European Commission

Preparatory study and impact assessment support study on tyres

Draft report
Task 5 of the preparatory study

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May – 2026

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EUROPEAN COMMISSION

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European Commission
B-1049 Brussels

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Task 5 of the Preparatory study

Version 1

Directorate-General for Environment
<Name of the programme/activity>

20XX

EUR <number> EN

Submitted by:

vito

In collaboration with:

Öko-Institut Consult GmbH ecomatters Trinomics

Manuscript completed in May 2026

Draft edition

Luxembourg: Publications Office of the European Union, 2026

Print	ISBN <xxx-xx-xx-xxxxx-x>	ISSN <xxxx-xxxx>	doi:10.<xxxx/xx...x>	<xx-xx-xx-xxx-xx-x>
PDF	ISBN <xxx-xx-xx-xxxxx-x>	ISSN <xxxx-xxxx>	doi:10.<xxxx/xx...x>	<xx-xx-xx-xxx-xx-x>
EPUB	ISBN <xxx-xx-xx-xxxxx-x>	ISSN <xxxx-xxxx>	doi:10.<xxxx/xx...x>	<xx-xx-xx-xxx-xx-x>
HTML	ISBN <xxx-xx-xx-xxxxx-x>	ISSN <xxxx-xxxx>	doi:10.<xxxx/xx...x>	<xx-xx-xx-xxx-xx-x>

Project Information

Title	Preparatory Study and Impact Assessment support study on tyres
Framework Contract No	ENV.B.4/FRA/2023/0018 Lot 1
Specific Contract No	2025/4500082801/ENV.B4/GROW
Service Request No	8
Project Duration	30 months
Starting Date	01/03/2025
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Oeko Institut	Germany
Ecomatters	The Netherlands
Trinomics	The Netherlands

Deliverable information

Deliverable No	D3
Version of Deliverable*	1
Task	2: Preparatory Study (PS) Phase 2
Sub-task	2.3 PS Tasks 1-7 MEErP Task 5: Environment
Main author(s)	Serena Cunsolo, Maria Papavasileiou, Max Sonnen (Ecomatters)
Reviewers	Wai Chung Lam & Nele Kelchtermans (VITO) Yifaat Baron & Daniel Hinchliffe (Oeko-Institut)
Recipient(s)	Lie Heymans (DG-ENV-B4) & Alexander Campenhausen (DG-GROW-I2)
Nature	DR – Draft Report
Dissemination Level	RE – Restricted to a group specified by the EC (including EC)
Contractual Delivery Date	M5 (08/2025) – Revised: M17 (05/2026)

*Version	Date	Description
(D3-T5) 0.1	02/12/2025	Template for input
(D3-T5) 0.2	09/04/2026	Input provided - Version for internal review
(D3-T5) 0.3	10/04/2026	Version with QA-1
(D3-T5) 0.4	21/04/2026	Reviewed version
(D3-T5) 0.5	22/04/2026	Version 0.5 sent to EC
(D3-T5) 0.6	08/05/2026	Version 0.6 with EC feedback
(D3-T5) 0.7	13/05/2026	Revised version 0.7 for internal review
(D3-T5) 0.8	18/05/2026	Version 0.8 with QA-2
(D3-T5) 1.0	18/05/2026	Version 1 (Revised with QA-2) (D2) sent to Stakeholders

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List of Abbreviations and definitions

3PMSF	Three-Peak Mountain Snowflake
ADAC	Allgemeiner Deeutscher Automobil-Club
BAT	Best Available Technology
BC	Base Case
BNAT	Best Not (yet) Available Technology
BOM	Bill of Materials
CB	Carbon Black
CLP	Classification, Labelling and Packaging
CN	Combined Nomenclature
dGTR	Devulcanised Ground Tyre Rubber
DPP	Digital Product Passport
EAF	Electric Arc Furnaces
EEA	European Environmental Agency
EF	Environmental Footprint
ELTs	End-of-Life Tyres
ELV	End-of-Life Vehicles
EPD	Environmental Product Declaration
EPREL	European Product Registry for Energy Labelling
EoL	End of Life
ESPR	Regulation (EU) 2024/1781 of 13 June 2024 establishing a framework for the setting of Ecodesign for Sustainable Products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC
EUT	End-of-Use Tyres
HICP	Harmonised Index of Consumer Prices
HS	Harmonised System
H_2S	Hydrogen Sulphide
ICE	Internal Combustion Engine
IQR	Interquartile Range
JRC	Joint Research Centre
LCA	Life Cycle Assessment
LCC	Life Cycle Costs
LLCC	Least Life Cycle Costs
LHV	Lower Heating Value
NACE	Nomenclature of Economic Activities
MEErP	Methodology for Ecodesign of Energy-related Products
OE	Original Equipment
OEM	Original Equipment Manufacturer
PAH	Poly Aromatic Hydrocarbons
PCR	Product Category Rules
PEFCR	Product Environmental Footprint Category Rules
PET	Polyethylene Terephthalate
rCB	Recycled Carbon Black
RCC	Rolling Resistance Coefficient
RFT	Run-Flat Tyres

sCB	Sustainable Carbon Black
TaaS	Tyre-as-a-Service
TDF	Tyre Derived Fuel
TPG	Tyre Pressure Gauges
TPO	Tyre Pyrolysis Oil
TPMS	Tyre Pressure Monitoring Systems
ToR	Terms of Reference
V2X	Vehicle To Everything
WFD	Waste Framework Directive or Directive 2008/98/EC on waste
wt-%	weight percent (share based on mass)
ZnO	Zinc Oxide

1. Executive Summary

This report assesses the environmental and economic impacts of the average product tyre for the EU market. The objective of this study is to evaluate the environmental performance of tyres through Life Cycle Assessment (LCA) to identify hotspot emissions across the lifecycle of the product. The analysis covers all the stages of a product's lifecycle, from raw materials acquisition and transport, to production facilities, product manufacturing, distribution, use phase and finally, end-of-life. The Life Cycle Costs (LCC) (e.g., purchase, operation, maintenance) of tyres have also been evaluated, and together with the results deriving from the product's environmental performance, they have enabled the identification of the design options for Ecodesign requirements in Task 6 of the MEErP methodology.

The assessment is based on the MEErP methodology and the LCA results are presented following the Product Environmental Footprint (PEF) impact assessment method, as outlined in Commission Recommendation (EU) 2021/2279 and further aligned with the 2025 JRC guidance Developing a method for the assessment of life-cycle environmental impacts of products, and integration in or relation with the Methodology for the Ecodesign of Energy-related Products. As for the LCC, the Ecoreport tool was used for the assessment of the economic impacts. In terms of data sourcing, the background data was derived from the Ecoinvent database, while foreground data was mainly obtained from stakeholders, scientific literature and Task 1-4 of the MEErP Preparatory study.

The use phase of a tyre has been identified as the emission hotspot regarding the climate change impacts throughout the entire lifetime of a tyre and for all the base cases considered in this study. This is followed by the climate change impacts deriving from the raw materials' supply, which represents the second contributor to the total climate change impacts. Results have been provided for all PEF impact categories and are also presented as PEF Single Score, where the impacts of all PEF categories have been combined into one dimensionless number after normalisation and weighting of each PEF impact category. Sensitivity analyses have been conducted on different parameters to gain insights on to what extent parameters' variations affect the environmental and economic impacts. The key outcomes of this analysis refer to the crucial role that the rolling resistance coefficient of a tyre plays in influencing the use phase impacts. This is because the higher the rolling resistance coefficient's value (i.e., the worse it is), the higher the energy consumption of a tyre, resulting in an increase of the fuel use, which affects both the climate change and PEF single score impacts of the use stage. Another analysis shows how the changes in the reference service life (RSL) of a tyre (expressed as Km) can also influence the use phase impacts, since more fuel is used when a tyre has a higher RSL. For this reason, and since the base cases feature different RSLs, results are reported not only for the total lifetime of the tyre, but also per Km driven to allow for comparison across base cases.

Finally, the results regarding the LCC analysis highlight that the fuel costs represent the top contributor in terms of economic impacts for all base cases. When considering the total annual costs per Km driven, BC3 shows the highest impact.

2. MEErP Task 5 – Environment

2.1. Objectives of MEErP Task 5

This study aims to provide an objective assessment of the environmental Life Cycle Assessment (LCA) and Life Cycle Costs (LCC) for the tires. The foundation of this analysis is the establishment of a Base Case (BC), a conceptual representation of the average product or product category for the EU market. The BC is essential for conducting environmental and cost assessments efficiently, given practical constraints such as data availability, time, and budget. The results of this study will serve as a baseline for evaluating design options for Ecodesign requirements in Task 6 of the MEErP. Additionally, the BC approach will be critically assessed in MEErP Task 7 for its applicability across different market segments through scenarios.

2.1.1. Environmental analysis

2.1.1.1. Goal definition

The goal of the assessment is to quantify the environmental impacts of a BC product throughout its lifecycle. This includes the entire process from the extraction of raw materials to the disposal of components at the end-of-life (cradle to grave). In this study under the Ecodesign for Sustainable Products Regulation (ESPR), the PEF methodology has been used as guidance to assess the life cycle impacts of the tyre.

The key method employed for this assessment is LCA, which entails:

- Life cycle inventory development: Detailing all incoming and outgoing material and energy flows for each lifecycle stage – design and manufacturing, transportation, usage, and end-of-life processing through the life cycle inventory per BC.
- Impact aggregation: Aggregating these flows over the product's lifetime to compute total environmental impacts. This computation uses a functional unit that aligns with the product's performance in its intended application.
- Environmental indicators: The study employs 25 predefined environmental indicators established for all Ecodesign studies under the MEErP review, with detailed descriptions provided in **Section 2.4.1**.
- Using BCs in LCA: Quantifying the environmental impacts offers the advantage of a comprehensive understanding of the resources consumed and the environmental side effects caused by a product. However, its inherent challenge lies in accounting for the variability in life cycles across products in a market. To address this, BCs approximate the 'average' product and serve as a basis for extrapolating the environmental impacts across the entire market for the product category under review.

The EcoReport tool (ERT) is commonly used for environmental impact assessment in preparatory studies; however, its suitability for this product category is limited. Modelling of the use-stage impacts in ERT is based on energy and utility consumption and therefore does not capture nuances specific to tyres. Consequently, LCA modelling and result calculations in this study are based on the Product Environmental Footprint (PEF) methodology, as outlined in Commission Recommendation (EU) 2021/2279 and further aligned with the 2025 JRC guidance Developing a method for the assessment of life-cycle environmental impacts of products, and integration in or relation with the Methodology for the Ecodesign of Energy-related Products (Gonzalez Torres, Maria et al., 2025).

The Commission Recommendation is used as the main guidance for modelling decisions, as no Product Environmental Footprint Category Rules (PEFCR) are available for this product category. For product-specific aspects, this approach is supported by Version 3.05 of the Product Category Rules (PCR) for preparing an Environmental Product Declaration (EPD) for the product category Tires (UL Solutions, 2025). This PCR is particularly relevant for modelling use-stage impacts, which would otherwise be derived from the modelling rules included in a valid PEFCR. The use phase represents the emission hotspot of the life cycle of the tyre due to the fuel consumption needed for the vehicle's operation (Baron et al., 2025), hence the relevance to use the methodology reported in the above-mentioned PCR for this purpose.

Because of the discontinuity of EF 3.1 database since January 2026, the Ecoinvent database and background datasets (Wernet et al., 2016) have been used in the PEF modelling. These are the primarily life cycle inventory (LCI) process datasets used as secondary data to model background (upstream/downstream) processes (materials, energy supply, transport, waste treatment, etc.).

2.1.1.2. Scope definition

As mandated by the PEF methodology, the scope of the study needs to be defined, describing the system to be evaluated. This includes the functional unit and system boundary definition. The functional unit is equivalent to '*one tyre being used over its lifetime*' and it applies to all BCs. All relevant BC characteristics are listed in **Section 2.2.**

The system boundary of the study is defined as cradle-to-grave and includes the life cycle stages raw material acquisition and pre-processing, manufacturing of the tyre, distribution of the tyre, use of the tyre, and end of life. Packaging as well as maintenance and repair stages are not relevant for the product and are therefore excluded from the study. A schematic overview of the system boundaries is illustrated in **Figure 2-1.** More details on each life cycle stage can be found in **Section 2.3**.

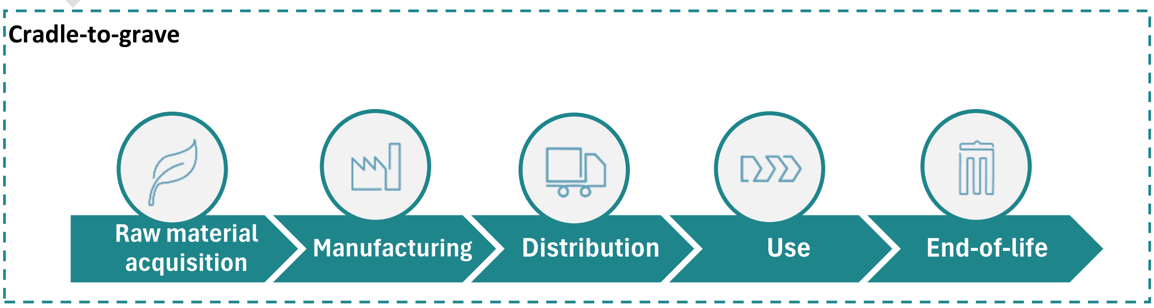

Figure 2-1: System boundaries of the study.

2.1.2. Life cycle costs

As part of the study, the LCC for each BC will be calculated using the structured methodology outlined in the MEErP as it is included in the ERT. The LCC analysis encompasses key cost elements over the product's lifecycle, including product price and operational costs. Both the LCA and LCC calculations are then scaled to the EU27 level for each BC. This broader market-based perspective allows for an evaluation of implications at scale. This dual approach ensures the study delivers actionable insights for stakeholders, facilitates robust policy development, and identifies opportunities to optimise both environmental and economic outcomes across the market.

2.1.3. New considerations in environmental analysis and Life Cycle Costs

This assessment incorporates updates introduced to the MEErP process based on the review and the new aspects resulting from the ESPR. These updates address:

- Lifetime Extension: Factors such as durability, reliability, reusability, upgradability, reparability, maintenance, and refurbishment.
- Material Efficiency: Considerations such as recycled content usage.

The ERT has been revised to integrate these elements, enabling more comprehensive evaluations of environmental impacts and LCCs.

2.1.4. Data quality and sensitivity analysis

The study is based on data extrapolated from literature, data collected from stakeholders (for the year 2024) via an LCA data collection questionnaire and Task 1-4 of the MEErP Preparatory study (Baron et al., 2025). A literature review assessment has been previously conducted on existing LCA studies on tyres to identify the relevant studies and assess availability of data to be used in Task 5 of the MEErP. While every effort has been made to ensure accuracy, variations in real-world performance introduce an element of approximation that cannot be entirely avoided. To maintain transparency, the quality and sources of each data point used are documented for the BC according to the criteria indicated in **Table 2-1.**

Table 2-1: Data quality scoring.

Data source	Data quality scoring
Stakeholder input	High quality
Scientific literature	High quality
Tasks 1-4 MEErP Preparatory Study (Baron et al., 2025)	High Quality
Product Category Rules (PCR) for preparing an Environmental Product Declaration (EPD) for the product category Tires (UL Solutions, 2025)	High quality
Expert judgement	Medium quality
Internet search	Fair quality

The sensitivity analyses in MEErP Task 5 (see **Section 2.7**) will assess the impact of assumptions on the results, ensuring consistency and reliability.

2.1.5. Study outcomes

The LCA and LCC calculations for the BCs are based on data collected from stakeholders (through an LCA data collection questionnaire), on data deriving from the literature assessment review, as mentioned in **Section 2.1.4**, and on data collected from Tasks 1-4 report (Baron et al., 2025). Together, the BCs serve as essential reference points for the subsequent stages of the study, including MEErP Task 6 (Design Options) and MEErP Task 7 (Scenarios).

Acknowledging the inherent uncertainties, this study provides the most robust and reliable estimates to date regarding the environmental impacts and LCC of tires within the EU.

2.2. Definition of Base Cases

This subsection defines and describes the BCs, building on insights from previous tasks, stakeholder input, literature search and expert judgement. BCs do not represent individual real-world products but are instead a representation of the average product on the market. When two or more products share similar Bills of Materials (BoM) and technical parameters, they may be grouped into a single BC.

The number of BCs that have been identified is four (**Table 2-2**). The three main BCs are aligned to the three main tyre classes (i.e., C1, C2 and C3 tyres) with the fourth BC being the retreaded tyre in C3.

Table 2-2: Overview of Base Cases for tyres.

Base Cases for Tyres
BC1: C1 tyres (passenger car tyres)
BC2: C2 tyres (buses, commercial vehicles and their trailers, with load capacity index ≤ 121, speed symbol ≥ 'N')
BC3: C3 tyres (buses, commercial vehicles and their trailers with load capacity index ≥ 122 or load index ≤121 and speed symbol ≤ 'M')

Base Cases for Tyres
BC4: C3 retreaded tyres

2.3. Product-specific inputs

In this section, the specific inputs for the PEF study are described per life cycle stage of the BCs. Detailed input tables per BC are in **Annex I – Inputs for LCA/LCC for Base Cases.**

2.3.1. Raw materials and transport

The life cycle phase Raw Materials is the production of all materials of the product, according to the Bill of Materials (BoM) (**Annex I – Inputs for LCA/LCC for Base Cases)**.

The raw materials that contribute the most by mass to the tyre's production are natural rubber, synthetic rubber, carbon black and steel. Other raw materials include silica, plasticisers and other additives, and textiles. For those raw materials that belong to the category of plasticisers and other additives, suitable proxies have been chosen, and they each contribute less than 2% to the total weight of the tyre. The list of all datasets used is reported in **Annex I – Inputs for LCA/LCC for Base Cases**. Furthermore, for the aramid cord fabric, the proxy for nylon was used, although not considered quite accurate; however, the aramid cord fabric contributes <0.01% to the total mass of the tyre, thus its impact is considered negligible. In the absence of a suitable proxy dataset for the natural rubber, the emission factors from the scientific literature were considered for the modelling (Cucci et al., 2025). Regarding the steel and fabric raw materials, the wire drawing process to make the steel belts and the weaving process for the fabrics, respectively, have also been included.

Transport of the raw materials was accounted for based on the information derived from Tasks 1-4 report (Baron et al., 2025) . This approach applies for all raw materials except for sulphur, for which transport was already included in the background dataset used. The transport distance considered for the raw materials is shown below (**Table 2-3**).

Table 2-3: Transport distance (Km) of the raw materials.

Raw Materials	Train	Lorry	Ship	Unit
Natural Rubber	2000	-	18000	Km
Synthetic Rubber and Carbon Black	-	5000	-	Km
Silica, Zinc Oxide and Plasticisers and other additives	-	1000	18000	Km
Steel and Textiles	-	1000	10000	Km
Sulphur	-	-	-	-

2.3.2. Packaging

The packaging was not modelled given that tyres are sold without packaging.

2.3.3. Manufacturing and assembly

The manufacturing phase of the life cycle refers to the energy consumption and any other relevant utilities that are used during the production and assembly of a tyre. These mainly included: electricity, heat from natural gas, steam, coal and process water. The datapoints and dataset used are reported for each BC in the **Annex I – Inputs for LCA/LCC for Base Cases**. The data for the manufacturing process was provided by stakeholders and collected through an LCA data questionnaire.

2.3.4. Distribution

Regarding the distribution, this was modelled by considering the weight of the tyre transported by truck. Through expert judgement, it was assumed that the transport takes place within the EU and the distance is equal to 1500 Km.

2.3.5. Use phase

The use phase is characterised by the emissions produced by a tyre and the contribution of the tyre to the energy consumption of the vehicle in which the tyre is used. The modelling and calculation of the tyre's environmental impacts during the use phase was conducted according to Product Category Rules (PCR) for preparing an Environmental Product Declaration (EPD) for the product category Tires which was developed and published by UL environment, (UL Solutions, 2025). As mentioned in **section 2.1.1.1**, this PCR is particularly relevant because it provides a methodology to evaluate the environmental impacts of the use phase, which represents the emission hotspot of the life cycle of the tyre due to the fuel consumption needed for the vehicle's operation (Baron et al., 2025).

The energy consumption related to the tyre consists of two types: 1) the tyre's rolling resistance coefficient (RRC), and 2) the tyre's acceleration resistance.

Energy consumption due to rolling resistance

The following equation (**Equation 2-1**) reported in the PCR has been used to compute the energy consumption due to rolling resistance attributable to one tyre (MJ/tyre):

$$\textbf{Energy consumption related to rolling resistance} \left[\frac{MJ}{tyre}\right] = RRCnew\left[\frac{Kg}{t}\right] * \left(1-\frac{RRCloss\%}{2}\right) * relevant\ tyre\ load\ (t) * RSLtire\ [Km] * \frac{g\ [m*s-2]}{\eta 1 * \eta 2} * \left(\frac{dmot}{d} + \left(1-\frac{dmot}{d}\right) * \eta 3\right) * \frac{1}{1}\left[\frac{kJ}{N*km}\right] * \frac{1}{1000}\left[\frac{MJ}{kJ}\right]$$

Equation 2-1: Equation for the calculation of the energy consumption due to rolling resistance.

The parameters shown in the equation are reported in the table below (**Table 2-4**) together with their description. Some of these parameters were set by the PCR, while others were obtained from stakeholders via the LCA Data collection questionnaire.

For C3 retreaded tyres, the rolling resistance coefficient was taken to be the same as new C3 tyres. There is limited available data on the RRC for retreaded tyres as the RRC is not yet widely tested for retreads. Datasets from the IDIADA study to support the retreading label find that the RRC of the retread depends mostly on the use of a quality (or original) tread compound on a high-quality casing, the retreading process itself plays a smaller role with cold-cure processes performing marginally better. The IDIADA measurements aimed primarily to understand tolerances in the retreading process, finding a variation of 2.6 N/kN from the casing, 1.4 N/kN from the tread and 0.8 N/kN from the process (Applus + IDIADA, 2024). The following other sources were found relating to the retread RRC:

- A study by Fraunhofer UMSICHT on retreads found the RRC to be the same between new and retreaded tyres at similar starting tread depths (Blömer et al., 2023).
- In discussions with one manufacturer which retreads their own tyres, it was stated that the retread rolling resistance is usually no more than 0.3 kg/t higher than that of the original tyre (likely to be in a B or C class). It was noted that if buyers were willing to pay for a A rated RRC retread, then this would also be achieved but there is limited market interest for this.
- Tests on retreaded tyres from Marangoni have also shown the retread to have the same rolling resistance as the new tyre (Sannicolò, 2022).
- Freight companies which rely on retreads for their fleets would not use these if the RRC led to major increases in fuel costs.
- A large part of the retreading market (~70%) (Retreading Label team, 2025) belongs to large tyre manufacturers who have access to their own high-quality casings and the same tread compounds from the original tyre, while retreader networks of the large manufacturers may also apply these tread materials.

It should also be noted that retreaded tyres are in a price segment comparable to budget tyres, which tend to have 1-1.5 t/kg RRC worse than a new tyre that is typically retreaded, i.e. BC3 (current legislative threshold for C3 tyres is 6.5 kg/t in UN R117 until Sept. 2028). It was therefore decided to take a good retread with the same RRC as a new tyre of the same type, and in section 1.7.4. apply a sensitivity analysis for different rolling resistance coefficients to determine the break-even point where rolling resistance losses in the use phase counteract the savings from materials on a single retread. To enable a fair comparison in the same price segment, a further sensitivity analysis of comparably priced tyres is also conducted, with shorter lifetimes and lower RRC.

Table 2-4: Parameters used in Equation 2-1 by Base Case.

Parameter	Unit	Description	BC1	BC2	BC3	BC4
RRC_{new}	Kg/t	Rolling Resistance coefficient (RRC)	8.4	6	5.3	5.3
$RRC_{loss\%}$	%	Reduction of the RRC of a used tyre (at the end of its RSL) compared to a new one	20	20	34	34
Relevant Tire Load	t	Relevant tyre load	0.39	0.49	2.7	2.7
RSL_{tire}	km	Reference Service Life	40000	57000	253410	245920
g	m/s^2	Standard acceleration due to gravity	9.81	9.81	9.81	9.81
η_1	-	Efficiency n˚1 depending on vehicle technology	0.37	0.42	0.46	0.46
η_2	-	Efficiency n˚2 depending on vehicle technology	0.9	0.9	0.9	0.9
η_3	-	Efficiency n˚3 depending on vehicle technology	0	0	0	0
d_{mot}/d	-	% of driving cycle with energy torque demand	0.8	0.8	0.8	0.8
Energy consumption due to rolling resistance	MJ/tyre	-	2743.8	3115.4	55970.5	54625.4

Energy consumption due to acceleration resistance

The following equation (**Equation 2-2**) reported in the PCR has been used to compute the energy consumption due to acceleration resistance attributable to one tyre (MJ/tyre):

$$\textbf{\textit{Energy consumption related to acceleration resistance}} \left[\frac{\textbf{\textit{MJ}}}{\textbf{\textit{tyre}}}\right]$$
$$= \frac{Inertia\ Force\ of\ the\ tire\ [N]}{\eta 1 * \eta 2} * \left(1 - \frac{RRCloss\%}{2}\right) * RSLtire\ [Km]$$
$$* \left(\frac{dmot}{d} + \left(1 - \frac{dmot}{d}\right) * \eta 3\right) * \frac{1}{1}\left[\frac{kJ}{N * km}\right] * \frac{1}{1000}\left[\frac{MJ}{kJ}\right]$$

where:

$$\textbf{\textit{Inertia Force of the tyre}}\ [\textbf{\textit{N}}]$$
$$= \left(Weight\ new\ [Kg] - \frac{TWL\ [Kg]}{2} + \frac{Inertia\ Moment\ [Kg.m2]}{Outer\ radius\ [m2]}\right)$$
$$* \gamma [m.s2]$$

$$\textbf{\textit{Inertia moment}}\ [\textbf{\textit{Kg.m2}}]$$
$$= 0.8 * \left(Weight\ new\ [Kg] - \frac{TWL\ [Kg]}{2}\right) * Outer\ radius\ [m2] +\ 0.2$$
$$* \left(Weight\ new\ [Kg] - \frac{TWL\ [Kg]}{2}\right) * Seat\ Radius\ [m2]$$

Equation 2-2: Equations for the calculation of the energy consumption due to acceleration resistance.

The acceleration resistance is directly related to the inertia force (due to the tyre's mass and inertia moment) and to the cycle positive accelerations (UL Solutions, 2025). The parameters shown in the equations above are reported in the table below (**Table 2-5**) together with their description.

Table 2-5: Parameters used in Equation 2-2 by Base Case.

Parameter	Unit	Description	BC1	BC2	BC3	BC4
RSL_{tire}	km	Reference Service Life	40000	57000	253410	245920
$Weight_{new}$	Kg	Weight of a new tyre	8.18	13.5	64.11	66.25
TWL	Kg	Tyre Wear Loss	1.6	1.91	12.31	12.31
Outer Radius	m	Distance from the centre of the rim to the top of the tyre tread	0.32	0.34	0.51	0.51
Seat Radius	m	Distance from the centre of the rim to where the tyre is seated on the rim	0.2	0.2	0.29	0.29

Parameter	Unit	Description	BC1	BC2	BC3	BC4
η_1	-	Efficiency n°1 depending on vehicle technology	0.37	0.42	0.46	0.46
η_2	-	Efficiency n°2 depending on vehicle technology	0.9	0.9	0.9	0.9
η_3	-	Efficiency n°3 depending on vehicle technology	0	0	0	0
γ	m/s^2	Positive acceleration value of the considered cycle	0.16	0.16	0.03	0.8
Energy consumption due to acceleration resistance	MJ/tyre	-	213.6	453.6	1586.7	1596.8

After the calculation of the energy consumptions of the tyre due to the rolling resistance and acceleration resistance, these were converted into fuel amount (**Table 2-6**) that is then combusted by the engine by factoring in the lower heating value (**Table 2-7**) based on the type of fuel. For BC1, the petrol E10 blend was chosen by expert judgment, as it is considered the most common in Europe; and for BC2, BC3 and BC4, diesel fuel was selected.

Table 2-6: Calculated fuel (Kg) per tyre by Base Case that undergoes combustion.

Type of fuel	Unit	BC1	BC2	BC3	BC4
Petrol blend E10	Kg fuel/tyre	68.2	-	-	-
Diesel	Kg fuel/tyre	-	83.4	1344.8	1313.6

Table 2-7: Lower heating values used for the conversion of the energy consumption to fuel amount.

Type of fuel	Lower Heating Value	Unit	Reference
Petrol	45.2	MJ/Kg	(The Engineering ToolBox (2003))
Ethanol	26.7	MJ/Kg	(The Engineering ToolBox (2003))
Diesel	42.8	MJ/Kg	(Wernet et al., 2016)

The emission factors used to calculate the emissions deriving from the combustion of the different types of fuels were taken from the European Environment Agency air pollutant emission inventory guidebook (from Table 3-5 to Table 3-14) (Leonidas Ntziachristos, Zissis

Samaras, 2025). Finally, the impacts resulting from the supply of the fuels were also added to the Use phase calculations; the datasets that were selected are reported in **Annex I – Inputs for LCA/LCC for Base Cases**.

2.3.6. Maintenance and repair

The environmental impacts of the maintenance and repair have not been included as they have been deemed negligible. This is because the energy consumption and any other utilities used for the maintenance and repair stages are minimal, therefore their impacts are assumed to be negligible.

2.3.7. End-of-life

The End-of-Life (EoL) stage of the study consists of the treatment of the end-of-life tyres (ELTs) and the waste flows occurring at the tyre manufacturing stage. This chapter describes the EoL scenarios of this study as well as the EoL impact assessment with the application of the Circular Footprint Formula (CFF) as required by the PEF methodology defined in Commission Recommendation (EU) 2021/2279 (European Commission, 2021b).

2.3.7.1. End-of-life scenarios

The EoL stage of the product consists of five treatment paths as identified and described in detail in Tasks 1-4 report (section 7.6.2) (Baron et al., 2025). These treatment paths form the EoL scenario used in the impact calculations of this stage, as shown in **Table 2-8**. **Annex III – End-of-life and Circular Footprint Formula inputs for LCA** includes the LCA model input data for the five treatment paths.

Table 2-8. Overview of the end-of-life treatment scenario.

End-of-life treatment scenario	Share (%)
Mechanical recycling (granulation)	40.2%
Fuel substitution in cement kiln	48.8%
Pyrolysis	7.2%
Devulcanisation	0.5%
Civil engineering/backfilling/public works	3.3%

Mechanical recycling entails the shredding of ELTs and the separation of the rubber fraction from steel and textile components. The final product of mechanical recycling is recycled rubber granulate which can be used in multiple applications such as sports and leisure surfacing, artificial turf systems and industrial rubber and plastics compounding, as described in section 7.6.1.3 of the Task 1-4 report (Baron et al., 2025). The recycled rubber obtained from mechanical recycling is of lower quality than the virgin rubber. Based on the price difference between virgin synthetic rubber and recycled rubber granulate, a quality ratio of 9%[1] has been determined (Braithwaite et al., 2021; Imarc Group, 2025).

ELTs can also be used as fuel input in cement kilns, where they replace part of the fossil fuel mix used in the EU cement production. This fuel mix consists of 63% petroleum coke, 24% hard coal, 11% lignite and 2% natural gas (CEMBUREAU, 2025). In the present study, it is assumed that the whole tyre is fed to the cement kiln is applied, and the steel content is considered to substitute iron used as an additive in cement production. Furthermore, an ELT calorific value of 28 MJ/kg is used (Maga et al., 2023).

The treatment of ELTs through pyrolysis consists of two main steps: granulation and separation of the rubber fraction via mechanical recycling, followed by the thermochemical decomposition of organic materials at elevated temperatures under oxygen-deficient conditions in a pyrolysis plant, where pyrolysis gas, pyrolysis coke and pyrolysis oil are produced. Pyrolysis coke is further processed into carbon black agglomerates. All three pyrolysis products can replace valuable materials and have potential applications, as described in section 7.6.1.6 of the Task 1-4 report (Baron et al., 2025).

Similarly to pyrolysis, devulcanisation entails the separation of ground rubber via mechanical recycling, followed by the process of breaking the sulphur cross-links in vulcanised rubber to restore its plasticity (devulcanisation). The process output, devulcanised rubber, can replace virgin rubber in applications such as tyre manufacturing, conveyor belts and moulded goods production, as described in section 7.6.1.4 of the Task 1-4 report (Baron et al., 2025).

Finally, ELTs can be used in backfilling, civil engineering applications, and public works, where whole tyres serve as erosion barriers, breakwaters, and similar structures. In this scenario no prior treatment is applied, and it is assumed that the whole tyre behaves as inert material.

For all EoL scenarios, a default transport distance of 100km has been assumed for the transportation of tyres to the EoL treatment facilities, based on the PEF methodology.

2.3.7.2. Circular Footprint Formula

The EoL stage impact is calculated with the CFF, an approach developed within the European Commission's Product Environmental Footprint (PEF) method (European Commission, 2021a). According to this approach, depending on the balance between supply and demand of the recycled material in the European market, the burdens of recycling are divided between the primary and secondary life cycles. This balance is expressed by the "A factor", a factor that allocates burdens and credits from recycling and virgin material production between the two life cycles.

All impacts associated with material recycling, as well as credits for avoiding the use of primary materials, heat, and electricity in the secondary life cycle, are included in the study for both EoL tyres and tyre manufacturing waste flows. Specifically, credits are assigned for the avoidance of virgin raw materials due to tyre recycling. These credits are linked to the output flows of each

[1] This means that 1kg of recycled rubber granulate is considered to perform equivalently to 0.09 kg of virgin rubber in terms of quality and functionality.

recycling scenario, namely recycled rubber, recycled steel, recycled carbon black, recycled pyrolysis gas and recycled pyrolysis oil.

For each of these output flows, the environmental impact of the equivalent virgin raw material production impact is considered avoided and is therefore credited to the system. In the case of fuel substitution in cement kilns, credits are assigned for the avoided use of conventional fuels. Finally, for the manufacturing waste flows that are incinerated, credits for heat and electricity are granted due to energy recovery**. Annex III – End-of-life and Circular Footprint Formula inputs for LCA** contains an overview of the CFF parameters applied to each scenario, including the datasets for the impact calculations.

2.3.8. Life cycle costs

The Life Cycle Costs (LCC) of each BC are calculated using the ERT with the consumer purchase price (in 2024 euros, including markup by retailers), installation costs, repair and maintenance costs as well as the costs of fuel use due to rolling resistance. The economic input parameters used in the calculations are sourced from Task 1-4 report (Baron et al., 2025) and they are based on stakeholder input, literature reviews and expert judgement. **Table 2-9** provides an overview of the main costs used per BC.

