockpile fires benefit public health by lowering smoke exposure and accident risks (Tyrewise, 2020; Health and Safety at Work Act 2015, 2015).

Why New Zealand stands out in ELT management

New Zealand's approach is notable for implementing a single, nationwide, regulated product stewardship scheme for tires in a relatively small, geographically dispersed market, coupling EPR financing with end-to-end digital tracking and performance-based contracting. The country has leveraged a pragmatic portfolio of recovery routes. The scheme's multi-stakeholder design, developed over years of consultation, balances environmental integrity with operational feasibility and market development, and ties ELT management to broader climate and circular economy strategies.

3.2
Actions taken and their impact

Across many countries, ELT management has evolved from an ad hoc disposal approach to structured, circular systems that prioritize prevention, recovery, and safe valorization. Governments and industry have adopted policies and programs that reduce stockpiles, boost collection rates, stimulate recycling markets, and curb environmental and fire risks while creating economic value. These measures span regulatory frameworks, financial instruments, technological pathways, and public-private coordination.

Implementation of the ELT management scheme: implementing an end-of-life tire management system delivers clear environmental, economic, and public health benefits. By formalizing collection and processing, it curbs illegal dumping and open burning, reducing air, soil, and water contamination and associated health risks. Take India as an example: before 2022, India's informal end-of-life tire handling led to improper disposal, pollution, and health risks; EPR now drives formalization, stronger compliance, and higher resource recovery by shifting responsibility to manufacturers, advancing a more circular system and recycling innovation.

Government partners with non-profit organizations and anchors ELT management in clear legislation: laws set standards and accountability, while nonprofits extend reach through community engagement, training, and monitoring, helping formalize collection networks and integrate informal workers. This collaboration boosts compliance and traceability, reduces dumping and open burning, and raises recycling and recovery rates through better infrastructure and technology adoption. The combined approach delivers cleaner environments, safer jobs, and a more transparent, circular tire economy. For example, Ecopneus and Ecotyre from Italy, as well asthe closed substance cycle waste management law (Kreislaufwirtschaftsgesetz – KrWG) in Germany.

Tracking and monitoring ELT management on a digital platform: This is essential for accountability, compliance, and real results. By capturing real-time, geotagged data from collection to processing, assigning unique IDs to material flows, and automating chain-of-custody and credit issuance. Such platforms provide end-to-end traceability, deter illegal dumping and fraud, and simplify reporting and audits under EPR. For example, Aliabase, the ELT information management system in France, connects all stakeholders, including producers, holders, collectors, and recyclers, through a unified digital platform. It enables digital tracking, monitoring, and compliance within the ELT sector.

Practical guidance

Part IV

4.1 Practical guidance

This part of the ELT Toolkit is designed to turn knowledge into action. While earlier chapters provide theoretical background, case studies, and system comparisons, this part offers practical, step-by-step guidance for policymakers, associations, manufacturers, and other core audiences seeking to implement or improve ELT management in their own context. It contains clear instructions on how to:

- Assess the maturity of an ELT management scheme
- Develop effective ELT regulations
- Identify and address environmental and health risks
- Develop effective recovery routes
- Collect and report relevant data

The goal of this part is to make it easy to navigate and apply the Toolkit's recommendations to real-world situations.

This chapter supports both new setups and optimizations, providing guidance ranging from big-picture insights to detailed, step-by-step instructions.

4.1.1 Assess the maturity of ELT management scheme

Put policy into action
4.1.1-4.1.3, 4.1.5

← PREVIOUS
→ NEXT

Note: Click on the stakeholder icon to go back to key stakeholder profiles and navigation guide.

To improve an ELT management scheme as effectively as possible, it is helpful to start by understanding the current baseline. Whether you are a policymaker, association, manufacturer, or other stakeholder, this assessment is a starting point for targeted improvement.

Step-by-step guide to assessing maturity

Step 1 Understand the four pillars

The assessment is built around four key pillars, each representing a critical area of ELT management. These cover the regulatory foundation, stakeholder understanding and public awareness (including policymakers, associations, and manufacturers), recovery methods, and data quality for informed decision-making. Each pillar represents a key dimension required to strengthen circular and environmentally sound ELT management.

1	2	3	4
Regulatory Context	**Understanding and public awareness**	**Recovery methods**	**ELT data collection**
Existence of laws, policies, standards, enforcement, and management schemes.	Awareness of environmental and health risks, and public engagement.	Diversity and efficiency of recovery routes, and adherence to best practices.	Quality, standardization, and use of data for decision-making.

Step 2 Answer guiding questions for each pillar

For each pillar, answer a set of guiding questions. These questions help you reflect on your current situation and identify where you are strong and where you need improvement.

TIP provided the respective template in the Annex: Template 1

Step 3 Rate your maturity

For every question, rate your system as:

- **Beginner**: Little or no structure, weak enforcement, or minimal awareness
- **Intermediate**: Some systems or awareness in place, but with gaps or inconsistencies
- **Advanced**: Comprehensive, well-enforced systems, high awareness, and effective data use

Step 4 Document notes and next steps

For each area, add notes on specific strengths, weaknesses, and ideas for improvement. This will help you prioritize actions and track progress over time.

Step 5 Interpret your results

If you have mixed ratings (e.g., advanced in data, beginner in public awareness), focus first on your weakest areas, using the following chapters of the Toolkit to find tools and recommendations tailored to your needs and target maturity level. Set clear priorities for improvement and revisit the assessment regularly.

- **Be objective and specific** in your ratings and notes. The more accurate your assessment, the more useful your action plan will be.
- **Involve relevant stakeholders** (e.g., government, industry, NGOs) to get a complete picture.
- **Use your results to navigate the Toolkit**: focus on the sections that address your weakest pillars first.
- **Repeat the assessment** regularly to track progress and adjust your strategy.

4.1.2 Concrete steps for an effective ELT management scheme (focus on regulations)

Put policy into action
4.1.1-4.1.3, 4.1.5
← PREVIOUS
→ NEXT

Support implementation
4.1.2-4.1.4
← PREVIOUS
→ NEXT

Effective ELT management depends on a robust regulatory and policy framework. This sub-chapter provides practical, actionable guidance for policymakers, associations, and other stakeholders to establish, strengthen, or review the legal and institutional foundations for ELT management. Whether you are starting from the beginning or seeking to improve an existing system, this chapter outlines how to ensure your country's ELT management is both sustainable and future-ready.

Relevance for core audience

Policymakers	Associations	Manufacturers
High	**Medium**	**Low**
directly responsible for designing and enforcing the ELT regulatory framework.	involved in stakeholder coordination and policy implementation support.	primarily subject to the established regulations.

General foundation for national strategies on ELT management

Establishing a robust national strategy for ELT management begins with a solid foundation of policies, regulations, institutional arrangements, and standards.

These elements define the legal and operational framework, ensuring that all actors understand their roles and responsibilities.

Securing stable financing mechanisms is equally critical, as sustainable funding underpins the effective collection, treatment, and recovery of ELT.

Building technical capacity - through training, infrastructure, and enforcement resources - enables consistent implementation and compliance with best practices.

Finally, fostering stakeholder engagement and transparent communication ensures that all relevant parties — government agencies, industry, NGOs, and civil society — are actively involved in shaping, executing, and continuously improving ELT management schemes. NGOs, in particular, can play a critical role by advocating stronger regulations, monitoring compliance, and facilitating community education programs. Equally important is raising public awareness of the environmental and health risks associated with poorly managed end-of-life tires. Helping consumers and communities understand these risks can encourage responsible disposal behaviors and strengthen support for policies that promote sustainable ELT management. Together, these foundations create conditions for a resilient, adaptive, and impactful approach to ELT management at the national level.and incineration without energy recovery.

For countries without an ELT management scheme in place

Step 1

Understand the relevant dimensions for building the big picture

- Legal and institutional framework
- Financing arrangements
- Technical and safety standards
- Market measures and incentives
- Monitoring, data, and enforcement
- Inclusion and stakeholder engagement

Step 2

Evaluate the status quo with a checklist

Find and complete the checklist in Annex: Template 2, answering the guiding questions to identify gaps. Additionally, TIP provides recommendations in case you answer the questions with "no."

Step 3

Document notes and next steps

For each dimension, add notes on specific strengths, weaknesses, and ideas for improvement. This will help you prioritize actions and track progress over time.

Step 4

Interpret your results and develop a roadmap

Get an overview of all the answers. Take advantage of any existing assets, initiatives, or resources identified in the questions you marked with "yes." Activities resulting from any "no" responses should be prioritized in line with the country's specific circumstances. It is recommended to discuss these with other stakeholders and schedule them using a roadmap to ensure concrete action in the short, medium, and long term.

Following are four principles to ensure the efficiency and effectiveness of an ELT regulation:

1. **Make regulation outcome-based and predictable**
   - Treat ELT regulation as an enabler, not a burden.
   - Focus on outcomes: keep it risk-proportionate, predictable, and market creating.
   - Aim for compliance to be the easiest and most valuable path, steering ELT up the waste hierarchy while protecting health and the environment.
2. **Use effective ELT management scheme design tools**
   - Apply proven policy and practical tools such as:
     - Full net cost coverage[10]
     - Transparent fee setting
   - Build robust registries and data systems to reduce administrative burden.
   - Align incentives with higher-value outcomes.
3. **Set effective ELT management scheme requirements**
   - Define clear roles and responsibilities.
   - Establish measurable objectives and high-quality data reporting.
   - Ensure transparency and cost internalization.
   - Protect compliant firms by preventing free riders.
4. **Apply risk-based practices**
   - Use risk-based good practices for ELT collection, storage, and transport.
   - Keep the technical baseline technology-neutral and proportionate.
   - Support efficient permitting and inspections (Basel Convention, 2022). without energy recovery.

[10] Net cost coverage refers to the requirement that producers financially cover the total costs associated with managing ELT, after accounting for any revenues generated from recycling or energy recovery.

