

Preparatory study and impact support study on tyres

Draft report
Task 6 of the preparatory study

Draft for SH meeting

Written by: Yifaat Baron, Daniel Hinchliffe, Fred Adjei, Lucía Gascón, Diana Hay, Izabela Kosińska-Terrade, Felix Mayer
(Oeko-Institut), Corina Haita-Falah, Lucia Van den Boogaart (Trinomics)
May – 2026

 **Oeko-Institut**
Consult GmbH

Trinomics 

 **vito**

 **ecomatters**

Draft for SH meeting 2

EUROPEAN COMMISSION

Directorate-General for Environment
Directorate B — Circular Economy
Unit B4 — Sustainable Products

E-mail: ENV-B04-ARES@ec.europa.eu

*European Commission
B-1049 Brussels*

Preparatory Study and Impact Assessment support study on tyres

Draft report
Tasks 6 of the Preparatory study
Version 1

Submitted by:



In collaboration with:



Manuscript completed in May 2026

Draft edition

This document has been prepared for the European Commission; however, it reflects the views only of the authors, and the European Commission is not liable for any consequences stemming from the reuse of this publication.

Luxembourg: Publications Office of the European Union, 2026

© European Union, 2026



The reuse policy of European Commission documents is implemented by Commission Decision 2011/833/EU of 12 December 2011 on the reuse of Commission documents (OJ L 330, 14.12.2011, p. 39). Unless otherwise noted, the reuse of this document is authorised under a Creative Commons Attribution 4.0 International (CC BY 4.0) licence (<https://creativecommons.org/licenses/by/4.0/>). This means that reuse is allowed, provided appropriate credit is given and any changes are indicated.

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
Framework Contract Manager	
Name	Tatiana Pasquel Garcia
Organisation	VITO
Address	Boeretang 200, 2400 Mol (Belgium)
E-Mail	tatiana.pasquelgarcia@vito.be
Telephone	+32 14 33 58 86
Technical Team Leader	
Name	Yifaat Baron & Daniel Hinchliffe
Organisation	Oeko-Institut Consult GmbH
Address	Merzhauser Str. 173, 79100 Freiburg (Germany)
E-Mail	Y.Baron@oeko.de ; D.Hinchliffe@oeko.de
Telephone	Germany +49 761 45295 266; +49 30 405085-343

Partners

Organisation	Country
VITO	Belgium
Oeko Institut	Germany
Ecomatters	The Netherlands
Trinomics	The Netherlands

Deliverable information

Deliverable No	D3
Version of Deliverable*	1.0
Task	2: Preparatory Study (PS) Phase 2
Sub-task	2.3 PS Tasks 6
Main author(s)	Daniel Hinchliffe, Yifaat Baron, Felix Mayer (Oeko-Institut) Serena Cunsolo, Maria Papavasileiou, Max Sonnen (Ecomatters)
Reviewers	Francesca Vanoverberghe & Nele Kelchtermans (VITO)
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-T6) 0.1	02/12/2025	Template for input
(D3-T6) 0.2	09/04/2026	Input provided - Version for internal review
(D3-T6) 0.3	10/04/2026	Version with QA-1
(D3-T6) 0.4	26/04/2026	Reviewed version
(D3-T6) 0.5	26/04/2026	Version 0.5 sent to EC
(D3-T6) 0.6	08/05/2026	Version 0.6 with EC feedback
(D3-T6) 0.7	15/05/2026	Revised version 0.7 for internal review
(D3-T6) 0.8	18/05/2026	Version 0.8 with QA-2
(D3-T6) 1.0	19/05/2026	Version 1 sent to Stakeholders

Contents

0. Overview	1
1. Methodology for Ecodesign of Energy-related Products (MEErP) Task 6 – Design Options	2
1.1. Objectives of MEErP Task 6	2
1.2. Specific environmental objectives	3
1.2.1. Environmental hotspots	3
1.2.2. Problem drivers	4
1.3. Overview of Design Options	7
1.4. Design Options not considered in quantitative assessment	10
1.5. Technical Analysis of Quantifiable Design Options.....	2
1.5.1. Path A: Closing the Loop.....	2
1.5.2. Path B: Bio-Transition	14
1.5.3. Path C: Reduction of impacts in the Use Phase.....	20
1.5.4. Path D: Life Extension	21
1.6. BAT for specific DOs.....	27
1.7. Stakeholder consultation process.....	28
1.8. Input parameters design options per base case.....	29
1.8.1. BC1: C1 Tyre.....	30
1.8.2. BC2: Modelling Pending.....	36
1.8.3. BC3: C3 Tyre.....	37
1.9. Environmental & life cycle costing impact of design options per base case	42
1.9.1. BC1: C1 Tyre.....	43
1.9.2. BC2: Results pending	48
1.9.3. BC3: C3 Tyre.....	48
1.10. Analysis of design options per base case.....	53
1.10.1. Calculation method PEF single score	53
1.10.2. PEF single score per base case and design option.....	55
1.10.3. Total yearly cost per base case and design option.....	56
1.10.4. Evaluation of selected design options per base case	57
1.10.5. Evaluation of selected design options per base case, excluding the use phase impact.....	60
1.10.6. Conclusions.....	64
2. Digital Product Passport Analysis.....	65
2.1. Step A: Scope & Context	65