The repair and maintenance costs were assumed to be the same for all BCs and cover activities such as wheel alignment, tyre balancing and patching/puncture repair, as indicated in the Tasks 1-4 report (section 5.5.3) (Baron et al., 2025). Each repair activity was assumed to performed once during a tyre's lifetime. The installation costs, cover the tyre mounting and balancing activities, as described in the Tasks 1-4 report (section 5.5.4) (Baron et al., 2025). The fuel rate used for the calculations is based on the price for Euro super 95 and diesel as collected in May 2025. Finally, it is assumed that the changes in manufacturing costs as well as EoL costs are reflected in the purchase price. A full list of the LCC input data is presented in **Annex I – Inputs for LCA/LCC for Base Cases**.

Table 2-9. Life cycle costing input data for all Base Cases.

Life Cycle Costing parameter	Unit	BC1	BC2	BC3	BC4
Product price	Euro/tyre	71	111	419	363
Installation costs	Euro/tyre	19	19	19	19
Fuel rate (Euro-super 95 for BC1 and diesel for the rest)	Euro/MJ	0.047	0.039	0.039	0.039
Repair and maintenance costs	Euro/tyre	59	59	59	59
Lifetime	year	4	3	3	3
Lifetime	Km driven/year	10000	19000	84470	81973

One of the parameters for the LCC is the escalation rate, which is the real (inflation-corrected) annual growth of running costs. The only running cost applicable to tyres is the cost of fuel. The escalation rate can be calculated from the extrapolated prices growth rate after correcting for inflation (using historical data both for fuel price and for inflation). An overview of the escalation rate calculations is provided in **Annex I – Inputs for LCA/LCC for Base Cases.**

2.4. Base case environmental impact assessment

In this section, the life cycle assessment results for each BC are presented, followed by a contribution analysis of the main contributors to the life cycle environmental impact for each BC, and an interpretation of these results.

2.4.1. Environmental impact assessment method

The environmental impacts of the BCs were calculated using LCA modelling software SimaPro (version 10.2.0.0) and the data inputs presented in the previous section and in **Annex I – Inputs for LCA/LCC for Base Cases.** The results are presented following the PEF impact assessment method, as outlined in Commission Recommendation (EU) 2021/2279 (European Commission, 2021b). Twenty-five environmental impact categories are included, which are:

- Acidification, in mol H+-equivalent
- Climate change, total, in kg CO_2-equivalent
- Climate change - Biogenic, in kg CO_2-equivalent
- Climate change - Fossil, in kg CO_2-equivalent
- Climate change – Land use and LU change, in kg CO_2-equivalent
- Ecotoxicity, freshwater, in CTUe
- Ecotoxicity, freshwater - inorganics, in CTUe
- Ecotoxicity, freshwater - organics, in CTUe
- Particulate matter, in disease incidence
- Eutrophication, marine, in kg N-equivalent
- Eutrophication, freshwater, in kg P-equivalent
- Eutrophication, terrestrial, in mol N-equivalent
- Human toxicity, cancer, in CTUh
- Human toxicity, cancer - inorganics, in CTUh
- Human toxicity, cancer - organics, in CTUh
- Human toxicity, non-cancer, in CTUh
- Human toxicity, non-cancer - organics, in CTUh
- Human toxicity, non-cancer - inorganics, in CTUh
- Ionising radiation, human health, in kBq U235-equivalent
- Land use, in pt
- Ozone depletion, in kg CFC-11-equivalent

- Photochemical ozone formation, in kg NMVOC-equivalent
- Resource use, fossils, in MJ
- Resource use, minerals and metals, in kg Sb-equivalent
- Water use, in m^3 water-equivalent of deprived water

The LCA results are reported for each impact category and each life cycle stage:

- Raw materials
- Manufacturing
- Distribution
- Packaging
- Use
- Maintenance and repair
- End-of-life (impacts and credits)

For simplification of the graphs, the subcategories of the impact indicators 'Ecotoxicity', 'Human toxicity, cancer' and 'Human toxicity, non-cancer' related to organics and inorganics have not been included. A detailed breakdown of the results by life cycle stages is provided in **Annex II – Results of LCA/LCC per Base Case**.

2.4.2. PEF Single Score

To ensure a balanced assessment, the evaluation of the full range of environmental impacts is necessary. Therefore, in this task on BC impact assessment, as well as in the following tasks where the proposed design options are assessed and compared, a narrow focus on only one or two categories would introduce bias into the comparison and overlook trade-offs across the remaining impact categories.

To address this, the PEF single-score methodology is applied, transforming the impact category results into a single, normalised, weighted indicator. By aggregating climate change, toxicity, eutrophication, land use, and other life cycle impacts into one score, BCs and design alternatives can be ranked according to their overall environmental performance.

The PEF single score is calculated as follows:

$$PEF\ single\ score = \sum_{i=1}^{16} Ii * \frac{WFi}{NFi}$$

I = *calculated impact for PEF impact category (e.g. Climate change, Acidification, etc).*

WF = *Weighing factor for PEF impact category*

NF = *Normalisation factor PEF impact category*

Equation 2-3. Equation for the PEF Single score calculation.

The weighting factor reflects the relative importance of the impact category, and the normalisation factor anchors each impact to a per-capita baseline. The most recent set of weighing and normalisation factors was released in 2023 by the Joint Research Centre (JRC) (European Commission. Joint Research Centre., 2023), which builds on the original factors in Annex I of the Commission Recommendation (EU) 2021/2279 (European Commission, 2021b) on the use of the Environmental Footprint methods. The factors used for calculating the single score is included in **Table 2-10** below.

Table 2-10: PEF Single score normalisation factor and weighing factor per PEF impact category.

Impact categories	Unit	NF	WF
Climate change	kg CO_2 eq./person	7.55E+03	21.06%
Ozone depletion	kg CFC-11 eq./person	5.23E-02	6.31%
Human toxicity, cancer	CTUh/person	1.73E-05	2.13%
Human toxicity, non-cancer	CTUh/person	1.29E-04	1.84%
Particulate matter	disease incidences/person	5.95E-04	8.96%
Ionising radiation	kBq U-235 eq./person	4.22E+03	5.01%
Photochemical ozone formation	kg NMVOC eq./person	4.09E+01	4.78%
Acidification	mol H^+ eq./person	5.56E+01	6.20%
Eutrophication, terrestrial	mol N eq./person	1.77E+02	3.71%
Eutrophication, freshwater	kg P eq./person	1.61E+00	2.80%
Eutrophication, marine	kg N eq./person	1.95E+01	2.96%
Ecotoxicity, freshwater	CTUe/person	5.67E+04	1.92%
Land use	pt/person	8.19E+05	7.94%
Water use	m^3 water eq of deprived water/person	1.15E+04	8.51%
Resource use, minerals and metals	kg Sb eq./person	6.36E-02	7.55%

2.4.3. Results overview LCA

Table 2-11 and **Table 2-12** contain an overview of the impact of tyres for the total life cycle impact and per kilometre driven respectively. It can be observed from the results that BC3 and BC4 have the highest impact across all impact categories. When comparing the two, BC3 has a higher overall impact (PEF single score) than BC4, both for results expressed per total lifetime and per kilometre driven. This is because the quantity of the raw materials used in BC4 and its reference service lifetime are lower than those of BC3**.**

For all BCs, the raw materials input data is reported in **Annex I – Inputs for LCA/LCC for Base Cases** and the reference service lifetime is shown in **Table 2-4**.

Table 2-11. Total life cycle impact per tyre Base Case – total lifetime.

PEF Impact categories	unit	BC1	BC2	BC3	BC4
Acidification	mol H+ eq	9.18E-01	1.49E+00	3.25E+01	3.07E+01

PEF Impact categories	unit	BC1	BC2	BC3	BC4
Climate change	kg CO_2 eq	3.04E+02	3.93E+02	5.70E+03	5.41E+03
Climate change - Biogenic	kg CO_2 eq	4.31E-02	5.96E-02	4.32E-01	3.21E-01
Climate change - Fossil	kg CO_2 eq	3.03E+02	3.93E+02	5.70E+03	5.41E+03
Climate change - Land use and LU change	kg CO_2 eq	4.34E-02	6.50E-02	4.83E-01	2.73E-01
Ecotoxicity, freshwater	CTUe	4.13E+02	7.66E+02	4.27E+03	2.67E+03
Ecotoxicity, freshwater - inorganics	CTUe	3.06E+02	4.54E+02	3.28E+03	2.21E+03
Ecotoxicity, freshwater - organics	CTUe	1.10E+02	3.16E+02	1.01E+03	4.73E+02
Particulate matter	disease inc.	1.16E-05	2.04E-05	1.96E-04	1.79E-04
Eutrophication, marine	kg N eq	2.08E-01	5.81E-01	1.49E+01	1.43E+01
Eutrophication, freshwater	kg P eq	1.08E-02	1.72E-02	1.23E-01	5.36E-02
Eutrophication, terrestrial	mol N eq	2.95E+00	6.27E+00	1.63E+02	1.56E+02
Human toxicity, cancer	CTUh	3.38E-08	6.67E-08	3.92E-07	2.71E-07
Human toxicity, cancer - inorganics	CTUh	1.17E-08	1.30E-08	1.37E-07	1.11E-07
Human toxicity, cancer - organics	CTUh	2.01E-08	4.96E-08	2.24E-07	1.47E-07
Human toxicity, non-cancer	CTUh	2.38E-06	2.99E-06	2.23E-05	3.02E-05
Human toxicity, non-cancer - inorganics	CTUh	8.75E-07	1.24E-06	1.13E-05	8.30E-06
Human toxicity, non-cancer - organics	CTUh	1.30E-06	1.37E-06	8.05E-06	2.07E-05
Ionising radiation	kBq U-235 eq	4.47E+00	6.87E+00	4.44E+01	2.71E+01
Land use	Pt	4.03E+03	7.61E+03	5.92E+04	2.66E+04
Ozone depletion	kg CFC11 eq	1.46E-05	2.36E-05	1.46E-04	1.19E-04
Photochemical ozone formation	kg NMVOC eq	1.67E+00	2.25E+00	4.83E+01	4.68E+01
Resource use, fossils	MJ	4.19E+03	5.35E+03	7.42E+04	6.97E+04
Resource use, minerals and metals	kg Sb eq	3.68E-04	4.42E-04	2.68E-03	1.11E-03
Water use	m^3 depriv.	1.61E+01	2.13E+01	1.40E+02	7.37E+01
Total PEF Single Score		**2.13E-02**	**3.00E-02**	**4.52E-01**	**4.22E-01**

Table 2-12. Total life cycle impact per tyre Base Case – per kilometre driven.

PEF Impact categories	unit	BC1	BC2	BC3	BC4
Acidification	mol H+ eq	2.30E-05	2.61E-05	1.28E-04	1.25E-04
Climate change	kg CO_2 eq	7.59E-03	6.90E-03	2.25E-02	2.20E-02
Climate change - Biogenic	kg CO_2 eq	1.08E-06	1.05E-06	1.70E-06	1.31E-06
Climate change - Fossil	kg CO_2 eq	7.59E-03	6.90E-03	2.25E-02	2.20E-02
Climate change - Land use and LU change	kg CO_2 eq	1.09E-06	1.14E-06	1.90E-06	1.11E-06
Ecotoxicity, freshwater	CTUe	1.03E-02	1.34E-02	1.68E-02	1.09E-02
Ecotoxicity, freshwater - inorganics	CTUe	7.64E-03	7.96E-03	1.29E-02	8.98E-03

PEF Impact categories	unit	BC1	BC2	BC3	BC4
Ecotoxicity, freshwater - organics	CTUe	2.74E-03	5.54E-03	4.00E-03	1.92E-03
Particulate matter	disease inc.	2.90E-10	3.57E-10	7.75E-10	7.29E-10
Eutrophication, marine	kg N eq	5.21E-06	1.02E-05	5.88E-05	5.79E-05
Eutrophication, freshwater	kg P eq	2.70E-07	3.02E-07	4.84E-07	2.18E-07
Eutrophication, terrestrial	mol N eq	7.37E-05	1.10E-04	6.43E-04	6.34E-04
Human toxicity, cancer	CTUh	8.46E-13	1.17E-12	1.55E-12	1.10E-12
Human toxicity, cancer - inorganics	CTUh	2.92E-13	2.29E-13	5.40E-13	4.51E-13
Human toxicity, cancer - organics	CTUh	5.01E-13	8.69E-13	8.84E-13	5.97E-13
Human toxicity, non-cancer	CTUh	5.94E-11	5.25E-11	8.79E-11	1.23E-10
Human toxicity, non-cancer - inorganics	CTUh	2.19E-11	2.18E-11	4.46E-11	3.37E-11
Human toxicity, non-cancer - organics	CTUh	3.26E-11	2.40E-11	3.18E-11	8.43E-11
Ionising radiation	kBq U-235 eq	1.12E-04	1.21E-04	1.75E-04	1.10E-04
Land use	Pt	1.01E-01	1.34E-01	2.33E-01	1.08E-01
Ozone depletion	kg CFC11 eq	3.64E-10	4.14E-10	5.74E-10	4.82E-10
Photochemical ozone formation	kg NMVOC eq	4.17E-05	3.95E-05	1.90E-04	1.90E-04
Resource use, fossils	MJ	1.05E-01	9.38E-02	2.93E-01	2.83E-01
Resource use, minerals and metals	kg Sb eq	9.19E-09	7.75E-09	1.06E-08	4.49E-09
Water use	m^3 depriv.	4.02E-04	3.74E-04	5.53E-04	2.99E-04
Total PEF Single Score	-	**5.32E-07**	**5.26E-07**	**1.78E-06**	**1.71E-06**

2.4.4. Contribution analysis per Base Case

This section contains a detailed analysis on the contribution of each life cycle stage to the life cycle impact per BC. Furthermore, a contribution analysis is performed in the two highest contribution life cycle stages, namely use stage and raw materials production, per BC.

The use phase life cycle stage represents the emission hotspot across all BCs. This is due to the energy consumption related to the tyre's rolling resistance, which represents between 87% and 97% of the total energy consumption across the BCs. Therefore, the rolling resistance plays a primary role, affecting the vehicle's fuel consumption. More details on the role of the rolling resistance are given in the **Sensitivity Analysis** section.

2.4.4.1. BC1: C1 tyres

The detailed results by life cycle stages for BC1 tyres are presented in **Annex II – Results of LCA/LCC per Base Case**. In this chapter the contribution analyses of the full results and of the two highest contributing life cycle stages are presented in detail.

Most of the lifetime impact of C1 tyres is derived from the use phase and the raw materials input (to different degrees for the various impact categories) (**Figure 2-2**). Use phase is the top contributor to nine impact indicators (66 to 90%), including 'Climate change' (90%), 'Photochemical ozone formation' (89%), and 'Resource, fossils' (86%). This is mainly attributed to fuel extraction and use and emissions associated to it. Raw materials extraction stage is the highest contributor to nine impact categories, such as 'Land use' (94%), 'Resource use, minerals and metals' (82%), and 'Water use' (64%). This can be attributed to the impact associated with different raw materials. For the impact category 'Ionising radiation', the highest contributor is the manufacturing stage (40%), mainly due to the nuclear electricity fraction of the European average electricity consumption mix used during the production of the tyre.

In the EoL modelling, credits for avoided raw materials and energy consumption due to recycling of tyres are included, as calculated with the CFF. For BC1, the credits contribute negatively (i.e. lowering the impact) mainly for 'Eutrophication, freshwater' and 'Human toxicity, cancer' as a consequence of avoided fossil fuel use and extraction of raw materials. Most of the credits come from the dominant EoL tyre treatment scenarios, namely mechanical recycling and fuel substitution in cement kilns, as explained in **Table 2-8**.

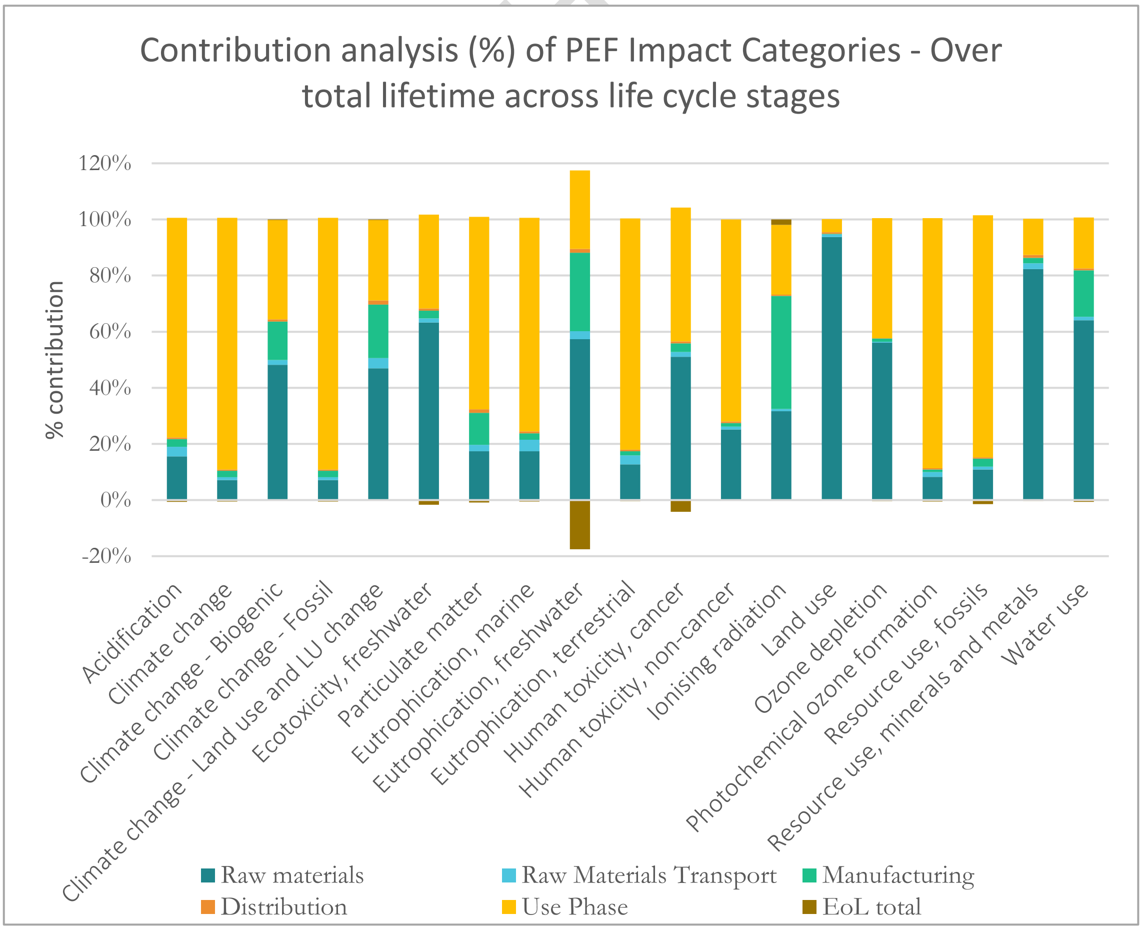

Figure 2-2: Life cycle stage contribution analysis, BC1.

In the use phase, the biggest contributor to most PEF impact categories is the supply of the petrol fuel (67% to 100%). This is however not the case for the 'Climate Change' impact category, where the emissions deriving from the combustion of petrol represent 75% of the total impact (**Figure 2-3**).

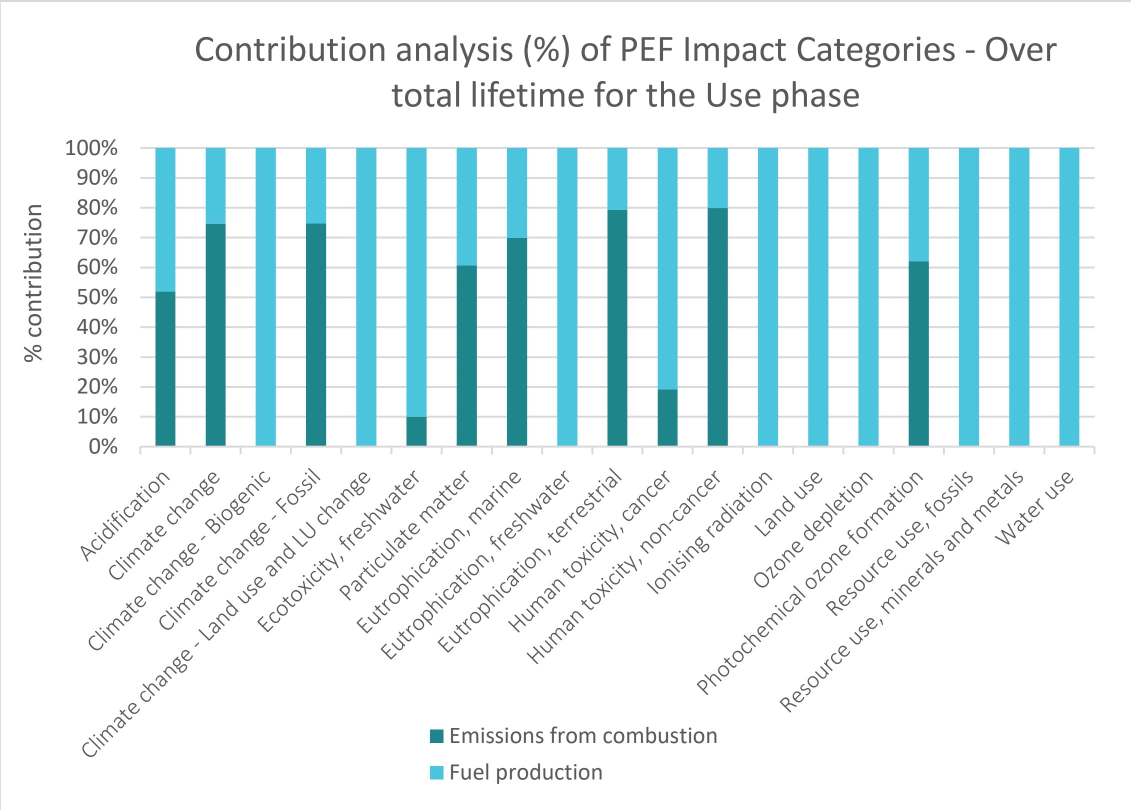

Figure 2-3: Contribution analysis of the Use phase, BC1.

In the Raw materials' supply life cycle stage, synthetic rubber has the highest impact in the 'Climate Change' impact category (26%) across all the raw materials. This is because it contributes the most by mass to the total weight of the tyre (ca. 25%). Synthetic rubber is then followed by carbon black and natural rubber, which contribute to 15% and 11% respectively to the total 'Climate Change' impacts.

2.4.4.2. BC2: C2 tyres

The detailed results by life cycle stages for BC2 tyres are presented in **Annex II – Results of LCA/LCC per Base Case**. In this chapter the contribution analyses of the full results and of the two highest contributing life cycle stages are presented in detail.

Most of the lifetime impact of C2 tyres is derived from the use phase and the raw materials input (to different degrees for the various impact categories) (**Figure 2-4**). Use phase is the top contributor to nine impact indicators (61% to 86%), including 'Climate change' (86%), 'Photochemical ozone formation' (86%), and 'Eutrophication, terrestrial' (85%). This is mainly attributed to fuel extraction and use and emissions associated to it. Raw materials extraction stage is the highest contributor to nine impact categories, such as 'Land use' (96%), 'Resource use, minerals and metals' (83%), and 'Ecotoxicity, freshwater' (78%). This can be attributed to the impact associated with different raw materials. For the impact category 'Ionising radiation', the highest contributor is the manufacturing stage (43%), mainly due to the nuclear electricity fraction of the European average electricity consumption mix used during the production of the tyre.

For BC2, credits contribute negatively (i.e. lowering the impact) mainly for 'Eutrophication, freshwater' and 'Human toxicity, cancer' as a consequence of avoided fossil fuel use and extraction of raw materials. Most of the credits come from the dominant EoL tyre treatment scenarios, namely mechanical recycling and fuel substitution in cement kilns, as explained in **Table 2-8**.

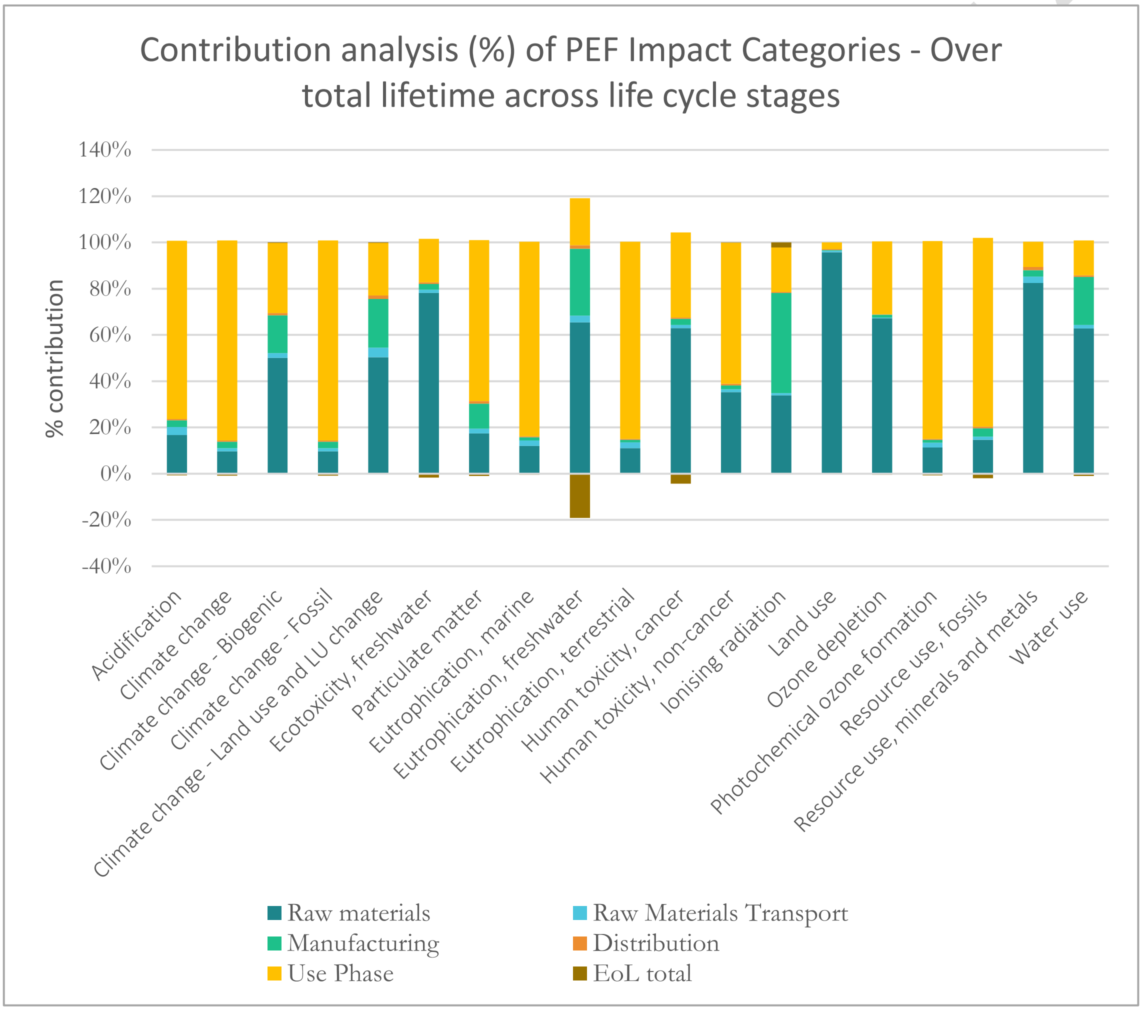

Figure 2-4: Life cycle stage contribution analysis, BC2.

In the use phase, the biggest contributor to most PEF impact categories is the supply of the diesel (56% to 100%). This is however not the case for the 'Climate Change' impact category, where the emissions deriving from the combustion of the fuel represent 79% of the total impact (**Figure 2-5**).

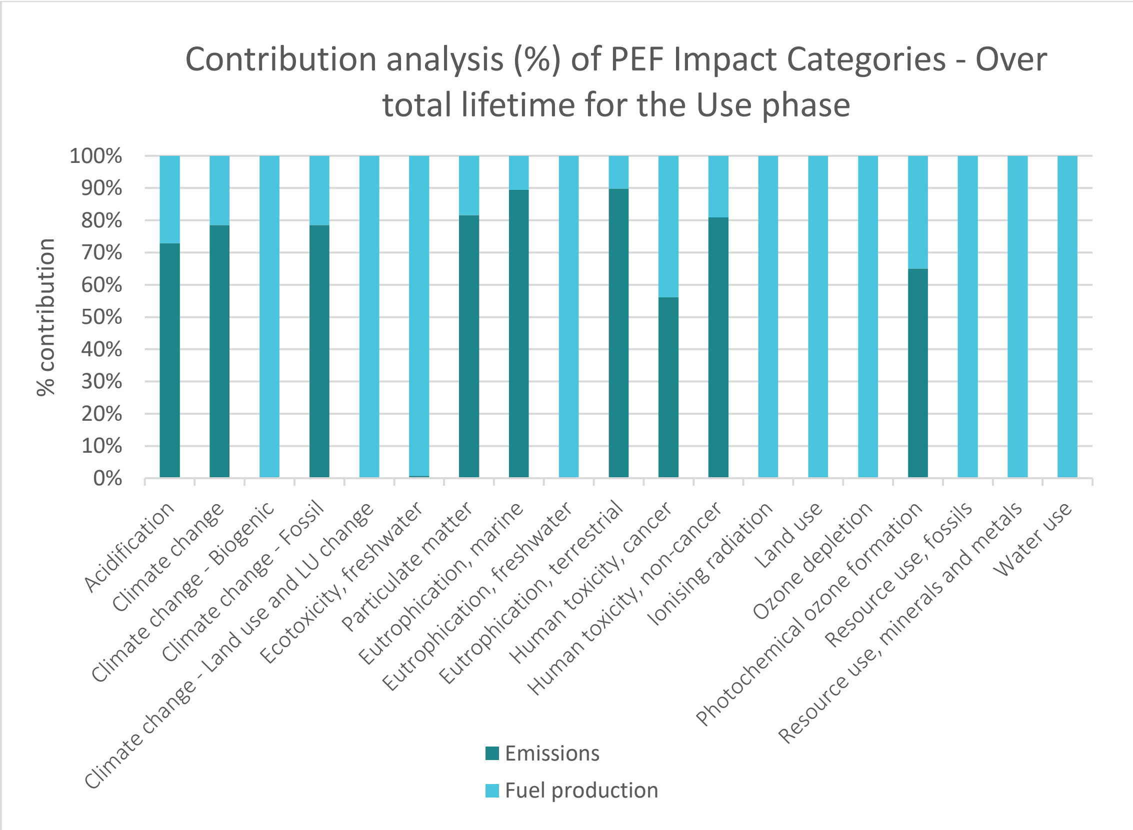

Figure 2-5: Contribution analysis of the Use phase, BC2.

In the life cycle stage of the raw materials' extraction, in the same way to C1 tyres, synthetic rubber has the highest impact in the 'Climate Change' impact category (22%) across all the raw materials. This is because it contributes the most by mass to the total weight of the tyre (.ca 23%). Synthetic rubber is then followed by carbon black and natural rubber, which contribute to 16% and 12% respectively to the total 'Climate Change' impacts.

2.4.4.3. BC3: C3 tyres

The detailed results by life cycle stages for BC3 tyres are presented in **Annex II – Results of LCA/LCC per Base Case**. In this chapter the contribution analyses of the full results and of the two highest contributing life cycle stages are presented in detail.

As shown in **Figure 2-6**, most of the lifetime impact of C3 tyres is derived from the use phase and the raw materials input (to different degrees for the various impact categories). The use phase is the top contributor to sixteen impact indicators (46% to 97%), including 'Climate change' (96%), 'Acidification' (95%), and Photochemical ozone formation (97%). This is mainly attributed to fuel extraction and use and emissions associated to it. Raw materials extraction stage is the highest contributor to three impact categories, such as 'Land use' (93%), 'Resource use, minerals and metals' (66%), and 'Water use' (47%). This can be attributed to the impact associated with different raw materials.

For BC3, credits contribute negatively (i.e. lowering the impact) mainly for 'Eutrophication, freshwater' and 'Human toxicity, cancer' as a consequence of avoided fossil fuel use and extraction of raw materials. Most of the credits come from the dominant EoL tyre treatment scenarios, namely mechanical recycling and fuel substitution in cement kilns, as explained in **Table 2-8**.

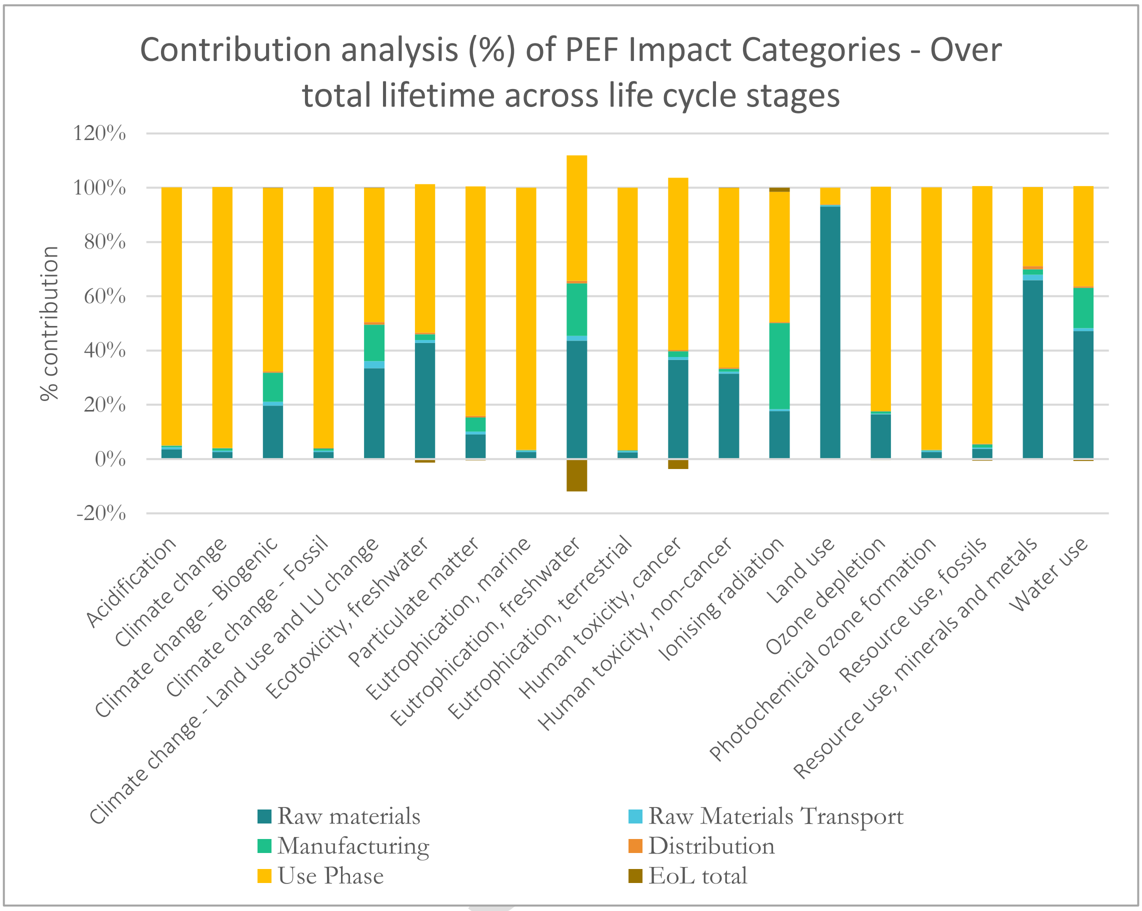

Figure 2-6: Life cycle stage contribution analysis, BC3.

