



# Material and energy recovery, and the latest innovations in ELT recycling technologies

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Vienna, 21 September 2023

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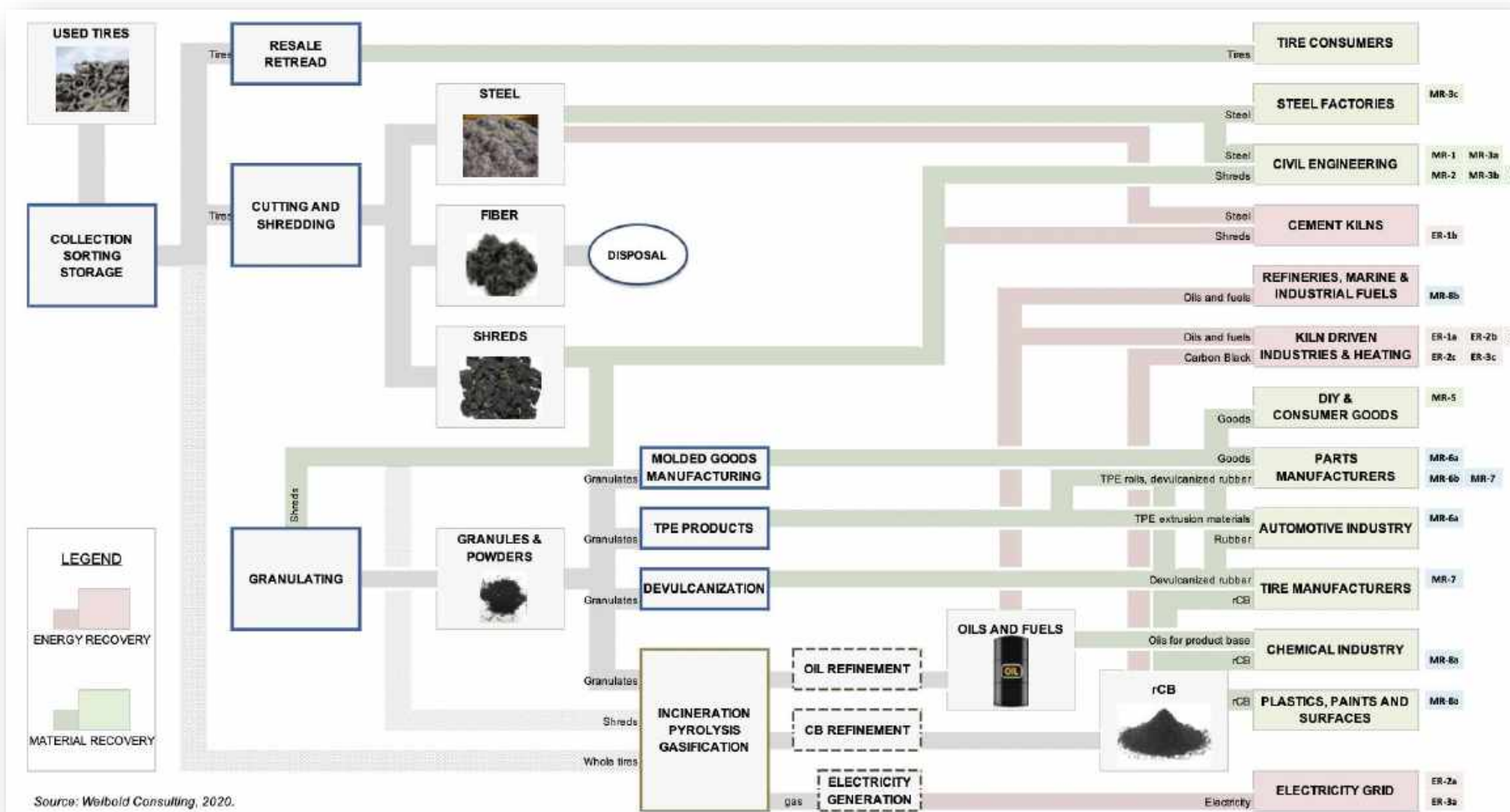
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# Introduction