2.1.1.	A.1 Product scope.....	65
2.1.2.	A.2 Market context and stakeholder data roles.....	65
2.1.3.	A.3 Existing policy and legal context	66
2.1.4.	A.4 Data collection status quo.....	68
2.2.	Step B: Identifying use cases & data needs	71
2.3.	Step B.1: Specification of Use Cases	71
2.3.1.	Active Life / Placing on the Market	74
2.3.2.	End of First Life (Read and Write).....	75
2.3.3.	Circular Secondary Processing.....	78
3.	Annexes.....	80
4.	References.....	87

Draft for SH meeting 2

List of Tables

Table 1-1: Overview of considered design options.....	7
Table 1-2: Stage 2 Limits under UN Regulation No. 117.....	11
Table 1-3: Stage 3 Limits under UN Regulation No. 117.....	11
Table 1-4: Overview of SoC measures (Chemicals).....	1
Table 1-5: Overview of tyre recyclates and their composition impacts.....	4
Table 1-6: BoM assumptions for a C1 tyre meeting recycled content targets 5 % rubber compound, 50 % reinforcement materials.....	5
Table 1-7: Comparison of C1 and C3 assumed recycled content targets via recycling pathways.....	8
Table 1-8: Base case targets as a percentage of tyre weight.....	9
Table 1-9: EoL pathways required to meet recycled content targets (C1, C3 – weighted average).....	9
Table 1-10: Overview of bio-based material classifications.....	16
Table 1-11: assumed bio-based substitution quantifications.....	19
Table 1-12: Impacts of minimum mileage requirements on models’ distribution (not sales weighted).....	25
Table 1-13: BoM assumed changes by Design Option for Base Case 1 (C1 tyre).....	30
Table 1-14: Use phase impacts assumed from design options.....	33
Table 1-15: EoL pathways impacts by design option.....	34
Table 1-16: Comparison of cost impacts by design option.....	35
Table 1-17: Comparison of BoM impacts by design option for Base Case 3 (C3 tyre).....	37
Table 1-18: Use phase impacts by design option base case 3 (C3 tyre).....	40
Table 1-19: Assumed impact on EoL pathways by design option (C3 tyre).....	41
Table 1-20: Comparison of cost impacts by design option (C3 base case).....	42
Table 1-21: Environmental impact per design option (full lifetime) compared to BC1.....	43
Table 1-22: LCC impact per design option compared to BC1.....	47
Table 1-23: Environmental impact per design option (full lifetime) compared to B3.....	49
Table 1-24: LCC impact per design option compared to BC3.....	52
Table 1-25: PEF Single score normalisation factor and weighing factor per PEF impact category.....	54
Table 1-26: PEF Single score per design option for each base case.....	55
Table 1-27: Total yearly costs in EUR per design option for each Base Case.....	56
Table 2-1: Current Data Fields Collected under EPREL.....	67
Table 2-2: Potential DPP Information Requirements from Design Options.....	72
Table 2-2: Overview of possible use cases for the DPP.....	73

Table 3-1: BC1 Recycled Content Material Composition 20% Rubber Compound, 80% reinforcement materials.	80
Table 3-1: BC3 Recycled Content Material Composition 5% Rubber Compound, 50% reinforcement materials.	82
Table 3-1: BC3 Recycled Content Material Composition 20% Rubber Compound, 80% reinforcement materials.	84

List of Figures

Figure 1-1: Share of materials suitable for a bio-based substitution of C1, C2 and C3 tyres.	18
Figure 1-2: Distribution of mileage performance of 159 C1 tyres tested under ADAC.	25
Figure 1-3: BC1 - PEF score change (in %) per design option per kilometre driven versus costs change per year (in %).	57
Figure 1-4: BC1 – Path A cumulative results: PEF score change (in %) per design option over the full lifetime versus costs change per year (in %).	58
Figure 1-5: BC3 - PEF score change (in %) per design option per kilometre driven versus costs change per year (in %).	59
Figure 1-6: BC3 – Path D cumulative results: PEF score change (in %) per design option per km driven versus costs change per year (in %).	60
Figure 1-7: BC1 - PEF score change excluding use phase (in %) per design option per kilometre driven versus costs change per year (in %).	61
Figure 1-8: BC1 – Path A cumulative results: PEF score change excluding use phase (in %) per design option versus costs change per year (in %).	62
Figure 1-9: BC3 - PEF score change excluding use phase (in %) per design option per kilometre driven versus costs change per year (in %).	63
Figure 1-10: BC3 – Path A cumulative results: PEF score change excluding use phase (in %) per design option versus costs change per year (in %).	63