In the use phase, the biggest contributor to most PEF impact categories is the supply of the diesel (51% to 100%). This is however not the case for the 'Climate Change' impact category, where the emissions deriving from the combustion of the fuel represent 79% of the total impact (**Figure 2-7**).

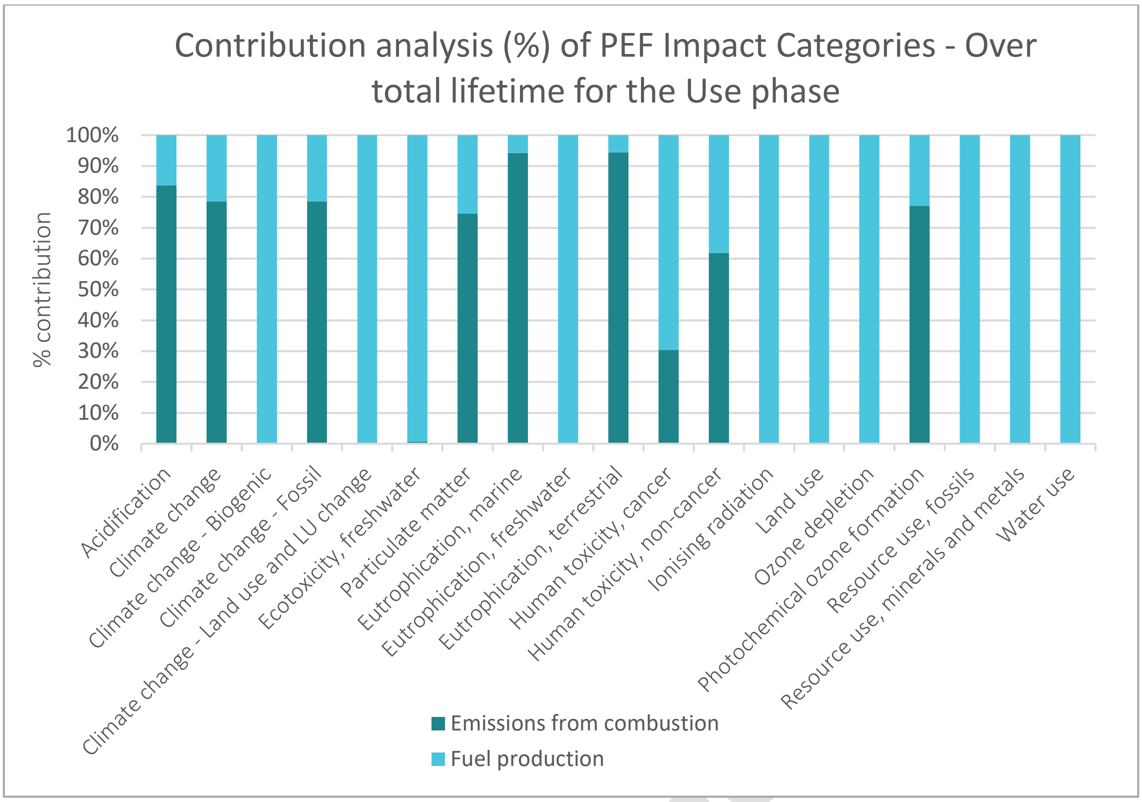

Figure 2-7: Contribution analysis of the Use phase, BC3

In the Raw materials' supply life cycle stage, unlike C1 and C3 tyres, natural rubber has the highest impact in the 'Climate Change' impact category (24%) across all the raw materials. This is because it contributes the most by mass to the total weight of the tyre (.ca 32%). Natural rubber's impacts are followed by those of carbon black and synthetic rubber, which contribute to 21% and 17% respectively to the total 'Climate Change' impacts.

2.4.4.4. BC4: C3 Retreaded tyres

The detailed results by life cycle stages for C3 retreaded tyres are presented in **Annex II – Results of LCA/LCC per Base Case**. In this chapter the contribution analyses of the full results and of the two highest contributing life cycle stages are presented in detail.

Most of the lifetime impact of the retreaded C3 tyres is derived from the use phase (**Figure 2-8**). Use phase is the top contributor to all impact indicators (69% to 100%) with the exception of 'Land Use', where the highest contributor is the raw materials input (86%). This is mainly attributed to fuel extraction and use, and emissions associated to it. Furthermore, retreaded tyres require significantly less raw material input compared to other BCs.

For BC4, credits contribute negatively (i.e. lowering the impact) mainly for 'Eutrophication, freshwater' and 'Human toxicity, cancer' as a consequence of avoided fossil fuel use and extraction of raw materials. Most of the credits come from the dominant EoL tyre treatment scenarios, namely mechanical recycling and fuel substitution in cement kilns, as explained in **Table 2-8**.

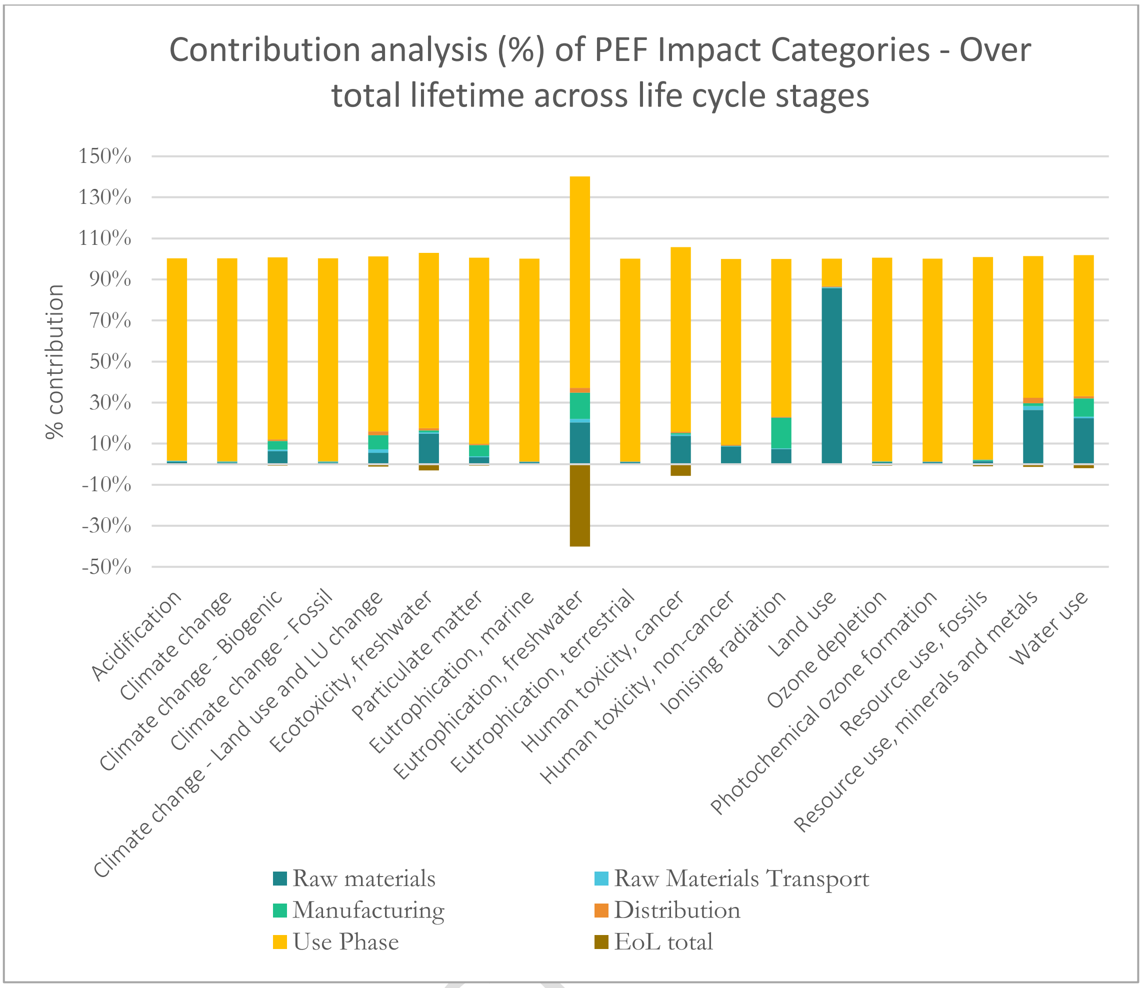

Figure 2-8: Life cycle stage contribution analysis, BC4.

In the use phase, the biggest contributor to most PEF impact categories is the supply of the petrol fuel (51% to 100%). This is however not the case for the 'Climate Change' impact category, where the emissions deriving from the combustion of petrol represent 79% of the total impact (**Figure 2-9**).

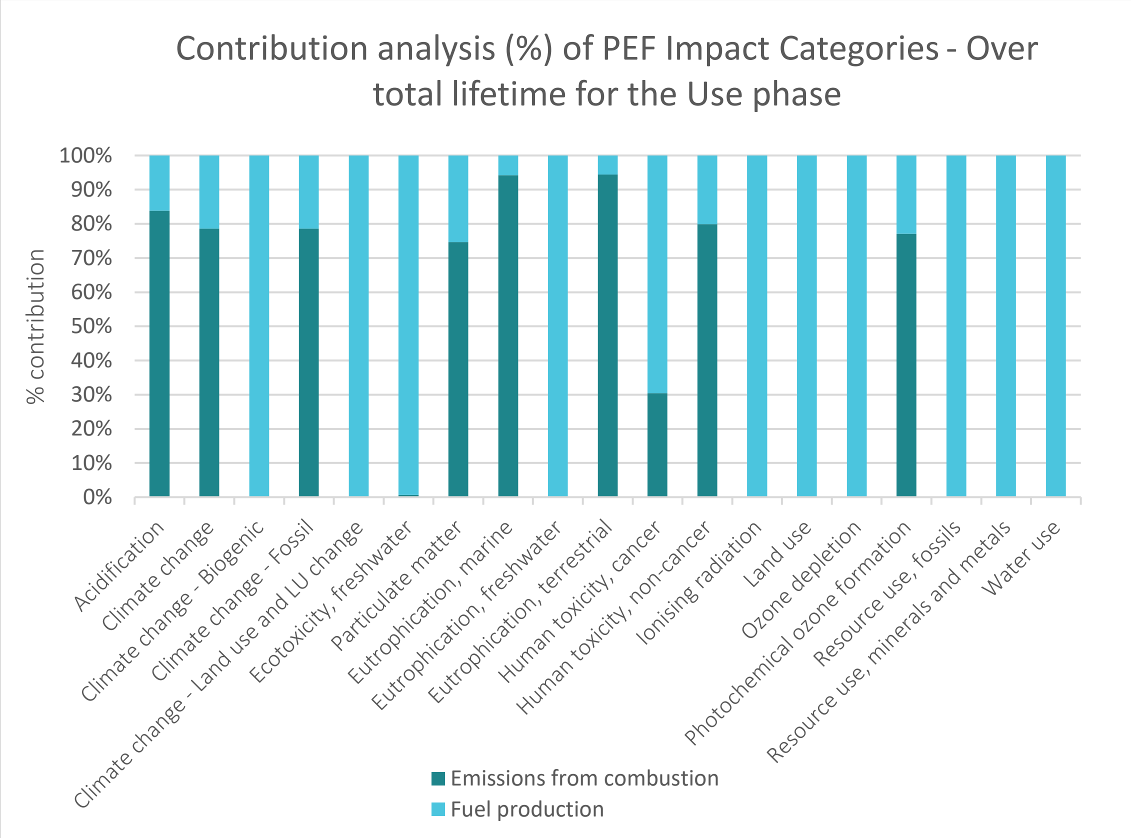

Figure 2-9: Contribution analysis of the Use phase for BC4.

In the Raw materials' supply life cycle stage, natural rubber has the highest impact in the 'Climate Change' impact category (32%). The same trend is observed in most impact categories. This is because the material contributes the most by mass to the total weight of the tyre (.ca 41%). Natural rubber's impacts are then followed by those of carbon black and synthetic rubber, which contribute to 31% and 25% respectively to the total 'Climate Change' impacts.

2.4.5. Results breakdown by life cycle stages excluding the Use Phase

Section 2.4.4 identified the Use Phase as the highest contributing life cycle stage to the overall environmental impact for most impact categories. Specifically, for 'Climate Change', use phase contributes by 86 - 99% to the total environmental impact. To gain further insight in the role of the remaining life cycle stages, the Climate Change impact per stage - excluding the Use Phase is presented in Figure 2-10.

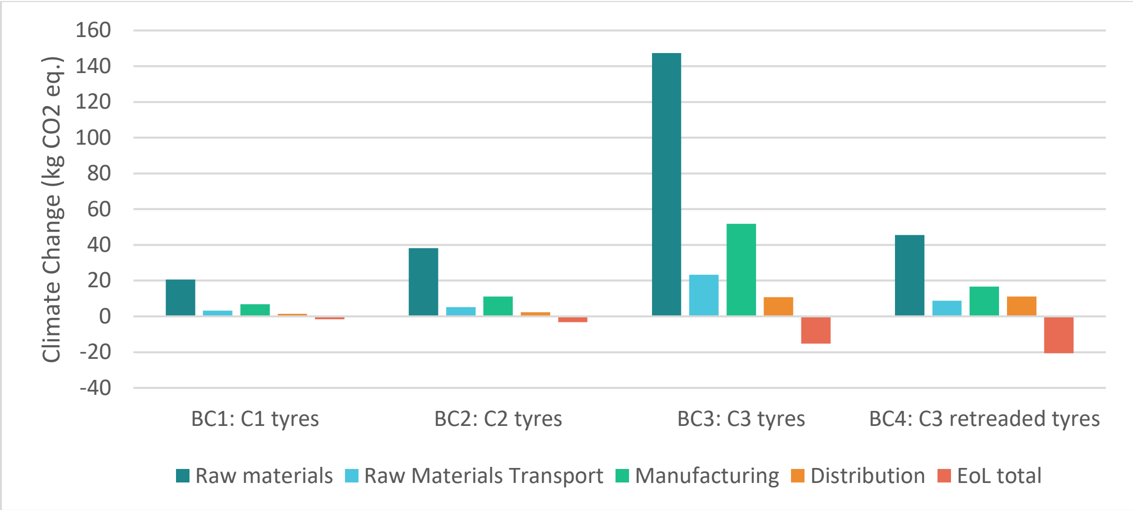

Figure 2-10. Results breakdown for all Base Cases, per life cycle stage – excluding the Use Phase (absolute values).

As shown in the graph, raw material extraction has the second highest impact across all BCs, followed by tyre manufacturing. For C1 and C2 tyres, raw material transport is the third most contributing stage, followed by tyre distribution. In contrast, for C3 and retreaded C3 tyres, tyre distribution is the third most contributing stage followed by raw material transport. Finally, the EoL stage has the lowest (negative) impact across all BCs. This result is driven by the credits allocated to each system by the CFF because of recycling practices.

2.4.6. EoL results per kg

To gain further insight into the environmental impact of the EoL scenarios, results per kg of tyre have been calculated and are presented in **Table 2-13** and **Figure 2-11** below.

Table 2-13: Total LCA results for each tyre EoL scenario, calculated per kg tyre – PEF single score.

	Mechanical Recycling	Pyrolysis	Fuel substitution in cement kiln	Devulca-nisation	Civil engineering
PEF Single Score	-1.2E-05	-5.8E-05	-4.5E-05	-1.1E-04	9.4E-07

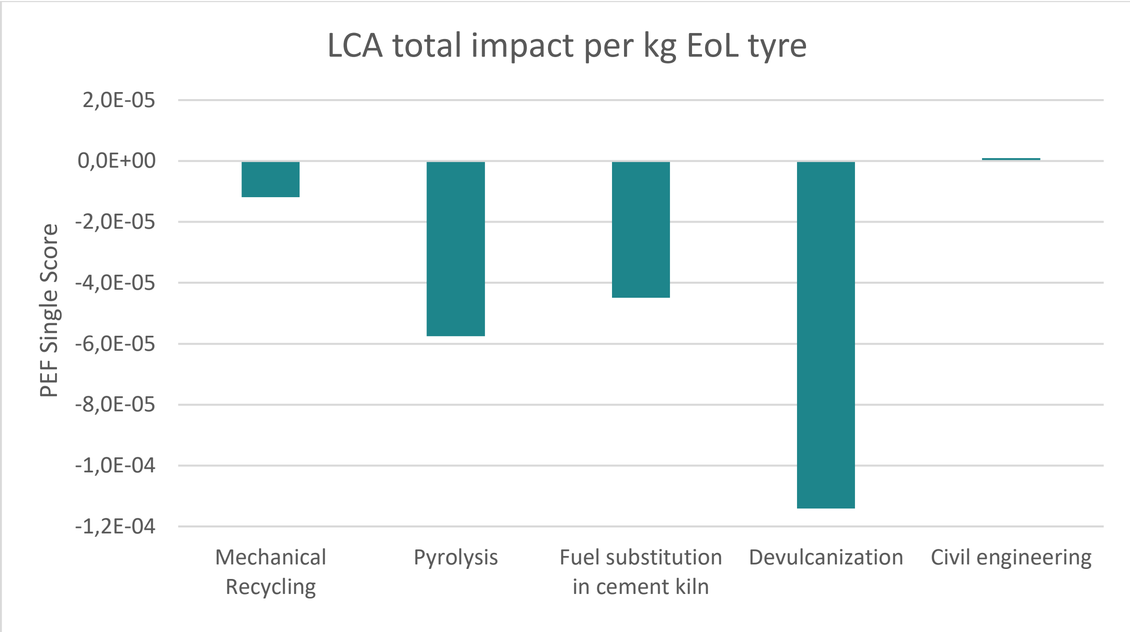

Figure 2-11: Total LCA results of each tyre EoL scenario, calculated per kg or tyre – PEF single score.

All EoL scenarios involving recycling or reuse of ELTs, namely mechanical recycling, pyrolysis, fuel substitution in cement kilns and devulcanisation, show an overall negative environmental impact due to the credits assigned through the CFF calculations. The more negative the environmental impact, the more environmentally preferable the scenario. This indicates that these treatment scenarios generate recycled materials or energy that can substitute for their virgin equivalents on the market, thereby avoiding the impacts associated with primary production. These avoided impacts are accounted for as credits under the CFF.

Devulcanisation shows the lowest impact of all EoL scenarios followed by pyrolysis, cement kiln fuel substitution and finally mechanical recycling. This ranking is directly related to the nature of virgin raw materials or energy that are substituted by their recycled equivalent from EoL tyre treatment, and the quality of the recycled product.

Devulcanised rubber can substitute virgin rubber at a high rate; the latter is a material associated with significant environmental impacts. Pyrolysis products can substitute carbon black, pyrolysis fuel oil and pyrolysis fuel gas, which generally have lower environmental impacts than natural rubber. Both recycling processes have minimal losses.

In the case of fuel substitution in cement kilns, ELTs substitute a mix of fossil fuels. The credits assigned to this scenario are determined by the impacts of the avoided fossil fuels and are lower than those assigned to the aforementioned recycling scenarios.

Finally, recycled rubber granulate from mechanical recycling can substitute a limited share of virgin synthetic rubber due to its lower quality. Therefore, the credit assigned to this scenario is comparatively smaller.

The use of ELTs in civil engineering applications is the only EoL scenario that has impact with a positive value. This is because no treatment of the ELT is considered in this scenario, and therefore no credits assigned, as the tyres are assumed to behave as inert material. The minimal impact observed in the results is primarily attributed to the transportation of the ELTs to the application site.

2.4.7. Estimation of impacts for C1 and C2 retreaded tyres

To have an indication of the difference in the potential impacts between BC1 and a retreaded C1 tyre and between BC2 and a retreaded C2 tyre, the following approach was taken. Data for retreaded C1 and C2 tyres was extrapolated from the datapoints obtained from stakeholders via the LCA Data collection questionnaire for retreaded C3 tyres, which represent in this study the fourth BC.

This data extrapolation was performed to estimate the BoM of the new tread. As for the energy consumption during the manufacturing the process, this was back calculated based on the utilities information provided for BC1 and BC2. Finally, the transport of the raw materials was recalculated based on the weight of the new tread. The final product's weight and the parameters related to both use phase (e.g., RRC, lifetime) and end-of-life have been assumed to be the same as those of the baseline BC1 and BC2.

In a similar way to the results obtained for C3 and C3 Retreaded tyres (**section 2.4.3**), the PEF single score results showed a higher impact for BC1 and BC2 compared to their retreaded counterparts. This is the case for both results expressed per total lifetime and per kilometre driven (**Table 2-14**). This is because the quantity of the raw materials used in C1 and C2 retreaded tyres is lower than that of BC1 and BC2, respectively.

Table 2-14: PEF single score results for both total lifetime and per Km driven for C1 and C2 retreaded tyres.

	PEF Single Score (total lifetime)	PEF Single Score (total lifetime per Km driven)
BC1	3.02E-02	7.55E-07
C1 Retreaded	2.70E-02	6.74E-07
Difference (%)	10.6%	10.73%
BC2	4.15E-02	7.30E-07
C2 Retreaded	3.58E-02	6.27E-07
Difference (%)	13.9%	14.12%

2.4.8. Assessment of Microplastics' emissions

Tyres have been considered one of the main sources of microplastics' emissions into the environment (Baensch-Baltruschat et al., 2021; Giechaskiel et al., 2024; Kole et al., 2017). Tyre wear occurs during driving because of the friction of the tyre with the road surface. The microplastics generated from tyres reaches various environmental matrices: the majority ends up in soils (45-75%), another considerable proportion reaches the aquatic environment (25-

55%), and finally a smaller fraction is released into the air (2-5%) (**Table 2-15**) (Giechaskiel et al., 2024) contributing to particulate matter emissions from road transport.

Table 2-15: Estimates (%) of microplastics released from tyres across environmental matrices.

Environmental compartment	% microplastics to the environment
Soil	45 - 75
Surface water	25 - 55
Air	2 - 5

The release and impacts of microplastics into the environment are not yet accounted for in the LCA methodology; the inclusion of the impacts deriving from microplastics in the EF method is currently under revision (Gonzalez Torres, Maria et al., 2025). For these impacts to be estimated in this study, the approach reported in the Product Environmental Footprint Category Rules (PEFCR) framework for synthetic turf surfaces used for sport or landscape applications was evaluated (Georgios Pallas et al., 2023). This assessment estimates the potential impacts of microplastics to freshwater ecotoxicity after calculating the amount of microplastics released into the environment (expressed as Kg per functional unit).

For this purpose, the tyre wear loss (TWL) was considered, and which was provided by stakeholders through the LCA Data Questionnaire (**Table 2-16**). According to the PCR used in this study for the calculations of the tyre's emissions during the use phase (**Section 2.3.5**), the TWL is defined as '*the weight of tire tread expected to be lost due to the friction between the tire and road surface*' (UL Solutions, 2025). The tyre wear emissions to air were also provided by stakeholders, and which were estimated through calculations outlined in the PCR for the two categories of particulate matter PM_{10} (particles that have a diameter of maximum 10 microns or less) and $PM_{2.5}$ (particles that do not exceed a diameter of 2.5 microns) (UL Solutions, 2025) (**Table 2-16**). The amount of microplastics lost to the environment was therefore calculated by deducting the PM_{10} fraction from the TWL (**Table 2-16**).

Table 2-16: Parameters and values used for the calculation of the quantity of microplastics released to the aquatic environment across BCs.

Parameter	BC1 (Kg/tyre)	BC2 (Kg/tyre)	BC3 (Kg/tyre)	BC4 (Kg/tyre)
Tyre Wear Loss (TWL)	1.6	1.9	12.3	12.3
Tyre Wear Emissions PM_{10}	0.06	0.08	0.49	0.49
Tyre Wear Emissions $PM_{2.5}$	0.02	0.02	0.15	0.15
Microplastics released to the environment minus the PM_{10} airborne fraction	1.54	1.83	11.81	11.81
Microplastics to the aquatic environment	0.61	0.73	4.72	4.72

Finally, the percentage of microplastics estimated to be released to waterways (Giechaskiel et al., 2024) was used to derive the quantity of microplastics that reach the aquatic compartment from the microplastics' amount lost to the environment from tyres mainly through run-off

(**Table 2-16**). Given that the percentage range of microplastics released to the aquatic matrix was obtained from the scientific literature, the midpoint of that range (25% - 55%, **Table 2-15**) was used for the calculation.

To translate the release of microplastics in the aquatic environment into their potential impacts from a freshwater ecotoxicity perspective, the PEFCR for synthetic turf was considered, as mentioned previously. This PEFCR is based on a method developed by (Salieri et al., 2021) who used the USEtox™ framework to calculate a simplified characterisation factor for the freshwater ecotoxicity impact category. The USEtox™ framework has found consensus across the LCA community to assess toxicological impacts, and it is recommended by the European Commission's PEF initiative (2013/179/EU, 2013). Three types of characterisation factors were calculated by (Salieri et al., 2021) based on the microplastic degradation rate (i.e., fast, mean and no degradation) expressed as PAF.m^3.day/Kg microplastic emitted. PAF refers to the 'potential affected fraction', which is the potential fraction of species affected by exposure to the substance. In the PEFCR for synthetic turfs, the characterisation factor with a mean degradation rate was used and this was also the type of characterisation factor considered in this study.

The impact assessment results of microplastics to the freshwater ecotoxicity impact category (PAF.m^3.day/functional unit) were calculated and are presented in **Table 2-17**.

Table 2-17: Impact assessment results of microplastics to freshwater ecotoxicity across BCs

Impact assessment	BC1	BC2	BC3	BC4
Freshwater ecotoxicity (PAF.m^3.day/tyre)	1971.6	2353.6	15156.7	15156.7

The impact assessment to the freshwater ecotoxicity impact of microplastics deriving exclusively from extrusion spikes present in new tyres is also considered. Extrusion spikes in tyres, also known as vent spews, are a result of the manufacturing process and do not contribute to the tyre performance. The impact assessment was calculated for C1 and C3 tyres.

The loss of the extrusion spikes for C1 and C3 tyres as well as the quantity of microplastics released into the aquatic environment are reported in **Table 2-18**.

Table 2-18: Parameters and values used for the calculation of the quantity of microplastics deriving from extrusion spikes in C1 and C3 tyres that are released to the aquatic environment.

Parameter	BC1 (Kg/tyre)	BC3 (Kg/tyre)
Loss of extrusion spikes in tyres	0.005	0.0113
Extrusion spikes Emissions PM_{10}	0.0002	0.0005
Extrusion spikes Emissions $PM_{2.5}$	0.00007	0.0001
Microplastics released to the environment minus the PM_{10} airborne fraction	0.005	0.0108
Microplastics to the aquatic environment	0.002	0.004

The impact assessment results of microplastics from extrusion spikes in C1 and C3 tyres to the freshwater ecotoxicity impact category (PAF.m^3.day/functional unit) were calculated and are presented in **Table 2-19**.

Table 2-19: Impact assessment results of microplastics from extrusion spikes in C1 and C3 tyres to freshwater ecotoxicity.

Impact assessment for Extrusion Spikes	BC1	BC3
Freshwater ecotoxicity (PAF.m^3.day/tyre)	6.7	13.9

2.5. Base Case life cycle costs for consumer

In this section, the life cycle costs for each BC are presented, followed by a contribution analysis per BC of the main contributors to the life cycle costs.

2.5.1. Results overview LCC

The life cycle costs of each BC were calculated with the consumer purchase price, installation costs, repair and maintenance costs as well as the costs of fuel use due to rolling resistance (**Table 2-20**; per BC in **Annex II – Results of LCA/LCC per Base Case)**. The total costs per year are calculated in the ERT by dividing the product price and repair/maintenance cost by the lifetime of the tyre and discounting the fuel costs to their net present value (based on present worth factor) to obtain the total costs per year.

Table 2-20: total life cycle costs per base case.

Product aspect	Unit	BC1	BC2	BC3	BC4
Consumer purchase price	EUR	71	111	419	363
Installation costs	EUR	19	19	19	19
Fuel costs due to rolling resistance	EUR/year	32	43	698	682
Repair and maintenance costs	EUR	59	59	59	59
Total costs (per year)	**EUR/year**	**69**	**106**	**864**	**829**
Total costs (per kilometre driven/year)	**EUR/km driven**	**0.0069**	**0.0056**	**0.0102**	**0.0101**

It can be observed from the data that depending on the tyre category, EU consumers are spending between € 71 and € 419 in the purchase of the product. Each time a consumer makes a buying decision, the decision is not just on the purchase price but on the total life cycle costs of the product, including fuel costs discounted to their net present value (between € 32 - 698 Euro/year). The fuel costs represent only the fuel consumption attributable to tyre use, specifically due to rolling resistance.

BC3 tyres have the highest annual life cycle costs of the four BCs, both for the results expressed per year and per km driven per year. This is mainly due to the size of the tyre, which influences both the consumer purchase price and its fuel use.

When comparing the results for BC1 and BC2 tyres on a yearly basis, BC2 tyres show higher costs than BC1 tyres. However, when costs are expressed per kilometre driven, the opposite trend is observed. This difference is explained by the variation in lifetime between the two BCs (see **Table 2-9**). Specifically, BC1 tyres have a longer lifetime in years but are associated with fewer kilometres driven per year compared to BC2 tyres. As a result, BC1 tyres are used less intensively on an annual basis, which explains the lower yearly costs despite their longer lifetime.

Although BC3 and BC4 have similar technical characteristics, it can be observed that the total cost per km driven is slightly higher for BC4. This can be explained by small differences in the purchase price and the kilometres driven per year (see **Table 2-9**).

2.5.2. Contribution analysis LCC

A contribution analysis was performed to analyse the main contributors to the total costs per year per BC. For this, the consumer purchase price, repair/maintenance costs and installation costs were divided by the lifetime to obtain the costs per year. The fuel costs are already provided per year by the ERT.

2.5.2.1. BC1: C1 tyres

The main contribution to the costs per C1 tyre (on an annual basis) is the fuel costs (46%), followed by the purchase price (26%) and the repair/maintenance costs (21%) (**Figure 2-12**). Thus, each time a consumer makes a buying decision, the decision is not just on a purchase price of € 71, but on the total life cycle costs of the product, including fuel costs discounted to their net present value, which is on average € 32 per year.

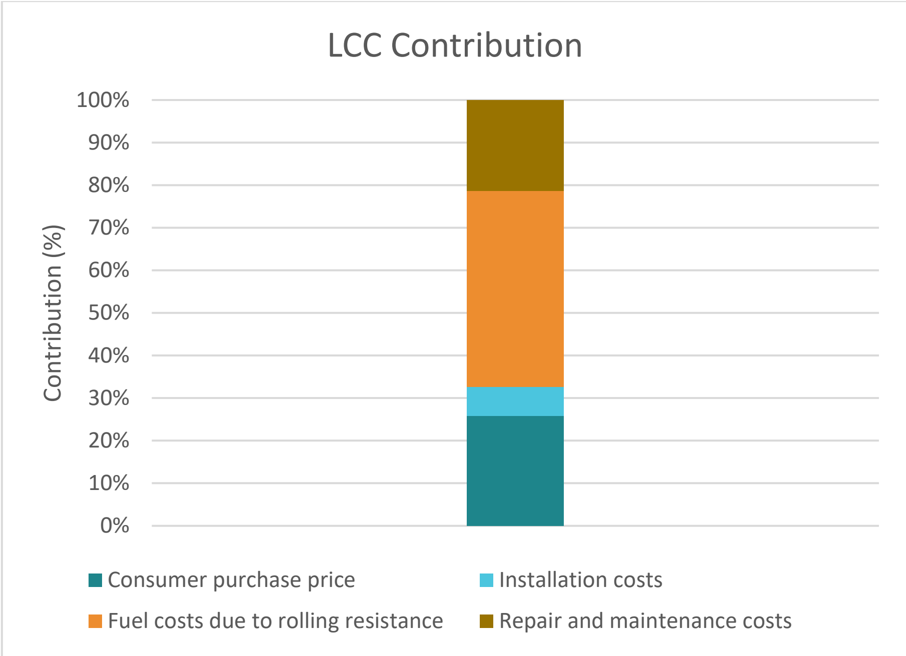

Figure 2-12: Contribution analysis (per year) – C1 tyres.

2.5.2.2. BC2: C2 tyres

The main contribution to the costs per C2 tyre (on an annual basis) is the fuel costs (41%), followed by the purchase price (35%) and the repair/maintenance costs (19%) (**Figure 2-13**). Thus, each time a consumer makes a buying decision, the decision is not just on a purchase price of € 111, but on the total life cycle costs of the product, including fuel costs discounted to their net present value, which is on average € 43 per year.

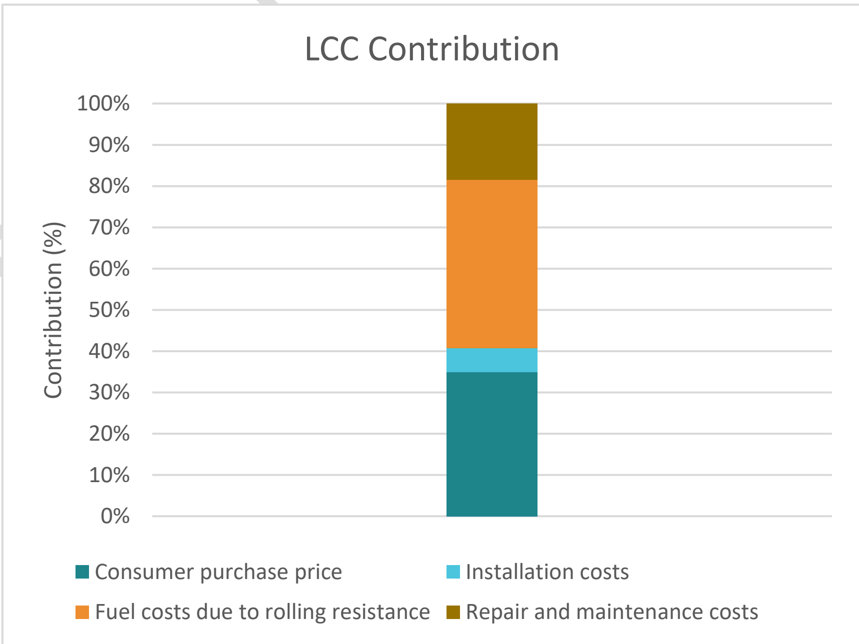

Figure 2-13: Contribution analysis (per year) – C2 tyres.

2.5.2.3. BC3: C3 tyres

The main contribution to the costs per C3 tyre (on an annual basis) is by far the fuel costs (80 %). This result is expected due to the size of the tyre. The consumer purchase price contributes by 16% to the total annual costs, while the repair/maintenance costs and installation costs are the least dominant (**Figure 2-14**). Thus, each time a consumer makes a buying decision, the decision is not just on a purchase price of € 419, but on the total life cycle costs of the product, mainly fuel costs discounted to their net present value, which is on average € 698 per year.