For countries with an ELT management scheme in place

Step 1

Understand the relevant dimensions

Same as for countries without an ELT management scheme in place, TIP recommends focusing on these dimensions:

- Legal and institutional framework
- Financing arrangements
- Technical and safety standards
- Market measures and incentives
- Monitoring, data, and enforcement
- Inclusion and stakeholder engagement

Step 2

Evaluate the status quo with a scorecard

Assess the current performance using the scorecard in the Annex: Template 3

Step 3

Document notes and next steps

For each dimension, add notes on specific strengths, weaknesses, and ideas for improvement. This will help you prioritize actions and track progress over time.

Step 4

Interpret your results

If you assess that the effectiveness of your ELT management is not "Leading" yet, use the descriptions in the higher categories to define specific measures.

4.1.3 Concrete steps to assess environmental and health risks and to raise public awareness

Understanding and managing the environmental and health risks associated with ELT is fundamental to responsible ELT management. This chapter provides practical guidance on how to systematically identify, assess, and mitigate these risks, and how to raise public awareness to drive safer, more sustainable outcomes. By following the steps and recommendations in this chapter, you can ensure that ELT management not only protects the environment and public health but also builds trust and engagement across society.

Put policy into action
4.1.1-4.1.3, 4.1.5
← PREVIOUS
→ NEXT

Support implementation
4.1.2-4.1.4
← PREVIOUS
→ NEXT

Relevance for core audience

Policymakers

Medium

responsible for setting risk assessment standards and supporting awareness initiatives.

Associations

High

central to coordinating research, outreach, and public education efforts.

Manufacturers

Medium

involved in mitigating operational risks and complying with safety standards.

Stakeholder roles and recommendations

Policymakers

- Lead risk mapping and monitoring efforts
- Fund and coordinate awareness campaigns
- Integrate ELT management into broader environmental and health strategies

Associations

- Conduct community surveys and workshops
- Partner with local leaders to tailor messages and interventions
- Monitor informal recycling and illegal disposal

Manufacturers

- Track product flows and identify high-risk disposal practices
- Support third-party monitoring and data collection
- Fund or partner in consumer-targeted awareness campaigns

Environmental and health risk assessment

Purpose

Identify, prioritize, and address the environmental and health risks associated with ELT at every stage of its lifecycle.

Key steps

Step 1

Map ELT hotspots

- Identify locations where ELT accumulates (dumpsites, tire markets, import points, informal storage).
- Toolkit suggestion: Use Geographic Information System (GIS) mapping and local knowledge to visualize risk areas.

Step 2

Conduct risk scoring

- Classify areas as low, medium, or high risk for environmental and health impacts (e.g., fire, leachate, vector-borne disease).
- Toolkit suggestion: Use a simple scoring matrix and update regularly.

Step 3

Support/conduct monitoring studies

- Test soil, water, and air quality near ELT accumulation points and/or stockpiles.
- Toolkit suggestion: Partner with universities or labs for field testing.

Step 4

Establish a risk register using Annex: Template 4

- Track incidents such as fires, illegal dumping, or mosquito outbreaks.
- Toolkit suggestion: Maintain a living document (incident reporting form Annex: Template 5) and update after each incident.

Raising public awareness

Purpose

Empower communities, businesses, and individuals to recognize ELT risks and act.

Key steps

Step 1

Develop awareness campaigns following Annex: Template 6

- Launch national or local campaigns highlighting health and environmental risks of ELT.
- Toolkit suggestion: Use multiple channels – radio, social media, schools, and community events.

Step 2

Integrate ELT management into public health programs

- Collaborate with health authorities to address vector-borne diseases and pollution.
- Toolkit suggestion: Include ELT topics in public health messaging and municipal waste initiatives.

Step 3

Establish reporting channels

- Set up hotlines, mobile apps, or web portals for reporting illegal dumping or ELT-related hazards.
- Toolkit suggestion: Ensure feedback is acknowledged and acted upon.

Step 4

Promote safe handling and storage

- Educate tire dealers, informal recyclers, and the public on best practices.
- Toolkit suggestion: Distribute simple guides and offer training sessions.

4.1.4 Concrete steps for developing effective ELT recovery routes

Support implementation
4.1.2-4.1.4
← PREVIOUS

Act effectively
4.1.4, 4.1.5
← PREVIOUS
→ NEXT

Developing robust recovery routes for ELT is central to building a sustainable, circular tire management system. Recovery routes determine whether ELTs become valuable resources or environmental burdens.

Relevance for core audience

Policymakers

Low

mainly provide the enabling framework and approvals for recovery operations.

Associations

Medium

facilitate coordination and knowledge exchange across recovery stakeholders.

Manufacturers

High

directly involved in developing, investing in, and operating recovery technologies and markets.

Step-by-step guide for developing effective ELT recovery routes

Step 1

Define objectives and understand side effects

- Clarify your goals: What is the geographical and tire product scope? Is there a retreading industry that can be supported by a used tire collection scheme? Are the main goals in ELT management to promote material reuse (e.g., crumb rubber, retreading), energy recovery (e.g., pyrolysis), and/or environmental protection (e.g., reducing illegal dumping)?
- Identify potential risks: Consider emissions, contamination, health and safety, and market saturation for each route.
- Toolkit suggestion: Use lifecycle assessment (LCA) and environmental impact assessment (EIA) to evaluate options.

Step 2

Assess technical feasibility and infrastructure needs

- Check technology readiness: Is recovery technology proven, scalable, and compliant with environmental and safety standards?
- Evaluate infrastructure: Do you have adequate collection networks, processing facilities, trained workforce, and utilities?
- Plan for mitigation: mEnsure emission controls, byproduct treatment, and safe logistics are in place.

Step 3

Analyze economic viability

- Estimate costs: Consider capital investment, operational costs, and logistics.
- Identify revenue streams: Look at sales of recycled materials, energy, carbon credits, and brand value.
- Compare scenarios: Use cost-benefit analysis and market studies to weigh options.
- Toolkit suggestion: Consider shared infrastructure or partnerships to reduce costs.

Step 4

Promote safe handling and storage

- Identify technology-specific risks: For example, pyrolysis (emissions, fire), rubber crumb (dust), cement kilns (air quality).
- Implement controls: Provide safety equipment, pollution control devices, and standard operating procedures.
- Monitor and evaluate: Use continuous environmental monitoring and regular audits to ensure compliance and improvement.

Use the "Decision-making framework for ELT recovery routes" in the Annex: Template 7 to follow this approach in practice.

Key recommendations

- **Prioritize material recovery** over energy recovery and disposal, in line with the ELT Management Hierarchy.
- **Embed circular economy principles** by designing tires for recyclability and supporting markets for secondary materials.
- **Engage stakeholders** (industry, municipalities, recyclers) early to ensure buy-in and practical implementation.
- **Continuously monitor and adapt recovery routes** as technologies, markets, and regulations evolve.

4.1.5 Concrete steps to conduct and monitor ELT data

Put policy into action
4.1.1-4.1.3, 4.1.5

← PREVIOUS

Act effectively
4.1.4, 4.1.5

← PREVIOUS

Reliable data is the backbone of effective ELT management. Without accurate, timely, and standardized data, it is impossible to track progress, identify gaps, or make informed decisions. This chapter provides guidance on how to systematically collect, consolidate, monitor, and report ELT data,- enabling transparency, accountability, and continuous improvement across the entire value chain.

Relevance for core audience

Policymakers

High

responsible for setting data standards, creating a central system for collection and publication, and using insights to refine policies and close regulatory gaps.

Associations

Medium

support data coordination and validation

Manufacturers

High

depend on reliable data to demonstrate compliance, benchmark, optimize operations, and contribute to continuous improvement in ELT management.

Step-by-step guide

Step 1

Data collection

- Identify priority sources: gather data from industry (manufacturers, associations), public institutions (government, PROs), and supplementary sources (academia, NGOs, recyclers).
- Retrieve data systematically: use standardized templates and plan for scheduled updates or automation.
- Toolkit suggestion: early engagement with key data holders ensures higher reliability and coverage.

Step 2

Data cleaning

- Detect and correct errors: address missing, inconsistent, or outlier data.
- Standardize formats: harmonize units, categories, and language inputs for comparability.
- Toolkit suggestion: use automated tools where possible to reduce manual errors.

Step 3

Data transformation

- Harmonize definitions: ensure all data uses the same terminology and structure.
- Aggregate and categorize: group data by relevant dimensions (e.g., region, recovery route, stakeholder).
- Toolkit suggestion: align with international standards for easier benchmarking.

Step 4

Data validation

- Cross-check values: compare data against independent sources and conduct stakeholder interviews where gaps exist.
- Document assumptions: clearly note any estimates or modeled data.
- Toolkit suggestion: use a tiered source hierarchy[11] to balance efficiency and quality.

Step 5

Data consolidation & reporting

- Merge and de-duplicate: store data in structured repositories ready for analysis and visualization.
- Regular reporting: publish key indicators and trends for all stakeholders.
- Toolkit suggestion: use dashboards or interactive maps for transparency and peer learning.

[11] A tiered source hierarchy ranks data sources according to their reliability, giving priority to verified primary data over secondary or estimated values. This approach helps maintain data consistency and transparency, particularly when high-quality information is limited (Intergovernmental Panel on Climate Change (IPCC), 2019).

You can find the “ELT data management checklist” in the Annex: Template 8.

Key indicators & metrics to track

- System implementation: type of ELT management scheme, scope, start date, maturity stage.
- Volumes & flows: number of tires placed on the market, ELT volumes (in tons) collected/reused/recycled/recovered, share of ELT with unknown management.
- Environmental Economic Social (EES) impacts: environmental (emissions, energy savings, avoided landfill), economic (job creation, market value), social (health and safety, community impacts).

The minimum data points to be collected at the starting stage are as follows: the total number of ELTs generated, the total number of ELTs managed, and the number of ELTs processed through material recovery and energy recovery. For advanced data collection, please find an example structure in the Annex: Template 9.