Tire Recycling Value Chain & Exemplary Statistics

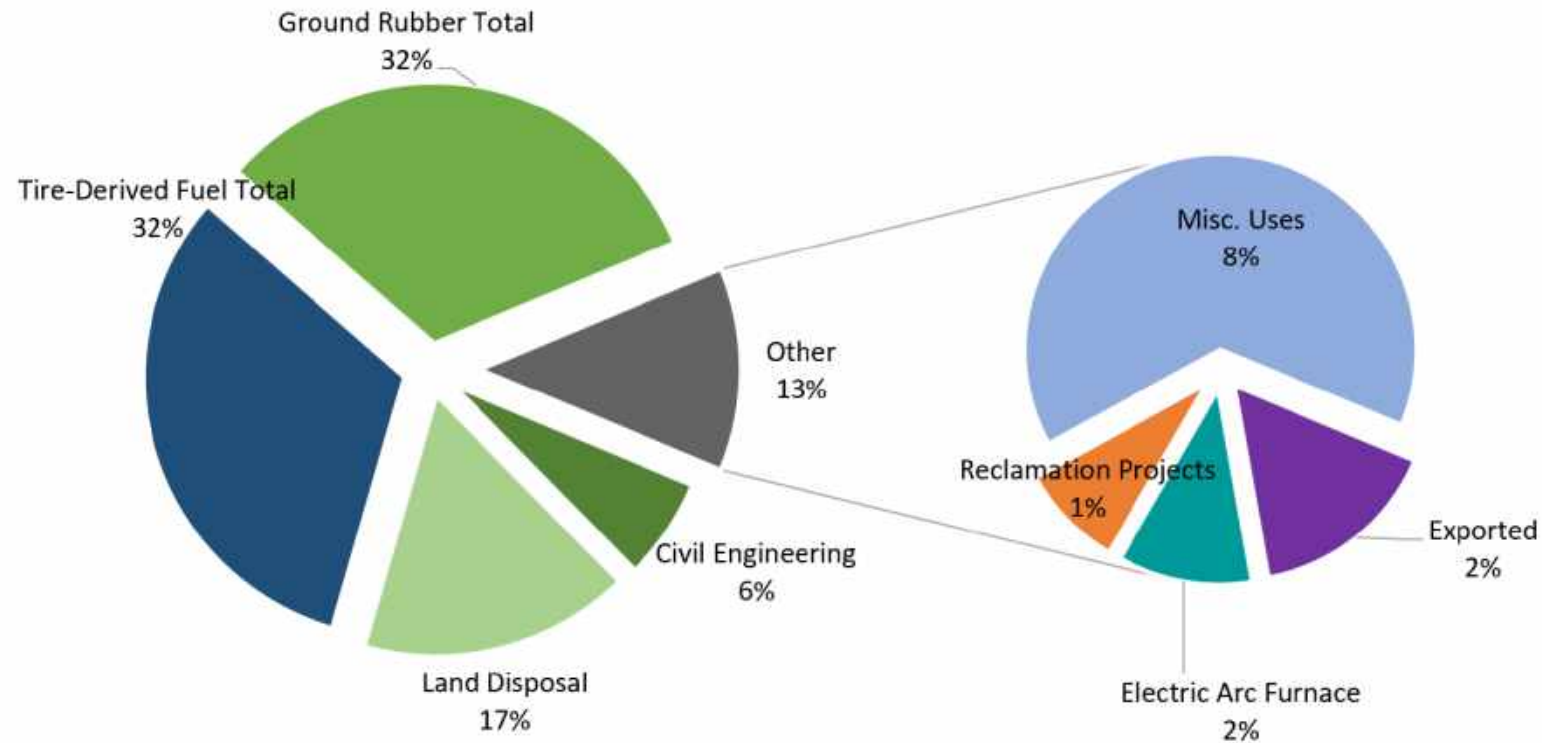
# Tire Recycling Value Chain

## ELT Generation to Final Products



# Example: US Scrap Tire Disposition 2021

*Percent of total tons of scrap tires consumed in market*

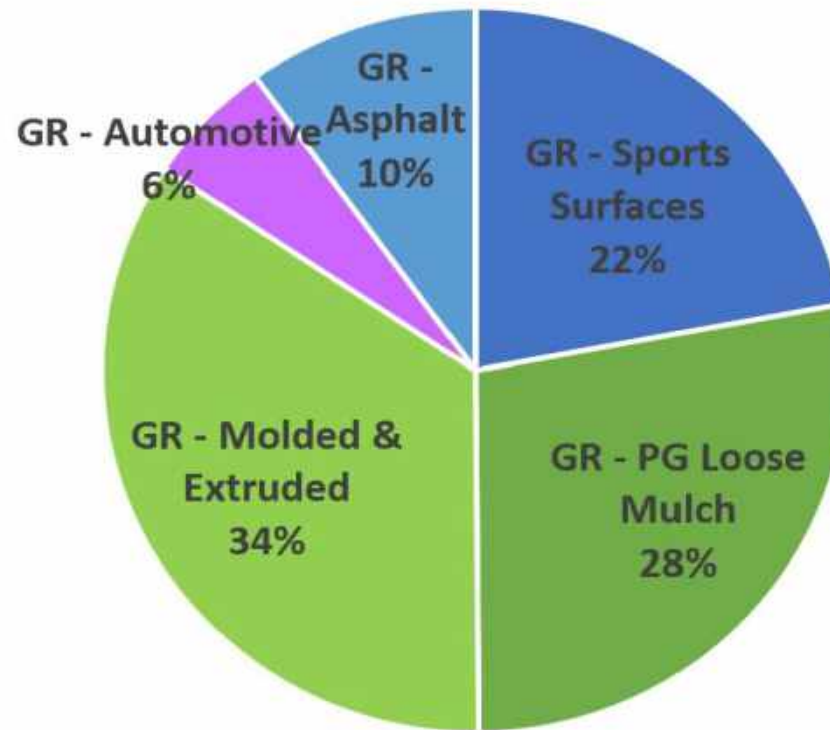


Source: U.S. Tire Manufacturers Association, 2022.

**Total scrap tires generated: 5 Million tons**

# Example: Ground Rubber (GR) Market North America 2021

*Percent of total tons of scrap tires consumed in market*

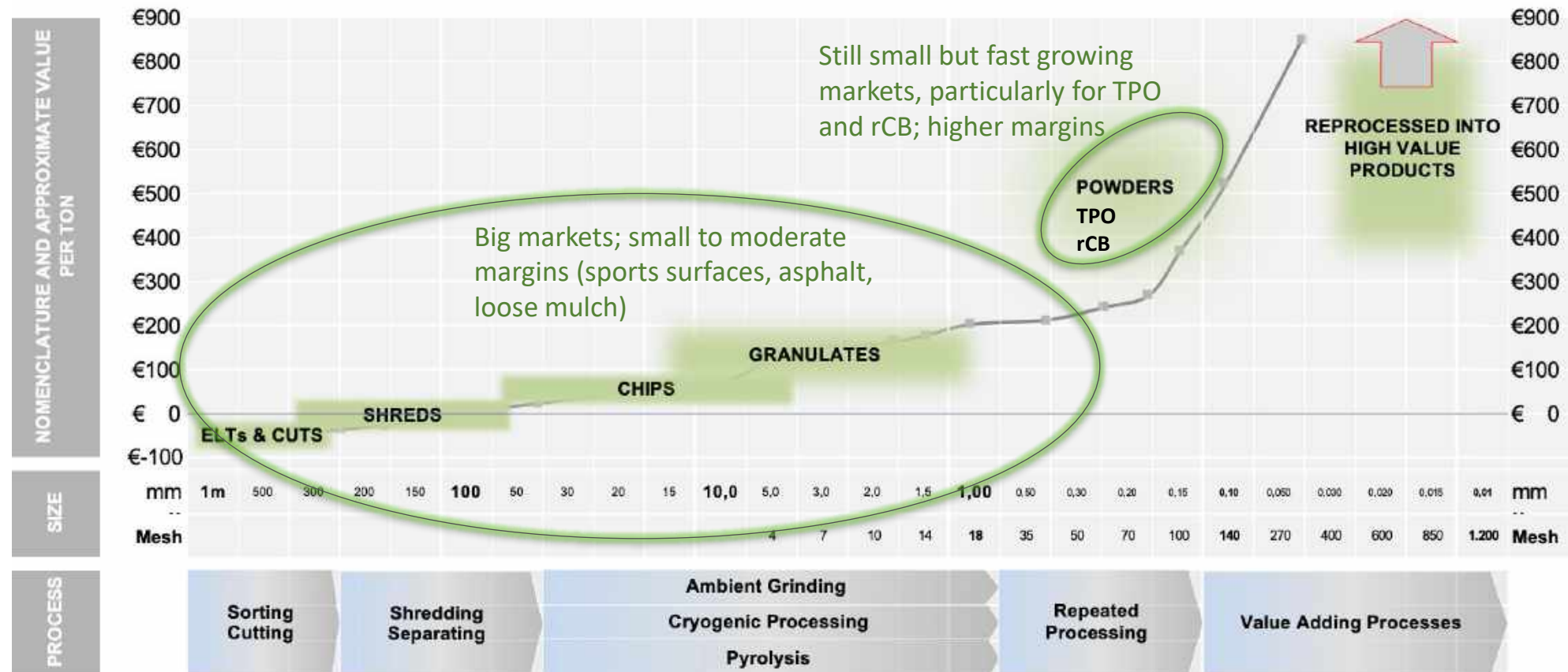


Source: U.S. Tire Manufacturers Association, 2022.

# Tire Recycling Value Chain

Developing existing and new markets is key to find a sustainable solution for the world's waste tires