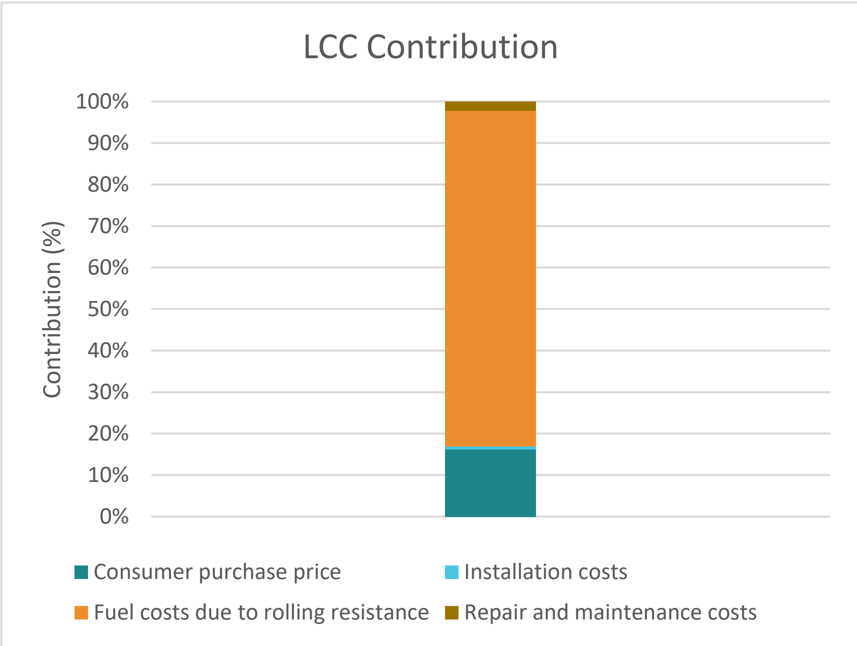

Figure 2-14: Contribution analysis (per year) – C3 tyres.

2.5.2.4. BC4: C3 Retreaded tyres

Similarly to C3 tyres, the main contribution to the costs per retreaded C3 tyre (on an annual basis) is the fuel costs (82%). The consumer purchase price contributes by 15% to the total annual costs, while the repair/maintenance costs and installation costs are the least dominant (**Figure 2-15**). Thus, each time a consumer makes a buying decision, the decision is not just on a purchase price of € 363, but on the total life cycle costs of the product, mainly fuel costs discounted to their net present value, which is on average € 682 per year.

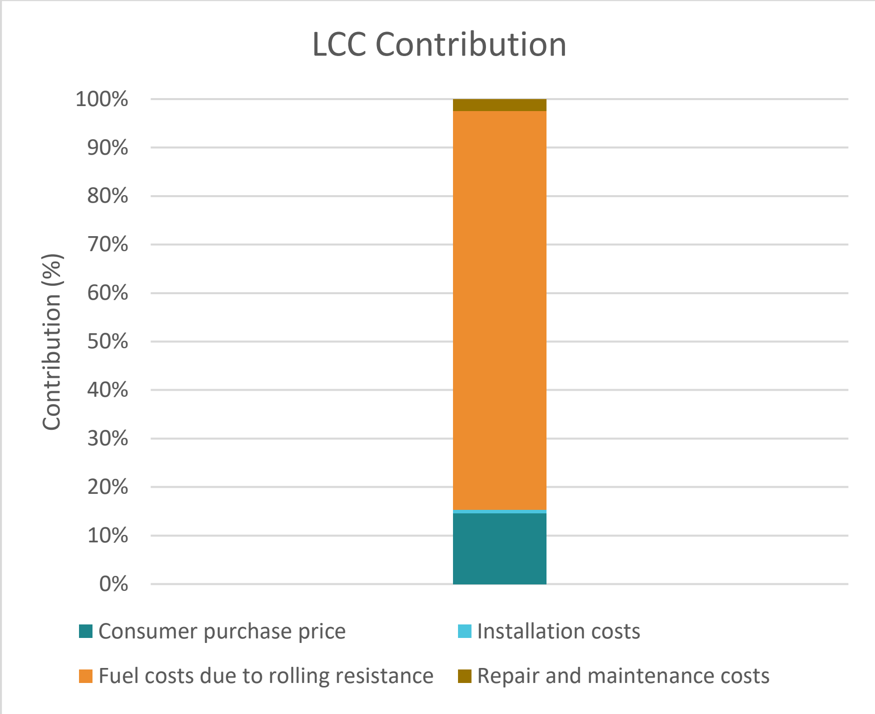

Figure 2-15: Contribution analysis (per year) – Retreaded C3 tyres.

2.6. EU Totals

In this section, the environmental and costs impacts on EU total level are presented. For this, the per product impacts are multiplied by the number of units in stock in the EU **(Table 2-11)**

Table 2-11 calculated from the annual sales values) to obtain the impact of all new products of the BC in the reference year in the EU and the impact of the total stock of the BC.

Table 2-21. Total EU stock numbers (as calculated in the ERT) for all Base Cases.

Base Case	Unit	EU Stock (calculated in ERT)	Latest annual sales
BC1	mln. Units	1,158	306
BC2	mln. Units	85	29
BC3	mln. Units	52	16.6
BC4	mln. Units	7.9	2

2.6.1. Life cycle assessment

Table 2-22 provides an overview of the environmental impact of the EU stock for all BCs. It can be observed that C1 tyres have the highest environmental impact at the EU level. This result is explained by the larger annual sales of C1 tyres compared to all other BCs, which consequently, leads to greater stock accumulation.

The EU stock of C3 tyres has the second highest environmental impact among the four BCs. This is due to the significantly higher lifetime environmental impact of C3 tyres compared to C2 tyres. Furthermore, although retreaded C3 tyres have a similar environmental impact to C3 tyres, their stock is significantly lower, resulting in a significantly reduced overall impact at the stock level. Finally, C2 tyres have the least impact at the EU stock level.

Table 2-22: Total life cycle impact of the entire EU stock per tyre Base Case.

PEF Impact categories	unit	BC1	BC2	BC3	BC4
Acidification	mol H+ eq	1.06E+09	1.26E+08	1.69E+09	2.42E+08
Climate change	kg CO_2 eq	3.52E+11	3.34E+10	2.96E+11	4.27E+10
Climate change - Biogenic	kg CO_2 eq	4.99E+07	5.06E+06	2.24E+07	2.53E+06
Climate change - Fossil	kg CO_2 eq	3.51E+11	3.34E+10	2.96E+11	4.27E+10
Climate change - Land use and LU change	kg CO_2 eq	5.03E+07	5.52E+06	2.51E+07	2.16E+06
Ecotoxicity, freshwater	CTUe	4.79E+11	6.51E+10	2.22E+11	2.11E+10
Ecotoxicity, freshwater - inorganics	CTUe	3.54E+11	3.86E+10	1.70E+11	1.74E+10
Ecotoxicity, freshwater - organics	CTUe	1.27E+11	2.68E+10	5.26E+10	3.73E+09
Particulate matter	disease inc.	1.34E+04	1.73E+03	1.02E+04	1.41E+03
Eutrophication, marine	kg N eq	2.41E+08	4.93E+07	7.74E+08	1.12E+08
Eutrophication, freshwater	kg P eq	1.25E+07	1.46E+06	6.36E+06	4.23E+05
Eutrophication, terrestrial	mol N eq	3.41E+09	5.32E+08	8.47E+09	1.23E+09
Human toxicity, cancer	CTUh	3.92E+01	5.67E+00	2.04E+01	2.14E+00
Human toxicity, cancer - inorganics	CTUh	1.35E+01	1.11E+00	7.11E+00	8.75E-01
Human toxicity, cancer - organics	CTUh	2.32E+01	4.21E+00	1.16E+01	1.16E+00
Human toxicity, non-cancer	CTUh	2.75E+03	2.54E+02	1.16E+03	2.39E+02
Human toxicity, non-cancer - inorganics	CTUh	1.01E+03	1.05E+02	5.87E+02	6.55E+01
Human toxicity, non-cancer - organics	CTUh	1.51E+03	1.16E+02	4.18E+02	1.64E+02
Ionising radiation	kBq U-235 eq	5.18E+09	5.84E+08	2.31E+09	2.14E+08
Land use	Pt	4.66E+12	6.47E+11	3.07E+12	2.10E+11
Ozone depletion	kg CFC11 eq	1.69E+04	2.00E+03	7.56E+03	9.36E+02
Photochemical ozone formation	kg NMVOC eq	1.99E+09	1.91E+08	2.54E+09	3.69E+08
Resource use, fossils	MJ	4.85E+12	4.54E+11	3.85E+12	5.50E+11
Resource use, minerals and metals	kg Sb eq	4.26E+05	3.75E+04	1.39E+05	8.72E+03
Water use	m^3 depriv.	1.86E+10	1.81E+09	7.28E+09	5.81E+08

2.6.2. Life cycle costs

Table 2-23 shows the total annual expenditure for all EU consumers (EU-27) in the purchase and operation of all BC tyres. In terms of annual expenditure, the EU-27 fuel costs related to rolling resistance of tyres range between 4,000 million Euro (C2) and 40,131million Euro (C1).

The fuel costs of all BCs are higher than their purchase costs. The results are dependent on the specific characteristics and lifetime of each tyre, and the costs are discounted to their net present value. Specifically, the fuel costs per year entail 82 to 86% of the total annual EU-27 expenditure for C3 and retreaded C3 tyres, while the equivalent share of C1 and C2 is 47% and 42% respectively. On the other hand, purchase costs entail 12 to 15% of the total annual EU-27 expenditure for C3 and retreaded C3 tyres, while the equivalent share of C1 and C2 is 22 to 40% respectively. This observation is related to the high fuel use of C3 and C3 retreaded tyres.

Table 2-23: total annual expenditure in the EU-27.

Product aspect	Unit	BC1	BC2	BC3	BC4
Consumer purchase price	mln. EUR/year	21,717	3,251	6,956	746
Installation costs	mln. EUR/year	5,731	550	311	39
Fuel (Euro-super 95) costs due to rolling resistance	mln. EUR/year	40,131	4,000	39,453	5,856
Repair and maintenance costs	mln. EUR/year	18,636	1,810	1,107	168
Total costs (per year)	**mln. EUR/year**	86,215	9,612	47,826	6,808

2.7. Sensitivity Analysis

In this section, the sensitivity of the LCA and LCC results is checked with several sensitivity analyses. Both sensitivity of results to the input data and sensitivity of some datasets was included. The aim of these sensitivity analyses is to check the robustness of the baseline model, as well as to understand what impacts different supply chain or material conditions have on the environmental performance of tyres. These sensitivity analyses will be further utilised in Task 7 to model fleet impacts across years as e.g. the budget proportion of C3 tyres increases in the market vs retreading, or to understand how impacts change as the vehicle fleet becomes more electric. An overview on the motivations for each sensitivity analysis carried out is given below, before presenting the results of each sensitivity analysis in the following sections.

S1: Natural rubber including Land Use Change emissions

When selecting emission factors for natural rubber, the study team was required to decide between deforestation free rubber and deforestation causing rubber. Since the EU DR shall require all rubber to come from deforestation free sources, the baseline model assumes that natural rubber does not contribute to deforestation. This first sensitivity analysis therefore applies the different emission factors to understand the changes that may occur from deforestation-causing rubber in the supply chain of tyres, should EU DR not be reliably implemented.

S2: Uncontrolled disposal burning for BC1 and BC3

In Task 3 (Baron et al., 2025), it was found that significant proportions of tyres (up to a third) are exported from the EU (+UK) for re-use and also as shredded ELT to countries which have limited formal waste management infrastructure for handling these wastes. In particular, numerous investigations have shown that a large proportion of these exports enter highly polluting rudimentary pyrolysis processes which do not apply appropriate health, safety or environmental controls in India, for example. Since no environmental factors for this pyrolysis exist, an open burning factor was applied to 10% and 20% assumed exports to better understand these impacts at End of Life. It is expected that the Waste Shipment Regulation (and similar interventions in the UK) reduce these exports, once implemented.

S3: Use phase modelling with EVs for BC1

The EU vehicle fleet is expected to transition to electric vehicles (EV) in the coming decades, with 90% of EU vehicle sales set as the goal for 2035. The baseline model is based upon Internal Combustion Engine (ICE) fuel use, which leads to dominant environmental impacts occurring in the use phase. As the fleet becomes more electric and the EU grid becomes more renewable, the use phase impacts of tyres caused from vehicle fuel use will reduce due to efficiency improvements and reduced emissions intensity. This scenario considers the impacts of 100% EV use on the current European grid mix and with 100% renewable energy to enable modelling of the use phase impacts over time in Task 7.

S4: Alternative rolling resistance coefficient for BC4

Given that the use phase dominates the environmental impacts of C3 tyres, it is of high importance that retreaded tyres do not lead to substantially higher rolling resistances during the use phase. This sensitivity analysis therefore compares the impacts of different RRC values for retreaded tyres vs. a retread with the same RRC value as a new C3 tyre to determine when a retread's rolling resistance leads to a break even with a new C3 tyre of the same type.

S5: Budget tyres for BC1 and BC3

Retreads do not compete on price with new premium tyres, but with budget tyres. A retread may have worse rolling resistance than a new premium C3 tyre but have a superior RRC and longer lifetime than a budget tyre at the same price point. To enable a comparison with a budget tyre at this price point, a sensitivity analysis of the base cases was therefore conducted using shorter lifetimes and rolling resistance in the lowest label class.

S6: Retreading: comparison of scenarios

The final sensitivity analysis compares a combination of prior sensitivity analyses over the course of a retreaded tyre's full lifetime versus the same number of budget tyres to reach this lifetime, and the same number of new C3 tyres to reach this lifetime. This enables a calculation of total waste avoided, raw materials saved and per km impacts between the altered Base Cases.

2.7.1. S1 – Natural rubber including Land Use Change emissions

Across all four BCs, the emission factors for natural rubber that were considered did not include the emissions deriving from the direct land use (e.g., land transformation and preparation for rubber plantation). Therefore, it was decided to conduct a sensitivity analysis by using emission factors of natural rubber that include instead the land use change emissions to assess the difference in the impacts. The emission factors used for the sensitivity analysis have been taken from the same scientific literature source (Cucci et al., 2025) considered for the emission factors used for the baseline scenarios of all four BCs.

The PEF single score results of the analysis show that the inclusion of the emissions deriving from the land use change results in an increase in 1.1%, 1.5%, 0.7% and 0.3% for BC1, BC2, BC3 and BC4, respectively (**Table 2-24**).

Table 2-24: PEF single score results across all BCs for the sensitivity scenario regarding the inclusion of land use change emissions in natural rubber

PEF Single Score	BC1	BC2	BC3	BC4
Baseline	2.13E-02	3.00E-02	4.52E-01	4.22E-01
Sensitivity	2.15E-02	3.04E-02	4.55E-01	4.23E-01
Difference (%)	1.1%	1.5%	0.7%	0.3%

If we consider the PEF Climate Change Total impact category alone, the difference between the baseline and the sensitivity scenarios refers to an increase in 3%, 4%, 2% and 1% for BC1, BC2, BC3 and BC4, respectively (**Table 2-25**).

Table 2-25: Climate Change, Total impact category results across all BCs for the sensitivity scenario regarding the inclusion of land use change emissions in natural rubber

Climate Change, Total (Kg CO2 eq.)	BC1	BC2	BC3	BC4
Baseline	3.04E+02	3.93E+02	5.70E+03	5.41E+03
Sensitivity	3.12E+02	4.09E+02	5.82E+03	5.46E+03
Difference (%)	3%	4%	2%	1%

2.7.2. S2 – Uncontrolled disposal burning for BC1 and BC3

The second sensitivity analysis was performed by testing two scenarios for BC1 and BC3, where 10% and 20% of the ELTs produced in Europe are exported outside of the EU and treated through an outdated pyrolysis process with no health and safety measures (Baron et al., 2025). To model these scenarios, the uncontrolled disposal burning dataset was selected in the Ecoinvent database. The remaining proportion of ELTs that are treated within Europe (90% and 80%, respectively) was modelled by considering the same breakdown of waste treatment streams as reported in **Table 2-8**.

The total lifetime PEF single score results for these scenarios for both BC1 and BC3 are reported in the table below (**Table 2-26**). The sensitivity analysis shows an increase by 0.6% and 1.1% for the 10% and 20% export scenario, respectively, for BC1 compared to the baseline scenario; and an increase by 0.2% and 0.4% for the 10% and 20% export scenario, respectively, for BC3 compared to the baseline scenario.

Table 2-26: PEF single score (full lifetime) results for the two export scenarios tested (10% and 20%) for the uncontrolled disposal burning for BC1 and BC3.

PEF Single Score – Full life time	BC1 (10% open burning)	BC1 (20% open burning)	BC3 (10% open burning)	BC3 (20% open burning)
Baseline	2.13E-02	2.13E-02	4.52E-01	4.515E-01
Sensitivity	2.14E-02	2.15E-02	4.525E-01	4.53E-01
Difference (%)	0.6%	1.1%	0.2%	0.4%

To further assess the impact of the sensitivity, a closer look was taken at the implications of open burning to the EoL stage specifically. **Table 2-27** shows an increase by 60.7% and 121.3% for the 10% and 20% export scenario, respectively, for BC1 compared to the baseline scenario; and an increase by 58.1% and 116.1% for the 10% and 20% export scenario, respectively, for BC3 compared to the baseline scenario.

Table 2-27. PEF single score (EoL stage) results for the two export scenarios tested (10% and 20%) for the uncontrolled disposal burning for BC1 and BC3.

PEF Single Score - EoL	BC1 (10% open burning)	BC1 (20% open burning)	BC3 (10% open burning)	BC3 (20% open burning)
Baseline	-1.98E-04	-1.98E-04	-1.64E-03	-1.64E-03
Sensitivity	-7.78E-05	4.22E-05	-6.88E-04	2.65E-04
Difference (%)	60.7%	121.3%	58.1%	116.1%

2.7.3. S3 – Use phase modelling with EVs for BC1

The third sensitivity analysis was implemented to investigate how the use of electric vehicles (EVs) instead of internal combustion engines (ICEs) would influence the impacts in the use phase of BC1. This sensitivity is relevant given that the use phase represents the main emission hotspot of the life cycle of a tyre (as shown in **section 2.4.3**) mainly due to the emissions deriving from the combustion of fuel in ICEs.

The results of the sensitivity analysis for the Climate Change impacts show a decrease by 41% from the baseline scenario (**Table 2-28**). The reason of the decrease is due to a lower amount of fuel being combusted because of the lower energy consumption due to acceleration and rolling resistance. The supply of electricity in the use phase was modelled according to PCR (UL Solutions, 2025) and by selecting an electricity grid mix dataset. Furthermore, the contribution of the raw materials to the total Climate Change impact increases from 7% to 12%, while the use phase contribution decreases from 90% to 83%.

Table 2-28: Climate Change, Total impact category results for BC1 for the sensitivity analysis regarding the use of EVs instead of ICE.

Climate Change, Total (Kg CO2 eq.)	BC1
Baseline	3.04E+02
Sensitivity	1.80E+02

Climate Change, Total (Kg CO_2 eq.)	BC1
Difference (%)	-41%

When considering the PEF single score (**Table 2-29**), the results show an opposite trend with a slight increase (2.3%) of the impacts of EVs compared to ICEs. The reason of this increase is due to the impacts of two PEF impact categories (i.e., Eutrophication freshwater and Resource use, minerals and metals), which are higher for the EVs compared to the baseline scenario. These impacts are higher because of the presence of energy sources of fossil origins in the background process used to model the electricity, which reflects the current mix of electricity sources in Europe, as represented in the Ecoinvent database.

Table 2-29: PEF single score results for the sensitivity analysis regarding the use of EVs (electricity grid mix) instead of ICE for BC1.

PEF Single Score	BC1
Baseline	2.12E-02
Sensitivity (electricity grid mix)	2.18E-02
Difference (%)	2.3%

In light of these results, another sensitivity analysis was conducted by replacing the electricity grid mix with electricity deriving from 100% renewable sources (i.e., 50% wind and 50% photovoltaic energies). The PEF single score result showed a decrease by 51% from the PEF single score impact of the baseline scenario (**Table 2-30**).

Table 2-30: PEF single score results for the sensitivity analysis regarding the use of EVs (renewable energy source) instead of ICE for BC1.

PEF Single Score	BC1
Baseline	2.12E-02
Sensitivity (renewable energy source)	1.03E-02
Difference (%)	-51%

2.7.4. S4 – Alternative rolling resistance coefficient for BC4

In this sensitivity analysis, increasing rolling resistance coefficients (RRCs) for BC4 have been used to investigate how this parameter influences the environmental impacts of the tyre in the use phase. In the tables below, the PEF single score results for both the total lifetime (**Table 2-31**) and the use phase only (**Table 2-32**) have been reported.

In both cases, an increase of the impacts is observed in the results for the sensitivity scenario as the RRC increases. This shows that the RRC plays a significant role in determining the environmental impacts of a tyre. Therefore, the worse is the RRC of a tyre (i.e., the higher is its value), the higher is its energy consumption due to acceleration and rolling resistance, and the higher is the fuel use. As a result, this leads to an increase of the environmental impacts.

Table 2-31: PEF single score results across the full lifetime of BC4 for the sensitivity analysis with different rolling resistance coefficients.

PEF Single Score (total lifetime)	BC4 (RRC=5.4 N/kN)	BC4 (RRC=5.5 N/kN)	BC4 (RRC=5.6 N/kN)	BC4 (RRC=5.8 N/kN)	BC4 (RRC=6.3 N/kN)
Baseline (RRC = 5.3 N/kN)	4.22E-01	4.22E-01	4.22E-01	4.22E-01	4.22E-01
Sensitivity	4.29E-01	4.37E-01	4.44E-01	4.59E-01	4.96E-01
Difference (%)	2%	4%	5%	9%	18%

An increase in the RRC value by 0.1 N/Kn shows an increase of the PEF single score results for both the total lifetime and use phase by 2%. The highest RRC value of 6.3 N/kN led to an increase in the impacts by 18%.

Table 2-32: PEF single score results for the use phase of BC4 for the sensitivity analysis with different rolling resistance coefficients.

PEF Single Score (use phase)	BC4 (RRC=5.4 N/kN)	BC4 (RRC=5.5 N/kN)	BC4 (RRC=5.6 N/kN)	BC4 (RRC=5.8 N/kN)	BC4 (RRC=6.3 N/kN)
Baseline (RRC = 5.3 N/kN)	4.11E-01	4.11E-01	4.11E-01	4.11E-01	4.11E-01
Sensitivity	4.19E-01	4.26E-01	4.33E-01	4.48E-01	4.86E-01
Difference (%)	2%	4%	5%	9%	18%

2.7.5. S5 – Budget tyres for BC1 and BC3

Another sensitivity analysis was performed for BC1 and BC3 to evaluate the difference in the environmental impacts between each BC and three variants of budget tyres. The budget tyres are reflected in different RRC and lifetime values compared to the original BCs.

2.7.5.1. Budget C1 tyres

For BC1, the three budget tyres differed from the original BC in terms of RRCs (i.e., 8.5 N/kN, 9 N/kN and 10 N/kN), while lifetime (i.e., 25000 Km) was kept the same for the three budget tyres.

The PEF single score results are shown in **Table 2-33**. To allow comparison they are expressed per Km driven, therefore they reflect the fuel used per Km. As the RRC value increases, more fuel is being used per Km because of the higher energy consumption due to rolling and acceleration resistance. It can be observed that the budget tyre with the highest RRC (i.e., 10 N/kN) shows an increase in the PEF single score impacts per Km driven up to 27%.

Table 2-33: PEF single score results per Km driven for the sensitivity analysis of three variants of budget tyres compared to the baseline BC1.

PEF Single Score (per Km driven)	BC1 (RRC=8.5 N/kN, 25000 Km)	BC1 (RRC=9 N/kN, 25000 Km)	BC1 (RRC=10 N/kN, 25000 Km)
Baseline (RRC = 8.4 N/kN; lifetime = 40000 Km)	5.32E-07	5.32E-07	5.32E-07
Sensitivity	6.04E-07	6.28E-07	6.74E-07
Difference (%)	14%	18%	27%

Finally, a LCC sensitivity analysis was also conducted to assess the differences in fuel costs between the baseline BC1 and the three types of budget tyres. The results showed an increase in the fuel costs (EUR/year) by 4%, 10% and 21% in the three budget tyres (**Table 2-34**), compared to the baseline scenario BC1.

Table 2-34: LCC sensitivity analysis of fuel costs for the three variants of budget tyres compared to the baseline BC1.

LCC, fuel costs (EUR/year)	BC1 (RRC=8.5 N/kN, 25000 Km)	BC1 (RRC=9 N/kN, 25000 Km)	BC1 (RRC=10 N/kN, 25000 Km)
Baseline (RRC = 8.4 N/kN; lifetime = 40000 Km)	3.16E+01	3.16E+01	3.16E+01
Sensitivity	3.29E+01	3.47E+01	3.82E+01
Difference (%)	4%	10%	21%

2.7.5.2. Budget C3 tyres

For BC3, the three budget tyres differed from the original BC in terms of RRCs (i.e., 6 N/kN, 6.5 N/kN and 7 N/kN), while lifetime (i.e., 130000 Km) was kept the same for the three budget tyres.

The PEF single score results are shown in **Table 2-35**. To allow comparison they are expressed per Km driven, therefore they reflect the fuel used per Km. As the RRC value increases, more fuel is being used per Km because of the higher energy consumption due to rolling and acceleration resistance. It can be observed that the budget tyre with the highest RRC (i.e., 7 N/kN) shows an increase in the PEF single score impacts per Km driven up to 37%.

Table 2-35. PEF single score results per Km driven for the sensitivity analysis of three variants of budget tyres compared to the baseline BC3.

PEF Single Score (per Km driven)	BC3 (RRC=6 N/kN, 130000 Km)	BC3 (RRC=6.5 N/kN, 130000 Km)	BC3 (RRC=7 N/kN, 130000 Km)
Baseline (RRC = 5.3 N/kN; lifetime = 253410 Km)	1.78E-06	1.78E-06	1.78E-06
Sensitivity	2.14E-06	2.29E-06	2.44E-06
Difference (%)	20%	29%	37%

Finally, a LCC sensitivity analysis was also conducted to assess the differences in fuel costs between the baseline BC3 and the three types of budget tyres. The results showed an increase in the fuel (diesel) costs (EUR/year) by 17%, 27% and 36% in the three budget tyres (**Table 2-36**), compared to the baseline scenario BC3.

Table 2-36. LCC sensitivity analysis of fuel (diesel) costs for the three variants of budget tyres compared to the baseline BC3.

LCC, fuel (diesel) costs (EUR/year)	BC3 (RRC=6 N/kN, 130000 Km)	BC3 (RRC=6.5 N/kN, 130000 Km)	BC3 (RRC=7 N/kN, 130000 Km)
Baseline (RRC = 5.3 N/kN; lifetime = 253410 Km)	8.64E+02	8.64E+02	8.64E+02
Sensitivity	9.97E+02	1.06E+03	1.13E+03
Difference (%)	17%	27%	36%

2.7.6. S6 – Retreading: comparison of scenarios

2.7.6.1. Environmental analysis

This analysis was undertaken to compare and evaluate the total environmental impacts of one lifecycle of BC3 which undergoes two retreading (BC4) lifecycles, versus those of BC3 as well as C3 budget tyres. For the purposes of comparison, the total lifetime (Km) of one lifecycle of BC3 with two lifecycles of BC4 was considered as reference to back calculate the total number of BC3 tyres and C3 budget tyres that are needed to reach the total lifetime of BC3 that undergoes two retreading cycles (**Table 2-37**).

Table 2-37. Overview of total number of BC3 and C3 budget tyres needed to reach the total lifetime of BC3 undergoing two retreading cycles.

Number of lifecycle of tyres	Lifetime (Km)	Total number of tyres
1x BC3 + 2x BC4	745250	3
BC3	253410	2.94
C3 budget tyre	130000	5.73

The total impacts (in terms of climate change and PEF single score results) per reference lifetime (i.e., 745250 Km) have been therefore calculated for the three scenarios described above and they are provided in the table below (**Table 2-38**). Regarding C3 budget tyres, the impacts considered referred to budget tyres with a RRC equal to 6.5 N/kN (**section 2.7.5.2**).

Table 2-38. Climate change, Total and PEF single score impacts per reference lifetime across the three scenarios investigated.

Impacts per reference lifetime (745250 Km)	1x BC3 + 2x BC4	2.94x BC3	5.73x C3 budget tyres
Climate change, Total (Kg CO2 eq.)	1.66E+04	1.68E+04	2.10E+04
PEF single score	1.30E+00	1.33E+00	1.71E+00

For the same lifetime considered, the results show that when BC3 tyres are used, there is an increase in the climate change, total and PEF single score impacts by 1.2% and 2.2%, respectively, compared to when a BC3 tyre that undergoes two retreading is used. When C3 budget tyres are used, there is an increase in the climate change, total and PEF single score impacts by 27% and 31.4%, respectively, compared to when a BC3 tyre that undergoes two retreading is used.

Finally, the savings (%) in terms of raw materials acquisition and waste produced through the retreading process were estimated and they are reported in **Table 2-39**. These estimates show that when a BC3 tyre that undergoes two retreading is used, around 43% less raw materials are needed and 54% less waste is produced compared to when 2.94 BC3 tyres are used over the same reference lifetime. When the comparison is made with C3 budget tyres: around 71% less raw materials are needed and 76% less waste is produced when BC3 that undergoes retreading twice is considered.

Table 2-39. Estimated savings (%) of raw materials and waste production for the retreading scenario.

Estimated savings for retreading	1x BC3 + 2x BC4 versus 2.94x BC3	1x BC3 + 2x BC4 versus 5.73x C3 budget tyres
Raw materials acquisition	43%	71%
Waste produced	54%	76%

2.7.6.2. Economic analysis

The life cycle costs for the three scenarios discussed in **section 2.7.6.1** were also evaluated and calculated in the ERT as described in **section 2.5.1**. The results are shown in **Table 2-40** and the total reference lifetime has been kept the same across the three scenarios, as previously done for the calculation of the environmental impacts (**section 2.7.6.1**), to allow for comparison. The reference lifetime is expressed in years to estimate the total annual costs.

Table 2-40. Total lifecycle costs per scenario investigated.

Product aspect	Unit	1x BC3 + 2x BC4	2.94x BC3	5.73x C3 budget tyres
Consumer purchase price	EUR	1146	1068	1146
	EUR/year	127	119	127

Product aspect	Unit	1x BC3 + 2x BC4	2.94x BC3	5.73x C3 budget tyres
Installation costs	EUR	56	66	107
	EUR/year	6	7	12
Fuel costs	EUR/year	6185	6282	7947
Repair and maintenance costs	EUR	176	173	337
	EUR/year	20	19	37
Total costs (per year)	**EUR/year**	**7563**	**7588**	**9537**
Lifetime (years)	**Year**	**9**	**9**	**9**

The analysis shows that total costs per year when using a BC3 tyre which is retreaded twice are close to the costs of using 2.94 BC3 tyres. However, when considering C3 budget tyres for the same reference lifetime, the annual costs increase by around 26%.

2.8. Preliminary conclusions Task 5

The LCA indicates that the use phase represents the emission hotspot of the lifecycle of a tyre. It has the highest environmental impact for climate change across BCs, followed by the raw materials' extraction stage. The impacts of the use phase mainly derive from the emissions originating from the fuel combustion related to one tyre (between 75% and 79% of the total impacts); while the remaining impacts originate from fuel extraction.

The heaviest tyres (BC3 and BC4) show the highest absolute climate change impacts for fuel consumption. However, when comparing impacts across BCs, it is important to consider the results per Km driven, given that the reference service life (expressed as Km) changes across BCs. The total PEF single score impacts per Km for the total lifetime of BC4 is slightly lower (ca. 4%) than BC3; the reason is because, despite having similar weights, the RSL of BC3 is slightly higher than that of BC4, resulting in more fuel being used over its lifetime.

A sensitivity analysis was conducted to investigate how variations in the rolling resistance coefficient affect the impacts of the use phase. The results show a direct correlation between the increase of the rolling resistance coefficient value and the fuel consumption of a tyre. Therefore, the rolling resistance coefficient plays a key role in determining the changes of impact in the use phase.

As for the contribution analysis of PEF impact categories by life cycle stage, the use phase represents the top contributor across BCs for categories such as 'Climate change', 'Acidification', 'Photochemical ozone formation', 'Resource, fossils', and 'Eutrophication, terrestrial'. The raw material extraction stage is instead the highest contributor to 'Land use', 'Resource use, minerals and metals', 'Water use', and 'Ecotoxicity, freshwater' categories.

The EoL scenario considered in this study consists of a combination of treatment processes, including mechanical recycling, fuel substitution in cement kilns, pyrolysis and devulcanisation, as well as use in civil engineering applications. The CFF was applied to account for the associated burdens and credits to these scenarios.

The results indicate an overall negative EoL impact across most PEF impact categories, reflecting environmental benefits from material and energy recovery. Mechanical recycling and fuel substitution in cement kilns are the main contributors to these results. However, the inclusion of uncontrolled disposal through burning (sensitivity scenario S2) leads to an increase in the total EoL impact. When comparing individual treatment options on a per kilogram basis, devulcanisation and pyrolysis show the lowest impacts, followed by fuel substitution in cement kilns, mechanical recycling, and civil engineering applications. These results are driven by the substitution of virgin materials and energy, leading to avoided production impacts.

The LCC analysis has shown that BC3 has the highest annual life cycle costs of the four BCs, both for the results expressed per year and per km driven per year. This is mainly due to the size of the tyre, which influences both the consumer purchase price and its fuel use. Specifically, the fuel costs, which refer only to the fuel consumption attributable to tyre use, specifically due to rolling resistance, represent the top contributor in terms of economic impacts for all BCs.

An LCC sensitivity analysis on three types of budget tyres that differed from the corresponding baseline in terms of both rolling resistance coefficients and RSL was also performed to assess the differences in fuel costs. These analyses were conducted for both BC1 and BC3. The results showed an increase in the fuel costs (EUR/year) in the three budget tyres compared to both BC1 and BC3, as the rolling resistance coefficient increased.

Another sensitivity analysis investigated how the use of electric vehicles (EVs) instead of internal combustion engines (ICEs) would influence the impacts in the use phase of BC1. The climate change impacts showed a reduction by around 40% when an EV is used. However, when the total lifetime PEF single score was calculated, the impact for the EVs was slightly higher than that of the ICEs. This increase is related to the higher impacts of two PEF impact categories (i.e., Eutrophication freshwater and Resource use, minerals and metals), compared to BC1. These impacts are higher because of the presence of energy sources of fossil origins in the background process used to model the electricity, which reflects the current mix of electricity sources in Europe, as represented in the Ecoinvent database. For this reason, in a follow-up analysis, a renewable energy dataset was selected to replace the electricity mix dataset previously used. The use of renewable energy led to a decrease by 51% of the PEF single score impact of BC1.