Key success factors

- Collaborating with established industry networks enables knowledge exchange and accelerates progress.
- In the absence of existing data, early engagement with diverse stakeholders — such as recyclers, importers, and government agencies — is essential to build a reliable data foundation.
- Standardization from the outset ensures data consistency and comparability through harmonized templates and definitions.
- Transparency in communicating data sources, confidence levels, and methodologies strengthens trust and credibility.
- Continuous improvement through regular data updates, indicator reviews, and adaptive reporting supports long-term system maturity.

Conclusion

Part V

5. *Conclusion*

The Toolkit represents an important contribution to sustainable and circular ELT management. Drawing from international case studies and a comprehensive analysis of regulatory, technical, and organizational factors, several key lessons have emerged:

Lessons learned

- Holistic approach: Integrating circular economy principles and ESM is essential to achieve environmental, economic, and social objectives. Countries with a clear ELT management scheme and consistent enforcement achieve the highest collection and recycling rates.
- Stakeholder engagement: Collaboration among policymakers, industry, associations, and civil society is a critical success factor. Effective ELT management schemes are built on transparency, robust data management, and a culture of continuous improvement.
- Technological diversity: Combining material recovery and energy recovery, building on mature technologies while developing innovative recycling technologies enables flexible adaptation to local market conditions and supports the development of new value chains.
- Awareness and education: Public outreach and targeted education initiatives build acceptance and engagement for sustainable ELT management — both within companies and among the public.
- Data collection and collaboration: Data collection requires persistence, structured coordination, and strong collaboration. Low response rates, inconsistent data formats, and uneven data availability can slow progress, but leveraging expert input, engaging stakeholders early, and maintaining clear communication ensures credible, actionable datasets for benchmarking and decision-making.

An ELT management transformation requires coordinated action across the value chain. Building on these lessons, stakeholders can translate insights into concrete steps that strengthen governance, drive innovation, and scale effective solutions. The following actions outline how different actors can contribute to advancing sustainable ELT management in practice.

Relevant actions for core audiences

Policymakers
Develop and enforce clear, outcome-based regulations that incentivize innovation and investment while safeguarding transparency, environmental, and social standards.

Associations and manufacturers
Promote best-practice sharing, standardization, and collective advocacy to actively shape the industry's transformation.

All stakeholders
Use the Toolkit's practical tools, checklists, and assessment frameworks to analyze existing systems, identify gaps, and implement targeted improvements.

Continuous improvement and further research: The Toolkit is designed as a living document. It will be periodically updated to incorporate new scientific findings, regulatory changes, and practical experiences. Users are encouraged to provide feedback and share their own insights. Ongoing research will focus on innovative technologies, data management, and impact measurements to further support the global transition to a sustainable tire industry.

Final note

Transforming ELT management is an ongoing journey that requires commitment, innovation, and collaboration from all stakeholders. The Toolkit provides practical, evidence-based guidance and will remain a resource through continuous updates on the path toward a more sustainable future.

If you want to learn more about ELT management, please visit **website**.

Follow **WBCSD TIP on LinkedIn** and stay informed about further updates.

Assessments, forms, and checklists

Annex

Template 1: ELT management maturity assessment

Check the appropriate box and make notes. Further instructions can be found in chapter 4.1.1

Regulatory context

Are there clear laws and policies for ELT management in your country?

- [ ] Beginner — No regulations or basic, non-comprehensive regulations.
- [ ] Intermediate — Some regulations exist but lack enforcement or coverage.
- [ ] Advanced — Comprehensive regulations actively enforced and aligned with international standards.

Notes / Next steps (ongoing)

Is there a defined scheme (EPR, tax, free- market) for ELT management?

- [ ] Beginner — No defined scheme or mostly informal practices
- [ ] Intermediate — A scheme exists but is not fully implemented or monitored.
- [ ] Advanced — A well-defined and functioning scheme is in place with clear roles and responsibilities.

Notes / Next steps (ongoing)

Are enforcement mechanisms and compliance checks in place?

- [ ] Beginner — No enforcement or compliance mechanisms.
- [ ] Intermediate — Some enforcement exists but is inconsistent.
- [ ] Advanced — Robust enforcement and compliance mechanisms are consistently applied.

Notes / Next steps (ongoing)

Understanding & public awareness

Is there public awareness of ELT-related environmental and health risks?

- [ ] Beginner — Limited or no public awareness campaigns.
- [ ] Intermediate — Some awareness efforts exist but lack reach or consistency.
- [ ] Advanced — Comprehensive and ongoing public awareness campaigns are in place.

Notes / Next steps (ongoing)

Are stakeholders educated on proper ELT handling and disposal?

- [ ] Beginner — No stakeholder education programs.
- [ ] Intermediate — Some programs exist but are not widely adopted.
- [ ] Advanced — Stakeholder education is integrated and regularly updated

Is there collaboration with NGOs or civil society on ELT awareness?

- [ ] Beginner — No enforcement or compliance mechanisms.
- [ ] Intermediate — Occasional collaboration with limited impact.
- [ ] Advanced — Active partnerships with NGOs and civil society for awareness and advocacy.

Notes / Next steps (ongoing)

Recovery methods

Are multiple recovery routes (reuse, recycling, energy recovery) available?

- [ ] Beginner — Limited or no recovery routes available.
- [ ] Intermediate — Some recovery routes exist but are underutilized.
- [ ] Advanced — Diverse and efficient recovery routes are implemented and optimized.

Notes / Next steps (ongoing)

Are best practices and ESM principles followed in recovery processes?

- [ ] Beginner — No adherence to best practices or ESM principles.
- [ ] Intermediate — Some adherences but lacks consistency or monitoring.
- [ ] Advanced — Recovery processes follow recognized best practices and ESM principles.

Notes / Next steps (ongoing)

Is there innovation or investment in new recovery technologies?

- [ ] Beginner — No innovation or investment in recovery technologies.
- [ ] Intermediate — Some investment but limited scalability or impact.
- [ ] Advanced — Ongoing innovation and investment in scalable recovery technologies.

Notes / Next steps (ongoing)

Data collection

Is ELT data collected regularly and systematically?

- [ ] Beginner — No data collection or ad hoc efforts.
- [ ] Intermediate — Data is collected but lacks standardization or completeness.
- [ ] Advanced — Systematic and standardized data collection is in place.

Notes / Next steps (ongoing)

Is the data used to inform decisions and track progress?

- [ ] Beginner — Data is not used for decision-making.
- [ ] Intermediate — Data is occasionally used but not consistently.
- [ ] Advanced — Data is actively used to guide decisions and monitor performance.

Notes / Next steps (ongoing)

Is data shared transparently with stakeholders?

- [ ] Beginner — Data is not shared or accessible.
- [ ] Intermediate — Some data is shared but lacks transparency.
- [ ] Advanced — Data is shared openly and transparently with all stakeholders.

Notes / Next steps (ongoing)

Template 2: Regulatory assessment for countries without an ELT management scheme

Dimension	Question	Yes No	Recommendation if "No"	Notes / Next Steps
Legal & institutional framework	Is ELT defined as a priority waste stream in national law?	☐ ☐	Initiate legal reform to explicitly define ELT as a priority waste stream.	
	Are roles and responsibilities for all actors clearly assigned?	☐ ☐	Revise legislation to assign clear responsibilities across the value chain.	
	Are waste hierarchy and EPR principles embedded in the framework?	☐ ☐	Integrate waste hierarchy and EPR into your legal framework.	
Financing arrangements	Is there a plan for stable, full-cost financing (e.g., EPR fees, taxes)?	☐ ☐	Design a financing mechanism that covers all costs and ensures sustainability.	
	Are transparency and auditing requirements built into the financing system?	☐ ☐	Mandate regular audits and transparent reporting.	
	Are financial responsibilities distributed fairly among stakeholders?	☐ ☐	Adjust the financing model to ensure equitable cost-sharing.	

Dimension	Question	Yes No	Recommendation if "No"	Notes / Next Steps
Technical & safety standards	Are there clear requirements for safe collection, storage, and transport?	☐ ☐	Develop technical standards and guidelines for safe handling.	
	Are standards for environmentally sound treatment and disposal in place?	☐ ☐	Define quality criteria for recycled materials.	
	Are there specifications for the quality of ELT-derived materials?	☐ ☐	Integrate waste hierarchy and EPR into your legal framework.	
	Are there restrictions (e.g., landfill bans) to steer flows toward recovery?	☐ ☐	Introduce restrictions to discourage disposal and promote recovery.	
Market measures & incentives	Are incentives in place to stimulate demand for recycled products?	☐ ☐	Implement incentives to create stable markets for ELT-derived materials.	
	Is there a balance between regulatory "push" and market "pull" measures?	☐ ☐	Review your policy mix for alignment and effectiveness.	

Dimension	Question	Yes No	Recommendation if "No"	Notes / Next Steps
Monitoring, data & enforcement	Are systems for producer registration, reporting, and tracking established?	☐ ☐	Set up a centralized registry and digital tracking system.	
	Is there capacity for enforcement and addressing illegal dumping?	☐ ☐	Invest in enforcement resources and training.	
	Are data collection and reporting requirements standardized and enforced?	☐ ☐	Mandate standardized data collection	
Inclusion & stakeholder engagement	Are informal collectors and small recyclers integrated into the system?	☐ ☐	Develop pathways for informal actors to participate legally.	
	Are public and private stakeholders actively collaborating?	☐ ☐	Establish multi-stakeholder platforms or working groups.	
	Is there transparent communication and regular consultation?	☐ ☐	Create regular channels for communication and feedback.	

What are your top three recommendations?	