Increasing the value for the industry AND the environment





# Pyrolysis (Chemical Recycling)

Closing the loop

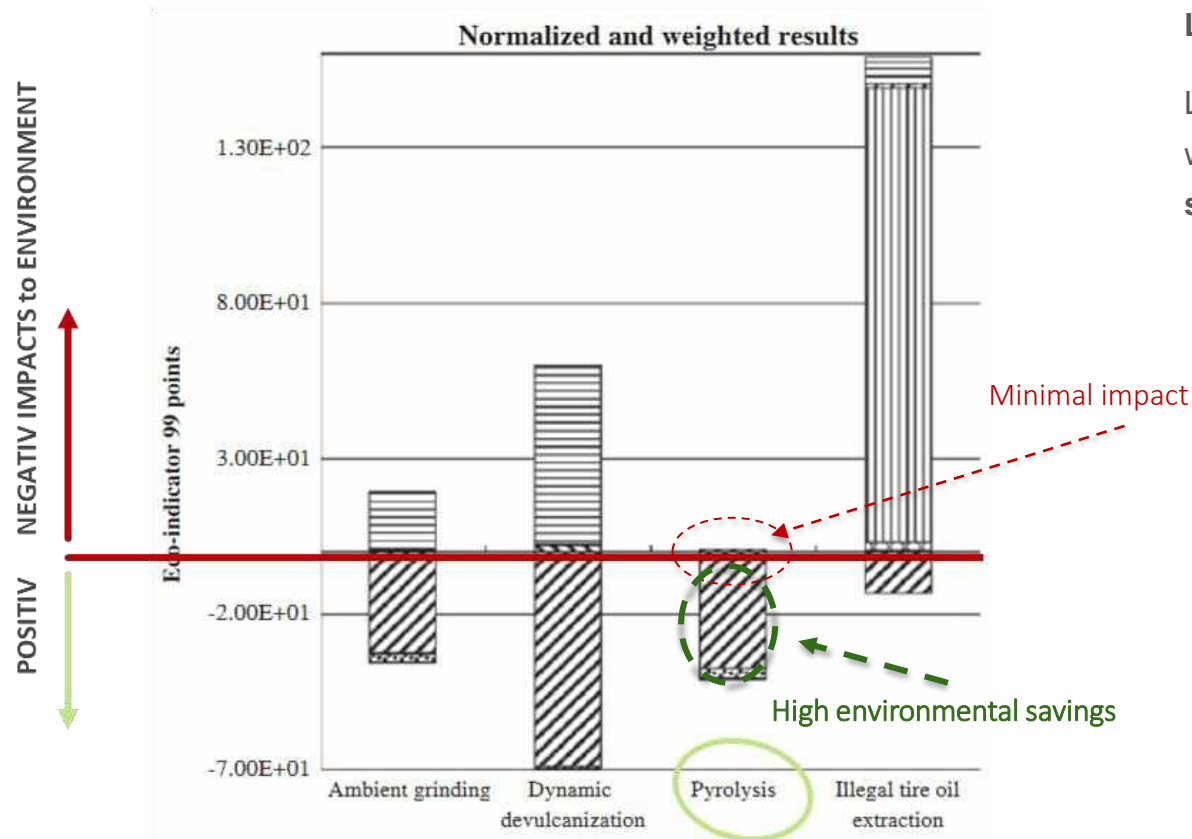
# The Missing Link for Circular ELT Material Flow

*Pyrolysis helps to get out of a one-way street to a truly circular economy*



# Environmental Aspects

*Tire Pyrolysis is proven to protect the environment and saving resources already in 2010*



Source: Li et.al., „Comparison of end-of-life tires treatment technologies; A Chinese case study”; Waste Management (2010), pg 2235 - 2246

## Life Cycle Assessment (LCA)

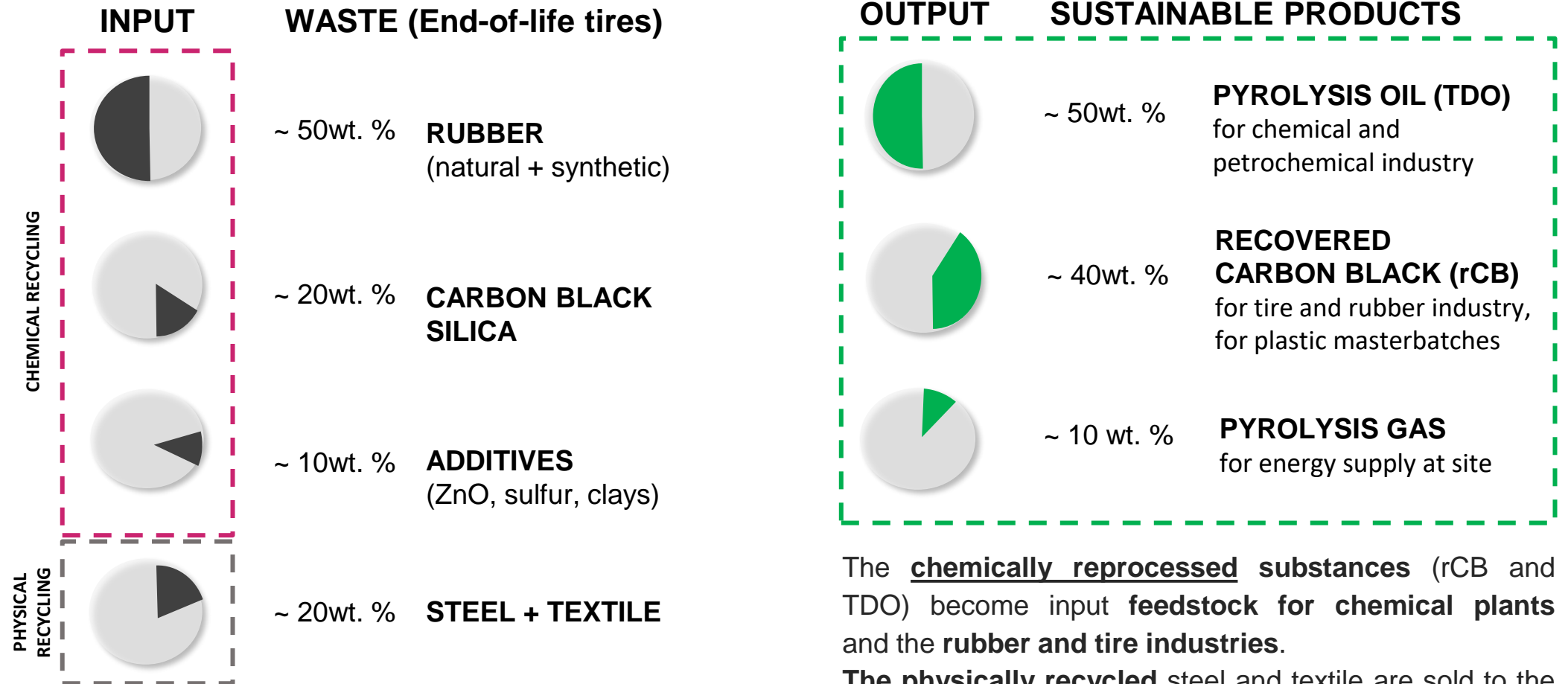
LCA studies show\*) that the **substitution of primary resources** (e.g., crude oil) with **tire derived pyrolysis products** enables **exorbitant environmental savings**.

- **Resource savings** in steel alloys, crude oil, and coal.
- **Reduced greenhouse gas emissions** through avoided production of diesel, soot, and steel.
- **Reduced human toxicity** through avoided chromium VI production in steel production.
- **Avoided aquatic toxicity** in steel production.
- **Avoided acidification potential** in diesel, soot, and steel production (SO<sub>2</sub>; sulfur dioxide).
- **Avoided eutrophication effects** by substituting diesel and carbon black production (avoided environmental effects are NO<sub>x</sub> and phosphate emissions, etc.)

\*) Müfide Banar, “Life cycle assessment of waste tire pyrolysis” in Fresenius Environmental Bulletin, PSP Volume 24 – No 4., January 2015

# Closing the Loop with Chemical Recycling

*Pyrolysis can decompose the complex tire rubbers to sustainable substances*



The chemically reprocessed substances (rCB and TDO) become input feedstock for chemical plants and the rubber and tire industries.

The physically recycled steel and textile are sold to the secondary raw material market.

# High Global Demand for rCB

Major industry stakeholders announcing aggressive sustainability goals

## TIRE MANUFACTURERS driving DEMAND

- High production capacities for the delivery of large quantities of recovered Carbon Black (rCB) in constant quality needed.
- Development of product standards and test methods need to be accelerated.