An analysis on the comparison of a retreading scenario with that of BC3 and C3 budget tyres across the same reference lifetime (i.e., multiple lifecycles) was investigated. The results showed that, for the same lifetime considered, when BC3 tyres are used, there is an increase in the climate change and PEF single score impacts by 1.2% and 2.2%, respectively, compared to when a BC3 tyre that undergoes two retreadings is used. When C3 budget tyres are used, there is an increase in the climate change and PEF single score impacts by 27% and 31.4%, respectively, compared to when a BC3 tyre that undergoes two retreadings is used.

Finally, the impacts of microplastics' emissions from tyres were also estimated. These are not yet accounted for in the LCA methodology and their inclusion in the EF method is currently under revision. The potential impacts of microplastics to freshwater ecotoxicity were estimated after calculating the amount of microplastics released into the environment. For this purpose, the approach reported in the PEFCR framework for synthetic turf surfaces used for sport or landscape applications was evaluated. This is based on the USEtox™ framework to calculate a simplified characterisation factor for the freshwater ecotoxicity impact category, and which is recommended by the European Commission’s PEF initiative.

3. Annexes

3.1. Annex I – Inputs for LCA/LCC for Base Cases

The background datasets were sourced from the Ecoinvent database (v. 3.11) (Wernet et al., 2016). As for the source of the foreground data, this is also specified and reported in the tables below, together with the data quality assessment, as explained in **section 2.1.4**.

3.1.1. BC1: C1 tyres

Table 3-1: Bill of Materials (BoM) and datasets used for BC1.

Raw Materials	Value (Kg/tyre)	Dataset	Reference	Data quality assessment
Natural rubber	1.41	-	Scientific literature (Cucci et al., 2025)	High quality
Synthetic rubber	2.03	Synthetic rubber {RER}| synthetic rubber production | Cut-off, S	Stakeholder input	High quality
Silica	1.08	Activated silica {GLO}| activated silica production | Cut-off, S	Stakeholder input	High quality
Carbon black	1.41	Carbon black {GLO}| carbon black production | Cut-off, S	Stakeholder input	High quality
Zinc oxide	0.12	Zinc oxide {RER}| zinc oxide production | Cut-off, S	Stakeholder input	High quality

Raw Materials	Value (Kg/tyre)	Dataset	Reference	Data quality assessment
Sulfur	0.10	Sulfur {GLO}| market for sulfur | Cut-off, S	Stakeholder input	High quality
Stearic acid	0.06	Stearic acid {GLO}| stearic acid production | Cut-off, S	Stakeholder input	High quality
Benzothiazoles-sulfonamides	0.09	Benzo[thia]diazole-compound {RER}| benzo[thia]diazole-compound production | Cut-off, S	Stakeholder input	High quality
Amines and plasticisers (6PPD, DPG, BENPAT, DMBC)	0.17	P-phenylene diamine {GLO}| p-phenylene diamine production | Cut-off, S; Dipropylene glycol monomethyl ether {RER}| dipropylene glycol monomethyl ether production | Cut-off, S	Stakeholder input	High quality
Oils	0.25	Base oil {Europe without Switzerland}| base oil production, petroleum refinery operation | Cut-off, S	Stakeholder input	High quality
Waxes	0.08	Petroleum slack wax {Europe without Switzerland}| petroleum slack wax production, petroleum refinery operation | Cut-off, S	Stakeholder input	High quality
Alkylphenols (PTOP, PTBP)	0.01	Bisphenol A, powder {RER}| bisphenol A production, powder | Cut-off, S	Stakeholder input	High quality
Phenolic resins, including resorcinol, HMT	0.02	Phenolic resin {RER}| phenolic resin production | Cut-off, S	Stakeholder input	High quality
Cobalt organic salts	0.02	Cobalt acetate {GLO}| cobalt production | Cut-off, S	Stakeholder input	High quality

Raw Materials	Value (Kg/tyre)	Dataset	Reference	Data quality assessment
Steel belts	0.66	Steel, low-alloyed {RER}| steel production, converter, low-alloyed | Cut-off, S; Wire drawing, steel {RER}| wire drawing, steel | Cut-off, S	Stakeholder input	High quality
Bead wire	0.33	Steel, low-alloyed {RER}| steel production, converter, low-alloyed | Cut-off, S; Wire drawing, steel {RER}| wire drawing, steel | Cut-off, S	Stakeholder input	High quality
Polyester cord fabric	0.18	Fibre, polyester {RoW}| polyester fibre production, finished | Cut-off, S; Weaving, synthetic fibre {GLO}| weaving of synthetic fibre, for industrial use | Cut-off, S	Stakeholder input	High quality
Rayon cord fabric	0.09	Fibre, viscose {GLO}| fibre production, viscose | Cut-off, S; Weaving, synthetic fibre {GLO}| weaving of synthetic fibre, for industrial use | Cut-off, S	Stakeholder input	High quality
Nylon cord fabric	0.09	Nylon 6 {RER}| nylon 6 production | Cut-off, S; Weaving, synthetic fibre {GLO}| weaving of synthetic fibre, for industrial use | Cut-off, S	Stakeholder input	High quality
Aramid cord fabric	0.001	Nylon 6 {RER}| nylon 6 production | Cut-off, S; Weaving, synthetic fibre {GLO}| weaving of synthetic fibre, for industrial use | Cut-off, S	Stakeholder input	High quality

1118 **Table 3-2: Manufacturing input data and datasets used for BC1.**

Manufacturing inputs	Unit	Value	Datasets	Reference	Data quality assessment
Electricity consumption	kWh/tyre	8.0	Market group for electricity, medium voltage (RER)	Stakeholder input	High quality
Heat consumption from natural gas	MJ/tyre	24.3	Heat production, natural gas, at industrial furnace >100kW (Europe without Switzerland)	Stakeholder input	High quality
Light fuel oil	MJ/tyre	0.2	Heat production, light fuel oil, at industrial furnace 1MW (Europe without Switzerland)	Stakeholder input	High quality
Petrol	MJ/tyre	0.01	Market for petrol, unleaded, burned in machinery (GLO)	Stakeholder input	High quality
Steam	MJ/tyre	11.5	Market for heat, from steam, in chemical industry (RER)	Stakeholder input	High quality
Coal	MJ/tyre	6.0	Heat production, at hard coal industrial furnace 1-10MW (Europe without Switzerland)	Stakeholder input	High quality
Diesel	MJ/tyre	0.3	Diesel, burned in diesel-electric generating set, 10MW (GLO)	Stakeholder input	High quality
Process water	Kg/tyre	46.6	Market for tap water (Europe without Switzerland)	Stakeholder input	High quality
Propane	MJ/tyre	0.1	Heat production, propane, at industrial furnace >100kW (RoW)	Stakeholder input	High quality
Solvent	Kg/tyre	0.005	Market for hexane (GLO)	Stakeholder input	High quality

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Table 3-3: Dataset used to model the impacts deriving from the extraction and production of petrol.

Type of fuel	Datasets
Petrol	Petrol, unleaded {RER}| market for petrol, unleaded | Cut-off, S

Table 3-4. LCC input data points for BC1.

LCC data point	Value	Unit	Reference	Source	Data quality assessment
Average expected initial life time	4.0	years	(Baron et al., 2025)	Scientific literature	High quality
Weibull shape parameter (b)	1.9	-	(Wu, n.d.)	Internet search	Fair quality
Latest Annual sales (2024)	305.7	mln. units/year	(Baron et al., 2025)	Stakeholder input	High quality
Assumed purchase price	71.05	Euro/unit	(Baron et al., 2025)	Expert judgement	Medium quality
EU sales and trade	2.91E+08	units	(Baron et al., 2025)	Stakeholder input	High quality
Number of priority parts for repair and upgrade	1	-		Expert judgement	Medium quality
Installation/acquisition costs	18.75	Euro/ unit	(Baron et al., 2025)	Expert judgement	Medium quality
Fuel rate	0.047	Euro/MJ	(Baron et al., 2025)	Expert judgement	Medium quality
Fuel consumption per km	0.074	MJ/km	Calculated		
Number of kilometers per year	10000	km/year	Calculated		
Repair & maintenance costs	59	Euro/ unit	(Baron et al., 2025)	Expert judgement	Medium quality
Discount rate (interest minus inflation)	3.0%	%	(Gama Caldas et al., 2024)	Scientific literature	High quality
Escalation rate (project annual growth of running costs)	-0.73%	%	Calculated, see **section 3.1.5**		

1123 **Table 3-5. Annual sales values for years 1994-2024 for BC1.**

Annual sales	Value	Unit	Reference
2024	305.658873	mln. units/year	Stakeholder input
2023	284.644637	mln. units/year	
2022	285.206419	mln. units/year	
2021	280.061841	mln. units/year	
2020	258.427734	mln. units/year	
2019	321.004812	mln. units/year	PRODCOM data
2018	333.192070	mln. units/year	
2017	311.567190	mln. units/year	
2016	301.374095	mln. units/year	
2015	289.727292	mln. units/year	
2014	291.786505	mln. units/year	
2013	276.896281	mln. units/year	
2012	278.730823	mln. units/year	
2011	361.766309	mln. units/year	
2010	333.064943	mln. units/year	
2009	264.501954	mln. units/year	
2008	283.620684	mln. units/year	
2007	320.911134	mln. units/year	
2006	323.899346	mln. units/year	
2005	300.318050	mln. units/year	Average value for years 2006-2024
2004	307.193016	mln. units/year	PRODCOM data

Annual sales	Value	Unit	Reference
2003	295.821324	mln. units/year	PRODCOM data
2002	300.318050	mln. units/year	Average value for years 2006-2024
2001	300.318050	mln. units/year	
2000	300.318050	mln. units/year	
1999	300.318050	mln. units/year	
1998	300.318050	mln. units/year	
1997	300.318050	mln. units/year	
1996	300.318050	mln. units/year	
1995	300.318050	mln. units/year	
1994	300.318050	mln. units/year	

3.1.2. BC2: C2 tyres

Table 3-6. Bill of Materials (BoM) and datasets used for BC2.

Raw Materials	Value (Kg/tyre)	Dataset	Reference	Data quality assessment
Natural rubber	2.73	-	Scientific literature (Cucci et al., 2025)	High quality
Synthetic rubber	3.08	Synthetic rubber {RER}| synthetic rubber production | Cut-off, S	Stakeholder input	High quality

Raw Materials	Value (Kg/tyre)	Dataset	Reference	Data quality assessment
Silica	0.88	Activated silica {GLO}| activated silica production | Cut-off, S	Stakeholder input	High quality
Carbon black	2.59	Carbon black {GLO}| carbon black production | Cut-off, S	Stakeholder input	High quality
Zinc oxide	0.25	Zinc oxide {RER}| zinc oxide production | Cut-off, S	Stakeholder input	High quality
Sulfur	0.16	Sulfur {GLO}| market for sulfur | Cut-off, S	Stakeholder input	High quality
Benzothiazoles-sulfonamides	0.305	Benzo[thia]diazole-compound {RER}| benzo[thia]diazole-compound production | Cut-off, S	Stakeholder input	High quality
Amines and plasticisers (6PPD, DPG, BENPAT, DMBC)	0.305	P-phenylene diamine {GLO}| p-phenylene diamine production | Cut-off, S; Dipropylene glycol monomethyl ether {RER}| dipropylene glycol monomethyl ether production | Cut-off, S	Stakeholder input	High quality
Alkylphenols (PTOP, PTBP)	0.393	Bisphenol A, powder {RER}| bisphenol A production, powder | Cut-off, S	Stakeholder input	High quality
Phenolic resins, including resorcinol, HMT	0.393	Phenolic resin {RER}| phenolic resin production | Cut-off, S	Stakeholder input	High quality
Steel belts	1.185	Steel, low-alloyed {RER}| steel production, converter, low-alloyed | Cut-off, S; Wire drawing, steel {RER}| wire drawing, steel | Cut-off, S	Stakeholder input	High quality
Bead wire	0.508	Steel, low-alloyed {RER}| steel production, converter, low-alloyed | Cut-off, S; Wire drawing, steel {RER}| wire drawing, steel | Cut-off, S	Stakeholder input	High quality
Polyester cord fabric	0.439	Fibre, polyester {RoW}| polyester fibre production, finished | Cut-off, S; Weaving, synthetic fibre {GLO}| weaving of synthetic fibre, for industrial use | Cut-off, S	Stakeholder input	High quality

Raw Materials	Value (Kg/tyre)	Dataset	Reference	Data quality assessment
Rayon cord fabric	0.219	Fibre, viscose {GLO}| fibre production, viscose | Cut-off, S; Weaving, synthetic fibre {GLO}| weaving of synthetic fibre, for industrial use | Cut-off, S	Stakeholder input	High quality
Nylon cord fabric	0.219	Nylon 6 {RER}| nylon 6 production | Cut-off, S; Weaving, synthetic fibre {GLO}| weaving of synthetic fibre, for industrial use | Cut-off, S	Stakeholder input	High quality

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1128 **Table 3-7. Manufacturing input data and datasets used for BC2.**

Manufacturing inputs	Unit	BC2	Datasets	Reference	Data quality assessment
Electricity consumption	kWh/tyre	13.3	Market group for electricity, medium voltage (RER)	Stakeholder input	High quality
Heat consumption from natural gas	MJ/tyre	40.1	Heat production, natural gas, at industrial furnace >100kW (Europe without Switzerland)	Stakeholder input	High quality
Light fuel oil	MJ/tyre	0.3	Heat production, light fuel oil, at industrial furnace 1MW (Europe without Switzerland)	Stakeholder input	High quality
Petrol	MJ/tyre	0.01	Market for petrol, unleaded, burned in machinery (GLO)	Stakeholder input	High quality
Steam	MJ/tyre	18.9	Market for heat, from steam, in chemical industry (RER)	Stakeholder input	High quality
Coal	MJ/tyre	9.9	Heat production, at hard coal industrial furnace 1-10MW (Europe without Switzerland)	Stakeholder input	High quality
Diesel	MJ/tyre	0.5	Diesel, burned in diesel-electric generating set, 10MW (GLO)	Stakeholder input	High quality

Manufacturing inputs	Unit	BC2	Datasets	Reference	Data quality assessment
Process water	Kg/tyre	77.0	Market for tap water (Europe without Switzerland)	Stakeholder input	High quality
Propane	MJ/tyre	0.1	Heat production, propane, at industrial furnace >100kW (RoW)	Stakeholder input	High quality
Solvent	Kg/tyre	0.04	Market for hexane (GLO)	Stakeholder input	High quality

Table 3-8. Dataset used to model the impacts deriving from the extraction and production of diesel.

Type of fuel	Datasets
Diesel	Diesel {Europe without Switzerland}| market for diesel | Cut-off, S

Table 3-9. LCC input data points for BC2.

LCC data point	Value	Unit	Reference	Source	Data quality assessment
Average expected initial life time	3	years	(Baron et al., 2025)	Scientific literature	High quality
Weibull shape parameter (b)	1.9	-	(Wu, n.d.)	Internet search	Fair quality
Latest Annual sales (2024)	29.3	mln. units/year	(Baron et al., 2025)	Stakeholder input	High quality
Assumed purchase price	110.83	Euro/unit	(Baron et al., 2025)	Expert judgement	Medium quality
EU sales and trade	3.58E+07	units	(Baron et al., 2025)	Stakeholder input	High quality
Number of priority parts for repair and upgrade	1	-		Expert judgement	Medium quality
Installation/acquisition costs	18.75	Euro/ unit	(Baron et al., 2025)	Expert judgement	Medium quality
Fuel rate	0.039	Euro/MJ	(Baron et al., 2025)	Expert judgement	Medium quality

LCC data point	Value	Unit	Reference	Source	Data quality assessment
Fuel consumption per km	0.063	MJ/km	Calculated		
Number of kilometers per year	19000	km/year	Calculated		
Repair & maintenance costs	59	Euro/ unit	(Baron et al., 2025)	Expert judgement	Medium quality
Discount rate (interest minus inflation)	3.0%	%	(Gama Caldas et al., 2024)	Scientific literature	High quality
Escalation rate (project annual growth of running costs)	-1.29%%	%	Calculated, see **section 3.1.5**		

1132 **Table 3-10. Annual sales values for years 1994-2024 for BC2.**

Annual sales	Value	Unit	Reference
2024	29.337152	mln. units/year	Stakeholder input
2023	26.780937	mln. units/year	
2022	29.976883	mln. units/year	
2021	29.325975	mln. units/year	
2020	23.529388	mln. units/year	
2019	30.338955	mln. units/year	PRODCOM data
2018	31.330393	mln. units/year	
2017	30.975961	mln. units/year	
2016	29.774079	mln. units/year	
2015	28.873640	mln. units/year	
2014	27.350539	mln. units/year	
2013	25.287594	mln. units/year	
2012	27.442243	mln. units/year	
2011	30.856137	mln. units/year	

Annual sales	Value	Unit	Reference
2010	30.296996	mln. units/year	
2009	26.546396	mln. units/year	
2008	34.009724	mln. units/year	
2007	37.762347	mln. units/year	
2006	36.574321	mln. units/year	
2005	29.808929	mln. units/year	Average value for years 2006-2024
2004	34.645759	mln. units/year	PRODCOM data
2003	33.896154	mln. units/year	PRODCOM data
2002	29.808929	mln. units/year	
2001	29.808929	mln. units/year	
2000	29.808929	mln. units/year	
1999	29.808929	mln. units/year	
1998	29.808929	mln. units/year	Average value for years 2006-2024
1997	29.808929	mln. units/year	
1996	29.808929	mln. units/year	
1995	29.808929	mln. units/year	
1994	29.808929	mln. units/year	

3.1.3. BC3: C3 tyres

Table 3-11. Bill of Materials (BoM) and datasets used for BC3.

Raw Materials	Value (Kg/tyre)	Dataset	Reference	Data quality assessment
Natural rubber	20.81	-	Scientific literature (Cucci et al., 2025)	High quality
Synthetic rubber	9.26	Synthetic rubber {RER}| synthetic rubber production | Cut-off, S	Stakeholder input	High quality
Silica	2.57	Activated silica {GLO}| activated silica production | Cut-off, S	Stakeholder input	High quality
Carbon black	13.04	Carbon black {GLO}| carbon black production | Cut-off, S	Stakeholder input	High quality
Zinc oxide	1.34	Zinc oxide {RER}| zinc oxide production | Cut-off, S	Stakeholder input	High quality
Sulfur	0.81	Sulfur {GLO}| market for sulfur | Cut-off, S	Stakeholder input	High quality
Stearic acid	0.50	Stearic acid {GLO}| stearic acid production | Cut-off, S	Stakeholder input	High quality
Benzothiazoles-sulfonamides	0.78	Benzo[thia]diazole-compound {RER}| benzo[thia]diazole-compound production | Cut-off, S	Stakeholder input	High quality
Amines and plasticisers (6PPD, DPG, BENPAT, DMBC)	0.85	P-phenylene diamine {GLO}| p-phenylene diamine production | Cut-off, S; Dipropylene glycol monomethyl ether {RER}| dipropylene glycol monomethyl ether production | Cut-off, S	Stakeholder input	High quality
Oils	0.46	Base oil {Europe without Switzerland}| base oil production, petroleum refinery operation | Cut-off, S	Stakeholder input	High quality

Raw Materials	Value (Kg/tyre)	Dataset	Reference	Data quality assessment
Waxes	0.25	Petroleum slack wax {Europe without Switzerland}| petroleum slack wax production, petroleum refinery operation | Cut-off, S	Stakeholder input	High quality
Alkylphenols (PTOP, PTBP)	0.06	Bisphenol A, powder {RER}| bisphenol A production, powder | Cut-off, S	Stakeholder input	High quality
Phenolic resins, including resorcinol, HMT	0.46	Phenolic resin {RER}| phenolic resin production | Cut-off, S	Stakeholder input	High quality
Cobalt organic salts	0.12	Cobalt acetate {GLO}| cobalt production | Cut-off, S	Stakeholder input	High quality
Steel belts	9.81	Steel, low-alloyed {RER}| steel production, converter, low-alloyed | Cut-off, S; Wire drawing, steel {RER}| wire drawing, steel | Cut-off, S	Stakeholder input	High quality
Bead wire	3.48	Steel, low-alloyed {RER}| steel production, converter, low-alloyed | Cut-off, S; Wire drawing, steel {RER}| wire drawing, steel | Cut-off, S	Stakeholder input	High quality
Nylon cord fabric	0.02	Nylon 6 {RER}| nylon 6 production | Cut-off, S; Weaving, synthetic fibre {GLO}| weaving of synthetic fibre, for industrial use | Cut-off, S	Stakeholder input	High quality

Table 3-12. Manufacturing input data and datasets used for BC3.

Manufacturing inputs	Unit	BC3	Datasets	Reference	Data quality assessment
Electricity consumption	kWh/tyre	63.0	Market group for electricity, medium voltage (RER)	Stakeholder input	High quality
Heat consumption from natural gas	MJ/tyre	180.0	Heat production, natural gas, at industrial furnace >100kW (Europe without Switzerland)	Stakeholder input	High quality
Light fuel oil	MJ/tyre	1.5	Heat production, light fuel oil, at industrial furnace 1MW (Europe without Switzerland)	Stakeholder input	High quality
Petrol	MJ/tyre	0.1	Market for petrol, unleaded, burned in machinery (GLO)	Stakeholder input	High quality
Steam	MJ/tyre	89.9	Market for heat, from steam, in chemical industry (RER)	Stakeholder input	High quality
Coal	MJ/tyre	47.1	Heat production, at hard coal industrial furnace 1-10MW (Europe without Switzerland)	Stakeholder input	High quality
Diesel	MJ/tyre	2.2	Diesel, burned in diesel-electric generating set, 10MW (GLO)	Stakeholder input	High quality
Process water	Kg/tyre	365.4	Market for tap water (Europe without Switzerland)	Stakeholder input	High quality
Propane	MJ/tyre	0.7	Heat production, propane, at industrial furnace >100kW (RoW)	Stakeholder input	High quality
Solvent	Kg/tyre	0.04	Market for hexane (GLO)	Stakeholder input	High quality

1139 **Table 3-13. Dataset used to model the impacts deriving from the extraction and production of diesel.**

Type of fuel	Datasets
Diesel	Diesel {Europe without Switzerland}| market for diesel | Cut-off, S

1140 **Table 3-14. LCC input data points for BC3.**

LCC data point	Value	Unit	Reference	Source	Data quality assessment
Average expected initial life time	3	years	(Baron et al., 2025)	Scientific literature	High quality
Weibull shape parameter (b)	1.9	-	(Wu, n.d.)	Internet search	Fair quality
Latest Annual sales (2024)	16.6	mln. units/year	(Baron et al., 2025)	Stakeholder input	High quality
Assumed purchase price	419	Euro/unit	(Baron et al., 2025)	Expert judgement	Medium quality
EU sales and trade	1.72E+07	units	(Baron et al., 2025)	Stakeholder input	High quality
Number of priority parts for repair and upgrade	1	-		Expert judgement	Medium quality
Installation/acquisition costs	18.75	Euro/ unit	(Baron et al., 2025)	Expert judgement	Medium quality
Fuel rate	0.039	Euro/MJ	(Baron et al., 2025)	Expert judgement	Medium quality
Fuel consumption per km	0.227	MJ/km	Calculated		
Number of kilometers per year	84470	km/year	Calculated		
Repair & maintenance costs	58.75	Euro/ unit	(Baron et al., 2025)	Expert judgement	Medium quality
Discount rate (interest minus inflation)	3.0%	%	(Gama Caldas et al., 2024)	Scientific literature	High quality
Escalation rate (project annual growth of running costs)	-1.29%	%	Calculated, see **section 3.1.5**		

1141 **Table 3-15. Annual sales values for years 1994-2024 for BC3.**

Annual sales	Value	Unit	Reference
2024	16.586987	mln. units/year	Stakeholder input

Annual sales	Value	Unit	Reference
2023	16.860753	mln. units/year	
2022	19.019878	mln. units/year	
2021	17.974128	mln. units/year	
2020	15.389195	mln. units/year	
2019	16.225135	mln. units/year	PRODCOM data
2018	16.249658	mln. units/year	
2017	16.122148	mln. units/year	
2016	15.852843	mln. units/year	
2015	14.962806	mln. units/year	
2014	13.688869	mln. units/year	
2013	12.992542	mln. units/year	
2012	12.013178	mln. units/year	
2011	15.781025	mln. units/year	
2010	13.842580	mln. units/year	
2009	8.418450	mln. units/year	
2008	13.944300	mln. units/year	
2007	18.365108	mln. units/year	
2006	15.590193	mln. units/year	
2005	15.256830	mln. units/year	Average value for years 2006-2024
2004	15.945956	mln. units/year	PRODCOM data
2003	15.883343	mln. units/year	PRODCOM data
2002	15.256830	mln. units/year	Average value for years 2006-2024

Annual sales	Value	Unit	Reference
2001	15.256830	mln. units/year	
2000	15.256830	mln. units/year	
1999	15.256830	mln. units/year	
1998	15.256830	mln. units/year	
1997	15.256830	mln. units/year	
1996	15.256830	mln. units/year	
1995	15.256830	mln. units/year	
1994	15.256830	mln. units/year	

3.1.4. BC4: C3 Retreaded tyres

Table 3-16. Bill of Materials (BoM) and datasets used for BC4.

Raw Materials	Value (Kg/tyre)	Dataset	Reference	Data quality assessment
Natural rubber	8.895552	-	Scientific literature (Cucci et al., 2025)	High quality
Synthetic rubber	4.110	Synthetic rubber {RER}| synthetic rubber production | Cut-off, S	Stakeholder input	High quality
Silica	0.458	Activated silica {GLO}| activated silica production | Cut-off, S	Stakeholder input	High quality
Carbon black	6.030	Carbon black {GLO}| carbon black production | Cut-off, S	Stakeholder input	High quality

Raw Materials	Value (Kg/tyre)	Dataset	Reference	Data quality assessment
Zinc oxide	0.492	Zinc oxide {RER}| zinc oxide production | Cut-off, S	Stakeholder input	High quality
Sulfur	0.248	Sulfur {GLO}| market for sulfur | Cut-off, S	Stakeholder input	High quality
Amines and plasticisers (6PPD, DPG, BENPAT, DMBC)	0.288	P-phenylene diamine {GLO}| p-phenylene diamine production | Cut-off, S; Dipropylene glycol monomethyl ether {RER}| dipropylene glycol monomethyl ether production | Cut-off, S	Stakeholder input	High quality
Oils	0.406	Base oil {Europe without Switzerland}| base oil production, petroleum refinery operation | Cut-off, S	Stakeholder input	High quality
Waxes	0.109	Petroleum slack wax {Europe without Switzerland}| petroleum slack wax production, petroleum refinery operation | Cut-off, S	Stakeholder input	High quality
Phenolic resins, including resorcinol, HMT	0.251	Phenolic resin {RER}| phenolic resin production | Cut-off, S	Stakeholder input	High quality

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1146 **Table 3-17. Manufacturing input data and datasets used for BC4.**

Manufacturing inputs	Unit	BC4	Datasets	Reference	Data quality assessment
Electricity consumption	kWh/tyre	18.2	Market group for electricity, medium voltage (RER)	Stakeholder input	High quality
Heat consumption from natural gas	MJ/tyre	61.3	Heat production, natural gas, at industrial furnace >100kW (Europe without Switzerland)	Stakeholder input	High quality

Manufacturing inputs	Unit	BC4	Datasets	Reference	Data quality assessment
Light fuel oil	MJ/tyre	0.5	Heat production, light fuel oil, at industrial furnace 1MW (Europe without Switzerland)	Stakeholder input	High quality
Petrol	MJ/tyre	0.02	Market for petrol, unleaded, burned in machinery (GLO)	Stakeholder input	High quality
Steam	MJ/tyre	29.0	Market for heat, from steam, in chemical industry (RER)	Stakeholder input	High quality
Coal	MJ/tyre	15.2	Heat production, at hard coal industrial furnace 1-10MW (Europe without Switzerland)	Stakeholder input	High quality
Diesel	MJ/tyre	0.7	Diesel, burned in diesel-electric generating set, 10MW (GLO)	Stakeholder input	High quality
Process water	Kg/tyre	118.0	Market for tap water (Europe without Switzerland)	Stakeholder input	High quality
Propane	MJ/tyre	0.2	Heat production, propane, at industrial furnace >100kW (RoW)	Stakeholder input	High quality
Solvent	Kg/tyre	0.01	Market for hexane (GLO)	Stakeholder input	High quality

1147 **Table 3-18. LCC input data points for BC4.**

LCC data point	Value	Unit	Reference	Source	Data quality assessment
Average expected initial life time	3	years	(Baron et al., 2025)	Scientific literature	High quality
Weibull shape parameter (b)	1.9	-	(Wu, n.d.)	Internet search	Fair quality
Latest Annual sales (2024)	2.06	mln. units/year	(Baron et al., 2025)	Stakeholder input	High quality
Assumed purchase price	363.17	Euro/unit	(Baron et al., 2025)	Expert judgement	Medium quality
EU sales and trade	1.04E+07	units	(Baron et al., 2025)	Stakeholder input	High quality
Number of priority parts for repair and upgrade	1	-		Expert judgement	Medium quality

LCC data point	Value	Unit	Reference	Source	Data quality assessment
Installation/acquisition costs	18.75	Euro/ unit	(Baron et al., 2025)	Expert judgement	Medium quality
Fuel rate	0.039	Euro/MJ	(Baron et al., 2025)	Expert judgement	Medium quality
Fuel consumption per km	0.229	MJ/km	Calculated		
Number of kilometers per year	81973.3	km/year	Calculated		
Repair & maintenance costs	58.75	Euro/ unit	(Baron et al., 2025)	Expert judgement	Medium quality
Discount rate (interest minus inflation)	3.0%	%	(Gama Caldas et al., 2024)	Scientific literature	High quality
Escalation rate (project annual growth of running costs)	-1.29%	%	Calculated, see **section 3.1.5**		

Table 3-19. Annual sales values for years 1994-2024 for BC4.

Annual sales	Value	Unit	Reference
2024	2.054886	mln. units/year	
2023	2.315614	mln. units/year	
2022	2.674513	mln. units/year	Stakeholder input
2021	3.915020	mln. units/year	
2020	2.514187	mln. units/year	
2019	2.491969	mln. units/year	
2018	2.640317	mln. units/year	
2017	2.808763	mln. units/year	
2016	3.316913	mln. units/year	PRODCOM data
2015	3.511405	mln. units/year	
2014	3.432511	mln. units/year	
2013	3.406601	mln. units/year	

Annual sales	Value	Unit	Reference
2012	3.402334	mln. units/year	
2011	4.553192	mln. units/year	
2010	4.288878	mln. units/year	
2009	3.761640	mln. units/year	
2008	4.398161	mln. units/year	
2007	6.255013	mln. units/year	
2006	6.360718	mln. units/year	
2005	5.162643	mln. units/year	Average value for years 2006-2024
2004	5.152169	mln. units/year	PRODCOM data
2003	5.061485	mln. units/year	PRODCOM data
2002	5.235425	mln. units/year	
2001	5.460222	mln. units/year	
2000	5.386323	mln. units/year	
1999	5.380947	mln. units/year	
1998	5.353632	mln. units/year	Average value for years 2006-2024
1997	5.186068	mln. units/year	
1996	5.186068	mln. units/year	
1995	5.186068	mln. units/year	
1994	5.186068	mln. units/year	

Table 3-20: Dataset used to model the impacts deriving from the extraction and production of diesel.

Type of fuel	Datasets
Diesel	Diesel {Europe without Switzerland}| market for diesel | Cut-off, S

3.1.5. Calculation of escalation rate

The escalation rate, the real (inflation-corrected) annual growth of running costs, was calculated based on the data in **Table 3-21**. The only running cost applicable to tyres is the cost of fuel. The escalation rate can be calculated from the extrapolated prices growth rate after correcting for inflation (using historical data both for fuel price and for inflation). Data from the Weekly Oil Bulletin (collected in November 2025), was used for the price of fuel (Euro-super 95 and diesel) and Eurostat data was used for the general inflation (Harmonised index of consumer prices, HICP) for the years 2014 – 2024. For all prices, EU-27 data was taken.

Table 3-21. Overview of datasets used for the escalation rate calculation.

Parameter	Dataset
General inflation (HICP)	HICP - annual data (average index and rate of change) (Eurostat, 2025)
Fuel - Euro-super 95 (l)	Weekly Oil Bulletin – EU price without tax, data collected until November 2025 (*Weekly Oil Bulletin*, n.d.)
Diesel	Weekly Oil Bulletin – EU price without tax, data collected until November 2025 (*Weekly Oil Bulletin*, n.d.)

For the fuel, the % increase in 2024 versus 2014 was calculated according to **Equation 3-1**.

$$Increase\ (\%) = \left(\frac{2024\ price}{2014\ price}^{\frac{1}{10}} - 1\right) \times 100\%$$

Equation 3-1: Calculation of % increase.

Subsequently, the escalation rate was calculated by **Equation 3-2**.

$$Escalation\ rate\ (\%) = \left(\frac{1 + \%\ increase\ product}{1 + \%\ increase\ HICP} - 1\right) \times 100\%$$

Equation 3-2: Calculation of % escalation rate.

The escalation rate for the Euro-super 95 fuel has been calculated as -0.73% and for diesel as -1.29%.

3.2. Annex II – Results of LCA/LCC per Base Case

In this Annex, the detailed LCA and LCC results are presented per Base Case (per lifetime, per kilometre driven and for the total product stock).

3.2.1. BC1: C1 tyres

Table 3-22. BC1 – Life cycle impact per product over the total lifetime.

