ENVIRONMENTAL IMPACTS OF RUBBER COMPOUNDS FROM RECYCLING IN THE TYRE INDUSTRY

Francesco Valentini[1], Paraskevi Karka[2], Francesco Picchioni[2], Giampaolo Brioschi[3], Marco Finelli[3], Stefano Gialanella[1], Andrea Dorigato[1]

[1] University of Trento and INSTM research unit, Department of Industrial Engineering, Via Sommarive 9 - 38123 Trento, Italy

[2] University of Groningen, Department of Chemical Engineering, Nijenborgh 3 9747, Groningen, The Netherlands

[3] Marangoni SpA, via del Garda 6, 38068, Rovereto, Italy

francesco.valentini@unitn.it

Co-funded by the European Union

INTRODUCTION

- **In 2019 the total amount of end-of-life tyres has been of around 30.9 million tons worldwide (around 1.5 % of total wastes)**
- **Problems related to tyres' EOL : (i) only 60% of wastes is correctly disposed, (ii) very low recycling rate, (iii) loss of valuable resources**
- **Natural rubber critical raw material for EU**

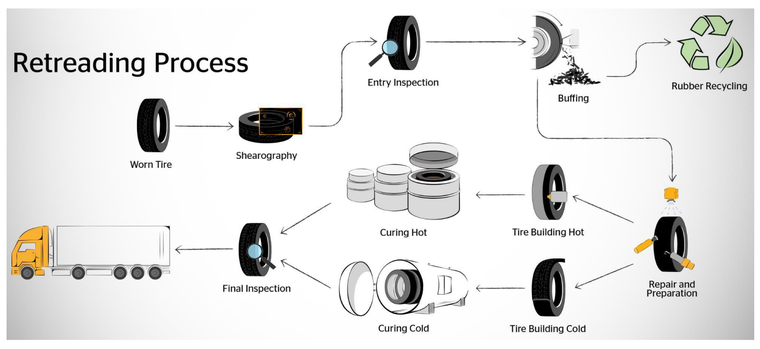
GOAL AND SCOPE

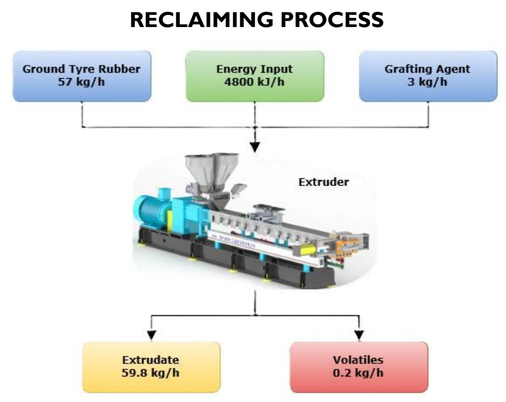
Aim of the work: evaluate possible environmental benefits from the use of reclaimed rubber in the tyre industry

Functional unit: 1 kg of elastomeric compound used for the production of a tread for the retreading process of truck tyres

Case studies:

- New tyre (manufacturing + wear + EOL) => tot 160,000 km
- Retreaded tyre (carcass + retreading + wear + EOL) => tot 320,000 km





LIFE CYCLE INVENTORY

New tyre composition		
Input	phr	wt%
natural rubber (TSR)	78.8	37.1
synthetic rubber (SBR)	21.2	10.0
carbon black	47.3	22.3
process oil	1.8	0.8
zinc oxide	4.4	2.1
sulfur	2.7	1.3
silica	2.8	1.3
steel cord	31.5	14.8
bead wire	13.3	6.3

Tread composition						
Input	RIF-L		RIF-W		RIF-P	
	phr	wt%	phr	wt%	phr	wt%
natural rubber (TSR)	100.0	58.7	-	-	68.1	40.7
synthetic rubber (SBR)	-	-	65.0	37.0	-	-
synthetic rubber (BR)	-	-	35.0	19.9	31.9	19.1
carbon black	54.5	32.0	53.0	30.1	52.0	31.1
zinc oxide	3.7	2.1	3.0	1.7	4.1	2.5
sulfur	1.2	0.7	1.4	0.8	1.2	0.7
rubber chemicals	11.1	6.5	18.4	10.4	9.9	5.9