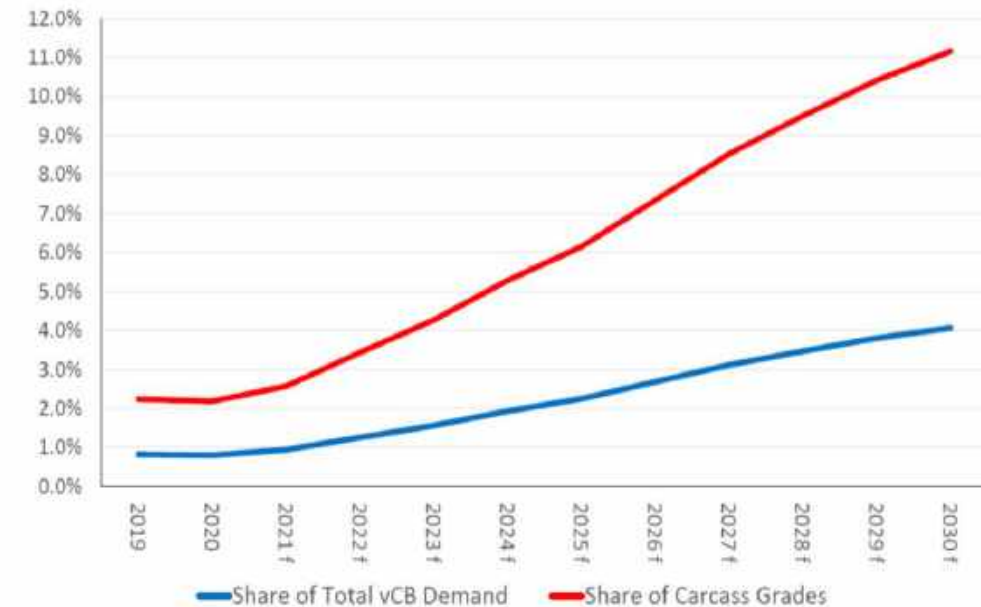


## RUBBER & CB INDUSTRY increase current high demand

- rCB has already leapt in industrial practice and is already making an essential contribution to closing the loop in the rubber, wetsuit, fiber industry (etc.)
- Rubber compounds with blends of rCB/CB demonstrate consistent results, even with 40% share\*) of rCB in the blend.

\*) MAKROCHEM published in [Tire Technology International](#) (November 2020)

## rCB Global Forecast (Notch): 400 kt in 2025, 800 kt in 2030



Source: NOTCH presentation (Paul Ita) in rCB Conference Amsterdam 2021

# Infinite TPO Demand

*Summary of TPO demand by application*

## Currently Recognized Large Scale Off-takers

- **BASF – Demand – 100,000 TPA**
  - TPO is fed into BASF's production network at the beginning of the value chain, thereby saving fossil resources.
  - Products made from pyrolysis oil have the exact same properties as products manufactured with primary fossil resources. (BASF)
- **BlackCycle Project – Demand 700,000 TPA**
  - BlackCycle aims to create a full Tire2Tire Value Chain
  - To chemically recycle at least 50% of the European ELTs

## Other Applications

### Refineries

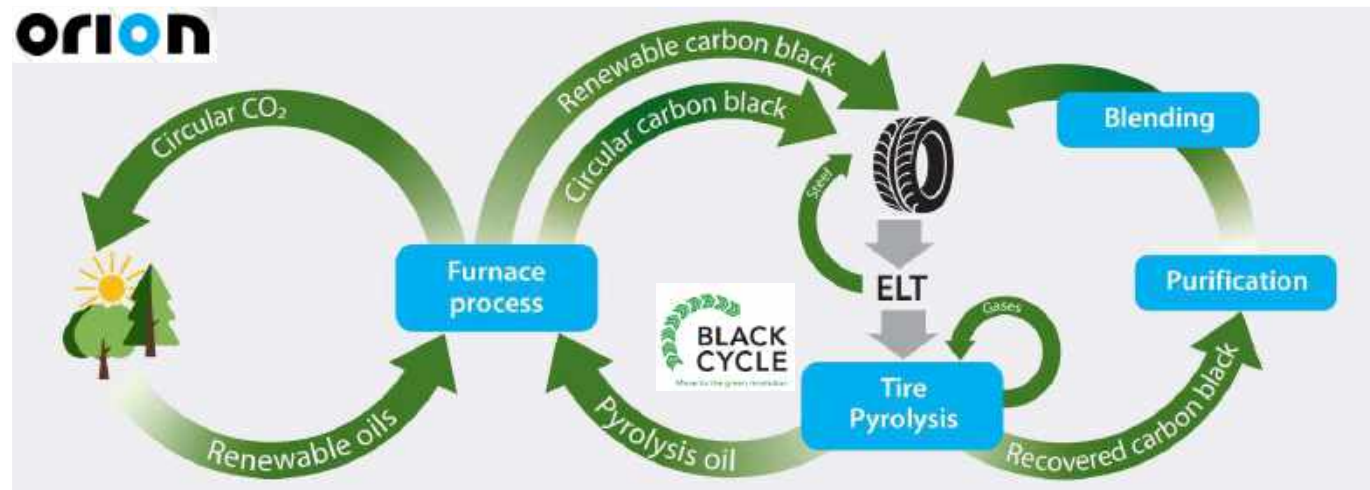
- TPO has a great potential to substitute petroleum-derived fuels in several industrial processes but is relatively unsuitable for direct use.
- Fractional distillation converts TPO into groups with similar properties as fossil fuel, which can then be further upgraded and used in different systems.
- TPO can be specified as advanced fuel pool component due to their biogenic content.

### Industrial Fuel and Others

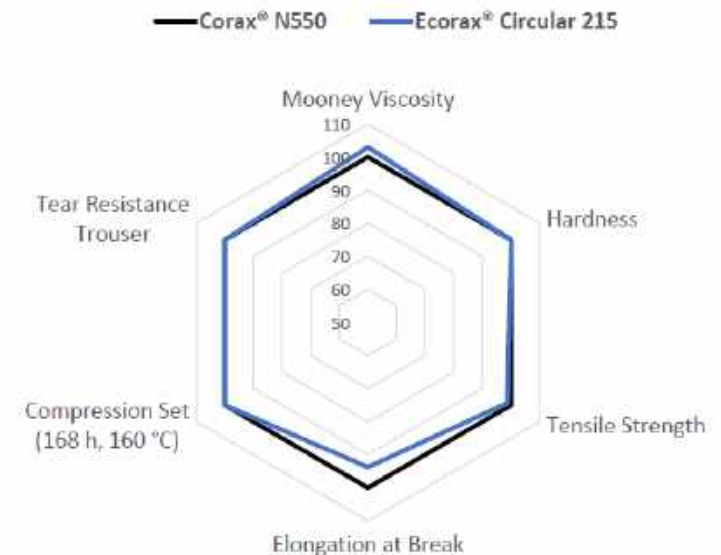
- TPO is largely used as industrial fuel in cement and other industries for energy in developing nations
- TPO is used in the road construction

# Exemplary Applications for TPOs – virgin Carbon Black feedstock

EU BLACKCYCLE project proving the heavy fraction of TPO as a suitable feedstock for ASTM grade virgin Carbon Black



Source: ORION Engineered Carbons; Celso Magri, Global Marketing and Sustainability; Berlin, November 2022