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Acidification	mol H^+ eq	1.4E-01	3.1E-02	2.6E-02	4.8E-03	7.2E-01	-9.0E-04	-4.2E-03	-7.1E-05	-4.1E-04	8.4E-06	9.13E-01
Climate change	kg CO_2 eq.	2.07E+01	3.17E+00	6.73E+00	1.37E+00	2.72E+02	-5.34E-01	-9.81E-01	-1.88E-02	-1.43E-01	2.42E-03	3.03E+02
Climate change - Biogenic	kg CO_2 eq.	1.9E-02	7.5E-04	5.9E-03	3.2E-04	1.5E-02	1.3E-04	-1.7E-04	-2.3E-05	1.5E-04	5.7E-07	4.10E-02
Climate change - Fossil	kg CO_2 eq.	2.1E+01	3.2E+00	6.7E+00	1.4E+00	2.7E+02	-5.3E-01	-9.8E-01	-1.9E-02	-1.4E-01	2.4E-03	3.02E+02
Climate change - Land use and LU change	kg CO_2 eq.	2.0E-02	1.6E-03	8.3E-03	6.2E-04	1.2E-02	8.7E-05	-2.3E-04	-1.1E-05	2.4E-04	1.1E-06	4.28E-02
Ecotoxicity, freshwater	CTUe	2.6E+02	6.4E+00	1.1E+01	3.2E+00	1.4E+02	-1.6E+00	-4.9E+00	-1.5E-01	-2.1E-01	5.7E-03	4.14E+02

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Ecotoxicity, freshwater - inorganics	CTUe	1.7E+02	6.1E+00	1.1E+01	3.1E+00	1.2E+02	-1.6E+00	-4.8E+00	-1.6E-01	-1.8E-01	5.5E-03	3.06E+02
Ecotoxicity, freshwater - organics	CTUe	9.2E+01	2.3E-01	1.7E-01	9.9E-02	1.7E+01	-1.1E-02	-1.0E-01	1.8E-02	-3.5E-02	1.8E-04	1.10E+02
Particulate matter	disease inc.	2.0E-06	2.6E-07	1.3E-06	1.3E-07	7.9E-06	-3.0E-08	-5.0E-08	-1.6E-09	-2.2E-08	2.4E-10	1.15E-05
Eutrophication, marine	kg N eq	3.5E-02	8.5E-03	4.7E-03	1.5E-03	1.6E-01	7.9E-05	-1.2E-03	-7.3E-06	-3.3E-05	2.7E-06	2.07E-01
Eutrophication, freshwater	kg P eq	6.4E-03	3.0E-04	3.0E-03	1.5E-04	3.0E-03	-1.7E-04	-1.8E-03	-3.7E-06	7.9E-05	2.6E-07	1.10E-02
Eutrophication, terrestrial	mol N eq.	3.7E-01	9.4E-02	4.3E-02	1.7E-02	2.4E+00	-6.1E-04	-9.7E-03	-7.6E-05	-5.6E-04	2.9E-05	2.94E+00
Human toxicity, cancer	CTUh	1.8E-08	5.6E-10	1.1E-09	2.2E-10	1.6E-08	-8.5E-10	-5.5E-10	-6.4E-12	-7.8E-12	3.9E-13	3.42E-08
Human toxicity, cancer - inorganics	CTUh	3.2E-09	2.9E-10	4.3E-10	9.5E-11	7.7E-09	3.7E-11	9.6E-12	-4.3E-12	-2.7E-12	1.7E-13	1.18E-08
Human toxicity, cancer - organics	CTUh	1.2E-08	2.7E-10	6.4E-10	1.3E-10	8.4E-09	-8.9E-10	-5.6E-10	-2.2E-12	-5.1E-12	2.2E-13	2.03E-08
Human toxicity, non-cancer	CTUh	6.0E-07	2.4E-08	3.0E-08	1.2E-08	1.7E-06	-1.2E-09	1.3E-09	-2.2E-10	-3.8E-10	2.2E-11	2.37E-06

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Human toxicity, non-cancer - inorganics	CTUh	3.7E-07	2.2E-08	2.8E-08	1.2E-08	4.4E-07	-1.2E-09	1.9E-09	-2.0E-10	-2.4E-10	2.1E-11	8.73E-07
Human toxicity, non-cancer - organics	CTUh	2.4E-08	1.5E-09	1.3E-09	7.6E-10	1.3E-06	-8.8E-11	-5.9E-10	-2.0E-11	-1.4E-10	1.3E-12	1.30E-06
Ionising radiation	kBq U-235 eq.	1.4E+00	3.8E-02	1.8E+00	1.7E-02	1.1E+00	3.8E-02	-1.6E-02	-6.2E-04	6.4E-02	3.0E-05	4.44E+00
Land use	Pt	3.8E+03	3.4E+01	1.2E+01	1.9E+01	1.9E+02	-6.5E-01	-2.6E+00	-1.0E-01	-2.1E-01	3.4E-02	4.02E+03
Ozone depletion	kg CFC11 eq.	6.1E-06	4.3E-08	1.7E-07	1.8E-08	6.2E-06	-2.1E-09	-5.1E-08	-8.8E-10	-1.3E-08	3.3E-11	1.25E-05
Photochemical ozone formation	kg NMVOC eq.	1.4E-01	2.9E-02	1.6E-02	6.8E-03	1.5E+00	-6.1E-04	-6.2E-03	-1.3E-04	-1.4E-03	1.2E-05	1.71E+00
Resource use, fossils	MJ	4.4E+02	4.3E+01	1.2E+02	2.0E+01	3.6E+03	-4.5E+00	-4.6E+01	-7.0E-01	-9.0E+00	3.5E-02	4.17E+03
Resource use, minerals and metals	kg Sb eq.	3.0E-04	7.4E-06	7.1E-06	3.8E-06	4.8E-05	1.4E-07	-5.9E-08	-4.6E-07	-5.4E-07	6.7E-09	3.62E-04
Water use	m3 depriv.	9.9E+00	2.0E-01	2.7E+00	1.0E-01	2.9E+00	-3.7E-02	-5.9E-02	-1.6E-02	8.6E-03	1.8E-04	1.57E+01
PEF Single Score	-	3.0E-03	3.1E-04	7.1E-04	1.2E-04	1.7E-02	-3.1E-05	-1.4E-04	-2.8E-06	-2.0E-05	2.0E-07	2.12E-02

1172 **Table 3-23. BC1 – Life cycle impact per product per km driven.**

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Acidification	mol H^+ eq	3.4E-06	7.8E-07	6.4E-07	1.2E-07	1.8E-05	-2.3E-08	-1.1E-07	-1.8E-09	-1.0E-08	2.1E-10	2.3E-05
Climate change	kg CO_2 eq.	5.17E-04	7.91E-05	1.68E-04	3.41E-05	6.81E-03	-1.34E-05	-2.45E-05	-4.71E-07	-3.57E-06	6.04E-08	7.56E-03
Climate change - Biogenic	kg CO_2 eq.	4.7E-07	1.9E-08	1.5E-07	8.0E-09	3.8E-07	3.3E-09	-4.3E-09	-5.8E-10	3.8E-09	1.4E-11	1.0E-06
Climate change - Fossil	kg CO_2 eq.	5.2E-04	7.9E-05	1.7E-04	3.4E-05	6.8E-03	-1.3E-05	-2.5E-05	-4.7E-07	-3.6E-06	6.0E-08	7.6E-03
Climate change - Land use and LU change	kg CO_2 eq.	4.9E-07	4.0E-08	2.1E-07	1.5E-08	3.1E-07	2.2E-09	-5.7E-09	-2.7E-10	6.1E-09	2.7E-11	1.1E-06
Ecotoxicity, freshwater	CTUe	6.5E-03	1.6E-04	2.9E-04	8.0E-05	3.4E-03	-4.1E-05	-1.2E-04	-3.7E-06	-5.4E-06	1.4E-07	1.0E-02
Ecotoxicity, freshwater - inorganics	CTUe	4.3E-03	1.5E-04	2.8E-04	7.7E-05	3.0E-03	-4.0E-05	-1.2E-04	-4.1E-06	-4.5E-06	1.4E-07	7.7E-03
Ecotoxicity, freshwater - organics	CTUe	2.3E-03	5.7E-06	4.4E-06	2.5E-06	4.3E-04	-2.8E-07	-2.6E-06	4.6E-07	-8.8E-07	4.4E-09	2.7E-03
Particulate matter	disease inc.	5.0E-11	6.6E-12	3.3E-11	3.3E-12	2.0E-10	-7.6E-13	-1.3E-12	-4.0E-14	-5.6E-13	5.9E-15	2.9E-10
Eutrophication, marine	kg N eq	8.8E-07	2.1E-07	1.2E-07	3.8E-08	4.0E-06	2.0E-09	-3.0E-08	-1.8E-10	-8.4E-10	6.8E-11	5.2E-06
Eutrophication, freshwater	kg P eq	1.6E-07	7.6E-09	7.6E-08	3.7E-09	7.6E-08	-4.3E-09	-4.5E-08	-9.3E-11	2.0E-09	6.6E-12	2.8E-07

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Eutrophication, terrestrial	mol N eq.	9.1E-06	2.3E-06	1.1E-06	4.2E-07	6.1E-05	-1.5E-08	-2.4E-07	-1.9E-09	-1.4E-08	7.4E-10	7.3E-05
Human toxicity, cancer	CTUh	4.4E-13	1.4E-14	2.7E-14	5.5E-15	4.0E-13	-2.1E-14	-1.4E-14	-1.6E-16	-1.9E-16	9.8E-18	8.6E-13
Human toxicity, cancer - inorganics	CTUh	8.0E-14	7.3E-15	1.1E-14	2.4E-15	1.9E-13	9.2E-16	2.4E-16	-1.1E-16	-6.8E-17	4.2E-18	2.9E-13
Human toxicity, cancer - organics	CTUh	3.1E-13	6.7E-15	1.6E-14	3.1E-15	2.1E-13	-2.2E-14	-1.4E-14	-5.4E-17	-1.3E-16	5.6E-18	5.1E-13
Human toxicity, non-cancer	CTUh	1.5E-11	6.0E-13	7.4E-13	3.1E-13	4.3E-11	-3.1E-14	3.2E-14	-5.5E-15	-9.5E-15	5.5E-16	5.9E-11
Human toxicity, non-cancer - inorganics	CTUh	9.4E-12	5.6E-13	7.1E-13	2.9E-13	1.1E-11	-2.9E-14	4.7E-14	-5.0E-15	-5.9E-15	5.2E-16	2.2E-11
Human toxicity, non-cancer - organics	CTUh	6.1E-13	3.7E-14	3.1E-14	1.9E-14	3.2E-11	-2.2E-15	-1.5E-14	-5.0E-16	-3.5E-15	3.4E-17	3.3E-11
Ionising radiation	kBq U-235 eq.	3.5E-05	9.4E-07	4.5E-05	4.2E-07	2.8E-05	9.5E-07	-4.0E-07	-1.5E-08	1.6E-06	7.5E-10	1.1E-04
Land use	Pt	9.4E-02	8.5E-04	2.9E-04	4.8E-04	4.7E-03	-1.6E-05	-6.5E-05	-2.6E-06	-5.4E-06	8.6E-07	1.0E-01
Ozone depletion	kg CFC11 eq.	1.5E-10	1.1E-12	4.2E-12	4.6E-13	1.6E-10	-5.2E-14	-1.3E-12	-2.2E-14	-3.2E-13	8.2E-16	3.1E-10

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Photochemical ozone formation	kg NMVOC eq.	3.4E-06	7.3E-07	3.9E-07	1.7E-07	3.8E-05	-1.5E-08	-1.5E-07	-3.3E-09	-3.4E-08	3.0E-10	4.3E-05
Resource use, fossils	MJ	1.1E-02	1.1E-03	2.9E-03	4.9E-04	9.0E-02	-1.1E-04	-1.2E-03	-1.7E-05	-2.2E-04	8.6E-07	1.0E-01
Resource use, minerals and metals	kg Sb eq.	7.4E-09	1.8E-10	1.8E-10	9.4E-11	1.2E-09	3.4E-12	-1.5E-12	-1.1E-11	-1.3E-11	1.7E-13	9.0E-09
Water use	m3 depriv.	2.5E-04	5.1E-06	6.7E-05	2.5E-06	7.3E-05	-9.1E-07	-1.5E-06	-4.1E-07	2.1E-07	4.5E-09	3.9E-04
PEF Single Score	-	7.5E-08	7.8E-09	1.8E-08	2.9E-09	4.3E-07	-7.9E-10	-3.6E-09	-6.9E-11	-4.9E-10	5.1E-12	5.3E-07

Table 3-24. BC1 - EU total life cycle impact of stock of products in the year of study.

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Acidification	mol H^+ eq	1.6E+08	3.6E+07	3.0E+07	5.5E+06	8.3E+08	-1.0E+06	-4.9E+06	-8.2E+04	-4.7E+05	9.7E+03	1.06E+09
Climate change	kg CO_2 eq.	2.4E+10	3.7E+09	7.8E+09	1.6E+09	3.2E+11	-6.2E+08	-1.1E+09	-2.2E+07	-1.7E+08	2.8E+06	3.50E+11
Climate change - Biogenic	kg CO_2 eq.	2.2E+07	8.7E+05	6.8E+06	3.7E+05	1.8E+07	1.5E+05	-2.0E+05	-2.7E+04	1.7E+05	6.5E+02	4.75E+07

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Climate change - Fossil	kg CO_2 eq.	2.4E+10	3.7E+09	7.8E+09	1.6E+09	3.2E+11	-6.2E+08	-1.1E+09	-2.2E+07	-1.7E+08	2.8E+06	3.50E+11
Climate change - Land use and LU change	kg CO_2 eq.	2.3E+07	1.8E+06	9.6E+06	7.1E+05	1.4E+07	1.0E+05	-2.7E+05	-1.3E+04	2.8E+05	1.3E+03	4.96E+07
Ecotoxicity, freshwater	CTUe	3.0E+11	7.4E+09	1.3E+10	3.7E+09	1.6E+11	-1.9E+09	-5.7E+09	-1.7E+08	-2.5E+08	6.5E+06	4.79E+11
Ecotoxicity, freshwater - inorganics	CTUe	2.0E+11	7.1E+09	1.3E+10	3.6E+09	1.4E+11	-1.9E+09	-5.6E+09	-1.9E+08	-2.1E+08	6.3E+06	3.54E+11
Ecotoxicity, freshwater - organics	CTUe	1.1E+11	2.7E+08	2.0E+08	1.1E+08	2.0E+10	-1.3E+07	-1.2E+08	2.1E+07	-4.1E+07	2.0E+05	1.27E+11
Particulate matter	disease inc.	2.3E+03	3.1E+02	1.5E+03	1.5E+02	9.2E+03	-3.5E+01	-5.8E+01	-1.9E+00	-2.6E+01	2.7E-01	1.34E+04
Eutrophication, marine	kg N eq	4.1E+07	9.8E+06	5.5E+06	1.8E+06	1.8E+08	9.1E+04	-1.4E+06	-8.4E+03	-3.9E+04	3.1E+03	2.40E+08
Eutrophication, freshwater	kg P eq	7.4E+06	3.5E+05	3.5E+06	1.7E+05	3.5E+06	-2.0E+05	-2.1E+06	-4.3E+03	9.1E+04	3.0E+02	1.27E+07
Eutrophication, terrestrial	mol N eq.	4.2E+08	1.1E+08	5.0E+07	1.9E+07	2.8E+09	-7.0E+05	-1.1E+07	-8.8E+04	-6.4E+05	3.4E+04	3.40E+09
Human toxicity, cancer	CTUh	2.0E+01	6.5E-01	1.2E+00	2.6E-01	1.9E+01	-9.8E-01	-6.4E-01	-7.5E-03	-9.0E-03	4.5E-04	3.96E+01
Human toxicity, cancer - inorganics	CTUh	3.7E+00	3.4E-01	4.9E-01	1.1E-01	8.9E+00	4.3E-02	1.1E-02	-5.0E-03	-3.1E-03	2.0E-04	1.36E+01

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Human toxicity, cancer - organics	CTUh	1.4E+01	3.1E-01	7.4E-01	1.5E-01	9.7E+00	-1.0E+00	-6.5E-01	-2.5E-03	-5.9E-03	2.6E-04	2.35E+01
Human toxicity, non-cancer	CTUh	6.9E+02	2.8E+01	3.4E+01	1.4E+01	2.0E+03	-1.4E+00	1.5E+00	-2.6E-01	-4.4E-01	2.6E-02	2.75E+03
Human toxicity, non-cancer - inorganics	CTUh	4.3E+02	2.6E+01	3.3E+01	1.4E+01	5.1E+02	-1.3E+00	2.2E+00	-2.3E-01	-2.7E-01	2.4E-02	1.01E+03
Human toxicity, non-cancer - organics	CTUh	2.8E+01	1.7E+00	1.4E+00	8.8E-01	1.5E+03	-1.0E-01	-6.8E-01	-2.3E-02	-1.6E-01	1.6E-03	1.51E+03
Ionising radiation	kBq U-235 eq.	1.6E+09	4.4E+07	2.1E+09	2.0E+07	1.3E+09	4.4E+07	-1.8E+07	-7.1E+05	7.4E+07	3.5E+04	5.14E+09
Land use	Pt	4.4E+12	3.9E+10	1.3E+10	2.2E+10	2.2E+11	-7.6E+08	-3.0E+09	-1.2E+08	-2.5E+08	4.0E+07	4.66E+12
Ozone depletion	kg CFC11 eq.	7.0E+03	5.0E+01	1.9E+02	2.1E+01	7.2E+03	-2.4E+00	-5.9E+01	-1.0E+00	-1.5E+01	3.8E-02	1.44E+04
Photochemical ozone formation	kg NMVOC eq.	1.6E+08	3.4E+07	1.8E+07	7.9E+06	1.8E+09	-7.0E+05	-7.1E+06	-1.5E+05	-1.6E+06	1.4E+04	1.98E+09
Resource use, fossils	MJ	5.1E+11	5.0E+10	1.4E+11	2.3E+10	4.2E+12	-5.2E+09	-5.3E+10	-8.1E+08	-1.0E+10	4.0E+07	4.83E+12
Resource use, minerals and metals	kg Sb eq.	3.4E+05	8.6E+03	8.2E+03	4.4E+03	5.5E+04	1.6E+02	-6.8E+01	-5.3E+02	-6.2E+02	7.7E+00	4.19E+05

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Water use	m3 depriv.	1.1E+10	2.4E+08	3.1E+09	1.2E+08	3.4E+09	-4.2E+07	-6.8E+07	-1.9E+07	1.0E+07	2.1E+05	1.81E+10

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1176 **Table 3-25. BC1 - Life cycle costs per product and total EU expenditure.**

Product items	LCC new product		Total annual consumer expenditure in EU27	
	Value	Unit	Value	Unit
Product price	71	EUR	21,717	mln. EUR/year
Installation/ acquisition costs	19	EUR	5,731	mln. EUR/year
Fuel (Euro-super 95) costs	32	EUR/year	40,131	mln. EUR/year
Repair & maintenance costs	59	EUR	18,636	mln. EUR/year
Total	69	EUR/year	86,215	mln. EUR/year

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3.2.2. BC2: C2 tyres

Table 3-26. BC2 – Life cycle impact per product over the total lifetime.

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufac-turing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Acidification	mol H^+ eq	2.5E-01	5.1E-02	4.3E-02	7.8E-03	1.1E+00	-1.6E-03	-8.2E-03	-1.2E-04	-7.2E-04	1.5E-05	1.5E+00
Climate change	kg CO_2 eq.	3.8E+01	5.2E+00	1.1E+01	2.3E+00	3.4E+02	-9.4E-01	-2.0E+00	-3.2E-02	-2.5E-01	4.2E-03	393.19
Climate change - Biogenic	kg CO_2 eq.	3.0E-02	1.3E-03	9.7E-03	5.3E-04	1.8E-02	2.3E-04	-3.1E-04	-3.9E-05	2.7E-04	9.9E-07	6.0E-02
Climate change - Fossil	kg CO_2 eq.	3.8E+01	5.2E+00	1.1E+01	2.3E+00	3.4E+02	-9.4E-01	-2.0E+00	-3.2E-02	-2.5E-01	4.2E-03	3.9E+02
Climate change - Land use and LU change	kg CO_2 eq.	3.3E-02	2.6E-03	1.4E-02	1.0E-03	1.5E-02	1.5E-04	-4.4E-04	-1.8E-05	4.3E-04	1.9E-06	6.5E-02
Ecotoxicity, freshwater	CTUe	6.0E+02	1.0E+01	1.9E+01	5.3E+00	1.4E+02	-2.9E+00	-9.0E+00	-2.5E-01	-3.8E-01	9.9E-03	7.7E+02
Ecotoxicity, freshwater - inorganics	CTUe	3.0E+02	1.0E+01	1.9E+01	5.1E+00	1.3E+02	-2.9E+00	-8.9E+00	-2.8E-01	-3.2E-01	9.6E-03	4.5E+02
Ecotoxicity, freshwater - organics	CTUe	3.0E+02	3.8E-01	3.2E-01	1.6E-01	1.5E+01	-1.9E-02	-1.8E-01	3.1E-02	-6.2E-02	3.1E-04	3.2E+02
Particulate matter	disease inc.	3.6E-06	4.4E-07	2.2E-06	2.2E-07	1.4E-05	-5.3E-08	-1.1E-07	-2.7E-09	-4.0E-08	4.1E-10	2.0E-05

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufac-turing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Eutrophication, marine	kg N eq	7.0E-02	1.4E-02	7.8E-03	2.5E-03	4.9E-01	1.4E-04	-2.3E-03	-1.2E-05	-5.9E-05	4.7E-06	5.8E-01
Eutrophication, freshwater	kg P eq	1.1E-02	5.0E-04	5.0E-03	2.4E-04	3.5E-03	-3.0E-04	-3.1E-03	-6.3E-06	1.4E-04	4.6E-07	1.7E-02
Eutrophication, terrestrial	mol N eq.	6.9E-01	1.5E-01	7.2E-02	2.7E-02	5.3E+00	-1.1E-03	-1.9E-02	-1.3E-04	-9.8E-04	5.2E-05	6.3E+00
Human toxicity, cancer	CTUh	4.2E-08	9.2E-10	1.8E-09	3.6E-10	2.4E-08	-1.5E-09	-1.3E-09	-1.1E-11	-1.4E-11	6.8E-13	6.7E-08
Human toxicity, cancer - inorganics	CTUh	4.7E-09	4.8E-10	7.0E-10	1.6E-10	6.9E-09	6.5E-11	6.1E-11	-7.3E-12	-4.8E-12	2.9E-13	1.3E-08
Human toxicity, cancer - organics	CTUh	3.3E-08	4.4E-10	1.1E-09	2.1E-10	1.8E-08	-1.6E-09	-1.4E-09	-3.7E-12	-8.9E-12	3.9E-13	5.0E-08
Human toxicity, non-cancer	CTUh	1.1E-06	3.9E-08	4.9E-08	2.1E-08	1.8E-06	-2.2E-09	5.3E-09	-3.8E-10	-6.7E-10	3.9E-11	3.0E-06
Human toxicity, non-cancer - inorganics	CTUh	6.2E-07	3.7E-08	4.7E-08	1.9E-08	5.1E-07	-2.0E-09	6.3E-09	-3.4E-10	-4.2E-10	3.6E-11	1.2E-06
Human toxicity, non-cancer - organics	CTUh	5.0E-08	2.4E-09	2.1E-09	1.3E-09	1.3E-06	-1.6E-10	-1.0E-09	-3.4E-11	-2.5E-10	2.4E-12	1.4E-06
Ionising radiation	kBq U-235 eq.	2.3E+00	6.3E-02	3.0E+00	2.8E-02	1.3E+00	6.7E-02	-2.9E-02	-1.0E-03	1.1E-01	5.2E-05	6.9E+00

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufac-turing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Land use	Pt	7.3E+03	5.6E+01	1.9E+01	3.2E+01	2.3E+02	-1.2E+00	-4.8E+00	-1.8E-01	-3.8E-01	6.0E-02	7.6E+03
Ozone depletion	kg CFC11 eq.	1.6E-05	7.0E-08	2.8E-07	3.0E-08	7.5E-06	-3.7E-09	-8.7E-08	-1.5E-09	-2.3E-08	5.7E-11	2.4E-05
Photochemical ozone formation	kg NMVOC eq.	2.5E-01	4.8E-02	2.6E-02	1.1E-02	1.9E+00	-1.1E-03	-1.1E-02	-2.3E-04	-2.4E-03	2.1E-05	2.3E+00
Resource use, fossils	MJ	7.9E+02	7.1E+01	2.0E+02	3.2E+01	4.4E+03	-8.0E+00	-8.0E+01	-1.2E+00	-1.6E+01	6.0E-02	5.3E+03
Resource use, minerals and metals	kg Sb eq.	3.6E-04	1.2E-05	1.2E-05	6.2E-06	4.8E-05	2.4E-07	8.9E-08	-7.8E-07	-9.5E-07	1.2E-08	4.4E-04
Water use	m3 depriv.	1.3E+01	3.4E-01	4.4E+00	1.7E-01	3.2E+00	-6.4E-02	-1.2E-01	-2.8E-02	1.5E-02	3.1E-04	2.1E+01
PEF Single Score	-	5.3E-03	5.1E-04	1.2E-03	1.9E-04	2.3E-02	-5.5E-05	-2.6E-04	-4.7E-06	-3.5E-05	3.6E-07	3.0E-02

Table 3-27. BC2 – Life cycle impact per product per km driven.

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribu-tion	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil enginee-ring	Total
Acidification	mol H^+ eq	4.4E-06	8.9E-07	7.5E-07	1.4E-07	2.0E-05	-2.8E-08	-1.4E-07	-2.1E-09	-1.3E-08	2.6E-10	2.6E-05

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Climate change	kg CO_2 eq.	6.71E-04	9.12E-05	1.95E-04	3.95E-05	5.96E-03	-1.65E-05	-3.44E-05	-5.61E-07	-4.43E-06	7.41E-08	6.90E-03
Climate change - Biogenic	kg CO_2 eq.	5.2E-07	2.2E-08	1.7E-07	9.2E-09	3.2E-07	4.1E-09	-5.4E-09	-6.9E-10	4.7E-09	1.7E-11	1.0E-06
Climate change - Fossil	kg CO_2 eq.	6.7E-04	9.1E-05	1.9E-04	3.9E-05	6.0E-03	-1.7E-05	-3.4E-05	-5.6E-07	-4.4E-06	7.4E-08	6.9E-03
Climate change - Land use and LU change	kg CO_2 eq.	5.8E-07	4.6E-08	2.4E-07	1.8E-08	2.6E-07	2.7E-09	-7.7E-09	-3.2E-10	7.6E-09	3.4E-11	1.1E-06
Ecotoxicity, freshwater	CTUe	1.1E-02	1.8E-04	3.3E-04	9.2E-05	2.5E-03	-5.0E-05	-1.6E-04	-4.4E-06	-6.6E-06	1.7E-07	1.3E-02
Ecotoxicity, freshwater - inorganics	CTUe	5.3E-03	1.8E-04	3.3E-04	9.0E-05	2.3E-03	-5.0E-05	-1.6E-04	-4.9E-06	-5.6E-06	1.7E-07	8.0E-03
Ecotoxicity, freshwater - organics	CTUe	5.3E-03	6.6E-06	5.5E-06	2.9E-06	2.6E-04	-3.4E-07	-3.2E-06	5.5E-07	-1.1E-06	5.4E-09	5.5E-03
Particulate matter	disease inc.	6.2E-11	7.6E-12	3.8E-11	3.9E-12	2.5E-10	-9.4E-13	-1.9E-12	-4.8E-14	-6.9E-13	7.2E-15	3.6E-10
Eutrophication, marine	kg N eq	1.2E-06	2.5E-07	1.4E-07	4.4E-08	8.6E-06	2.4E-09	-4.0E-08	-2.2E-10	-1.0E-09	8.3E-11	1.0E-05
Eutrophication, freshwater	kg P eq	2.0E-07	8.8E-09	8.8E-08	4.3E-09	6.2E-08	-5.3E-09	-5.5E-08	-1.1E-10	2.4E-09	8.0E-12	3.0E-07
Eutrophication, terrestrial	mol N eq.	1.2E-05	2.7E-06	1.3E-06	4.8E-07	9.4E-05	-1.9E-08	-3.3E-07	-2.3E-09	-1.7E-08	9.0E-10	1.1E-04

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Human toxicity, cancer	CTUh	7.4E-13	1.6E-14	3.1E-14	6.4E-15	4.3E-13	-2.6E-14	-2.4E-14	-1.9E-16	-2.4E-16	1.2E-17	1.2E-12
Human toxicity, cancer - inorganics	CTUh	8.2E-14	8.4E-15	1.2E-14	2.8E-15	1.2E-13	1.1E-15	1.1E-15	-1.3E-16	-8.4E-17	5.2E-18	2.3E-13
Human toxicity, cancer - organics	CTUh	5.8E-13	7.8E-15	1.9E-14	3.6E-15	3.1E-13	-2.7E-14	-2.5E-14	-6.5E-17	-1.6E-16	6.8E-18	8.7E-13
Human toxicity, non-cancer	CTUh	1.9E-11	6.9E-13	8.6E-13	3.6E-13	3.2E-11	-3.8E-14	9.3E-14	-6.6E-15	-1.2E-14	6.8E-16	5.3E-11
Human toxicity, non-cancer - inorganics	CTUh	1.1E-11	6.4E-13	8.2E-13	3.4E-13	9.0E-12	-3.6E-14	1.1E-13	-6.0E-15	-7.4E-15	6.4E-16	2.2E-11
Human toxicity, non-cancer - organics	CTUh	8.8E-13	4.2E-14	3.7E-14	2.2E-14	2.3E-11	-2.7E-15	-1.8E-14	-5.9E-16	-4.4E-15	4.1E-17	2.4E-11
Ionising radiation	kBq U-235 eq.	4.1E-05	1.1E-06	5.2E-05	4.9E-07	2.3E-05	1.2E-06	-5.0E-07	-1.8E-08	2.0E-06	9.2E-10	1.2E-04
Land use	Pt	1.3E-01	9.8E-04	3.4E-04	5.6E-04	4.0E-03	-2.0E-05	-8.4E-05	-3.1E-06	-6.6E-06	1.1E-06	1.3E-01
Ozone depletion	kg CFC11 eq.	2.8E-10	1.2E-12	4.9E-12	5.3E-13	1.3E-10	-6.4E-14	-1.5E-12	-2.6E-14	-4.0E-13	1.0E-15	4.1E-10
Photochemical ozone formation	kg NMVOC eq.	4.5E-06	8.5E-07	4.6E-07	2.0E-07	3.4E-05	-1.9E-08	-2.0E-07	-4.0E-09	-4.2E-08	3.7E-10	3.9E-05

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribu-tion	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL - Devulcanisation	EoL - Pyrolysis	EoL - Civil enginee-ring	Total
Resource use, fossils	MJ	1.4E-02	1.3E-03	3.4E-03	5.7E-04	7.7E-02	-1.4E-04	-1.4E-03	-2.1E-05	-2.8E-04	1.1E-06	9.4E-02
Resource use, minerals and metals	kg Sb eq.	6.4E-09	2.1E-10	2.1E-10	1.1E-10	8.5E-10	4.2E-12	1.6E-12	-1.4E-11	-1.7E-11	2.0E-13	7.8E-09
Water use	m3 depriv.	2.4E-04	5.9E-06	7.7E-05	2.9E-06	5.6E-05	-1.1E-06	-2.0E-06	-4.9E-07	2.7E-07	5.5E-09	3.7E-04
PEF Single Score	-	9.3E-08	9.0E-09	2.1E-08	3.3E-09	4.1E-07	-9.7E-10	-4.6E-09	-8.2E-11	-6.1E-10	6.3E-12	5.3E-07

Table 3-28. BC2 - EU total life cycle impact of stock of products in the year of study.

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Acidification	mol H^+ eq	2.1E+07	4.3E+06	3.6E+06	6.7E+05	9.7E+07	-1.4E+05	-6.9E+05	-1.0E+04	-6.1E+04	1.2E+03	1.26E+08
Climate change	kg CO_2 eq.	3.2E+09	4.4E+08	9.4E+08	1.9E+08	2.9E+10	-8.0E+07	-1.7E+08	-2.7E+06	-2.1E+07	3.6E+05	3.34E+10
Climate change - Biogenic	kg CO_2 eq.	2.5E+06	1.1E+05	8.3E+05	4.5E+04	1.5E+06	2.0E+04	-2.6E+04	-3.3E+03	2.3E+04	8.4E+01	5.06E+06
Climate change - Fossil	kg CO_2 eq.	3.2E+09	4.4E+08	9.4E+08	1.9E+08	2.9E+10	-8.0E+07	-1.7E+08	-2.7E+06	-2.2E+07	3.6E+05	3.34E+10

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisation	EoL - Pyrolysis	EoL - Civil engineering	Total
Climate change - Land use and LU change	kg CO_2 eq.	2.8E+06	2.2E+05	1.2E+06	8.7E+04	1.3E+06	1.3E+04	-3.7E+04	-1.6E+03	3.7E+04	1.6E+02	5.52E+06
Ecotoxicity, freshwater	CTUe	5.1E+10	8.9E+08	1.6E+09	4.5E+08	1.2E+10	-2.4E+08	-7.7E+08	-2.1E+07	-3.2E+07	8.4E+05	6.51E+10
Ecotoxicity, freshwater - inorganics	CTUe	2.6E+10	8.6E+08	1.6E+09	4.3E+08	1.1E+10	-2.4E+08	-7.5E+08	-2.4E+07	-2.7E+07	8.1E+05	3.86E+10
Ecotoxicity, freshwater - organics	CTUe	2.6E+10	3.2E+07	2.7E+07	1.4E+07	1.3E+09	-1.6E+06	-1.6E+07	2.7E+06	-5.3E+06	2.6E+04	2.68E+10
Particulate matter	disease inc.	3.0E+02	3.7E+01	1.9E+02	1.9E+01	1.2E+03	-4.5E+00	-9.1E+00	-2.3E-01	-3.4E+00	3.5E-02	1.73E+03
Eutrophication, marine	kg N eq	5.9E+06	1.2E+06	6.6E+05	2.1E+05	4.2E+07	1.2E+04	-1.9E+05	-1.0E+03	-5.0E+03	4.0E+02	4.93E+07
Eutrophication, freshwater	kg P eq	9.6E+05	4.3E+04	4.2E+05	2.1E+04	3.0E+05	-2.6E+04	-2.7E+05	-5.4E+02	1.2E+04	3.9E+01	1.46E+06
Eutrophication, terrestrial	mol N eq.	5.9E+07	1.3E+07	6.1E+06	2.3E+06	4.5E+08	-9.1E+04	-1.6E+06	-1.1E+04	-8.3E+04	4.4E+03	5.32E+08
Human toxicity, cancer	CTUh	3.6E+00	7.8E-02	1.5E-01	3.1E-02	2.1E+00	-1.3E-01	-1.1E-01	-9.3E-04	-1.2E-03	5.8E-05	5.67E+00
Human toxicity, cancer - inorganics	CTUh	4.0E-01	4.1E-02	6.0E-02	1.3E-02	5.9E-01	5.5E-03	5.2E-03	-6.2E-04	-4.1E-04	2.5E-05	1.11E+00
Human toxicity, cancer - organics	CTUh	2.8E+00	3.8E-02	9.0E-02	1.8E-02	1.5E+00	-1.3E-01	-1.2E-01	-3.1E-04	-7.6E-04	3.3E-05	4.21E+00

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufacturing	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Human toxicity, non-cancer	CTUh	9.0E+01	3.3E+00	4.2E+00	1.7E+00	1.6E+02	-1.9E-01	4.5E-01	-3.2E-02	-5.7E-02	3.3E-03	2.54E+02
Human toxicity, non-cancer - inorganics	CTUh	5.3E+01	3.1E+00	4.0E+00	1.6E+00	4.4E+01	-1.7E-01	5.4E-01	-2.9E-02	-3.6E-02	3.1E-03	1.05E+02
Human toxicity, non-cancer - organics	CTUh	4.3E+00	2.1E-01	1.8E-01	1.1E-01	1.1E+02	-1.3E-02	-8.6E-02	-2.9E-03	-2.1E-02	2.0E-04	1.16E+02
Ionising radiation	kBq U-235 eq.	2.0E+08	5.4E+06	2.5E+08	2.4E+06	1.1E+08	5.7E+06	-2.4E+06	-8.9E+04	9.6E+06	4.4E+03	5.84E+08
Land use	Pt	6.2E+11	4.7E+09	1.6E+09	2.7E+09	1.9E+10	-9.8E+07	-4.1E+08	-1.5E+07	-3.2E+07	5.1E+06	6.47E+11
Ozone depletion	kg CFC11 eq.	1.3E+03	6.0E+00	2.4E+01	2.6E+00	6.3E+02	-3.1E-01	-7.4E+00	-1.3E-01	-1.9E+00	4.8E-03	2.00E+03
Photochemical ozone formation	kg NMVOC eq.	2.2E+07	4.1E+06	2.2E+06	9.6E+05	1.6E+08	-9.1E+04	-9.6E+05	-1.9E+04	-2.0E+05	1.8E+03	1.91E+08
Resource use, fossils	MJ	6.7E+10	6.1E+09	1.7E+10	2.7E+09	3.7E+11	-6.8E+08	-6.8E+09	-1.0E+08	-1.3E+09	5.1E+06	4.54E+11
Resource use, minerals and metals	kg Sb eq.	3.1E+04	1.0E+03	1.0E+03	5.3E+02	4.1E+03	2.0E+01	7.5E+00	-6.6E+01	-8.1E+01	9.9E-01	3.75E+04
Water use	m3 depriv.	1.1E+09	2.9E+07	3.7E+08	1.4E+07	2.7E+08	-5.5E+06	-9.9E+06	-2.4E+06	1.3E+06	2.7E+04	1.81E+09

Table 3-29. BC2 - Life cycle costs per product and total EU expenditure.