Reclaimed tread composition			
Input	RIF-L_R wt%	RIF-W_R wt%	RIF-P_R wt%
reclaimed rubber	40.0	40.0	40.0
natural rubber (TSR)	35.2	-	24.4
synthetic rubber (SBR)	-	22.2	-
synthetic rubber (BR)	-	11.9	11.4
carbon black	19.2	18.1	18.6
zinc oxide	1.3	1.7	1.5
sulfur	0.4	0.5	0.4
rubber chemicals	3.9	6.3	3.6

Tyre mass: 79.9 kg, long-haul truck

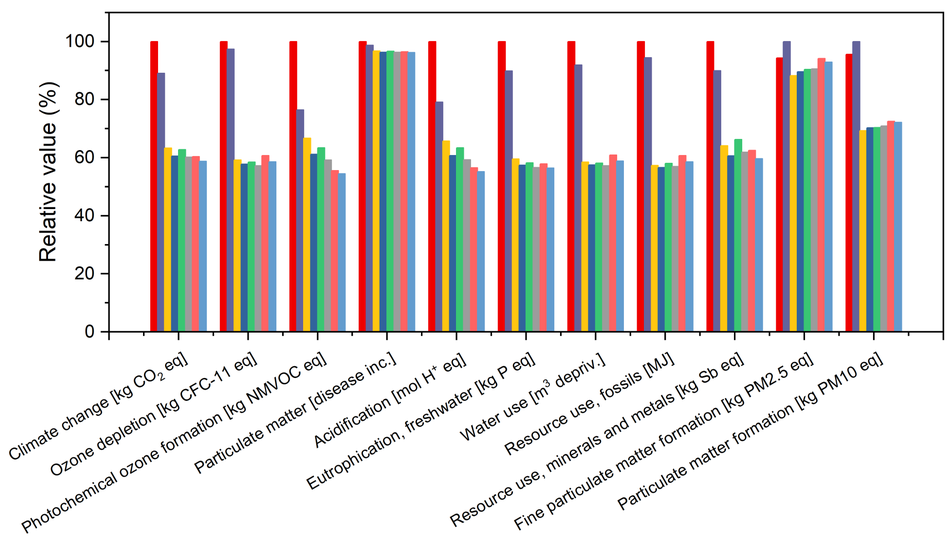
Tread mass: 17 kg, same performances

Use phase →Tread wear rate = 13.1 % of the tyre total mass (~ 12 kg)

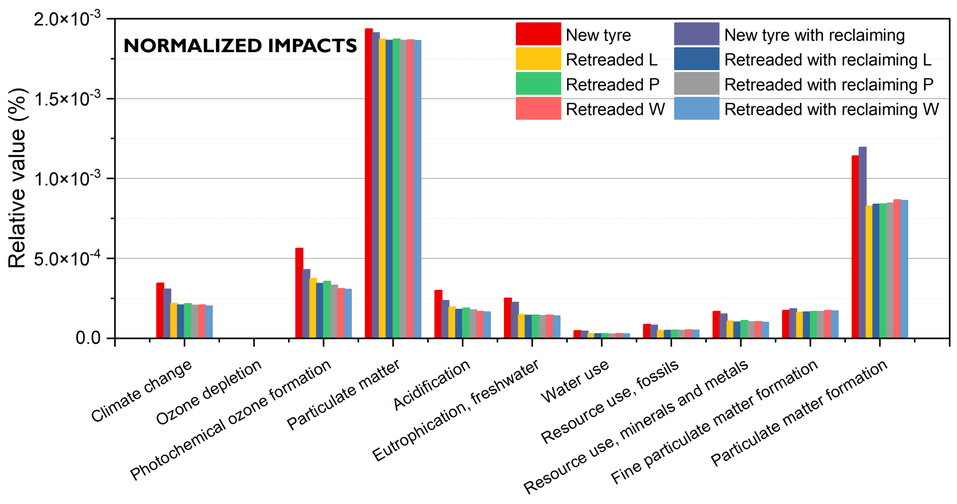
End-of-life stage modelled according to European statistics:

- Tyres: 3.5 backfilling, 4.3 % landfilling, 39.8 % incineration, 52.4 % recycling
- Plastic (packaging): 17.3 % landfill, 37.2 % incineration, 45.5 % recycling
- Paper/cardboard: 28 % incineration, 72 % recycling
- Steel: incineration: 10 %, recycling 90 %

LIFE CYCLE IMPACT ASSESSMENT



- **Retreaded tyres => reduction of 35-45 %**
- **Reclaimed rubber => further reduction of 3 %**



Particulate matter impact category with highest relevance => find solutions to reduce tyre wear and particulate emissions (not influenced by reclaimed rubber use).

NEW TYRE

1 Raw material supply (58 %) — involves modules A1 (57 %) and A2 (1 %)

2 Manufacturing (26 %) — entails module A3

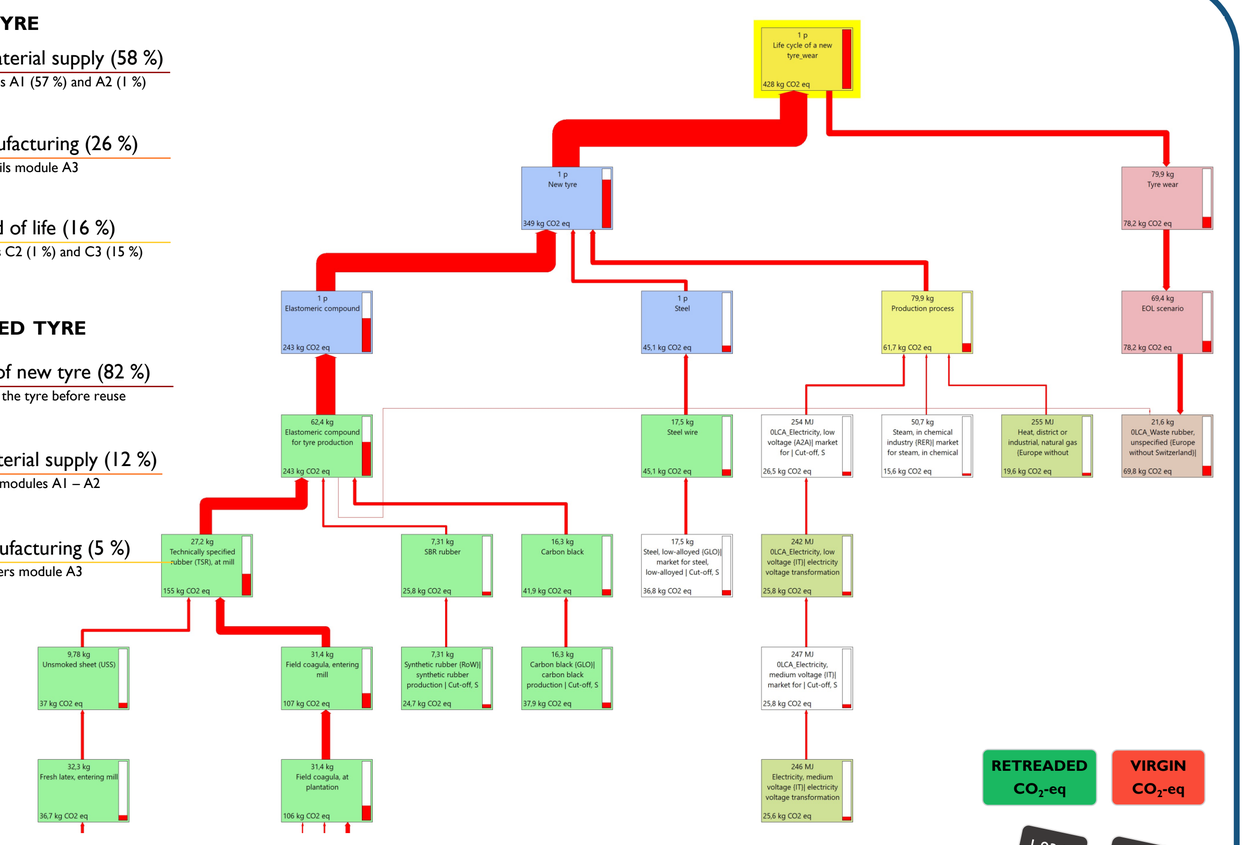
3 End of life (16 %) — covers modules C2 (1 %) and C3 (15 %)