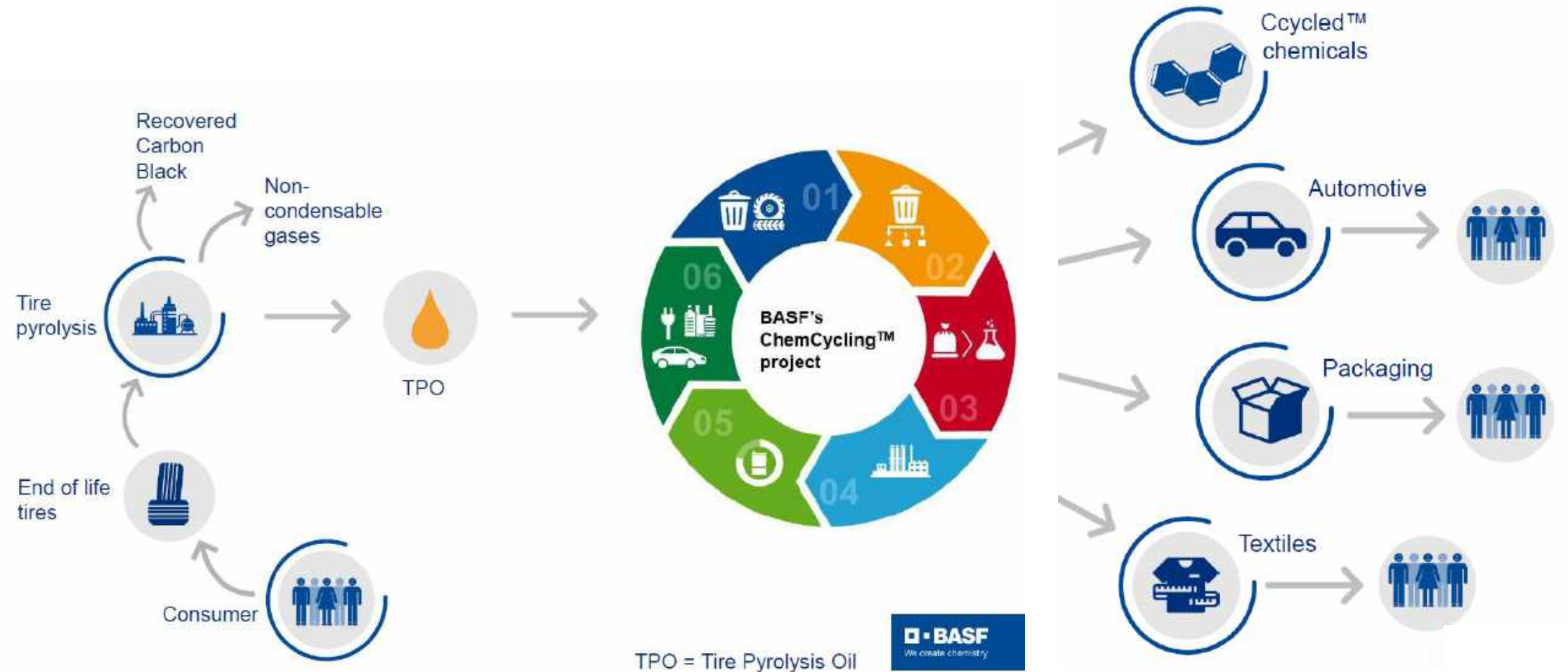


Rubber compound: AEM - ethylene acrylic elastomer

**Circular CB made from TPO as feedstock in a furnace CB process can also be used in MRG applications and fully replace ASTM grades.**  
(ORION, Nov. 2022)

# Exemplary Applications for TPOs – BASF ChemCycling

*BASF ChemCycling™: TPO (untreated as produced) as a feedstock for ccycled™ base chemicals*



Source: Dr. Martin Bohn (BASF); presentation at rCB Conference Berlin, 17 November 2022



# Direct Investment by Multinationals

*Investments, joint ventures, and cooperations spawn development of new solutions for sustainability*



Multi million rCB and TPO offtake contracts



Longtime customer recovered Carbon Black



Jointly develop single largest rCB production (200,000 tons of ELT/year)



Longtime customer rCB, supplying tire industry in Asia



Shareholder and major investor (Chile, Sweden)



Shareholder with multi-million Off-take contract



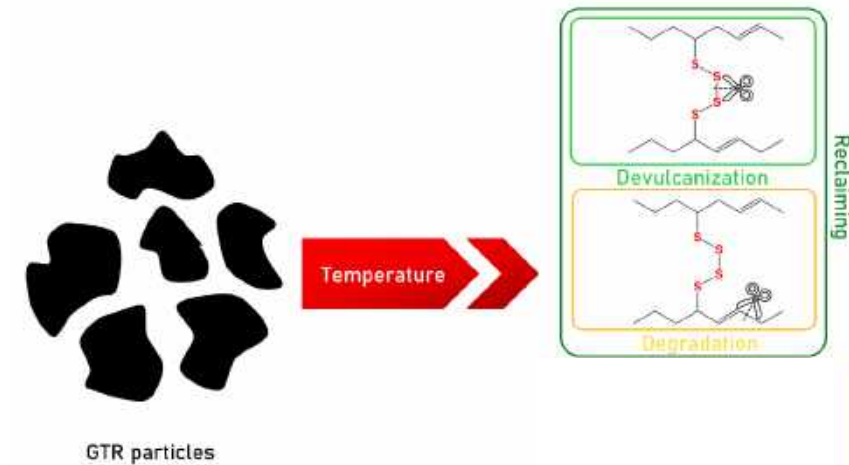
# Devulcanization

What is Devulcanization and it's Trends

# Devulcanization

## What is it?

- Devulcanization process is a **selective break-up** of sulfur-sulfur (S-S) and carbon-sulfur (C-S) bonds **without** breaking the long-chain polymer which would lead to a **degradation of the material**.
- Desired Feedstock is recycled tire rubber with **high natural rubber content**



Source: Waste Management 150 (2022) 174–184, Possible reactions during thermal treatment of GTR, P. Wiśniewska et al.

## Different types of Devulcanization Technologies

- Thermo-mechanical (used by the majority of companies)
- Combination of thermo-mechanical and supercritical CO<sub>2</sub>
- Chemical method
- Other

## Market share and outlook

- In the US only 2% of recycled rubber is currently turned into devulcanized rubber products.
- Limited growth potential due to the lack of suitable raw materials with high natural rubber content

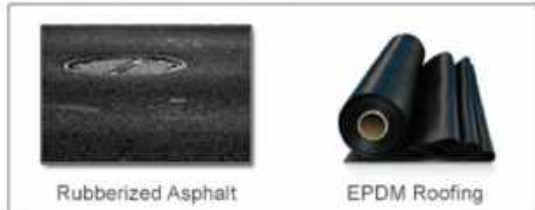
# Various Applications

## Conventional Applications

### Tire Industry



### Construction & Infrastructure



### Industrial



### Automotive



### Retail



## Novel Applications (partially replacing SBS/SEBS)



Asphalt Modifier



Polymer Modifier

Picture Sources:  
[Prism Worldwide](#)  
[New Rubber Technologies](#)

# Trends – stakeholder develop together and grow together

*Cooperation is key to success*

## Life Green Vulcan Project, IT:



EU contribution: 1.1 mio Euro

Compound for manufacturing spring pads for cars and light trucks, as well as a compound for manufacturing Passenger Car Radial (PCR) tyre treads. [📄](#)

Rubber Conversion raised an additional EUR 2.5 mio. [📄](#)

Source: [Life Green Vulcan](#)



## Next Lap project, PT:



Six pilot projects to use recycled tire rubber in footwear production. [📄](#) [📄](#)

# Trends – investors gain trust in the markets

*Slowly but steadily more and more money is invested*



## Prism Worldwide, U.S.




\$23.5 mio invested since 2019, Prism converts end-of-life tires (ELT) into like-new rubber and plastic polymers. replace virgin material in tires, materials for roofing and paving asphalts and for industrial rubber and plastic products.  

## Tyromer, Canada



Started up their first European devulcanization plant in The Netherlands and expanding to India and Australia among other countries.  

Tyromer's Tire Derived Polymer to be used for Apollo's new tires. 

Also Continental partners with Tyromer to reuse end-of-life tire rubber in production of new tires. 