Product items	LCC new product		Total annual consumer expenditure in EU27	
	Value	Unit	Value	Unit
Product price	111	EUR	3,251	mln. EUR/year
Installation/ acquisition costs	19	EUR	550	mln. EUR/year
Fuel (Euro-super 95) costs	43	EUR/year	4,000	mln. EUR/year
Repair & maintenance costs	59	EUR	1,810	mln. EUR/year
Total	106	EUR/year	9,612	mln. EUR/year

3.2.3. BC3: C3 tyres

Table 3-30. BC3 – Life cycle impact per product over the total lifetime.

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Acidification	mol H^+ eq	1.1E+00	2.6E-01	2.0E-01	3.7E-02	3.1E+01	-7.1E-03	-3.9E-02	-5.6E-04	-3.2E-03	6.6E-05	3.2E+01
Climate change	kg CO_2 eq.	1.5E+02	2.3E+01	5.2E+01	1.1E+01	5.5E+03	-4.2E+00	-9.8E+00	-1.5E-01	-1.1E+00	1.9E-02	5.7E+03
Climate change - Biogenic	kg CO_2 eq.	8.4E-02	6.0E-03	4.6E-02	2.5E-03	2.9E-01	1.1E-03	-1.4E-03	-1.8E-04	1.2E-03	4.4E-06	4.3E-01

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Climate change - Fossil	kg CO_2 eq.	1.5E+02	2.3E+01	5.2E+01	1.1E+01	5.5E+03	-4.2E+00	-9.8E+00	-1.5E-01	-1.1E+00	1.9E-02	5.7E+03
Climate change - Land use and LU change	kg CO_2 eq.	1.6E-01	1.2E-02	6.5E-02	4.8E-03	2.4E-01	6.8E-04	-2.1E-03	-8.5E-05	1.9E-03	8.6E-06	4.8E-01
Ecotoxicity, freshwater	CTUe	1.8E+03	4.6E+01	8.9E+01	2.5E+01	2.3E+03	-1.3E+01	-4.2E+01	-1.2E+00	-1.7E+00	4.4E-02	4.3E+03
Ecotoxicity, freshwater - inorganics	CTUe	1.1E+03	4.4E+01	8.8E+01	2.4E+01	2.1E+03	-1.3E+01	-4.1E+01	-1.3E+00	-1.4E+00	4.3E-02	3.3E+03
Ecotoxicity, freshwater - organics	CTUe	7.7E+02	1.7E+00	1.3E+00	7.8E-01	2.4E+02	-8.7E-02	-8.2E-01	1.4E-01	-2.8E-01	1.4E-03	1.0E+03
Particulate matter	disease inc.	1.8E-05	1.9E-06	1.0E-05	1.0E-06	1.7E-04	-2.4E-07	-5.6E-07	-1.3E-08	-1.8E-07	1.9E-09	2.0E-04
Eutrophication, marine	kg N eq	3.8E-01	7.1E-02	3.6E-02	1.2E-02	1.4E+01	6.2E-04	-1.1E-02	-5.7E-05	-2.6E-04	2.1E-05	1.5E+01
Eutrophication, freshwater	kg P eq	5.3E-02	2.3E-03	2.4E-02	1.2E-03	5.7E-02	-1.4E-03	-1.4E-02	-2.9E-05	6.2E-04	2.1E-06	1.2E-01
Eutrophication, terrestrial	mol N eq.	4.1E+00	7.9E-01	3.3E-01	1.3E-01	1.6E+02	-4.8E-03	-9.3E-02	-6.0E-04	-4.4E-03	2.3E-04	1.6E+02
Human toxicity, cancer	CTUh	1.4E-07	4.3E-09	8.3E-09	1.7E-09	2.5E-07	-6.7E-09	-7.6E-09	-5.1E-11	-6.1E-11	3.1E-12	3.9E-07
Human toxicity, cancer - inorganics	CTUh	2.2E-08	2.3E-09	3.3E-09	7.5E-10	1.1E-07	2.9E-10	4.7E-10	-3.4E-11	-2.1E-11	1.3E-12	1.4E-07

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Human toxicity, cancer - organics	CTUh	8.9E-08	2.0E-09	4.9E-09	9.8E-10	1.4E-07	-7.0E-09	-8.1E-09	-1.7E-11	-4.0E-11	1.7E-12	2.2E-07
Human toxicity, non-cancer	CTUh	7.0E-06	1.7E-07	2.3E-07	9.8E-08	1.5E-05	-9.8E-09	3.7E-08	-1.7E-09	-3.0E-09	1.7E-10	2.2E-05
Human toxicity, non-cancer - inorganics	CTUh	3.9E-06	1.6E-07	2.2E-07	9.2E-08	6.9E-06	-9.1E-09	4.1E-08	-1.6E-09	-1.9E-09	1.6E-10	1.1E-05
Human toxicity, non-cancer - organics	CTUh	1.8E-07	1.0E-08	9.7E-09	6.0E-09	7.9E-06	-6.9E-10	-4.5E-09	-1.6E-10	-1.1E-09	1.1E-11	8.0E-06
Ionising radiation	kBq U-235 eq.	7.9E+00	3.0E-01	1.4E+01	1.3E-01	2.1E+01	3.0E-01	-1.3E-01	-4.9E-03	5.0E-01	2.3E-04	4.4E+01
Land use	Pt	5.5E+04	2.3E+02	9.1E+01	1.5E+02	3.6E+03	-5.1E+00	-2.2E+01	-8.2E-01	-1.7E+00	2.7E-01	5.9E+04
Ozone depletion	kg CFC11 eq.	2.4E-05	3.1E-07	1.3E-06	1.4E-07	1.2E-04	-1.6E-08	-3.7E-07	-6.9E-09	-1.0E-07	2.6E-10	1.5E-04
Photochemical ozone formation	kg NMVOC eq.	1.3E+00	2.4E-01	1.2E-01	5.3E-02	4.7E+01	-4.8E-03	-5.2E-02	-1.1E-03	-1.1E-02	9.5E-05	4.9E+01
Resource use, fossils	MJ	2.8E+03	3.2E+02	9.1E+02	1.5E+02	7.0E+04	-3.6E+01	-3.6E+02	-5.5E+00	-7.1E+01	2.7E-01	7.4E+04

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Resource use, minerals and metals	kg Sb eq.	1.8E-03	5.2E-05	5.5E-05	3.0E-05	7.8E-04	1.1E-06	1.2E-06	-3.6E-06	-4.2E-06	5.2E-08	2.7E-03
Water use	m3 depriv.	6.5E+01	1.5E+00	2.1E+01	8.0E-01	5.2E+01	-2.9E-01	-5.8E-01	-1.3E-01	6.8E-02	1.4E-03	1.4E+02
PEF Single Score	-	2.5E-02	2.4E-03	5.5E-03	9.0E-04	4.2E-01	-2.5E-04	-1.2E-03	-2.2E-05	-1.5E-04	1.6E-06	4.5E-01

Table 3-31. BC3 – Life cycle impact per product per km driven.

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Acidification	mol H^+ eq	4.5E-06	1.0E-06	7.9E-07	1.5E-07	1.2E-04	-2.8E-08	-1.6E-07	-2.2E-09	-1.3E-08	2.6E-10	1.3E-04
Climate change	kg CO_2 eq.	5.81E-04	9.19E-05	2.05E-04	4.22E-05	2.16E-02	-1.66E-05	-3.85E-05	-5.85E-07	-4.44E-06	7.50E-08	2.25E-02
Climate change - Biogenic	kg CO_2 eq.	3.3E-07	2.4E-08	1.8E-07	9.9E-09	1.1E-06	4.1E-09	-5.5E-09	-7.2E-10	4.7E-09	1.8E-11	1.7E-06
Climate change - Fossil	kg CO_2 eq.	5.8E-04	9.2E-05	2.0E-04	4.2E-05	2.2E-02	-1.7E-05	-3.8E-05	-5.8E-07	-4.5E-06	7.5E-08	2.2E-02
Climate change - Land use and LU change	kg CO_2 eq.	6.4E-07	4.9E-08	2.6E-07	1.9E-08	9.4E-07	2.7E-09	-8.4E-09	-3.4E-10	7.6E-09	3.4E-11	1.9E-06

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Ecotoxicity, freshwater	CTUe	7.2E-03	1.8E-04	3.5E-04	9.9E-05	9.2E-03	-5.1E-05	-1.7E-04	-4.6E-06	-6.6E-06	1.8E-07	1.7E-02
Ecotoxicity, freshwater - inorganics	CTUe	4.3E-03	1.7E-04	3.5E-04	9.6E-05	8.3E-03	-5.0E-05	-1.6E-04	-5.1E-06	-5.6E-06	1.7E-07	1.3E-02
Ecotoxicity, freshwater - organics	CTUe	3.1E-03	6.7E-06	5.3E-06	3.1E-06	9.3E-04	-3.4E-07	-3.2E-06	5.7E-07	-1.1E-06	5.5E-09	4.0E-03
Particulate matter	disease inc.	7.0E-11	7.6E-12	4.1E-11	4.1E-12	6.5E-10	-9.4E-13	-2.2E-12	-5.0E-14	-6.9E-13	7.3E-15	7.7E-10
Eutrophication, marine	kg N eq	1.5E-06	2.8E-07	1.4E-07	4.7E-08	5.7E-05	2.4E-09	-4.3E-08	-2.3E-10	-1.0E-09	8.4E-11	5.9E-05
Eutrophication, freshwater	kg P eq	2.1E-07	8.9E-09	9.4E-08	4.6E-09	2.2E-07	-5.4E-09	-5.5E-08	-1.2E-10	2.5E-09	8.1E-12	4.8E-07
Eutrophication, terrestrial	mol N eq.	1.6E-05	3.1E-06	1.3E-06	5.1E-07	6.2E-04	-1.9E-08	-3.7E-07	-2.4E-09	-1.7E-08	9.2E-10	6.4E-04
Human toxicity, cancer	CTUh	5.7E-13	1.7E-14	3.3E-14	6.8E-15	9.8E-13	-2.6E-14	-3.0E-14	-2.0E-16	-2.4E-16	1.2E-17	1.5E-12
Human toxicity, cancer - inorganics	CTUh	8.8E-14	9.0E-15	1.3E-14	2.9E-15	4.2E-13	1.1E-15	1.8E-15	-1.3E-16	-8.4E-17	5.2E-18	5.4E-13
Human toxicity, cancer - organics	CTUh	3.5E-13	7.9E-15	1.9E-14	3.9E-15	5.6E-13	-2.8E-14	-3.2E-14	-6.7E-17	-1.6E-16	6.9E-18	8.8E-13
Human toxicity, non-cancer	CTUh	2.8E-11	6.6E-13	9.1E-13	3.9E-13	5.8E-11	-3.8E-14	1.5E-13	-6.9E-15	-1.2E-14	6.9E-16	8.8E-11

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL - Mechanical Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Human toxicity, non-cancer - inorganics	CTUh	1.5E-11	6.2E-13	8.8E-13	3.6E-13	2.7E-11	-3.6E-14	1.6E-13	-6.3E-15	-7.4E-15	6.4E-16	4.5E-11
Human toxicity, non-cancer - organics	CTUh	7.0E-13	4.1E-14	3.8E-14	2.4E-14	3.1E-11	-2.7E-15	-1.8E-14	-6.2E-16	-4.4E-15	4.2E-17	3.2E-11
Ionising radiation	kBq U-235 eq.	3.1E-05	1.2E-06	5.6E-05	5.2E-07	8.4E-05	1.2E-06	-5.1E-07	-1.9E-08	2.0E-06	9.3E-10	1.8E-04
Land use	Pt	2.2E-01	9.1E-04	3.6E-04	6.0E-04	1.4E-02	-2.0E-05	-8.9E-05	-3.3E-06	-6.7E-06	1.1E-06	2.3E-01
Ozone depletion	kg CFC11 eq.	9.5E-11	1.2E-12	5.0E-12	5.7E-13	4.7E-10	-6.4E-14	-1.5E-12	-2.7E-14	-4.0E-13	1.0E-15	5.7E-10
Photochemical ozone formation	kg NMVOC eq.	4.9E-06	9.5E-07	4.8E-07	2.1E-07	1.9E-04	-1.9E-08	-2.1E-07	-4.2E-09	-4.2E-08	3.8E-10	1.9E-04
Resource use, fossils	MJ	1.1E-02	1.2E-03	3.6E-03	6.0E-04	2.8E-01	-1.4E-04	-1.4E-03	-2.2E-05	-2.8E-04	1.1E-06	2.9E-01
Resource use, minerals and metals	kg Sb eq.	6.9E-09	2.1E-10	2.2E-10	1.2E-10	3.1E-09	4.2E-12	4.9E-12	-1.4E-11	-1.7E-11	2.1E-13	1.1E-08
Water use	m3 depriv.	2.6E-04	5.8E-06	8.2E-05	3.1E-06	2.0E-04	-1.1E-06	-2.3E-06	-5.1E-07	2.7E-07	5.6E-09	5.5E-04
PEF Single Score	-	1.0E-07	9.3E-09	2.2E-08	3.6E-09	1.7E-06	-9.8E-10	-4.8E-09	-8.6E-11	-6.1E-10	6.3E-12	1.8E-06

1190 **Table 3-32. BC3 - EU total life cycle impact of stock of products in the year of study.**

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Acidification	mol H^+ eq	5.9E+07	1.4E+07	1.0E+07	1.9E+06	1.6E+09	-3.7E+05	-2.0E+06	-2.9E+04	-1.7E+05	3.4E+03	1.69E+09
Climate change	kg CO_2 eq.	7.7E+09	1.2E+09	2.7E+09	5.6E+08	2.8E+11	-2.2E+08	-5.1E+08	-7.7E+06	-5.8E+07	9.9E+05	2.96E+11
Climate change - Biogenic	kg CO_2 eq.	4.4E+06	3.1E+05	2.4E+06	1.3E+05	1.5E+07	5.5E+04	-7.3E+04	-9.4E+03	6.2E+04	2.3E+02	2.24E+07
Climate change - Fossil	kg CO_2 eq.	7.6E+09	1.2E+09	2.7E+09	5.6E+08	2.8E+11	-2.2E+08	-5.1E+08	-7.7E+06	-5.9E+07	9.9E+05	2.96E+11
Climate change - Land use and LU change	kg CO_2 eq.	8.4E+06	6.4E+05	3.4E+06	2.5E+05	1.2E+07	3.6E+04	-1.1E+05	-4.4E+03	1.0E+05	4.5E+02	2.51E+07
Ecotoxicity, freshwater	CTUe	9.5E+10	2.4E+09	4.6E+09	1.3E+09	1.2E+11	-6.7E+08	-2.2E+09	-6.0E+07	-8.8E+07	2.3E+06	2.21E+11
Ecotoxicity, freshwater - inorganics	CTUe	5.6E+10	2.3E+09	4.6E+09	1.3E+09	1.1E+11	-6.6E+08	-2.1E+09	-6.7E+07	-7.3E+07	2.2E+06	1.70E+11
Ecotoxicity, freshwater - organics	CTUe	4.0E+10	8.8E+07	7.0E+07	4.0E+07	1.2E+10	-4.5E+06	-4.2E+07	7.5E+06	-1.4E+07	7.2E+04	5.26E+10
Particulate matter	disease inc.	9.2E+02	9.9E+01	5.4E+02	5.4E+01	8.6E+03	-1.2E+01	-2.9E+01	-6.6E-01	-9.1E+00	9.6E-02	1.02E+04
Eutrophication, marine	kg N eq	2.0E+07	3.7E+06	1.9E+06	6.2E+05	7.5E+08	3.2E+04	-5.6E+05	-3.0E+03	-1.4E+04	1.1E+03	7.74E+08
Eutrophication, freshwater	kg P eq	2.8E+06	1.2E+05	1.2E+06	6.0E+04	2.9E+06	-7.1E+04	-7.2E+05	-1.5E+03	3.2E+04	1.1E+02	6.36E+06

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Eutrophication, terrestrial	mol N eq.	2.1E+08	4.1E+07	1.7E+07	6.8E+06	8.2E+09	-2.5E+05	-4.8E+06	-3.1E+04	-2.3E+05	1.2E+04	8.47E+09
Human toxicity, cancer	CTUh	7.5E+00	2.2E-01	4.3E-01	9.0E-02	1.3E+01	-3.5E-01	-4.0E-01	-2.6E-03	-3.2E-03	1.6E-04	2.04E+01
Human toxicity, cancer - inorganics	CTUh	1.2E+00	1.2E-01	1.7E-01	3.9E-02	5.6E+00	1.5E-02	2.4E-02	-1.7E-03	-1.1E-03	6.9E-05	7.11E+00
Human toxicity, cancer - organics	CTUh	4.6E+00	1.0E-01	2.6E-01	5.1E-02	7.4E+00	-3.6E-01	-4.2E-01	-8.9E-04	-2.1E-03	9.1E-05	1.16E+01
Human toxicity, non-cancer	CTUh	3.6E+02	8.6E+00	1.2E+01	5.1E+00	7.7E+02	-5.1E-01	1.9E+00	-9.1E-02	-1.6E-01	9.0E-03	1.16E+03
Human toxicity, non-cancer - inorganics	CTUh	2.0E+02	8.1E+00	1.2E+01	4.8E+00	3.6E+02	-4.7E-01	2.1E+00	-8.3E-02	-9.7E-02	8.5E-03	5.87E+02
Human toxicity, non-cancer - organics	CTUh	9.2E+00	5.3E-01	5.0E-01	3.1E-01	4.1E+02	-3.6E-02	-2.3E-01	-8.1E-03	-5.8E-02	5.5E-04	4.18E+02
Ionising radiation	kBq U-235 eq.	4.1E+08	1.5E+07	7.3E+08	6.9E+06	1.1E+09	1.6E+07	-6.7E+06	-2.5E+05	2.6E+07	1.2E+04	2.31E+09
Land use	Pt	2.9E+12	1.2E+10	4.7E+09	7.9E+09	1.9E+11	-2.7E+08	-1.2E+09	-4.3E+07	-8.8E+07	1.4E+07	3.07E+12
Ozone depletion	kg CFC11 eq.	1.2E+03	1.6E+01	6.6E+01	7.5E+00	6.2E+03	-8.5E-01	-1.9E+01	-3.6E-01	-5.2E+00	1.3E-02	7.56E+03
Photochemical ozone formation	kg NMVOC eq.	6.5E+07	1.2E+07	6.3E+06	2.8E+06	2.5E+09	-2.5E+05	-2.7E+06	-5.5E+04	-5.6E+05	4.9E+03	2.54E+09

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Resource use, fossils	MJ	1.5E+11	1.6E+10	4.7E+10	7.9E+09	3.7E+12	-1.8E+09	-1.8E+10	-2.9E+08	-3.7E+09	1.4E+07	3.85E+12
Resource use, minerals and metals	kg Sb eq.	9.1E+04	2.7E+03	2.9E+03	1.5E+03	4.1E+04	5.5E+01	6.4E+01	-1.9E+02	-2.2E+02	2.7E+00	1.38E+05
Water use	m3 depriv.	3.4E+09	7.7E+07	1.1E+09	4.1E+07	2.7E+09	-1.5E+07	-3.0E+07	-6.7E+06	3.5E+06	7.4E+04	7.24E+09

Table 3-33. BC3 - Life cycle costs per product and total EU expenditure.

Product items	LCC new product		Total annual consumer expenditure in EU27	
	Value	Unit	Value	Unit
Product price	419	EUR	6,956	mln. EUR/year
Installation/ acquisition costs	19	EUR	311	mln. EUR/year
Fuel (Euro-super 95) costs	698	EUR/year	39,453	mln. EUR/year
Repair & maintenance costs	59	EUR	1,107	mln. EUR/year
Total	**864**	**EUR/year**	**47,826**	**mln. EUR/year**

1194 ### 3.2.4. BC4: C3 retreaded tyres

1195 **Table 3-34. BC4 – Life cycle impact per product over the total lifetime.**

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Acidification	mol H^+ eq	3.6E-01	8.8E-02	6.1E-02	3.8E-02	3.0E+01	-1.3E-02	-5.0E-02	-1.0E-03	-7.2E-03	6.8E-05	3.1E+01
Climate change	kg CO_2 eq.	4.6E+01	8.8E+00	1.7E+01	1.1E+01	5.3E+03	-6.0E+00	-1.2E+01	-2.5E-01	-2.3E+00	2.0E-02	5.41E+03
Climate change - Biogenic	kg CO_2 eq.	2.0E-02	2.3E-03	1.3E-02	2.6E-03	2.8E-01	-9.9E-04	-1.9E-03	-3.1E-04	9.6E-04	4.6E-06	3.2E-01
Climate change - Fossil	kg CO_2 eq.	4.6E+01	8.8E+00	1.7E+01	1.1E+01	5.3E+03	-6.0E+00	-1.2E+01	-2.4E-01	-2.3E+00	2.0E-02	5.4E+03
Climate change - Land use and LU change	kg CO_2 eq.	1.5E-02	4.7E-03	1.9E-02	5.0E-03	2.3E-01	-2.2E-03	-2.7E-03	-1.8E-04	1.8E-03	8.9E-06	2.7E-01
Ecotoxicity, freshwater	CTUe	4.0E+02	1.8E+01	2.6E+01	2.6E+01	2.3E+03	-1.7E+01	-5.6E+01	-1.9E+00	-3.6E+00	4.6E-02	2.7E+03
Ecotoxicity, freshwater - inorganics	CTUe	1.7E+02	1.7E+01	2.5E+01	2.5E+01	2.1E+03	-1.7E+01	-5.5E+01	-2.0E+00	-3.1E+00	4.5E-02	2.2E+03
Ecotoxicity, freshwater - organics	CTUe	2.4E+02	6.4E-01	4.2E-01	8.0E-01	2.3E+02	-1.1E-01	-1.2E+00	1.3E-01	-4.4E-01	1.4E-03	4.7E+02
Particulate matter	disease inc.	6.2E-06	7.6E-07	9.7E-06	1.1E-06	1.6E-04	-2.6E-07	-6.5E-07	-2.0E-08	-2.8E-07	1.9E-09	1.8E-04

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Eutrophication, marine	kg N eq	1.4E-01	2.4E-02	1.2E-02	1.2E-02	1.4E+01	-6.2E-04	-1.4E-02	-1.3E-04	-8.7E-04	2.2E-05	1.4E+01
Eutrophication, freshwater	kg P eq	1.1E-02	9.0E-04	6.9E-03	1.2E-03	5.5E-02	-2.3E-03	-2.0E-02	-6.1E-05	5.9E-04	2.1E-06	5.4E-02
Eutrophication, terrestrial	mol N eq.	1.5E+00	2.7E-01	1.0E-01	1.3E-01	1.5E+02	-1.4E-02	-1.2E-01	-1.4E-03	-1.1E-02	2.4E-04	1.6E+02
Human toxicity, cancer	CTUh	3.7E-08	1.6E-09	2.2E-09	1.8E-09	2.4E-07	-7.3E-09	-7.9E-09	-8.2E-11	-1.7E-10	3.2E-12	2.7E-07
Human toxicity, cancer - inorganics	CTUh	3.2E-09	8.2E-10	8.4E-10	7.7E-10	1.0E-07	1.6E-10	3.1E-10	-5.2E-11	-7.5E-11	1.4E-12	1.1E-07
Human toxicity, cancer - organics	CTUh	2.1E-08	7.8E-10	1.4E-09	1.0E-09	1.4E-07	-7.4E-09	-8.2E-09	-3.0E-11	-9.9E-11	1.8E-12	1.5E-07
Human toxicity, non-cancer	CTUh	2.6E-06	6.5E-08	6.9E-08	1.0E-07	2.7E-05	-2.2E-08	2.8E-08	-2.8E-09	-7.6E-09	1.8E-10	3.0E-05
Human toxicity, non-cancer - inorganics	CTUh	1.3E-06	6.1E-08	6.6E-08	9.5E-08	6.7E-06	-2.0E-08	3.5E-08	-2.5E-09	-5.7E-09	1.7E-10	8.3E-06
Human toxicity, non-cancer - organics	CTUh	5.8E-08	4.0E-09	3.0E-09	6.2E-09	2.1E-05	-1.1E-09	-6.4E-09	-2.4E-10	-1.8E-09	1.1E-11	2.1E-05
Ionising radiation	kBq U-235 eq.	2.0E+00	1.2E-01	4.0E+00	1.4E-01	2.1E+01	-3.3E-01	-1.8E-01	-1.8E-02	5.1E-01	2.4E-04	2.7E+01
Land use	Pt	2.3E+04	9.2E+01	2.7E+01	1.6E+02	3.6E+03	-9.0E+00	-3.0E+01	-1.3E+00	-4.0E+00	2.8E-01	2.7E+04

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Ozone depletion	kg CFC11 eq.	1.1E-06	1.2E-07	4.1E-07	1.5E-07	1.2E-04	-3.4E-08	-5.5E-07	-1.1E-08	-1.7E-07	2.7E-10	1.2E-04
Photochemical ozone formation	kg NMVOC eq.	4.7E-01	8.4E-02	3.8E-02	5.5E-02	4.6E+01	-7.7E-03	-7.0E-02	-1.7E-03	-1.8E-02	9.8E-05	4.7E+01
Resource use, fossils	MJ	1.0E+03	1.2E+02	2.8E+02	1.6E+02	6.9E+04	-6.0E+01	-5.1E+02	-8.7E+00	-1.2E+02	2.8E-01	7.0E+04
Resource use, minerals and metals	kg Sb eq.	2.9E-04	2.1E-05	1.6E-05	3.1E-05	7.6E-04	-2.6E-06	2.5E-07	-5.4E-06	-7.5E-06	5.4E-08	1.1E-03
Water use	m3 depriv.	1.6E+01	5.8E-01	6.5E+00	8.2E-01	5.1E+01	-5.2E-01	-7.1E-01	-2.0E-01	7.8E-03	1.5E-03	7.4E+01
PEF Single Score	-	8.5E-03	8.8E-04	2.7E-03	9.3E-04	4.1E-01	-3.8E-04	-1.6E-03	-3.5E-05	-2.9E-04	1.7E-06	4.2E-01

Table 3-35. BC4 – Life cycle impact per product per km driven.

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Acidification	mol H^+ eq	1.5E-06	3.6E-07	2.5E-07	1.6E-07	1.2E-04	-5.1E-08	-2.0E-07	-4.1E-09	-2.9E-08	2.8E-10	1.2E-04
Climate change	kg CO_2 eq.	1.85E-04	3.58E-05	6.79E-05	4.50E-05	2.18E-02	-2.46E-05	-4.88E-05	-9.97E-07	-9.21E-06	7.99E-08	2.20E-02

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Climate change - Biogenic	kg CO_2 eq.	8.3E-08	9.5E-09	5.4E-08	1.1E-08	1.2E-06	-4.0E-09	-7.8E-09	-1.3E-09	3.9E-09	1.9E-11	1.3E-06
Climate change - Fossil	kg CO_2 eq.	1.9E-04	3.6E-05	6.8E-05	4.5E-05	2.2E-02	-2.5E-05	-4.9E-05	-9.9E-07	-9.2E-06	8.0E-08	2.2E-02
Climate change - Land use and LU change	kg CO_2 eq.	6.2E-08	1.9E-08	7.6E-08	2.0E-08	9.5E-07	-8.9E-09	-1.1E-08	-7.3E-10	7.2E-09	3.6E-11	1.1E-06
Ecotoxicity, freshwater	CTUe	1.6E-03	7.3E-05	1.0E-04	1.1E-04	9.3E-03	-7.1E-05	-2.3E-04	-7.6E-06	-1.5E-05	1.9E-07	1.1E-02
Ecotoxicity, freshwater - inorganics	CTUe	6.8E-04	7.0E-05	1.0E-04	1.0E-04	8.3E-03	-7.0E-05	-2.2E-04	-8.1E-06	-1.3E-05	1.8E-07	9.0E-03
Ecotoxicity, freshwater - organics	CTUe	9.8E-04	2.6E-06	1.7E-06	3.3E-06	9.4E-04	-4.6E-07	-4.7E-06	5.2E-07	-1.8E-06	5.8E-09	1.9E-03
Particulate matter	disease inc.	2.5E-11	3.1E-12	4.0E-11	4.4E-12	6.6E-10	-1.1E-12	-2.6E-12	-8.1E-14	-1.2E-12	7.8E-15	7.3E-10
Eutrophication, marine	kg N eq	5.8E-07	1.0E-07	4.8E-08	5.0E-08	5.7E-05	-2.5E-09	-5.7E-08	-5.4E-10	-3.5E-09	9.0E-11	5.8E-05
Eutrophication, freshwater	kg P eq	4.5E-08	3.6E-09	2.8E-08	4.9E-09	2.2E-07	-9.4E-09	-8.0E-08	-2.5E-10	2.4E-09	8.7E-12	2.2E-07
Eutrophication, terrestrial	mol N eq.	6.2E-06	1.1E-06	4.2E-07	5.5E-07	6.3E-04	-5.6E-08	-4.7E-07	-5.7E-09	-4.4E-08	9.7E-10	6.3E-04
Human toxicity, cancer	CTUh	1.5E-13	6.5E-15	9.0E-15	7.3E-15	9.9E-13	-3.0E-14	-3.2E-14	-3.3E-16	-7.1E-16	1.3E-17	1.1E-12

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Human toxicity, cancer - inorganics	CTUh	1.3E-14	3.3E-15	3.4E-15	3.1E-15	4.3E-13	6.5E-16	1.3E-15	-2.1E-16	-3.1E-16	5.6E-18	4.5E-13
Human toxicity, cancer - organics	CTUh	8.6E-14	3.2E-15	5.6E-15	4.1E-15	5.6E-13	-3.0E-14	-3.3E-14	-1.2E-16	-4.0E-16	7.4E-18	6.0E-13
Human toxicity, non-cancer	CTUh	1.1E-11	2.7E-13	2.8E-13	4.1E-13	1.1E-10	-8.8E-14	1.2E-13	-1.1E-14	-3.1E-14	7.3E-16	1.2E-10
Human toxicity, non-cancer - inorganics	CTUh	5.4E-12	2.5E-13	2.7E-13	3.9E-13	2.7E-11	-8.3E-14	1.4E-13	-1.0E-14	-2.3E-14	6.9E-16	3.4E-11
Human toxicity, non-cancer - organics	CTUh	2.4E-13	1.6E-14	1.2E-14	2.5E-14	8.4E-11	-4.6E-15	-2.6E-14	-9.9E-16	-7.5E-15	4.5E-17	8.4E-11
Ionising radiation	kBq U-235 eq.	8.1E-06	4.8E-07	1.6E-05	5.6E-07	8.5E-05	-1.4E-06	-7.3E-07	-7.4E-08	2.1E-06	9.9E-10	1.1E-04
Land use	Pt	9.3E-02	3.8E-04	1.1E-04	6.4E-04	1.4E-02	-3.6E-05	-1.2E-04	-5.3E-06	-1.6E-05	1.1E-06	1.1E-01
Ozone depletion	kg CFC11 eq.	4.6E-12	4.8E-13	1.7E-12	6.1E-13	4.8E-10	-1.4E-13	-2.2E-12	-4.4E-14	-6.8E-13	1.1E-15	4.8E-10
Photochemical ozone formation	kg NMVOC eq.	1.9E-06	3.4E-07	1.5E-07	2.2E-07	1.9E-04	-3.1E-08	-2.9E-07	-6.9E-09	-7.3E-08	4.0E-10	1.9E-04
Resource use, fossils	MJ	4.2E-03	4.9E-04	1.1E-03	6.4E-04	2.8E-01	-2.4E-04	-2.1E-03	-3.5E-05	-4.9E-04	1.1E-06	2.8E-01

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Resource use, minerals and metals	kg Sb eq.	1.2E-09	8.4E-11	6.5E-11	1.2E-10	3.1E-09	-1.1E-11	1.0E-12	-2.2E-11	-3.0E-11	2.2E-13	4.5E-09
Water use	m3 depriv.	6.7E-05	2.4E-06	2.7E-05	3.3E-06	2.1E-04	-2.1E-06	-2.9E-06	-8.0E-07	3.2E-08	6.0E-09	3.0E-04
PEF Single Score	-	3.4E-08	3.6E-09	1.1E-08	3.8E-09	1.7E-06	-1.6E-09	-6.7E-09	-1.4E-10	-1.2E-09	6.7E-12	1.7E-06

Table 3-36. BC4 - EU total life cycle impact of stock of products in the year of study.