Template 3: ELT management policy effectiveness scorecard

Dimension	1. No or weak performance	2. Emerging	3. Moderate	4. Advanced	5. Leading
Legal and institutional framework	☐ No ELT-specific rules; unclear responsibilities	☐ Basic references in law; weak enforcement	☐ Defined roles but gaps in enforcement or compliance	☐ Structured ELT framework with defined responsibilities and oversight	☐ Comprehensive framework with strong enforcement, aligned with circular economy goals
Notes / Next steps					
Financing arrangements	☐ No financing mechanism; costs externalized	☐ Ad hoc financing; unstable or partial cost recovery	☐ Some producers or consumer fees, but not full coverage	☐ Stable financing via EPR, taxes, or hybrid models; transparent allocation	☐ Full net cost coverage; transparent fees; financial sustainability ensured
Notes / Next steps					
Technical and safety standards	☐ No standards for collection, storage, or treatment	☐ Minimal standards; risks poorly managed	☐ Some standards exist but inconsistently applied	☐ Standards for storage, transport, emissions, and fire prevention widely applied	☐ Comprehensive, up-to-date standards; best available techniques applied
Notes / Next steps					
Market measures and incentives	☐ No recovery markets or incentives	☐ Small/informal markets; limited incentives	☐ Recovery markets exist but are volatile; limited quality standards	☐ Stable end markets supported by standards and procurement; some incentives	☐ Strong demand for ELT-derived products; integrated incentives; circular economy value chains
Notes / Next steps					
Monitoring, data, and enforcement	☐ No data or monitoring; no enforcement	☐ Limited data collection; fragmented reporting; weak enforcement	☐ Some monitoring but incomplete or unreliable; moderate	☐ Regular monitoring and reporting; partial public access; active enforcement	☐ Comprehensive data system with traceability, verification, full transparency; robust enforcement
Notes / Next steps					
Inclusion and stakeholder engagement	☐ No engagement; informal wactors excluded	☐ Occasional engagement; limited inclusion	☐ Some engagement; partial inclusion of stakeholders	☐ Regular engagement; informal actors integrated; multi-stakeholder platforms	☐ Active, inclusive engagement; strong collaboration across all actors
Notes / Next steps					

Template 4: Risk register

Location	Risk Type	Severity (low,medium, high)	Data identified	Action taken	Status	Responsible person/ entity	Notes

How to use:

- Fill in each row for every identified risk (e.g., illegal dumping, fire hazard, vector-borne disease).
- Update "Status" (e.g., Open, In Progress, Closed) and "Action Taken" as you address each risk.
- Use "Notes" for additional context or follow-up.
- Set your country specific definitions, e.g., on how to evaluate high, medium, or low severity.

Template 5: Incident reporting form

Field	Description	Entry
Data of incident	[YYYY-MM-DD]	
Time of incident	[HH:MM]	
Location	[Site, city, GPS coordinates, etc.]	
Reported by	[Name, role, contact details]	
Risk type	[e.g., Fire, Illegal dumping, Pollution, Injury]	
Description of incident	[Brief summary of what happened]	
Severity	[high, medium, low]	
Immediate actions taken	[Describe what was done immediately]	
Status	[open, in progress, closed]	
Responsible person / entity	[Who is following up?]	
Follow - up actions required	[What needs to be done next?]	
Notes	[Additional comments, lessons learned]	

How to use:

- Record every ELT-related incident (e.g., fire, illegal dumping, pollution, injury) as soon as it is discovered, using the form's fields for location, risk type, severity, and actions taken.
- Assign responsibility for follow-up, update the status as actions are completed, and use the notes section to capture lessons learned or additional context.
- Regularly review all submitted forms to identify trends, recurring risks, and opportunities for prevention or system improvement

Template 6: Awareness campaign checklist

Step	Completion status	Notes
Define target audience(s)		
Select communication channels		
Develop key messages		
Identify partners		
Set timeline and metrics for success		
Launch campaign		
Monitor and evaluate impact		
For a more comprehensive guide on designing effective awareness campaigns, refer to this best practice example from **UNEP: Recipe of Change Campaign**		

How to use:

- For each step, note progress, responsible parties, and any key decisions or learnings.
- Add rows as needed for additional steps or campaign-specific action

Template 7: Decision making framework for ELT recovery routes

Step		Key questions	Practical Actions	Tools / Indicators
Step 1	Outcome & side effects	What is the goal? What risks arise?	LCA, EIA, case studies	Material reuse %, emission levels
Step 2	Technical feasibility	Is it possible locally? What infrastructure?	Assess facilities, workforce, utilities	Technical readiness, resource availability
Step 3	Economic viability	Is it profitable? Cost vs benefit?	Cost estimates, revenue projections	Return on investment, cost-benefit ratio
Step 4	Preventive measures	How to mitigate environmental/ health risks?	Standard Operating Procedures, safety equipment, pollution control	Risk assessment matrix, monitoring reports

Template 8: ELT data management checklist

Dimension	Question	Yes No	Recommendation if "No"	Notes / Next Steps
Data collection	Have you identified and engaged all relevant data sources (industry, government, PROs, NGOs, academia, recyclers)?	☐ ☐	Map all potential data holders and initiate formal requests or partnerships to access their data.	
	Are data collection and reporting procedures standardized?	☐ ☐	Develop and implement a standardized data template and clear definitions for all data fields; provide training to all contributors.	
	Is data regularly updated and scheduled for review?	☐ ☐	Set up a regular data collection calendar (e.g., quarterly, or annually) and assign responsibility for updates.	
Data cleaning	Is data checked for errors, inconsistencies, or outliers?	☐ ☐	Establish a routine data cleaning process using automated tools or manual review; document and correct errors.	
	Are formats and units harmonized across sources?	☐ ☐	Convert all data to common units and formats before consolidation; provide a conversion guide if needed.	

Dimension	Question	Yes No	Recommendation if "No"	Notes / Next Steps
Data Transformation	Are definitions and categories harmonized?	☐ ☐	Align all data with international standards (e.g., EPR, recovery route definitions) and update legacy data as needed.	
	Is data aggregated and categorized for analysis?	☐ ☐	Group data by relevant dimensions (region, recovery route, stakeholder) and use pivot tables or dashboards for analysis.	

Dimension	Question	Yes No	Recommendation if "No"	Notes / Next Steps
Data validation	Is data cross-checked with independent sources?	☐ ☐	Validate key figures with alternative datasets, stakeholder interviews, or third-party audits.	
	Are assumptions and estimates clearly documented?	☐ ☐	Add a "methodology" section to your data report, listing all assumptions, models, and confidence levels.	

Dimension	Question	Yes No	Recommendation if "No"	Notes / Next Steps
Data consolidation	Is data merged, de-duplicated, and stored in a structured repository?	☐ ☐	Use a central database or cloud repository with access controls and version history.	
Reporting	Are key indicators and trends reported transparently to stakeholders?	☐ ☐	Publish regular data reports or dashboards and share them with all relevant audiences (internal and external).	
Continuous improvement	Is there a process for continuous improvement and stakeholder feedback?	☐ ☐	Set up a feedback loop (e.g., annual review meeting, online form) to gather suggestions and update processes.	

Template 9: ELT data collection structure (example)

Category	Data points (tons)	Description
Generation & sales	Total ELT arising	Total amount of End-of-Life Tires (ELTs) generated annually within the country/region.
	Total tires sold	Total quantity of tires sold to the replacement market within the country/region.
Management by hierarchy	Material recovery	ELTs repurposed into new products (e.g., through shredding, granulation, devulcanization, etc.).
	Civil engineering & backfilling	ELTs used in civil engineering or land reclamation projects.
	Recovery hybrid	ELTs processed through thermal rec
	Energy recovery	ELTs used as substitute fuel (e.g., in furnaces or combustion).
	Disposal – Landfill	ELTs used as substitute fuel (e.g., in furnaces or combustion).
	Disposal – Incineration	ELTs burned without energy recovery.
	Other	Any other ELT management route not listed above.

Glossary

Glossary

Term	Definition
Ambient milling	A process where rubber is granulated and sieved at ambient temperatures and separated into granulates and powders.
Cement kilns	An industrial equipment used for the thermal processing stage of manufacture of cement.
Char	A solid carbonaceous residue formed during carbonization of organic compounds. The residue is formed via polymer decomposition and coking reactions during the pyrolysis of rubber goods, a process during which the organic components are thermally cracked and recovered predominantly as gas and oil products. A portion of this organic matter additionally cokes in-situ, creating carbonaceous residue. This carbonaceous residue can form on the surface of the fillers in the rubber article and in the reactor. The amount formed is highly process dependent. In the absence of mechanical post treatment, char has low commercial value.
Chemical recycling	A process which converts polymeric waste by changing its chemical structure to produce substances that are used as products or as raw materials for the manufacturing of products. Products exclude those used as fuels or means to generate energy.
Circular economy	An economic system that uses a systemic approach to maintain a circular flow of resources, by recovering, retaining or adding to their value, while contributing to sustainable development.
Closed loop recycling	A resource flow model which uses ELT-derived secondary raw materials, such as rubber compounds, to manufacture components for new tires.
Combustion	An energy recovery method for ELT tires. ELT is utilized as fuel in boilers or kilns to maximize energy recovery.
Cryogenic milling	A technology for processing materials at very low temperatures. It is commonly used to embrittle rubber producing pulverized tires or rubber powder.
Devulcanization	A process of reversing rubber vulcanization by breaking or modifying cross-links between rubber molecules, typically sulfur-based, to make the rubber reusable. Methods include thermal (using heat), chemical (using agents like thiols), mechanical (using shear forces), ultrasound (using high-frequency sound waves), and microbial (using microorganisms). It aims to restore rubber to a virgin-like state for reuse.
Eco-organization	An Eco-organization can be understood as a non-profit organization designated by the French Ministry of the Environment to manage the collection, recycling, and recovery of specific waste streams under the EPR framework. These organizations are responsible for implementing and overseeing the recycling systems for various product categories, such as textiles, packaging, and electronics. They operate under a public service delegation model and ensure that producers comply with their obligations to reduce the environmental impact of their products at the end of their life cycle.
Electric arc furnace	A method where scrap metal is introduced into an electric arc furnace, followed by tires (shredded or whole), to convert carbon monoxide gas into carbon dioxide in the furnace. Carbon dioxide, in turn, is often used in steelworks.
Energy recovery from ELT	A process that involves extracting the fuel or heat value from whole or processed tires through combustion.
Gasification of rubber	A method where chemical or heat processes are used to convert rubber into gas.
Granulation	A recovery method which involves breaking down ELTs into increasingly smaller pieces, down to fine particles through different processes to obtain rubber granulate and powder. In the process, textiles and metals are separated from the rubber.
Incineration	A process that involves reducing combustible wastes, such as scrap tires, to inert residue through controlled high-temperature process. Incineration does not lead to energy recovery.
Landfilling	A disposal method involving the final depositing of solid waste at, below or above ground level at engineered disposal sites, excluding uncontrolled waste disposal such as open burning and dumping.