# Thermoplastic Elastomers

Use of Micronized Rubber from ELTs in TPE

# Thermoplastic Elastomers (TPE)

## What is TPE?

### Definition - Thermoplastic Elastomer

- According to ASTM D1566, a thermoplastic elastomer (TPE) can be generically defined as a “rubber-like material that, unlike conventional rubbers, can be processed and recycled like thermoplastic materials”.
- i.e., a material that repeatedly can be softened by heating and hardened by cooling through a temperature range characteristics of the polymer and, in the softened state, can be shaped into articles.
- Preferred technology: twin screw extruder



Pictures: [Maris](#)

### Advantages

- 100% Recyclable (“circularity”)
- Easier processing – Can be processed with traditional thermoplastic techniques such as injection molding, extrusion, and blow molding.
- Can be colored

### Market share and outlook

- In the US only 2% of recycled rubber is currently turned into TPE based products.
- Huge growth potential due to the need for more recycled content in automotive products.



# Thermoplastic Elastomers (TPE)

## Micronized Tire Rubber in Plastic Applications

### Injection Molded



Equestrian fake jumping branch

Roof Vent

Mop Bucket and Trash Can

Truck step cover

### Blow Molded



Kayak Seat

Air duct for large vehicle

Soap dispenser

### Compression Molded and Profile Extrusion



Compression molded pallet  
50% rubber – 50% polypropylene

Profile extruded post wrap. 30% rubber  
– 70% linear low density polyethylene

Source: EcoGreen Webinar, April 12 - 2023  
[https://www.youtube.com/watch?v=SH4ggh\\_6INA&t=1759s](https://www.youtube.com/watch?v=SH4ggh_6INA&t=1759s)

# Future applications of Thermoplastic Elastomers (TPE)

## *Automotive parts*



# Molded Goods

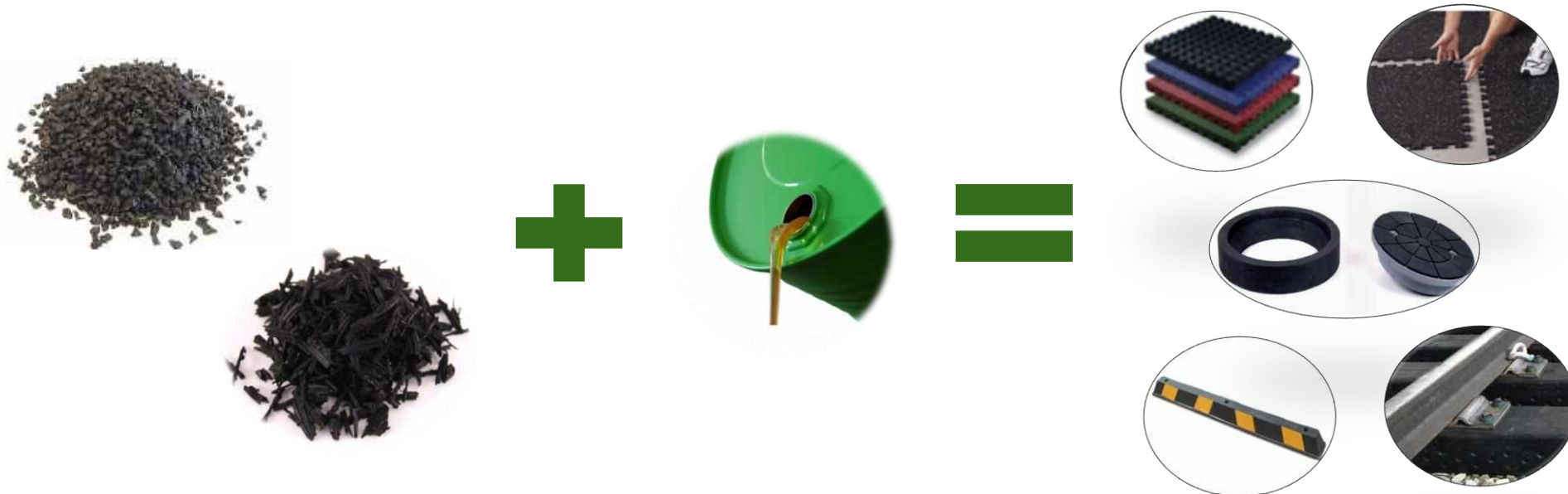
Novel Applications

# What are molded goods?

**Recycled Rubber Molded Goods** are products manufactured with molding presses using a combination of ELT rubber granules or buffings, and polyurethane binders.

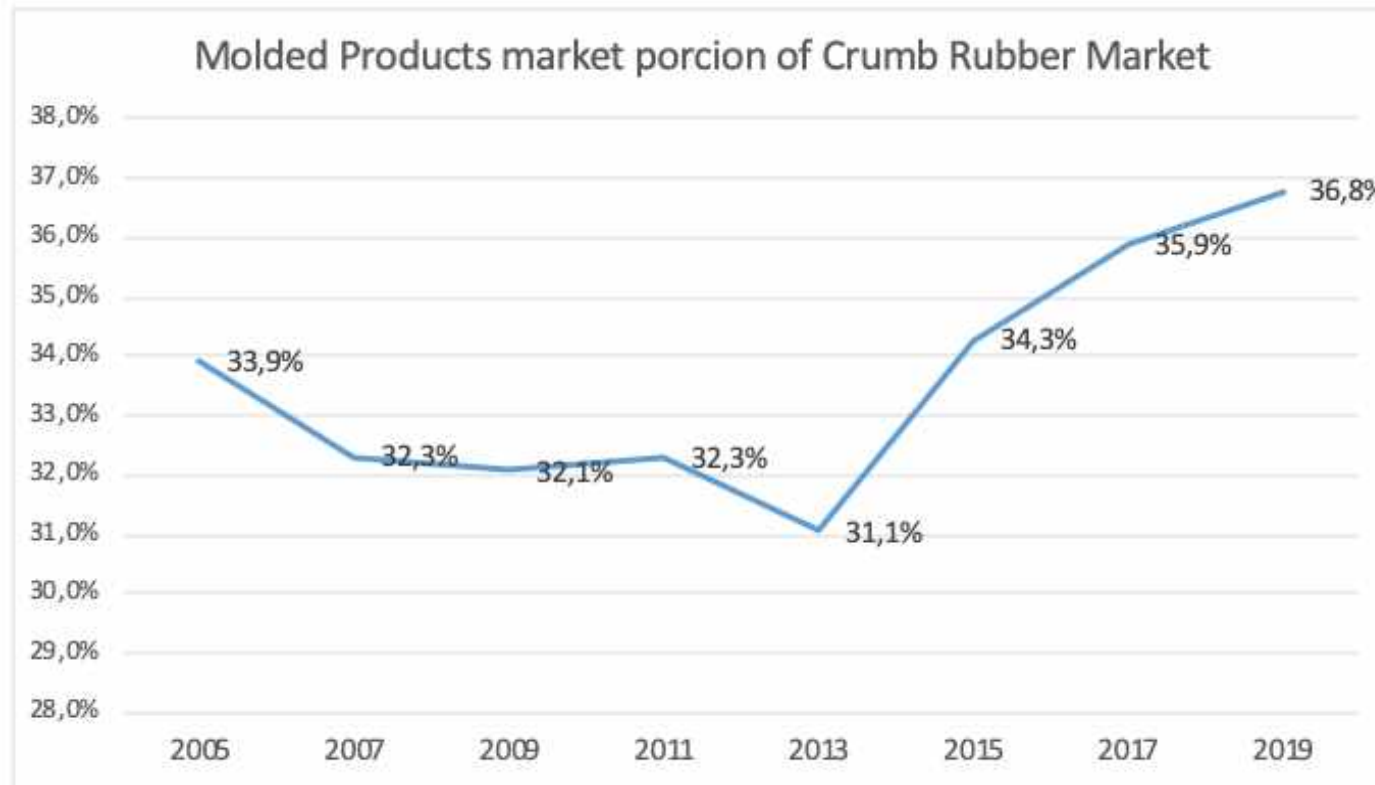
Molded goods are one of the most versatile applications for recycled rubber from tires!