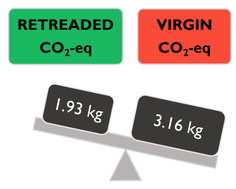
RETREADED TYRE

1 LC of new tyre (82 %) — life cycle of the tyre before reuse

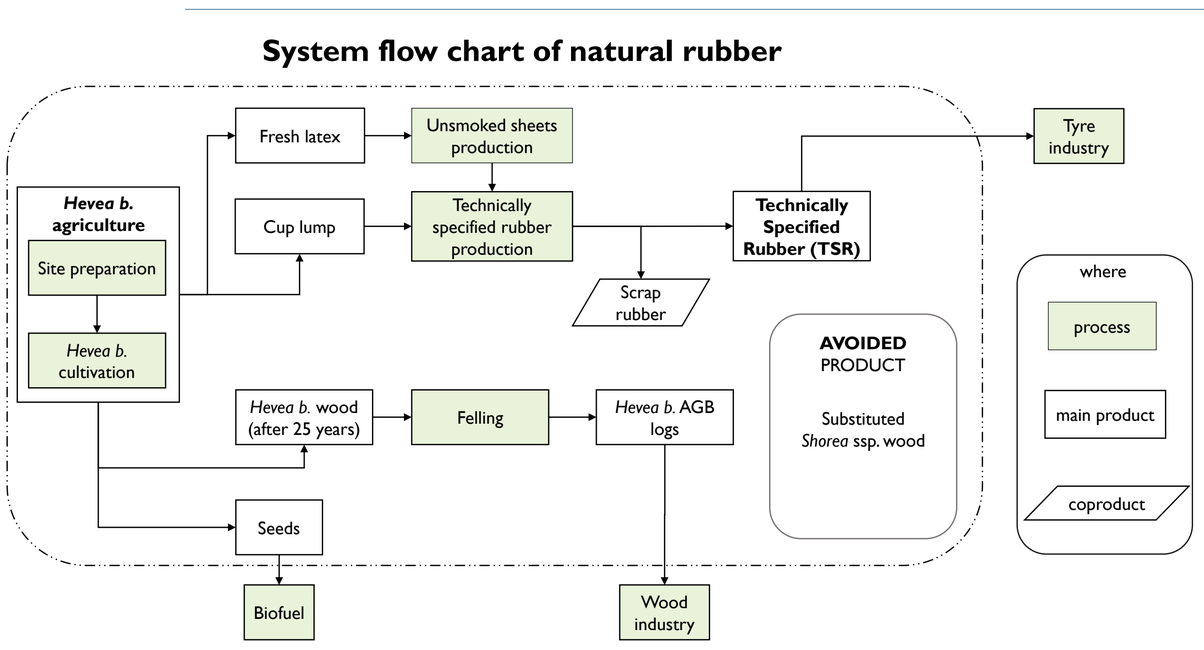
2 Raw material supply (12 %) — entails modules A1 – A2