Term	Definition
Material recycling / recovery	A process in which ELTs are recovered as new materials.
Mechanical recycling of ELT	A process in which ELTs are shredded and processed into materials such as crumb rubber and rubber powder, which can be used in construction (e.g., rubberized asphalt), consumer and industrial products.
Open loop recycling	A resource flow model which utilizes ELT-derived secondary raw materials for non-tire applications across various sectors, such as construction, public works, automotive components, and consumer goods.
Pyrolysis of ELT	A thermochemical decomposition process, occurring in the absence of oxygen, that breaks down waste such as tires at end of life through high-temperature heating (400-700°C) to produce high-quality raw materials.
Reclamation of rubber	A process where scrap rubber is treated to recover its original plasticity and flexibility. Unlike devulcanization, reclamation does not fully reverse vulcanization but rather involves softening rubber through heat and mechanical action and to partially break down the rubber matrix with chemicals.
Recovered carbon black (rCB)	A material obtained by the pyrolysis of ELT rubber for tire-to-tire closed loop applications. A mix of carbon blacks derived from the tire and ash (silica, ZnO, etc.), the material is semi-reinforcing and used as a filler to enhance the properties of rubber in tire formulations. As a filler, the overall quality is lower than that of sustainable carbon black (see definition of TPO-based carbon black below).
Recycling	A method that involves the reprocessing of articles such as ELT to produce products, materials, or substances. This excludes the production of tire-derived fuel, which converts scrap tires into energy.
Regrooving	A technique that consists of cutting a pattern into the tire's base rubber to extend the duration of its use.
Repair	A process aimed at extending a tire's lifetime by repairing punctures or other damage.
Retreading	A process of reconditioning/refurbishing a used tire by replacing the worn tread with a new tread material, which can also include renovation of the outermost sidewall surface and replacement of the crown plies or the protective breaker.
Reuse	Any operation where products or components that are not waste are used again for the same purpose for which they were created. This is a key waste prevention practice, a priority over recycling in the waste hierarchy, because it means the materials never become waste in the first place. In the case of tires, reuse involves remounting a used tire that is still fit for safe use on a vehicle or is made fit for continued use following repair, regrooving and/or retreading.
Rubber powder	A material known as micronized rubber powder (MRP) composed of dry powdered rubber particles, usually smaller than 1000µm.
Shredding	A recovery method which involves cutting ELTs into pieces ranging typically from 5 to 30 cm across.
TPO-based carbon black	A material produced from tire pyrolysis oil, or TPO, characterized by properties and performances like those of virgin carbon black. Sustainable carbon black (s-CB), a related form, is produced from distillated tire pyrolysis oil, and is considered "sustainable" because it is an equivalent substitute for carbon black produced from virgin fossil fuel feedstock, having the same properties. Both are used as a filler to reinforce the properties of rubber in tire formulations.
Waste	A term describing objects or substances that are discarded, intended for disposal, or mandated to be discarded, often due to lack of utility or necessity.

About the Tire Industry Project

About the Tire Industry Project

Formed in 2005, the Tire Industry Project (TIP) is the tire industry's primary global forum on sustainability topics. Operating under the umbrella of the World Business Council for Sustainable Development (WBCSD), TIP is a voluntary CEO-led initiative that brings together 10 leading tire companies, representing more than 60% of the world's tire-manufacturing capacity (Tire Industry Project, 2021).

In 2025, TIP marked its 20th anniversary—a milestone that reflects its long-term commitment to advancing scientific knowledge and fostering collective industry action to improve sustainability across the tire value chain. For more information, visit **The Tire Industry Project**.

TIP aims to be a leading and trusted source of knowledge on the potential human and environmental impacts of tires through their life cycle and proactively drives research to where it is most relevant and where findings can have the most impact (Tire Industry Project, 2021).

TIP works on a range of topics relevant to the key stages of the life cycle of tires: from the sourcing of raw materials, through the manufacturing and use phases, to the management of ELT.

Figure 4: TIP members (status: 02.2026)

Figure 5: TIP affiliate members (status: 09.2025)

Disclaimer: TIP is committed to advancing research that enhances the understanding of ELT management as tire recovery technologies continue to evolve. Future research will focus on evaluating recovery technologies in the context of ESM principles to more concretely define or quantify benefits and challenges. TIP continues to collaborate closely with stakeholders across the value chain to foster innovation and support informed decision-making.

References

References

Aliapur. (n.d.). What is Aliapur? Retrieved from Aliapur: **https://www.aliapur.fr/en/new/1-what-is-aliapur.html#**

Arbeitsschutzgesetz (ArbSchG). (n.d.). Retrieved from Bundesamt für Justiz: **https://www.gesetze-im-internet.de/arbschg/index.html**

Baidya, R., Ghosh, S., & Parlikar, U. (2017). Sustainability of cement kiln co-processing of wastes in India: a pilot study. Environmental Technology, 38(13-14), 1650-1659. doi:**https://doi.org/10.1080/09593330.2017.1293738**

Barišić, I., Zvonarić, M., Netinger Grubeša, I., & Šurdonja, S. (2021). Recycling waste rubber tyres in road construction. Archives of Civil Engineering 2021/67/1, Vol. LXVII, 499–512. doi:**https://doi.org/10.24425/ace.2021.136485**

Basel Convention. (2014). Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. Retrieved from **https://www.basel.int/portals/4/basel%20convention/docs/text/baselconventiontext-e.pdf**

Basel Convention. (2022). Technical guidelines. Retrieved from **https://www.basel.int/Implementation/Wastetyres/Technicalguidelines/tabid/9423/Default.aspx**

Basel Convention. (n.d.). Environmentally sound management (ESM) toolkit. Retrieved from Basel Convention: **https://www.basel.int/Implementation/CountryLedInitiative/EnvironmentallySoundManagement/ESMToolkit/Overview/tabid/5839/Default.aspx**

Batuecas, E., Serrano, D., Horvat, A., & Abelha, P. (2023). Sustainable conditions for waste tires recycling through gasification in a bubbling fluidized bed. Journal of Cleaner Production, 415, 137839. doi:**https://doi.org/10.1016/j.jclepro.2023.137839**

Bolsa Verde do Rio de Janeiro (BVRio). (n.d.). Developing the Reverse Logistics Credits system. Retrieved from BVRio: **https://www.bvrio.org/reverse-logistics-credits/#**

Bünemann, A., Brinkmann, J., Dr. Löhle, S., & Bartnik, S. (2020). How Germany's EPR system for packaging waste went from a single PRO to multiple PROs with a register. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH PREVENT Waste Alliance. Retrieved from **https://prevent-waste.net/wp-content/uploads/2023/06/Germany.pdf**

Buttlar, W., & Rath, P. (2021). State of knowledge report on rubber modified asphalt. Retrieved from **https://www.ustires.org/sites/default/files/2024-03/Rubber-Modified-Asphalt_5-27-2021-FINAL.pdf**

Chien, Y., Ton, S., Lee, M., Chia, T., Shu, H., & Wu, Y. (2003). Assessment of occupational health hazards in scrap-tire shredding facilities. The Science of the Total Environment, 309(1–3), 35–46. doi:**https://doi.org/10.1016/s0048-9697(03)00009-3**

Clean Air Conservation Act. (1990). Clean Air Conservation Act. Retrieved from **https://importlicensing.wto.org/sites/default/files/members/78/Clean%20Air%20Conservation%20Act_01.08.1990.pdf**

Councell, T. B., Duckenfield, K. U., Landa, E. R., & Callender, E. (2004). Tire-Wear particles as a source of zinc to the environment. Environmental Science & Technology, 38(15), 4206–4214. doi:**https://doi.org/10.1021/es034631f**

Croatian Parliament. (2013, July 18). Act on Sustainable Waste Management. Retrieved from **https://mingo.gov.hr/UserDocsImages/NASLOVNE%20FOTOGRAFIJE%20I%20KORI%C5%A0TENI%20LOGOTIPOVI/doc/act_on_sustainable_waste_management.pdf**

Da Silva, R. J., Vitor Chaves S. G. Francisco, R., & Oliveira Lopes, A. (2017). Co-processing of Scrap Tires and Waste from the Re-refining of Used Lube Oil in Cement Kilns. International Journal of Engineering and Applied Sciences (IJEAS), 4, 1-4. Retrieved from **https://www.ijeas.org/download_data/IJEAS0406001.pdf**

Dabic-Miletic, S., Simic, V., & Karagoz, S. (2021). End-of-life tire management: a critical review. Environmental Science and Pollution Research, 28(48), 68053–68070. doi:**https://doi.org/10.1007/s11356-021-16263-6**

De Oliveira Neto, G., Carvalho Chaves, L., Rodrigues Pinto, L., Curvelo Santana, J., Castro Amorim, M., & Ferreira Rodrigues, M. (2019). Economic, Environmental and Social Benefits of Adoption of Pyrolysis Process of Tires: A Feasible and Ecofriendly Mode to Reduce the Impacts of Scrap Tires in Brazil. Sustainability, 11(7), 1-18. doi:**https://doi.org/10.3390/su11072076**