The most common and popular molded goods are **playground tiles** and **flooring mats**, but there are **infinite combinations** of products which can be manufactured using this process.



## Example: North American market

Molded goods have a significant market share (similar in Europe)



Source: 2005 to 2020 scrap tire rubber users directory

# Novel Applications

*Replacing concrete manhole systems with molded rubber ring*



# Novel Applications

## *Rail tracks*

Molded goods made of recycled rubber are products manufactured with molding presses using a combination of ELT rubber granules and polyurethane binders (plastic material).

## New Applications

### [Greenrail Group](#) (Italy)

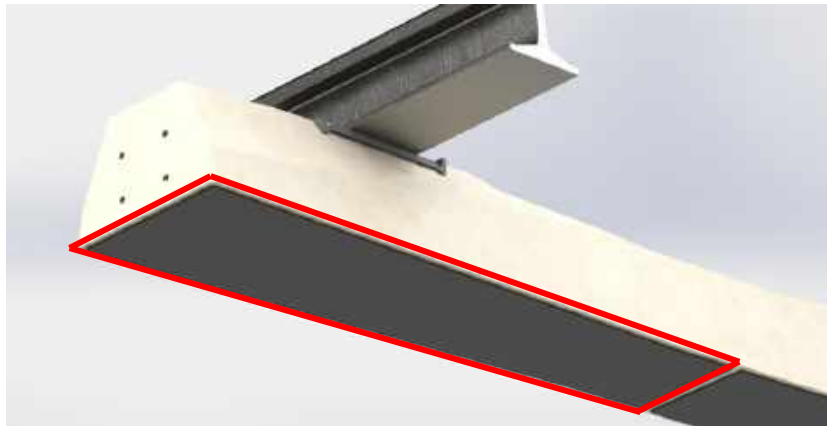
- Constructed using end-of-life plastics and tires, 1 km track requires 17.5 tons of EL plastics and tires each.



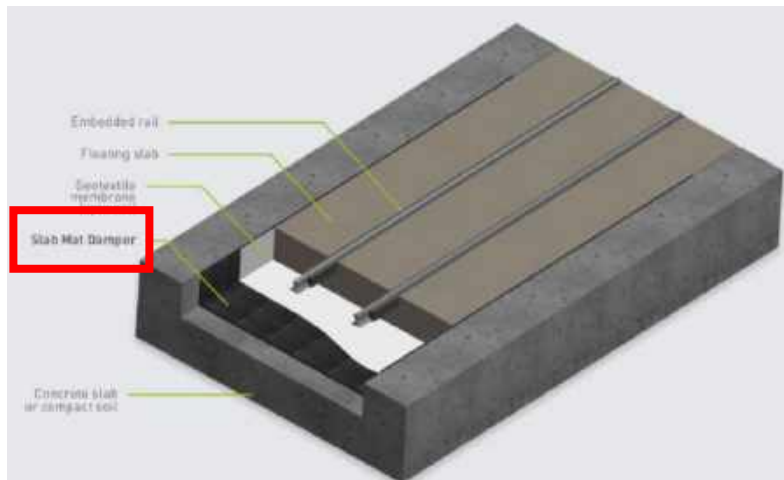
Variations of Greenrail Sleepers (<https://www.greenrailgroup.com/en/rd-2/>)

# Novel Applications

## Railway sleepers



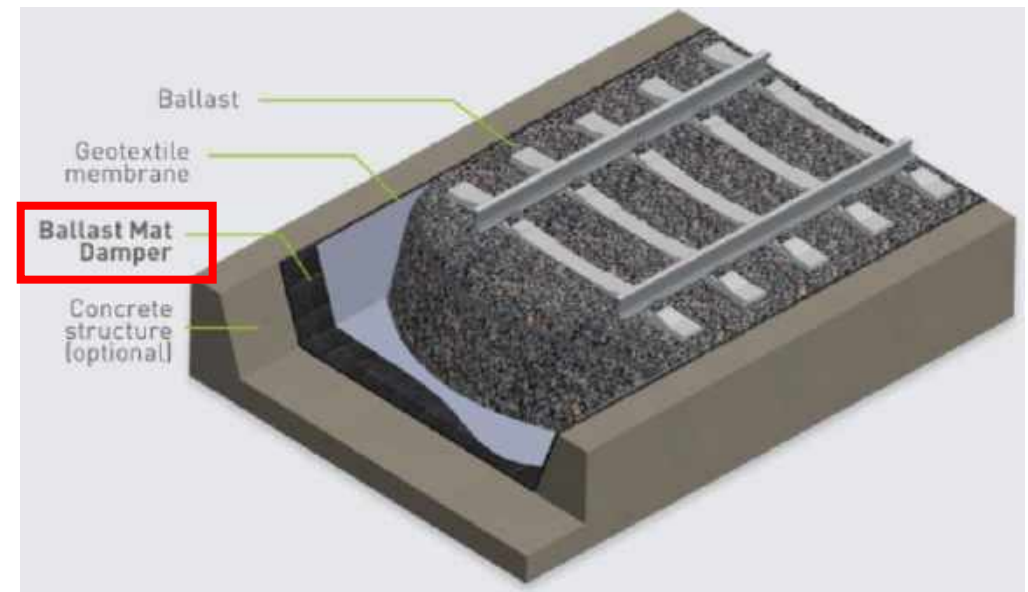
Undersleeper Pad



Slab Mat Damper

## [Rubbergren](#) (Belgium)

- Undersleeper pad = Track stabilisation and decreasing of weariness
- Slab Mat Damper – Reduces vibration in urban areas (up to ~20 dB)
- Ballast Mat Damper – Antivibrating mat installed under ballast track to reduce the vibration level in urban areas (up to ~20 dB)



Ballast Mat Damper



# Other Niche Applications

Concrete and Rubberised Asphalt

# ELTs in Concrete

*9% of world-wide greenhouse gas emissions for concrete production!*

- **Tire Stewardship, Australia: crumb rubber in concrete road barriers**

Passing the crash test at 100km an hour: Australian ingenuity delivers next generation of **road barriers to increase public safety and decrease waste.** [📄](#)

- **RMIT University, Australia: The Use of Scrap Tyres in Concrete Production**

Developed a **new method for casting prefabricated concrete products** made with rubber tires and construction and demolition waste that **are up to 35 per cent stronger than traditional concrete.** The team identified an optimal mixture – 0.5% fine crumb rubber to 99.5% RCA – that delivered on shear strength while maintaining good cohesion between the two materials. [📄](#)