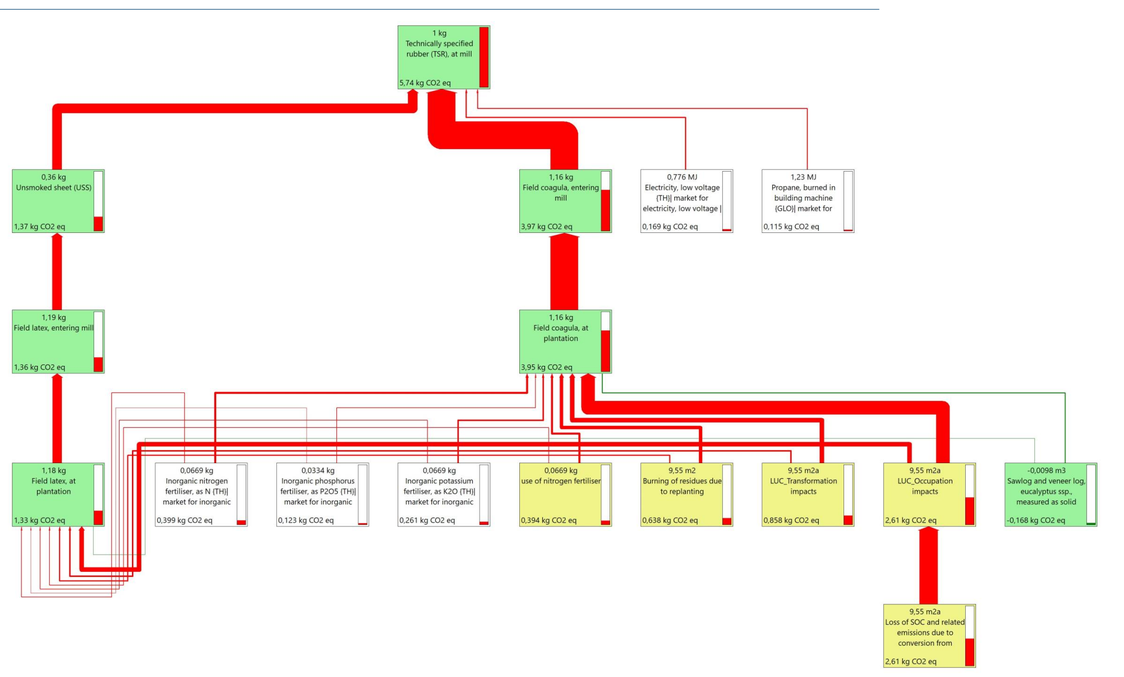
3 Manufacturing (5 %) — covers module A3





- Environmental impact mainly caused by raw materials extraction (60 %)
- **Very high impact of natural rubber** (land use change)
- **Retreading is the first way to drastically reduce the environmental impact of tyres**
- Necessity of solutions to (i) improve recycling rate, (ii) avoid landfilling, (iii) retread car tyres
- Reclaimed rubber interesting but should be applied also on new tyres and not only to the tread => influence of mechanical properties and performances under investigation
- **Reclaimed rubber reduces EU dependency on import of natural rubber (strategic)**





First complete study exploring environmental impacts of natural rubber used in tyres. Environmental impact caused by land use change (deforestation to make space for new plantations).

CONCLUSIONS

- **Retreaded tyres deliver an environmental impact reduction of ~ 40% across almost all impact categories, with a further reduction of 4 % introducing the reclaimed rubber.**
- **Considering a driving distance equal to 1 million km, 1 retreaded tyre allows to save 1060 kg CO_2 eq compared to a new virgin tyre, and the introduction of reclaimed rubber allows to save others 67 kg CO_2eq.**

References: G. Cucci, F. Valentini, A. Dorigato. Cradle to gate life cycle assessment of Tyre-grade natural rubber produced in Thailand. 2025. https://doi.org/10.1016/j.scitotenv.2025.179653

Acknowledgments: this project has received funding from the European Union's LIFE Programme within the project LIFE23-PRE-IT-NORUBTREET_4_LIFE: NOvel RUBber blends for Tyres with a REduced Environmental impacT, for a better LIFE (Grant Agreement No 101148761).