Directorate-General for Environment. (2023, March 20). Waste shipments: Report shows increase in quantity and more detections of illegal shipments . Retrieved from European Commission: **https://environment.ec.europa.eu/news/waste-shipment-regulation-report-2023-03-20_en#**

Donnelly, K. (2025, July 10). Environmental impact of tire recycling: Complete benefits analysis for sustainable waste management. Retrieved from Gradeall: **https://gradeall.com/environmental-impact-tire-recycling-benefits-analysis/#**

Downard, J., Singh, A., Bullard, R., Jayarathne, T., Rathnayake, C. M., Simmons, D. L., . . . Stone, E. A. (2014). Uncontrolled combustion of shredded tires in a landfill – Part 1: Characterization of gaseous and particulate emissions. Atmospheric Environment, 104, 195–204. doi:**https://doi.org/10.1016/j.atmosenv.2014.12.059**

Ecopneus. (2023, May 29). The circular economy of End-of-Life Tyres in Italy between opportunities and future challenges. Retrieved from Ecnopneus: **https://www.ecopneus.it/en/news-en/the-circular-economy-of-end-of-life-tyres-in-italy-between-opportunities-and-future-challenges/**

Ecopneus. (n.d.). Second life of ELT- Material recovery. Retrieved from **https://www.ecopneus.it/_public-file/03B_Second%20life%20of%20ELT-%20Material%20recovery.pdf**

EcoTyre. (n.d.). Legal Framework. Retrieved from EcoTyre L´Economia Circolare dei PFU: **https://www.ecotyre.it/en/elt-management/regulations#**

Environment, Climate, Energy and Agriculture Authority. (n.d.). Waste and disposal - electronic waste detection procedure (eANV). Retrieved from hamburg.com: **https://www.hamburg.com/publicservice/info/11927312#**

Environmental Protection and Energy Efficiency Fund. (n.d.). Waste tyres. Retrieved from Environmental Protection and Energy Efficiency Fund: **https://www.fzoeu.hr/en/waste-tyres/7749#**

Ernst & Young. (2016). The socio-economic impact of truck tyre retreading in Europe: The circular economy of tyres in danger. Retrieved from **https://www.etrma.org/wp-content/uploads/2019/09/201611-ey_retreading_lr.pdf**

European Climate, Infrastructure and Environment Executive Agency. (2023, December 14). LIFE project aims to revolutionise Europe's approach to recycling end-of-life tyres. Retrieved from European Commission: **https://cinea.ec.europa.eu/news-events/news/life-project-aims-revolutionise-europes-approach-recycling-end-life-tyres-2023-12-14_en#**

European Commission. (2023, May 12). Zero pollution: Commission consults citizens and stakeholders on the "polluter pays" principle. Retrieved from **https://environment.ec.europa.eu/news/zero-pollution-commission-consults-citizens-and-stakeholders-polluter-pays-principle-2023-05-12_en#**

European Commission. (n.d.). Environmental Protection and Energy Efficiency Fund. Retrieved from **https://clean-energy-islands.ec.europa.eu/supporting-organisations/environmental-protection-and-energy-efficiency-fund#**

European Environment Agency. (2024, April 16). Leachate pollution from landfills (Signal). Retrieved from **https://www.eea.europa.eu/en/european-zero-pollution-dashboards/indicators/emission-from-waste-management-facilities#**

European Parliament and Council. (1999). Council Directive 1999/31/EC on the landfill of waste. L182. Official Journal of the European Communities. Retrieved from **https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31999L0031**

European Tyre and Rubber Manufacturing Association. (2024, March 13). New End-of-Life Tyres statistics for 2020 and 2021. Retrieved from Tyres Europe: **https://tyreseurope.org/new-end-of-life-tyres-statistics-for-2020-and-2021/**

Fidalgo, J., & Marcilio, F. (2024, September 12). Reverse Logistics: Brazilian legislation and how to implement it. Retrieved from KLA Advogados: **https://klalaw.com.br/en/reverse-logistics-brazilian-legislation-how-implement/#**

Global Recycling. (2025). Tire Recycling Business in Germany: A Billion-Euro Industry Paving the Way to Climate Neutrality. Retrieved from **https://global-recycling.info/archives/10418#**

Han, B., Kumar, D., Pei, Y., Norton, M., Adams, S. D., Khoo, S. Y., & Kouzani, A. Z. (2024a). Sustainable transformation of end-of-life tyres into value-added products using thermochemical processes. Carbon Research, 3, 73. doi:**https://doi.org/10.1007/s44246-024-00167-4**

Han, C., Jang, M., Yoon , J., Lee, B., Kim , J., Jang , H., & Benmarhnia , T. (2024b). Estimating the Acute Health Effects of Smoke Exposure from an Urban Factory Fire Accident: A Case Study of a Tire Factory Fire in Korea. Environmental Health Perspectives, 132(8), 87008. doi:**https://doi.org/10.1289/ehp14115**

Hankook Tire. (2019). Technical Manual Regrooving Guide. Retrieved from **https://www.hankooktire.com/content/dam/hankooktire/local/pdf/tbr-support/technical-manual/nl/2019_Technical_Manual_Regrooving_Guide.pdf**

Hashamfirooz, M., Dehghani, M., Mohammad, K., Mina, A., Parnia, B., Mohammad Sadegh, H., . . . Momeniha, F. (2025). A systematic review of the environmental and health effects of waste tires recycling. Heliyon 11, e41909, 1-14. doi:**https://doi.org/10.1016/j.heliyon.2025.e41909**

Health and Safety at Work Act 2015. (2015). Retrieved from New Zealand Legislation: **https://www.legislation.govt.nz/act/public/2015/0070/latest/DLM5976914.html**

Huayin. (n.d.). What is the use of the tire pyrolysis oil. Retrieved from **https://huayinre.com/what-is-the-use-of-tire-pyrolysis-oil/**

Infiniteria. (n.d.). Pyrolysis Oil. Retrieved from **https://infiniteria.com/pyrolysis-oil/**

Intergovernmental Panel on Climate Change (IPCC). (2019). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Retrieved from **https://beta.ghg.inergy.vn/upload/others/2025/03/27/19R_V5_IPCC%202019_Waste_B%E1%BA%A3n%20%C4%91%E1%BA%A7y%20%C4%91%E1%BB%A7-94ef79b7-a22f-4339-8c0c-36763a149144.pdf**

International Organization for Standardization (ISO). (2024). Title of standard (ISO 59004). Retrieved from **https://www.iso.org/obp/ui/en/#iso**:std:iso:59004:ed-1:v1:en

International Organization for Standardization. (2008). Plastics — Guidelines for the recovery and recycling of plastics waste (ISO 15270:2008). Retrieved from **https://www.iso.org/standard/45089.html**

International Organization for Standardization. (2015). Plastics — Guidelines for the recovery and recycling of plastics waste (ISO 14001:2015). Retrieved from **https://www.iso.org/standard/60857.html**

International Organization for Standardization. (2024). Circular economy — Vocabulary, principles and guidance for implementation (ISO 59004:2024). Retrieved from **https://www.iso.org/standard/80648.html**

Kain, J., Zapata, P., & Campos, M. J. (2021). Inclusive and sustainable waste governance: Strengthening innovative linkages between local governments and waste picker organizations. Swedish International Centre for Local Democracy. Retrieved from **https://icld.se/wp-content/uploads/media/icld_policybrief_17_web.pdf**

Kaur, R. (2024, February 22). Why are waste tyres a growing environmental concern? Retrieved from Mongabay-India: **https://india.mongabay.com/2024/02/explainer-why-are-waste-tyres-a-growing-environmental-concern/#**

Khan, W., Shyamal, D., & Kazmi, A. (2024). Management of end-of-life tyres in India: current practices, regulatory framework, challenges, and opportunities. Journal of Material Cycles and Waste Management 26.3, 26(3), 1310-1325. doi:**https://doi.org/10.1007/s10163-024-01937-3**

Kharrati, K. (2025, November 16). India Tire Recycling Market 2024–2033. Retrieved from Custom Market Insights: **https://www.custommarketinsights.com/report/india-tire-recycling-market/**

Kim, J. (2012). Extended producer responsibility (EPR) and job creation in Korea. WIT Transactions on Ecology and the Environment, 1, 75–82. Retrieved from **https://doi.org/10.2495/wm120071**

Klean Industries. (2025, Februrary 24). Setting Up a Tyre Pyrolysis Recycling Business In India. Retrieved from Klean Industries: **https://kleanindustries.com/insights/market-analysis-reports/setting-up-tyre-pyrolysis-recycling-business-india-equipment-for-sale/#**

Klean Industries. (n.d.). Joint development: Implementing Klean Industries' advanced tire pyrolysis technology in Japan with Life 4 Tyres (L4T). Retrieved from Klean Industries: **https://kleanindustries.com/projects/tire-pyrolysis/life-for-tyres-japan/**

Korea Environment Corporation. (n.d.). Operation of Allbaro System. Retrieved from Korea Environment Corporation: **https://www.keco.or.kr/en/lay1/S295T387C403/contents.do#**

Korea Herald. (2024, June 19). LD Carbon Closes $28M Investment to Scale Production of Sustainable Carbon Black and Pyrolysis Oil. Retrieved from The Korea Herald: **https://www.koreaherald.com/article/3416129#**

Lee, S. (2024). Sustainable Recycling of End-of-Life Tires. Korea Institute for Industrial Economics and Trade Research Paper No. 24/IER/29/02/03, 30-38. doi:**https://doi.org/10.2139/ssrn.4868495**

Lilley, Z. (2024, September 06). How should you dispose of used tyres in France? Retrieved from The Connexion: **https://www.connexionfrance.com/practical/how-should-you-dispose-of-used-tyres-in-france/677223**

Machin, E. B., Travieso Pedroso, D., & Andrade de Carvalho Jr., J. (2016). Energetic valorization of waste tires. Renewable and Sustainable Energy Reviews 69, 68, 306-315. doi:**https://doi.org/10.1016/j.rser.2016.09.110**