Source: TSA



Source: RMIT University

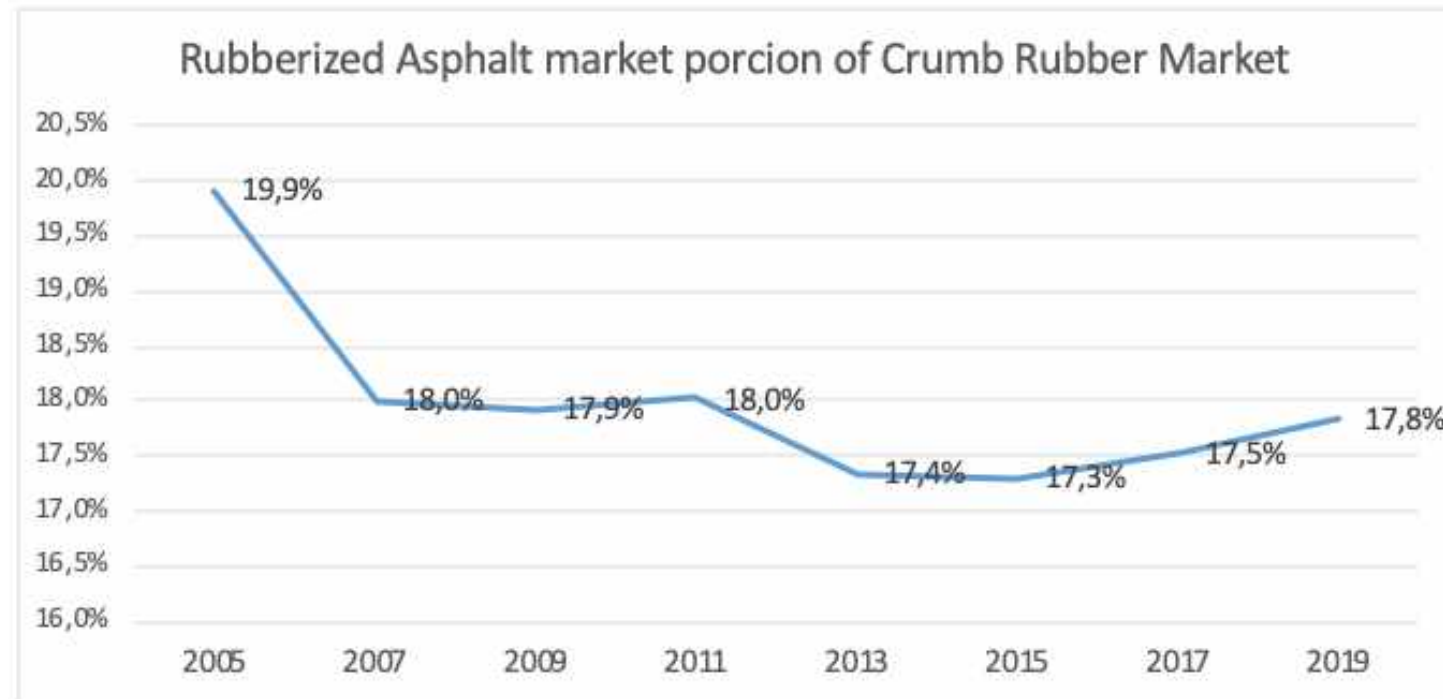
# ELTs in Rubberized Asphalt

- Porous Lane, Australia:

Create permeable pavements out of used tires, which can **avoid stormwater flooding in municipal areas**. According to the University of Melbourne, Porous Lane **pavements are less expensive, more durable, and simpler to maintain** than its rivals, with the added bonus of containing at least 50% recycled content.



## Example: North American market



Source: 2005 to 2020 scrap tire rubber users directory

# Trends

Demand for Sustainable Materials

# Trends - multinationals go greener

## PUSH for Upcycled Materials

Increasing public demand for ENVIRONMENTALLY FRIENDLY PRODUCTS and pressure to fulfil the SUSTAINABLE DEVELOPMENT GOALS

### Continental, Germany:

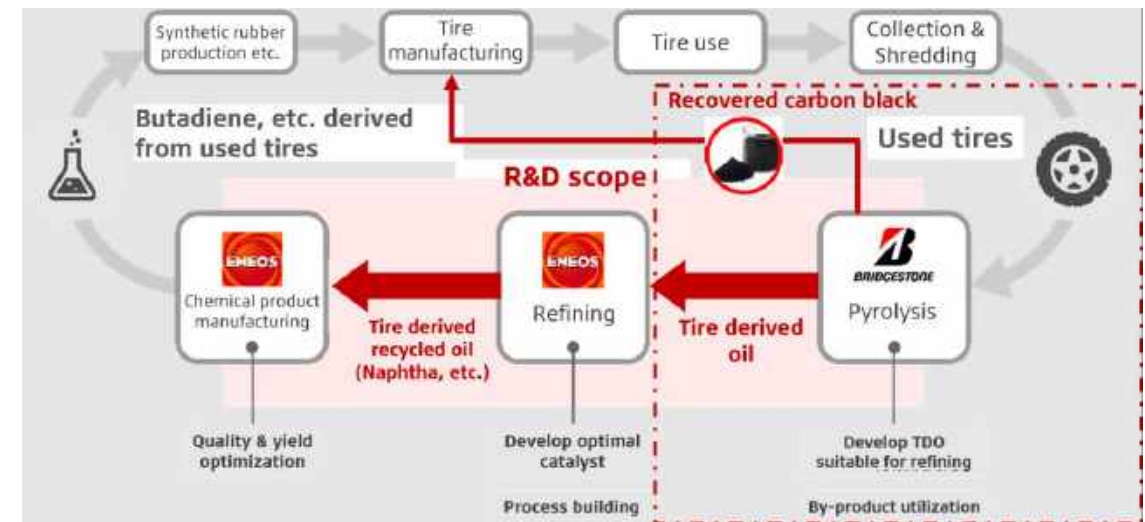
For all of its tire production plants, Continental aims to fully transition to sustainable raw materials by the year 2050 [📄](#).



### Bridgestone, Japan:

The R&D program will promote high-yield production of isoprene by chemically decomposing used tyres with a specialised catalyst at low temperatures. [📄](#)

Bridgestone recently commenced the production of tire derived oil and recovered carbon black from test units installed at Bridgestone Innovation Park in Kodaira City, Tokyo. This project is one of two R&D projects and this project is conducted as part of a joint project with ENEOS Corporation.



# Trends – multinationals go greener

*Drive from conglomerate for sustainable products*

## Goodyear, United States:



Goodyear has created a 70% sustainable-material version of its Assurance all-season tire. The company is making strides toward its aim of developing a tire that is **100 percent sustainable by 2030**. [📄](#)

## Nokian Tyres, Finland:



Nokian Tyres has set ambitious goals in terms of sustainability: by the **end of 2030, 50% of all raw materials used in the tires will be recycled or renewable**, and the CO2 emissions from production will be reduced by 50%. In January 2022, Nokian Tyres introduced the Nokian Tyres Green Step concept tire consisting of 93% of the materials recycled or renewable. [📄](#)

## Apollo Tyres, India:



Pledged to increase the usage of sustainable raw materials to 40% by 2030, with 10% being recycled material and 30% biomaterials [📄](#).

Apollo Tyres partnered with **Tyromer Inc** for the supply of devulcanized rubber [📄](#)

## Hankook Tires, Korea



Global leading tire company Hankook Tire collaborates with shoes brand YASE to launch eco-friendly shoes made of recycled tires. [📄](#)



# How can Weibold help the industry!

*Large and medium scale plants in the pipeline*

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**Report: Global Tire Pyrolysis Market Update, Trends & Technology Suppliers 2023**

A high-level market survey on the tire pyrolysis industry and market (production volumes by region), comprehensive market trends, market forecasts and the...



**Report: The Business of Tire Devulcanization 2023**

This devulcanization report contains a detailed introduction to the devulcanization, taking into consideration the complete product spectrum; a section about understanding the tire devulcanization technology; a well informed...



**Tire Pyrolysis Stakeholders Database 2023**

Who's who in the pyrolysis - a database of stakeholders in the pyrolysis with focus on technology (investors and operators of pyrolysis plants, spanning all players in the value chain. Weibold continuously surveys the global industry and market...

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November 21, 2022 Robert Weibold, tire recycling and pyrolysis consultant from Weibold...

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**Burning or recycling? EU considers possibilities regarding end-of-life tires**

Recycling companies warn that proposed EU regulations could result in the export of millions of tires for Skopje or incineration. The European Recycling Industry...

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**Enviro's pyrolysis oil was successfully tested by leading US oil company**

Scandinavian Enviro Systems (Enviro) received in February 2022 an order for pyrolysis oil from the subsidiary of a leading US oil company for production...

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## Recovered Carbon Black 2023

6th - 8th November 2023 (Barcelona)

10% discount PROMO CODE 'RCB2310'



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# Thank you!

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