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Acidification	mol H^+ eq	2.8E+06	6.9E+05	4.8E+05	3.0E+05	2.4E+08	-9.9E+04	-4.0E+05	-8.0E+03	-5.7E+04	5.4E+02	2.42E+08
Climate change	kg CO_2 eq.	3.6E+08	7.0E+07	1.3E+08	8.7E+07	4.2E+10	-4.8E+07	-9.5E+07	-1.9E+06	-1.8E+07	1.6E+05	4.27E+10
Climate change - Biogenic	kg CO_2 eq.	1.6E+05	1.8E+04	1.0E+05	2.0E+04	2.2E+06	-7.8E+03	-1.5E+04	-2.4E+03	7.6E+03	3.6E+01	2.53E+06
Climate change - Fossil	kg CO_2 eq.	3.6E+08	7.0E+07	1.3E+08	8.7E+07	4.2E+10	-4.8E+07	-9.5E+07	-1.9E+06	-1.8E+07	1.6E+05	4.27E+10
Climate change - Land use and LU change	kg CO_2 eq.	1.2E+05	3.7E+04	1.5E+05	3.9E+04	1.8E+06	-1.7E+04	-2.1E+04	-1.4E+03	1.4E+04	7.0E+01	2.16E+06

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Ecotoxicity, freshwater	CTUe	3.1E+09	1.4E+08	2.0E+08	2.0E+08	1.8E+10	-1.4E+08	-4.4E+08	-1.5E+07	-2.8E+07	3.6E+05	2.11E+10
Ecotoxicity, freshwater - inorganics	CTUe	1.3E+09	1.4E+08	2.0E+08	2.0E+08	1.6E+10	-1.4E+08	-4.4E+08	-1.6E+07	-2.5E+07	3.5E+05	1.74E+10
Ecotoxicity, freshwater - organics	CTUe	1.9E+09	5.1E+06	3.3E+06	6.3E+06	1.8E+09	-9.0E+05	-9.1E+06	1.0E+06	-3.5E+06	1.1E+04	3.73E+09
Particulate matter	disease inc.	4.9E+01	6.0E+00	7.7E+01	8.5E+00	1.3E+03	-2.1E+00	-5.1E+00	-1.6E-01	-2.2E+00	1.5E-02	1.41E+03
Eutrophication, marine	kg N eq	1.1E+06	1.9E+05	9.3E+04	9.8E+04	1.1E+08	-4.9E+03	-1.1E+05	-1.1E+03	-6.9E+03	1.7E+02	1.12E+08
Eutrophication, freshwater	kg P eq	8.7E+04	7.1E+03	5.4E+04	9.5E+03	4.4E+05	-1.8E+04	-1.6E+05	-4.8E+02	4.6E+03	1.7E+01	4.23E+05
Eutrophication, terrestrial	mol N eq.	1.2E+07	2.1E+06	8.1E+05	1.1E+06	1.2E+09	-1.1E+05	-9.2E+05	-1.1E+04	-8.6E+04	1.9E+03	1.23E+09
Human toxicity, cancer	CTUh	3.0E-01	1.3E-02	1.7E-02	1.4E-02	1.9E+00	-5.7E-02	-6.2E-02	-6.4E-04	-1.4E-03	2.5E-05	2.14E+00
Human toxicity, cancer - inorganics	CTUh	2.5E-02	6.5E-03	6.7E-03	6.1E-03	8.3E-01	1.3E-03	2.5E-03	-4.1E-04	-5.9E-04	1.1E-05	8.75E-01
Human toxicity, cancer - organics	CTUh	1.7E-01	6.1E-03	1.1E-02	8.0E-03	1.1E+00	-5.9E-02	-6.5E-02	-2.3E-04	-7.8E-04	1.4E-05	1.16E+00
Human toxicity, non-cancer	CTUh	2.1E+01	5.2E-01	5.4E-01	8.0E-01	2.2E+02	-1.7E-01	2.2E-01	-2.2E-02	-6.0E-02	1.4E-03	2.39E+02

PEF Impact categories	Unit	Raw materials	Raw Materials Transport	Manufactu-ring	Distribution	Use Phase	EoL – Mechani-cal Recycling	EoL - Fuel use in cement kiln	EoL – Devulcanisa-tion	EoL - Pyrolysis	EoL - Civil engineering	Total
Human toxicity, non-cancer - inorganics	CTUh	1.1E+01	4.8E-01	5.2E-01	7.5E-01	5.3E+01	-1.6E-01	2.7E-01	-2.0E-02	-4.5E-02	1.3E-03	6.55E+01
Human toxicity, non-cancer - organics	CTUh	4.6E-01	3.2E-02	2.3E-02	4.9E-02	1.6E+02	-8.9E-03	-5.1E-02	-1.9E-03	-1.5E-02	8.7E-05	1.64E+02
Ionising radiation	kBq U-235 eq.	1.6E+07	9.3E+05	3.2E+07	1.1E+06	1.6E+08	-2.6E+06	-1.4E+06	-1.4E+05	4.0E+06	1.9E+03	2.14E+08
Land use	Pt	1.8E+11	7.3E+08	2.1E+08	1.2E+09	2.8E+10	-7.1E+07	-2.4E+08	-1.0E+07	-3.1E+07	2.2E+06	2.10E+11
Ozone depletion	kg CFC11 eq.	9.0E+00	9.3E-01	3.2E+00	1.2E+00	9.3E+02	-2.7E-01	-4.4E+00	-8.6E-02	-1.3E+00	2.1E-03	9.36E+02
Photochemical ozone formation	kg NMVOC eq.	3.7E+06	6.6E+05	3.0E+05	4.4E+05	3.6E+08	-6.0E+04	-5.6E+05	-1.3E+04	-1.4E+05	7.8E+02	3.69E+08
Resource use, fossils	MJ	8.2E+09	9.5E+08	2.2E+09	1.2E+09	5.4E+11	-4.7E+08	-4.0E+09	-6.9E+07	-9.5E+08	2.2E+06	5.50E+11
Resource use, minerals and metals	kg Sb eq.	2.3E+03	1.6E+02	1.3E+02	2.4E+02	6.0E+03	-2.1E+01	2.0E+00	-4.3E+01	-5.9E+01	4.3E-01	8.72E+03
Water use	m3 depriv.	1.3E+08	4.6E+06	5.2E+07	6.5E+06	4.0E+08	-4.1E+06	-5.6E+06	-1.5E+06	6.2E+04	1.2E+04	5.81E+08

Table 3-37. BC4 - Life cycle costs per product and total EU expenditure.

Product items	LCC new product		Total annual consumer expenditure in EU27	
	Value	Unit	Value	Unit
Product price	363	EUR	746	mln. EUR/year
Installation/ acquisition costs	19	EUR	39	mln. EUR/year
Fuel (Euro-super 95) costs	682	EUR/year	5,856	mln. EUR/year
Repair & maintenance costs	59	EUR	168	mln. EUR/year
Total	**829**	**EUR/year**	**6,808**	**mln. EUR/year**

3.3. Annex III – End-of-life and Circular Footprint Formula inputs for LCA

The background datasets presented in this Annex were sourced from the Ecoinvent database (v. 3.11) (Wernet et al., 2016). As for the source of the foreground data, this is also specified and reported in the tables below, together with the data quality assessment, as explained in **section 2.1.4**.

3.3.1. Circular Footprint Formula

The Circular Footprint Formula (CFF), as described in the European Commission's Product Environmental Footprint (PEF) method, is a calculation approach used to allocate environmental impacts and credits for recycled and reused materials across product life cycles (European Commission, 2021a). The formula is expressed as a combination of *'material + energy + disposal'* as shown in the equations below (**Figure 3-1**). **Table 3-38** contains a list of all the CFF parameters along with a short description.

Material

$$(1 - R_1)E_V + R_1 \times \left(A \times E_{recycled} + (1 - A)E_V \times \frac{Q_{Sin}}{Q_p}\right) + (1 - A)R_2 \times \left(E_{recyclingEoL} - E_V^* \times \frac{Q_{Sout}}{Q_P}\right)$$

Energy

$$(1 - B)R_3 \times (E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec})$$

Disposal

$$(1 - R_2 - R_3)E_D$$

Figure 3-1: Circular Footprint Formula (European Commission, 2021a).

Table 3-38: List of CFF parameters and their definition.

CFF Parameter	Definition
A	allocation factor of burdens and credits between supplier and user of recycled materials
B	allocation factor of energy recovery processes. It applies both to burdens and credits
Qsin	quality of the ingoing secondary material, i.e. the quality of the recycled material at the point of substitution.
Qsout	quality of the outgoing secondary material, i.e. the quality of the recyclable material at the point of substitution
Qp	quality of the primary material, i.e. quality of the virgin material
R1	the proportion of material in the input to the production that has been recycled from a previous system.
R2	the proportion of the material in the product that will be recycled (or reused) in a subsequent system. Therefore, R2 shall take into account the inefficiencies in the collection and recycling (or reuse) processes. R2 shall be measured at the output of the recycling plant.
R3	the proportion of the material in the product that is used for energy recovery at EoL
Erecycled (Erec)	specific emissions and resources consumed (per functional unit) arising from the recycling process of the recycled (reused) material, including collection, sorting and transportation process.

CFF Parameter	Definition
ErecyclingEoL (ErecEoL)	specific emissions and resources consumed (per functional unit) arising from the recycling process at EoL, including the collection, sorting and transportation processes.
Ev	specific emissions and resources consumed (per functional unit) arising from the acquisition and preprocessing of virgin material
E*v	specific emissions and resources consumed (per functional unit) arising from the acquisition and preprocessing of virgin material assumed to be substituted by recyclable materials.
EER	specific emissions and resources consumed (per functional unit) arising from the energy recovery process (e.g. incineration with energy recovery, landfill with energy recovery, etc.).
ESE,heat and ESE,elec	specific emissions and resources consumed (per functional unit) that would have arisen from the specific substituted energy source, heat and electricity respectively
ED	specific emissions and resources consumed (per functional unit) arising from the disposal of waste material at the analysed product's EoL, without energy recovery
XER,heat and XER,elec	the efficiency of the energy recovery process for both heat and electricity
LHV	lower heating value of the material in the product used for energy recovery.

3.3.2. Mechanical Recycling

Table 3-39 contains the input data for the mechanical recycling process for each tyre BC, along with the source of each data point and the data quality assessment.

Table 3-39: Input data for mechanical recycling EoL scenario.

Dataset	Unit	BC1	BC2	BC3	BC4	Reference	Source	Data quality assessment
Inputs								
ELT tyre	kg	6.6	11.6	51.8	53.9	(Bianco et al., 2021; Corti, 2004; Maga et al., 2023)	Stakeholder input	High quality
market group for electricity, medium voltage	kWh	2.0	3.5	15.5	16.2		Scientific literature	High quality

Dataset	Unit	BC1	BC2	BC3	BC4	Reference	Source	Data quality assessment
market group for tap water	kg	0.003	0.006	0.026	0.027		Scientific literature	High quality
market for natural gas, high pressure	MJ	0.45	0.79	3.55	3.69		Scientific literature	High quality
market group for heavy fuel oil	MJ	0.01	0.02	0.08	0.08		Scientific literature	High quality
transport, passenger, bus, diesel, regular	MJ	1.19	2.10	9.36	9.75		Scientific literature	High quality
market for steel, low-alloyed	kg	0.004	0.007	0.031	0.032		Scientific literature	High quality
Lubricating oil production	kg	0.0001	0.0002	0.001	0.001		Scientific literature	High quality
Outputs								
Sand and gravel	kg	0.03	0.05	0.21	0.22		Scientific literature	High quality
Steel fraction	kg	1.32	2.32	10.36	10.79		Scientific literature	High quality
Textile fraction	kg	0.59	1.04	4.66	4.85		Scientific literature	High quality
Rubber granulate fraction	kg	4.94	8.70	38.85	40.46		Scientific literature	High quality
treatment of wastewater, average, wastewater treatment	kg	0.003	0.006	0.026	0.027		Scientific literature	High quality
Dust/PM	kg	0.0002	0.0004	0.0018	0.0019		Scientific literature	High quality

Table 3-40 contains the CFF parameters values applied to all output flows of the mechanical recycling process, as modelled in **Table 3-39. Table 3-38** includes an overview of all CFF parameters and their definition.

1220 **Table 3-40: Circular Footprint Formula parameters per waste flow for the mechanical recycling EoL scenario.**

CFF parameters	Rubber granulate fraction	Steel	Mixed waste materials (textiles, sand and gravel)	Reference
A	0.5	0.2	0.5	(European Commission, 2020)
R1	0%	21%	0%	(European Commission, 2020)
R2	100%	85%	0%	(European Commission, 2020)
Material for Q	Recycled rubber	Steel	N/A	
Qsin/Qp	1	1	1	
Qsout/Qp	9%	1	1	(Braithwaite et al., 2021; Imarc Group, 2025)
Ev vs Ev*	Ev/=E*v	Ev/=E*v	N/A	
B	0%	0%	0%	(European Commission, 2020)
R3	0%	15%	100%	(European Commission, 2020)
LHV * X_ER_heat (MJ/kg)	0	0	3.58	Ecoinvent dataset
LHV * X_ER_elec (MJ/kg)	0	0	1.78	Ecoinvent dataset
CFF Datasets				
E_v	synthetic rubber	market for steel, low-alloyed	N/A	Ecoinvent dataset
E*_v	market for acrylonitrile-butadiene-styrene, pellets, recycled	pig iron production	N/A	Ecoinvent dataset
E_recycled	N/A	steel production, electric, low-alloyed	N/A	Ecoinvent dataset

CFF parameters	Rubber granulate fraction	Steel	Mixed waste materials (textiles, sand and gravel)	Reference
E_recycling_eol	Mechanical recycling model	sorting and pressing of iron scrap	N/A	Ecoinvent dataset
E_ER	N/A	treatment of waste steel, municipal incineration	treatment of waste textile, soiled, municipal incineration	Ecoinvent dataset
E_SE_heat	N/A	N/A	market for heat, district or industrial, natural gas	Ecoinvent dataset
E_SE_elec	N/A	N/A	market group for electricity, medium voltage	Ecoinvent dataset
E_D	N/A	N/A	N/A	
CFF Factors				
E*_v	-0.05	-0.68	0	Calculated
E_recycled	0	0.04	0	Calculated
E_recycling_eol	0.5	0.68	0	Calculated
E_ER	0	0.15	1	Calculated
E_SE_heat	0	0	-3.58	Calculated
E_SE_elec	0	0	-1.78	Calculated
E_D	0	0	0	Calculated

1221

1222 **Table 3-41** contains all the datasets used to model the recycling impacts and credits allocated to the system boundary of the study for each BC. The values have
1223 been calculated using the formula in **Figure 3-1** and the values in **Table 3-40**.

Table 3-41: Circular Footprint Formula model input data for mechanical recycling EoL scenario.

CFF datasets	Unit	BC1	BC2	BC3	BC4
E*_v					
market for acrylonitrile-butadiene-styrene, pellets, recycled	kg	-0.23	-0.40	-1.81	-2.77
pig iron production	kg	-0.89	-1.58	-7.04	-7.34
E_recycled					
steel production, electric, low-alloyed	kg	0.06	0.10	0.44	0.45
E_recycling_eol					
Mechanical recycling model	kg	0.50	0.50	0.50	0.50
sorting and pressing of iron scrap	kg	0.89	1.58	7.04	7.34
E_ER					
treatment of waste steel, municipal incineration	kg	0.20	0.35	1.55	1.62
treatment of waste textile, soiled, municipal incineration		0.62	1.09	4.87	5.07
E_SE_heat					
market for heat, district or industrial, natural gas	MJ	-2.21	-3.90	-17.43	-18.15
E_SE_elec					
market group for electricity, medium voltage	kWh	-0.31	-0.54	-2.41	-9.03
E_D					
N/A		N/A	N/A	N/A	N/A
Transport					
transport, freight, lorry >32 metric ton, EURO5	tkm	0.69	1.21	5.41	7.55

3.3.3. Pyrolysis

Table 3-42 contains the input data for the pyrolysis process for each tyre BC, along with the source of each data point and the data quality assessment.

Table 3-42: Input data for pyrolysis EoL scenario.

Dataset	Unit	BC1	BC2	BC3	BC4	Reference	Source	Data quality assessment	Comment
Inputs									
Rubber granulate fraction from mechanical recycling	kg	4.94	8.70	38.85	40.46	(Maga et al., 2023)	Scientific literature	High quality	
market group for electricity, medium voltage	kWh	4.26	7.51	33.54	34.92		Scientific literature	High quality	Electricity consumption for pyrolysis as well as cooling demand and own consumption of CHP unit
market group for tap water	kg	2.78	4.89	21.87	22.77		Scientific literature	High quality	Water demand
lubricating oil production	kg	0.00	0.00	0.00	0.00		Scientific literature	High quality	Lubricants
lubricating oil production	kg	0.00	0.00	0.01	0.01		Scientific literature	High quality	Oil consumption compressor
market group for electricity, medium voltage	kWh	2.36	4.16	18.57	19.34		Scientific literature	High quality	Electricity consumption (pyrolysis coke treatment to carbon black)
market for heat, district or industrial, natural gas	MJ	6.52	11.48	51.31	53.43		Scientific literature	High quality	Thermal energy from natural gas (pyrolysis coke treatment to carbon black)
market group for tap water	kg	1.62	2.86	12.77	13.30		Scientific literature	High quality	Water demand (pyrolysis coke treatment to carbon black)

Dataset	Unit	BC1	BC2	BC3	BC4	Reference	Source	Data quality assessment	Comment
Outputs									
Pyrolysis gas	kg	1.05	1.85	8.25	8.59		Scientific literature	High quality	
Carbon black	kg	2.43	4.28	19.12	19.91		Scientific literature	High quality	Pyrolysis coke converted to carbon black
Pyrolysis oil	kg	1.29	2.27	10.14	10.56		Scientific literature	High quality	
treatment of wastewater, average, wastewater treatment	m3	0.00	0.00	0.00	0.00		Scientific literature	High quality	
Pyrolysis sludge	kg	0.05	0.08	0.37	0.38		Scientific literature	High quality	
Evaporated water	kg	2.78	4.89	21.87	22.77		Scientific literature	High quality	

Table 3-43 contains the CFF parameters values applied to the pyrolysis process, as modelled in **Table 3-42. Table 3-38** includes an overview of all CFF parameters and their definition.

Table 3-43: Circular Footprint Formula parameters per waste flow for the pyrolysis EoL scenario.

CFF parameters	Ground tyres (from mechanical recycling)	Reference
A	0.5	(European Commission, 2020)
R1	0%	(European Commission, 2020)
R2	100%	(European Commission, 2020)

CFF parameters	Ground tyres (from mechanical recycling)	Reference
Material for Q	Rubber	
Qsin/Qp	n/a	
Qsout/Qp	97%	Expert judgement
Ev vs Ev*	Ev/=E*v	
B	0%	(European Commission, 2020)
R3	0%	(European Commission, 2020)
LHV * X_ER_heat (MJ/kg)	17.11	Ecoinvent dataset
LHV * X_ER_elec (MJ/kg)	1.27	Ecoinvent dataset
CFF Datasets		
E_v	Mechanical recycling model	Process model
E*_v	Multiple products (carbon black, pyrolysis oil, pyrolysis gas)	Process model
E_recycled	N/A	
E_recycling_eol	pyrolysis model	Process model
E_ER	treatment of refinery sludge, hazardous waste incineration	Ecoinvent dataset
E_SE_heat	market for heat, district or industrial, natural gas	Ecoinvent dataset
E_SE_elec	market group for electricity, medium voltage	Ecoinvent dataset
E_D	N/A	
CFF Factors		
E*_v	-0.49	Calculated
E_recycled	0	Calculated
E_recycling_eol	0.5	Calculated
E_ER	0	Calculated

CFF parameters	Ground tyres (from mechanical recycling)	Reference
E_SE_heat	0	Calculated
E_SE_elec	0	Calculated
E_D	0	Calculated

1232 **Table 3-44** contains all the datasets used to model the recycling impacts and credits allocated to the system boundary of the study for each BC. The values have
1233 been calculated using the formula in **Figure 3-1** and the values in **Table 3-43**.

1234 **Table 3-44: Circular Footprint Formula model input data for pyrolysis EoL scenario.**

CFF datasets	Unit	BC1	BC2	BC3	BC4
E*_v					
carbon black production	kg	-1.18	-2.08	-9.27	-14.23
pyrolysis fuel oil: unsaturated hydrocarbons production, steam cracking operation, average	kg	-0.62	-1.10	-4.92	-7.55
pyrolysis fuel gas: unsaturated hydrocarbons production, steam cracking operation, average	kg	-0.51	-0.90	-4.00	-6.14
E_recycled					
N/A		N/A	N/A	N/A	N/A
E_recycling_eol					
pyrolysis model	kg	0.5	0.5	0.5	0.5
E_ER					
treatment of refinery sludge, hazardous waste incineration	MJ	0.05	0.08	0.37	0.38
E_SE_heat					
market for heat, district or industrial, natural gas	MJ	0.80	1.40	6.27	6.53
E_SE_elec					
market group for electricity, medium voltage	kWh	0.02	0.03	0.13	0.13

CFF datasets	Unit	BC1	BC2	BC3	BC4
E_D					
N/A		N/A	N/A	N/A	N/A
Transport					
transport, freight, lorry >32 metric ton, EURO5	tkm	0.48	0.85	3.79	5.86

3.3.4. Fuel substitution in cement kiln

Table 3-45 contains the input data for the 'use as fuel in cement' process for each tyre BC, along with the source of each data point and the data quality assessment.

Table 3-45: Input data for use as fuel in cement kiln EoL scenario.

Dataset	Unit	BC1	BC2	BC3	BC4	Reference	Source	Data quality assessment
Inputs						(Baron et al., 2025; Maga et al., 2023)		
End-of-life tyre	kg	6.58	11.59	51.80	53.94		Scientific literature	High quality
Outputs								
End-of-life tyre used as fuel	kg	5.92	9.91	42.00	44.14		Scientific literature	High quality
Iron scrap used as additive in cement production	kg	0.66	1.69	9.80	9.80		Scientific literature	High quality

Table 3-46 contains the CFF parameters values applied to the 'use as fuel in cement' process. **Table 3-38** includes an overview of all CFF parameters and their definition.

1241 **Table 3-46: Circular Footprint Formula parameters per waste flow for the use as fuel in cement kiln EoL scenario.**

CFF parameters	ELTs used as fuel	Iron scrap used as additive in cement production	Reference
A	0.5	0.2	(European Commission, 2020)
R1	0%	21%	(European Commission, 2020)
R2	100%	85%	(European Commission, 2020)
Material for Q	Mixed materials	Steel	
Qsin/Qp	n/a	1	
Qsout/Qp	1	1	Expert judgement
Ev vs Ev*	Ev/=E*v	Ev/=E*v	
B	0%	0%	(European Commission, 2020)
R3	0%	15%	(European Commission, 2020)
LHV * X_ER_heat (MJ/kg)	0	0	Ecoinvent dataset
LHV * X_ER_elec (MJ/kg)	0	0	Ecoinvent dataset
CFF Datasets			
E_v	N/A	market for steel, low-alloyed	Ecoinvent dataset
E*_v	fossil fuels mix used in cement kilns	pig iron production	Ecoinvent dataset
E_recycled	N/A	steel production, electric, low-alloyed	Ecoinvent dataset
E_recycling_eol	Use as fuel in cement kiln model	sorting and pressing of iron scrap	Ecoinvent dataset
E_ER	N/A	treatment of waste steel, municipal incineration	Ecoinvent dataset
E_SE_heat	N/A	N/A	
E_SE_elec	N/A	N/A	
E_D	N/A	N/A	
CFF Factors			
E*_v	-0.5	-0.68	Calculated

CFF parameters	ELTs used as fuel	Iron scrap used as additive in cement production	Reference
E_recycled	0	0.042	Calculated
E_recycling_eol	0.5	0.68	Calculated
E_ER	0	0.15	Calculated
E_SE_heat	0	0	Calculated
E_SE_elec	0	0	Calculated
E_D	0	0	Calculated

Table 3-47 contains all the datasets used to model the recycling impacts and credits allocated to the system boundary of the study for each BC. The values have been calculated using the formula in **Figure 3-1** and the values in **Table 3-46**.

Table 3-47: Circular Footprint Formula model input data for the use as fuel in cement kiln EoL scenario.

CFF datasets	Unit	BC1	BC2	BC3	BC4
E*_v					
market for lignite	kg	-1.04	-1.73	-7.35	-11.08
hard coal	kg	-0.71	-1.19	-5.04	-7.60
petroleum coke production, petroleum refinery operation	kg	-1.49	-2.50	-10.58	-15.95
natural gas and other fossil fuels (natural gas, high pressure)	m3	-0.05	-0.08	-0.33	-0.49
pig iron production	kg	-0.45	-1.15	-6.66	-6.66
E_recycled					
steel production, electric, low-alloyed	kg	0.03	0.07	0.41	0.41
E_recycling_eol					
Use as fuel in cement kiln model	kg	0.5	0.5	0.5	0.5
sorting and pressing of iron scrap	kg	0.45	1.15	6.66	6.66

CFF datasets	Unit	BC1	BC2	BC3	BC4
E_ER					
treatment of waste steel, municipal incineration	kg	0.10	0.25	1.47	1.47
E_SE_heat					
N/A	MJ	N/A	N/A	N/A	N/A
E_SE_elec					
N/A	MJ	N/A	N/A	N/A	N/A
E_D					
N/A		N/A	N/A	N/A	N/A
Transport					
transport, freight, lorry >32 metric ton, EURO5	tkm	0.66	1.16	5.18	7.31

3.3.5. Devulcanisation

Table 3-48 contains the input data for the devulcanisation process for each tyre BC, along with the source of each data point and the data quality assessment.

Table 3-48: Input data for devulcanisation EoL scenario.

Dataset	Unit	BC1	BC2	BC3	BC4	Source	Data quality assessment	Comment
Inputs								
Rubber granulate fraction from mechanical recycling	kg	4.935	8.695	38.850	40.458	Stakeholder input	High quality	

Dataset	Unit	BC1	BC2	BC3	BC4	Source	Data quality assessment	Comment
oxalic acid production, RoW	kg	0.017	0.031	0.137	0.143	Stakeholder input	High quality	
market for urea, RER	kg	0.032	0.057	0.255	0.266	Stakeholder input	High quality	
base oil production, petroleum refinery operation, Europe without Switzerland	kg	0.139	0.244	1.091	1.136	Stakeholder input	High quality	
lubricating oil production, RER	kg	0.071	0.125	0.559	0.583	Stakeholder input	High quality	
tris(2,4-ditert-butylphenyl) phosphite production	kg	0.036	0.063	0.280	0.291	Stakeholder input	High quality	
market group for electricity, medium voltage, RER	kWh	1.974	3.478	15.540	16.183	Stakeholder input	High quality	
market group for electricity, medium voltage, RER	kWh	1.371	2.415	10.792	11.238	Stakeholder input	High quality	Supplied cooling
market for nitrogen, liquid, RER	kg	0.004	0.006	0.028	0.029	Stakeholder input	High quality	
market for compressed air, 700 kPa gauge, RER	m3	0.0005	0.0009	0.0039	0.0040	Stakeholder input	High quality	
market group for tap water, Europe without Switzerland	kg	0.49	0.87	3.89	4.05	Stakeholder input	High quality	
Outputs								
Devulcanised Rubber	kg	4.69	8.26	36.91	38.43	Stakeholder input	High quality	
treatment of wastewater, average, wastewater treatment	m3	0.0005	0.0009	0.0039	0.0040	Stakeholder input	High quality	

Dataset	Unit	BC1	BC2	BC3	BC4	Source	Data quality assessment	Comment
Rubber waste	kg	0.25	0.43	1.94	2.02	Stakeholder input	High quality	
VOC, volatile organic compounds, unspecified origin	kg	0.003	0.005	0.024	0.025	Stakeholder input	High quality	
Carbon dioxide	kg	0.002	0.004	0.017	0.018	Stakeholder input	High quality	

Table 3-49 contains the CFF parameters values applied to the devulcanisation process**. Table 3-38** includes an overview of all CFF parameters and their definition.

Table 3-49: Circular Footprint Formula parameters per waste flow for the devulcanisation EoL scenario.

CFF parameters	Ground tyres (from mechanical recycling)	Reference
A	0.5	(European Commission, 2020)
R1	0%	(European Commission, 2020)
R2	100%	(European Commission, 2020)
Material for Q	Rubber	
Qsin/Qp	n/a	
Qsout/Qp	0.95	Expert judgement
Ev vs Ev*	Ev/=E*v	
B	0%	(European Commission, 2020)
R3	0%	(European Commission, 2020)
LHV * X_ER_heat (MJ/kg)	6.36	Ecoinvent dataset
LHV * X_ER_elec (MJ/kg)	3.25	Ecoinvent dataset
CFF Datasets		

CFF parameters	Ground tyres (from mechanical recycling)	Reference
E_v	Mechanical recycling dataset	Process model
E*_v	Multiple products	Process model
E_recycled	N/A	
E_recycling_eol	Devulcanisation model	Process model
E_ER	treatment of waste rubber, unspecified, municipal incineration	Ecoinvent dataset
E_SE_heat	market for heat, district or industrial, natural gas	Ecoinvent dataset
E_SE_elec	market group for electricity, medium voltage	Ecoinvent dataset
E_D	N/A	
CFF Factors		
E*_v	-0.475	Calculated
E_recycled	0	Calculated
E_recycling_eol	0.5	Calculated
E_ER	0	Calculated
E_SE_heat	0	Calculated
E_SE_elec	0	Calculated
E_D	0	Calculated

Table 3-50 contains all the datasets used to model the recycling impacts and credits allocated to the system boundary of the study for each BC. The values have been calculated using the formula in **Figure 3-1** and the values in **Table 3-49**.

Table 3-50: Circular Footprint Formula model input data for devulcanisation EoL scenario.

CFF datasets	Unit	BC1	BC2	BC3	BC4
E*_v					

CFF datasets	Unit	BC1	BC2	BC3	BC4
synthetic rubber	kg	-2.23	-3.92	-17.53	-26.90
E_recycled					
N/A	kg	N/A	N/A	N/A	N/A
E_recycling_eol					
Devulcanisation model	kg	0.50	0.50	0.50	0.50
E_ER					
treatment of waste rubber, unspecified, municipal incineration	kg	0.25	0.43	1.94	2.98
E_SE_heat					
market for heat, district or industrial, natural gas	MJ	1.57	2.77	12.35	18.96
E_SE_elec					
market group for electricity, medium voltage	kWh	0.22	0.39	1.75	2.69
E_D					
N/A		N/A	N/A	N/A	N/A
Transport					
transport, freight, lorry >32 metric ton, EURO5	tkm	0.49	0.87	3.89	5.96

3.3.6. Civil engineering/backfilling/public works

Table 3-51 contains the input data for the civil engineering/backfilling/public works EoL scenario for each tyre BC, along with the source of each data point and the data quality assessment. In this scenario, waste tyres are considered inert materials, and do not undergo any treatment. Therefore, transportation to the site is the only process considered in this model. CFF is not applicable in this scenario.

Table 3-51: Input data for civil engineering/backfilling/public works EoL scenario.

Input	Unit	BC1	BC2	BC3	BC4	Reference	Source	Data quality assessment
End-of-life tyre	kg	6.58	11.59	51.80	73.1		Stakeholder input	High quality
Transport	tkm	0.66	1.16	5.18	7.310	Default PEF transport scenario - 100km, lorry	Scientific literature	High quality

3.3.7. Manufacturing waste

According to the PEF methodology, CFF shall be applied to all waste flows within the system boundaries of the study, including manufacturing waste. **Table 3-52** contains the CFF parameters values applied to the manufacturing waste. **Table 3-38** includes an overview of all CFF parameters and their definition.

Table 3-52: Circular Footprint Formula parameters per waste flow for the manufacturing waste.

CFF parameters	Rubber waste	Steel waste	Textiles waste	Other waste [not specified]	Reference
A	0.5	0.2	0.5	0.5	(European Commission, 2020)
R1	0%	21%	0%	0	(European Commission, 2020)
R2	0%	85%	0%	0	(European Commission, 2020)
Material for Q	Rubber	Steel	N/A	N/A	
Qsin/Qp	n/a	1	1	1	
Qsout/Qp	100%	1	1	1	Expert judgement
Ev vs Ev*	Ev/=E*v	Ev/=E*v	N/A	N/A	
B	0%	0%	0%	0	(European Commission, 2020)
R3	100%	15%	100%	1	(European Commission, 2020)

CFF parameters	Rubber waste	Steel waste	Textiles waste	Other waste [not specified]	Reference
LHV * X_ER_heat (MJ/kg)	6.36	0	3.58	17.11	Ecoinvent dataset
LHV * X_ER_elec (MJ/kg)	3.25	0	1.78	1.27	Ecoinvent dataset
CFF Datasets					
E_v	natural and synthetic rubber	market for steel, low-alloyed	N/A	N/A	Ecoinvent dataset
E*_v	N/A	pig iron production	N/A	N/A	Ecoinvent dataset
E_recycled	N/A	steel production, electric, low-alloyed	N/A	N/A	Ecoinvent dataset
E_recycling_eol	N/A	sorting and pressing of iron scrap	N/A	N/A	Ecoinvent dataset
E_ER	treatment of waste rubber, unspecified, municipal incineration	treatment of waste steel, municipal incineration	treatment of waste textile, soiled, municipal incineration	treatment of hazardous waste, hazardous waste incineration	Ecoinvent dataset
E_SE_heat	market for heat, district or industrial, natural gas	N/A	market for heat, district or industrial, natural gas	market for heat, district or industrial, natural gas	Ecoinvent dataset
E_SE_elec	market group for electricity, medium voltage	N/A	market group for electricity, medium voltage	market group for electricity, medium voltage	Ecoinvent dataset
E_D	N/A	N/A	N/A	N/A	
CFF Factors					

CFF parameters	Rubber waste	Steel waste	Textiles waste	Other waste [not specified]	Reference
E*_v	0.00	-0.68	0	0	Calculated
E_recycled	0	0.04	0	0	Calculated
E_recycling_eol	0.0	0.68	0	0	Calculated
E_ER	1	0.15	1	1	Calculated
E_SE_heat	-6.36	0	-3.58	-17.11	Calculated
E_SE_elec	-3.25	0	-1.78	-1.27	Calculated
E_D	0	0	0	0	Calculated

Table 3-53 contains all the datasets used to model the recycling impacts and credits allocated to the system boundary of the study for each BC. The values have been calculated using the formula in **Figure 3-1** and the values in **Table 3-52**.

Table 3-53: Circular Footprint Formula model input data for the manufacturing waste.

CFF datasets	Unit	BC1	BC2	BC3	BC4
E*_v					
pig iron production	kg	-0.0022	-0.0037	-0.0174	0
E_recycled					
steel production, electric, low-alloyed	kg	0.0001	0.0002	0.0011	0
E_recycling_eol					
sorting and pressing of iron scrap	kg	0.0022	0.0037	0.0174	0
E_ER					
treatment of waste rubber, unspecified, municipal incineration	kg	0.0025	0.0041	0.0192	0.2556
treatment of waste steel, municipal incineration	kg	0.0005	0.0008	0.0038	0
treatment of waste textile, soiled, municipal incineration	kg	0.0327	0.0540	0.2564	0

CFF datasets	Unit	BC1	BC2	BC3	BC4
treatment of hazardous waste, hazardous waste incineration	kg	0.0573	0.0945	0.4487	0
E_SE_heat					
market for heat, district or industrial, natural gas	MJ	-0.0156	-0.0258	-0.1223	-1.6253
market for heat, district or industrial, natural gas	MJ	-0.1171	-0.1933	-0.9180	0
market for heat, district or industrial, natural gas	MJ	-0.9797	-1.6169	-7.6781	0
E_SE_elec					
market group for electricity, medium voltage	kWh	-0.0022	-0.0037	-0.0035	-0.2307
market group for electricity, medium voltage	kWh	-0.0162	-0.0267	-0.1268	0
market group for electricity, medium voltage	kWh	-0.0202	-0.0333	-0.1583	0
E_D					
N/A		N/A	N/A	N/A	N/A
Transport					
transport, freight, lorry >32 metric ton, EURO5	tkm	0.00957	0.015795	0.075005	0.0255552

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