Malekiha, M., & Hajiahmad, M. (2015). Waste Tire as an Alternative Fuel of Cement Production Process in Iran. Climate Technology Centre and Network. Retrieved from **https://www.ctc-n.org/resources/waste-tire-alternative-fuel-cement-production-process-iran**

Mentes, D., Tóth, C. E., Nagy, G., Muránszky, G., & Póliska, C. (2022). Investigation of gaseous and solid pollutants emitted from waste tire combustion at different temperatures. Waste Management, 149, 302–312. doi:**https://doi.org/10.1016/j.wasman.2022.06.027**

Ministry for the Environment. (2024, March 01). Regulations supporting tyre product stewardship. Retrieved from **https://environment.govt.nz/acts-and-regulations/regulations/regulations-supporting-tyre-product-stewardship/#**

Molla, A., Shams, H., Harun, Z., Che Kasim, A., Manoj Kumar, N., & Ab Rahman, M. (2023). Evaluation of end-of-life vehicle recycling system in India in responding to the sustainability paradigm: An explorative study. Scientific Reports, 13(1), 4169. doi:**https://doi.org/10.1038/s41598-023-30964-7**

Murphy, C. (2025, July 9). French Tyre Recycling: Leading Europe's Circular Economy Revolution. Retrieved from Gradeall: **https://gradeall.com/french-tyre-recycling/**

Nakomcic-Smaragdakis, B., Cepic, Z., Senk, N., Doric, J., & Radovanovic, L. (2016). Use of scrap tires in cement production and their impact on nitrogen and sulfur oxides emissions. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 38(4), 485-493. doi:**https://doi.org/10.1080/15567036.2013.787473**

Narra, M., Agboka, K., Narra, S., & Nelles, M. (2025). Implementing extended producer responsibility for tyre waste in Togo: a circular economy perspective. Frontiers in Sustainability, 6. doi:**https://doi.org/10.3389/frsus.2025.1631139**

New Life. (2022, September 05). New Life. Retrieved from **https://initiative-new-life.de/en/press-and-media/sustainable-raw-material-with-a-future-recycled-rubber-granulate-from-old-tyres-elt/#**

New Zealand Government. (2020, July 29). Government to regulate environmentally harmful plastic packaging, tyres, e-waste. Retrieved from **Beehive.govt.nz: https://www.beehive.govt.nz/release/government-regulate-environmentally-harmful-plastic-packaging-tyres-e-waste#**

Nokian Tyres. (2024, May 3). How are tires made: The tire manufacturing process. Retrieved from **https://www.nokiantyres.com/tips/choosing-your-tires/how-are-tires-made/**

Oboirien, B., & North, B. (2017). A review of waste tyre gasification. Journal of Environmental Chemical Engineering, 5(5), 5169–5178. doi:**https://doi.org/10.1016/j.jece.2017.09.057**

OECD. (2016). Extended Producer Responsibility: Updated Guidance for Efficient Waste Management. OECD. Retrieved from **http://dx.doi.org/10.1787/9789264256385-en**

Okonkwo, F. O., Njan, A. A., Ejike, C. E., Nwodo, U. U., & Onwurah, I. N. (2018). Health Implications of Occupational Exposure of Butchers to Emissions from Burning Tyres. Annals of Global Health, 84(3), 387–396. doi:**https://doi.org/10.29024/aogh.2321**

Oliveira, M., Arantes de Oliveira, E., & Fonseca, A. (2021). Strategies to promote circular economy in the management of construction and demolition waste at the regional level: a case study in Manaus, Brazil. Clean Technologies and Environmental Policy 23.9, 23(9), 2713-2725. doi:**https://doi.org/10.1007/s10098-021-02197-7**

Padilla, L., Díaz, Á., & Anzules, W. (2025). Eco-management of end-of-life tires: Advances and challenges for the Ecuadorian case. Waste Management & Research 43.2, 181-191. doi:**https://doi.org/10.1177/0734242x241237104**

Palermo, A., Tasalloti, A., Chiaro, G., Granello, G., Banasiak, L., & Rees, S. (2020, October 10). Sustainable recycling of end-of-life tyres in civil (geotechnical) engineering applications. Retrieved from New Zealand Geotechnical Society: **https://www.nzgs.org/libraries/sustainable-recycling-of-end-of-life-tyres-in-civil-geotechnical-engineering-applications/**

Pan, D., Jiang, W., Guo, R., Huang, Y., & Pan, W. (2021). Thermogravimetric and kinetic analysis of Co-Combustion of waste tires and coal blends. ACS Omega, 6(8), 5479–5484. doi:**https://doi.org/10.1021/acsomega.0c05768**

Pereira, R. J., dos Santos de Sousa Teodósio, A., & Viegas da Costa, D. (2025). From useless to valued: Social enterprises in tire recycling. Revista Pensamento Contemporâneo em Administração, 19(2), 1-18. doi:**https://doi.org/10.12712/rpca.v.192.68192**

Quantum Leap Corp. (2025, September 24). Japan End-of-life Tire (ELT) Management Market Size By Application 2025. Retrieved from LinkedIn: **https://www.linkedin.com/pulse/japan-end-of-life-tire-elt-management-market-size-application-s9jzc/**

Recycling Europe. (2022). Mechanical Tyre Recycling Factsheet. Retrieved from **https://euric.org/resource-hub/reports-studies/mechanical-tyre-recycling-factsheet**

Renew Tire Recycle. (n.d.). Tire-Derived Fuel: A Smart Business Choice. Retrieved from **https://www.renewtire.com/tire-derived-fuel/**

Rubberman. (2025, August 4). Choosing Retreaded Truck Tires? A Guide to Quality & Efficiency. Retrieved from **https://rubbermanindonesia.com/choosing-retreaded-truck-tires-a-guide-to-quality-efficiency/**

Salvadori. (n.d.). Andrea Pitto, Salvadori Sales Manager, outlines the importance of mining tire recycling. Retrieved from Salvadori: **https://www.salvadori.com/blog/andrea-pitto-salvadori-sales-manager-outlines-the-importance-of-mining-tire-recycling/#**

Schwab, S. T., Nelson, T. F., & Mecking, S. (2024). Chemically recyclable and biodegradable vulcanized rubber. ACS Sustainable Chemistry & Engineering, 12(16), 6281–6288. doi:**https://doi.org/10.1021/acssuschemeng.3c08435**

Secretariat of the Pacific Regional Environment Programme (SPREP). (2022, February). End of Life Tyre Management: Thermal Processing Options. Retrieved from Green Policy Platform: **https://www.greenpolicyplatform.org/research/end-life-tyre-management-thermal-processing-options**

Shetkar, R. (2023, April 20). Germany End-of-Life (ELT) Management Market Forecast 2023-2030. Retrieved from **https://hackmd.io/**@yBcmRaVnTpC8hSmfv-uglw/S1odiYRf2

Silva, C. M., Maganinho, C., Mendes, A., Rocha, J., Portugal, I., & Silva, C. M. (2025). Recovered carbon black: A comprehensive review of activation, demineralization, and incorporation in rubber matrices. Carbon Resources Conversion, 100334. doi:**https://doi.org/10.1016/j.crcon.2025.100334**

Speirs, K. (2012, March 14). Tyrewise funding. Retrieved from Tyrewise: **https://www.tyrewise.co.nz/tyrewise/#**

Speirs, K. (2025, March 11). MIlestone 1: New Zealand's first tyre recycling scheme exceeds expectations. Retrieved from Tyrewise: **https://www.tyrewise.co.nz/new-zealands-first-tyre-recycling-scheme-exceeds-expectations/#**

Stockholm Convention. (n.d.). Updated general technical guidelines for the environmentally sound management (ESM) of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs). Retrieved from **https://chm.pops.int/Portals/0/Repository/IMPL1/UNEP-POPS-IMPL.1-REL-3.English.PDF**

Sundaram, R. (2025, January 10). Environment Protection (End-Of-Life Vehicles) Rules, 2025 : Towards A Sustainable Automotive Future. Retrieved from mondaq: **https://www.mondaq.com/india/waste-management/1567392/environment-protection-end-of-life-vehicles-rules-2025-towards-a-sustainable-automotive-future#**

The Japan Automobile Tyre Manufacturers Association, Inc. (n.d.). End of Life Tyres(ELT). Retrieved from The Japan Automobile Tyre Manufacturers Association, Inc.: **https://www.jatma.or.jp/english/environment_recycle/tyrerecycling.html#CurrentStatusonELT**

Thives , L., Ghisi, E., & Thives Júnior, J. (2022). Assessment of disposal and recycling of waste tyres in Brazil. Ciência e Natura, 44(e11), 1-23. doi:**https://doi.org/10.5902/2179460x68822**

Tire Industry Project. (2010). End-of-Life Tires: A framework for effective management systems. Retrieved from **https://www.wbcsd.org/resources/end-of-life-tires-a-framework-for-effective-management-systems/**

Tire Industry Project. (2019). Global ELT Management – A global state of knowledge on regulation, management systems, impacts of recovery and technologies. World Business Council for Sustainable Development. Retrieved from **https://docs.wbcsd.org/2019/12/Global_ELT_Management%E2%80%93A_global_state_of_knowledge_on_regulation_management_systems_impacts_of_recovery_and_technologies.pdf**

Tire Industry Project. (2021). End-of-life tire (ELT) management Toolkit. Retrieved from **https://tireindustryproject.org/wp-content/uploads/2023/09/WBCSD_TIP_End-of-Life-Tire-Management-Toolkit-FINAL-v9-2.pdf**

Tire Industry Project. (2023). Perspectives on End-of-Life Tire (ELT) Management: Challenges and potential solutions in the US, Europe and China. Retrieved from **https://tireindustryproject.org/wp-content/uploads/2023/08/WBCSD_TIP_Perpectives-End-of-Life-Tire-Management_ELT_tires_sustainability.pdf**

Tire Industry Project. (2024). Sustainability Driven: KPIs for the Tire Sector 2019-2023. Retrieved from **https://www.consultdss.com/4adebc/globalassets/assets/documents/ar-tip-report.pdf**

Tire Industry Project. (2025, October). Latest KPI report demonstrates significant progress made by Tire Industry Project member companies between 2021-2024. Retrieved from **https://tireindustryproject.org/news/latest-kpi-report-demonstrates-significant-progress-made-by-tire-industry-project-member-companies-between-2021-2024/**

Tire Retread & Repair Information Bureau. (n.d.). Environmental benefits of retreading. Retrieved from **https://www.retread.org/environmental-benefits-of-retreading**

Trentinella, T. (2014). EPR in Brazil and sectoral agreements: Developments and critique. The Sustainable City IX. 191, pp. 1347-1355. WIT Press. doi:**https://doi.org/10.2495/SC141132**

TUEV Sued. (2022, December). FRANCE: France publishes the specifications of eco-organizations and individual systems for the EPR sector of textiles, footwear, and household linen. Retrieved from TUEV Sued: **https://www.tuvsud.com/en-us/e-ssentials-newsletter/consumer-products-and-retail-essentials/e-ssentials-16-2022/france-publishes-the-specifications-of-eco-organizations-and-individual-systems-for-the-epr-sector**

Tyrewise. (2020). Regulated Product Stewardship for End-of-Life Tyres "Tyrewise 2.0". Retrieved from **https://www.tyrewise.co.nz/wp-content/uploads/2022/07/Tyrewise-2.0-Master-Report-Final-Released-22July2020-with-disclaimer.pdf**

Tyrewise. (2024). Scheme Manager Report. Retrieved from **https://www.tyrewise.co.nz/wp-content/uploads/2024/12/Operational-Delivery-Plan-Scheme-Manager-Report-Milestone-01_for-release_web.pdf**

Umwelt Bundesamt. (2014, January 22). End-of-life-vehicles. Retrieved from **https://www.umweltbundesamt.de/en/topics/waste-resources/product-stewardship-waste-management/end-of-life-vehicles#end-of-life-vehicles-in-germany**

United Nations Department of Economic and Social Affairs. (2015, September). Sustainability development goals. Retrieved from The 17 goals: **https://sdgs.un.org/goals**

United Nations Economic and Social Commission for Asia and the Pacific. (2021, July 19). 10 principles to create inclusive waste management systems and reduce marine plastic pollution. Retrieved from **https://www.unescap.org/blog/10-principles-create-inclusive-waste-management-systems-and-reduce-marine-plastic-pollution**

United Nations Environment Programme. (n.d.). Gender and Waste management. Retrieved from **https://www.unep.org/ietc/what-we-do/gendehttps**://www.unep.org/ietc/what-we-do/**gender-and-waste-management#**

Valentini, F., & Pegoretti, A. (2022). End-of-life options of tyres. A review. Advanced Industrial and Engineering Polymer Research , 5(4), 203-2013. doi:**https://doi.org/10.1016/j.aiepr.2022.08.006**

Vilella, M., & Arribas, C. (n.d.). Cement, waste and carbon markets Problems related to waste incineration in cement kilns under the EU ETS. European Commission.

Wagner, J., Steinmetzer, S., Theophil, L., Strues, A.-S., Kösegi, N., & Dr. Hoyer, S. (2022). Evaluation der Erfassung und Verwertung ausgewählter Abfallströme zur Fortentwicklung der Kreislaufwirtschaft. Umweltbundesamt.

Wang, S., Cheng, M., Xie, M., Yang, Y., Liu, T., Zhou, T., . . . Li, B. (2025). From waste to energy: Comprehensive understanding of the thermal-chemical utilization techniques for waste tire recycling. Renewable and Sustainable Energy Reviews, 211, 115354. doi:**https://doi.org/10.1016/j.rser.2025.115354**

Weibold. (2022, August 02). India expands EPR Scheme to include end-of-life tire management rules. Retrieved from Weibold – Tire Recycling & Pyrolysis Consulting: **https://weibold.com/india-expands-epr-scheme-to-include-endoflife-tire-management-rules#**

Woodrooffe, J. (2024). The State of Retread Tires in the United States & Canada: 2024 Addendum to the 2018. Retrieved from **https://s7d1.scene7.com/is/content/bridgestone/retread-report-2024pdf**

World Bank Group. (2021, March 25). Croatia: Circular Economy Approaches in Solid Waste Management. Retrieved from **https://www.worldbank.org/en/country/croatia/brief/croatia-circular-economy-approaches-in-solid-waste-management**

World Bank Group. (2023, June 26). From Raw Material to Waste and Back — Integrating Circular Economy Principles in Croatia's Construction Waste Management. Retrieved from World Bank Group: **https://www.worldbank.org/en/results/2023/06/26/from-raw-material-to-waste-and-back-integrating-circular-economy-principles-in-croatia-s-construction-waste-management#**

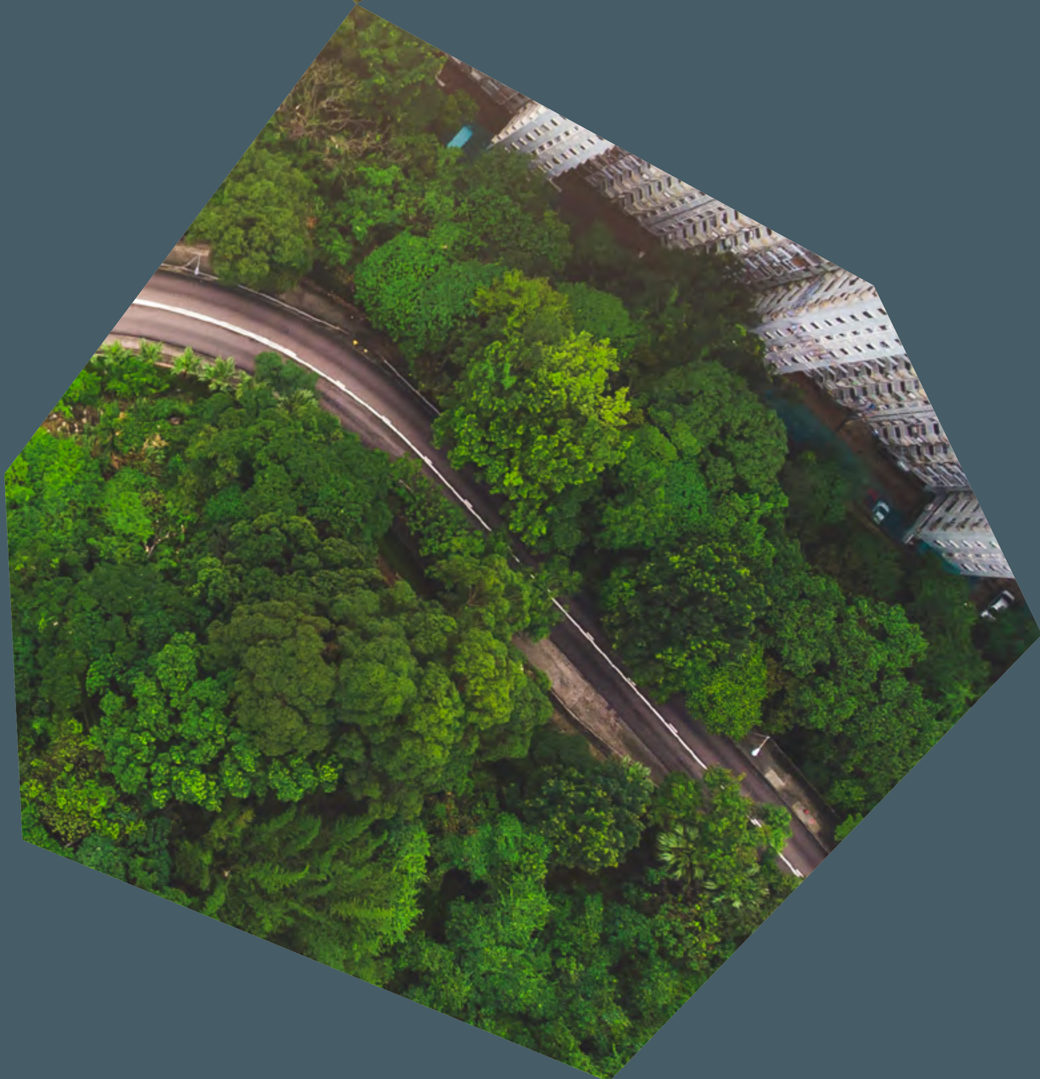
Xavier, L. H., & Mofati, L. (2025). Brazilian reverse logistics credits system - Decree No 11,413/2023. doi:**https://doi.org/10.13140/RG.2.2.31447.38565**

Xiao, Z., Pramanik, A., Basak, A., Prakash, C., & Shankar, S. (2022). Material recovery and recycling of waste tyres-A review. Cleaner Materials, 5, 100115. doi:**https://doi.org/10.1016/j.clema.2022.100115**

Zabaniotou, A., Antoniou, N., & Bruton, G. (2014). Analysis of good practices, barriers and drivers for ELTs pyrolysis industrial application. Waste Management Volume 34, Issue 11, 34(11), 2335-2346. doi:**https://doi.org/10.1016/j.wasman.2014.08.002**

Zertifizierte Altreifen Entsorger. (n.d.). Retreaded tires. Retrieved from **https://zertifizierte-altreifenentsorger.de/en/recovery-methods/retread/**

ZKG International . (n.d.). CEMBUREAU & ETRMA call for support of combined waste treatment options. Retrieved from **https://www.zkg.de/en/artikel/zkg_CEMBUREAU_ETRMA_call_for_support_of_combined_waste_treatment_options-2209892.html#**



World Business Council for Sustainable Development

Geneva, Beijing, Delhi, London, New York, Singapore

www.wbcsd.org

February 2026

World Business Council for Sustainable Development

Tire Industry Project