List of Abbreviations and definitions

3PMSF	Three-Peak Mountain Snowflake
ADAC	Allgemeiner Deutscher Automobil-Club
API	Application Programming Interface
BAT	Best Available Technology
BNAT	Best Not (yet) Available Technology
BoM	Bill of Materials
CB	Carbon Black
DOs	Design Options
DPP	Digital Product Passport
ELT	End-of-Life Tyres
EPREL	European Product Registry for Energy Labelling
EUDR	EU Deforestation Regulation
EoL	End-of-Life
EPR	Extended Product Regulation
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
ERT	Ecoreport Tool
ETRTO	European Tyre and Rim Technical Organisation
GDSO	Global Data Service Organisation
HDS	Highly Dispersible Silica
LCA	Life Cycle Assessment
LCC	Life Cycle Costs
LLCC	Least Life Cycle Costs
MEErP	Methodology for Ecodesign of Energy-related Products
MSA	Market Surveillance Authorities
OEM	Original Equipment Manufacturer
PAH	Poly Aromatic Hydrocarbons
PEF	Product Environmental Footprint
PET	Polyethylene Terephthalate
PoM	Placed on the market
rCB	Recycled Carbon Black
RCC	Rolling Resistance Coefficient
REACH	Registration, Evaluation, Authorisation and restrictions of Chemicals
RFD	Radio-frequency Identification
RFT	Run-Flat Tyres
sCB	Sustainable Carbon Black
TCO	Total Cost of Ownership
TPO	Tyre Pyrolysis Oil
TPMS	Tyre Pressure Monitoring Systems
TRL	Technology Readiness Level
ZnO	Zinc Oxide

1 0. Overview

2 This draft report presents the initial findings from Task 6 to support the second stakeholder
3 meeting for the Ecodesign for Sustainable Products Regulation (ESPR) of tyres. The aim and
4 approach of Task 6 is explained in Section 1.1: to develop and quantify design options to address
5 the main environmental impacts and problem drivers identified in tasks 1-5 of the preparatory
6 study (Section 1.2). 14 Design Options were shortlisted for the initial analysis (Section 1.3) and
7 sent to stakeholders in March 2026 as part of a feedback questionnaire sharing initial
8 assumptions for the modelling of impacts.

9 In a first step, the number of DOs was reduced to those with highest relevance for Ecodesign.
10 Deprioritised DOs for the quantitative analysis are covered in Section 1.4. Although impacts in
11 the use phase were found to dominate in Task 5, Design Options related to rolling resistance,
12 abrasion limits, and several Substances of Concern (SoCs) are considered to be already dealt
13 with under existing or forthcoming legislation relating to UN R117, Euro 7 and REACH
14 respectively. Criteria for re-use were considered out of the scope of Ecodesign due to market
15 entry requirements (but potentially relevant for the digital product passport), while other DOs
16 were deprioritised for quantitative assessment due to unclear impacts on the lifecycle
17 parameters (Substances of Concern, reparability, DPP).

18 The DOs prioritised for deeper quantitative assessment in Section 1.5 were clustered according
19 to the following pathways:

- 20 - Pathway A - Closing the Loop: Recycled Content targets, Design for Recycling
21 (information requirements or restrictions on substances that hinder circularity)
- 22 - Pathway B - Bio-Transition: Bio-Based Content targets
- 23 - Pathway C - Reducing Use Phase Impacts: Rolling resistance/abrasion out of scope, but
24 extrusion spikes considered.
- 25 - Pathway D - Lifetime Extension and Retreading: mileage indicators and retreadability
26 requirements.

27 For each of these DOs, assumptions were made on the extent to which they affect the Bill of
28 Materials, use phase performance, End of Life phase and costs of C1 and C3 tyres (Section 1.8).
29 These changes were then applied to the base cases developed in task 5 using the Product
30 Environmental Footprint LCA model and Ecoreport tool to determine lifecycle impacts vs the Base
31 Case (1.10). These DO impacts are used in Task 7 to model the impacts of tyres and potential
32 savings across the EU market. Since several retreading measures affect predominantly the
33 market (i.e. the retreading rate), and not technical feasibility, these are covered in more detail
34 in Task 7.

35 The Digital Product Passport (DPP) DO was not quantified due to its nature as an enabling factor.
36 It is assumed that the DPP supports implementation of other prioritised DOs through
37 information requirements. The DPP assessment follows an additional methodology to define
38 relevant data fields, published by the JRC in March 2026 (Chawla, K., Chirvasuta, T., Wolf, M.-A.,
39 Wolf, K., Rongen, S. et al., 2026). In this report, the first parts of the DPP methodology are
40 applied, with initial consideration of use cases defined in Section 2 of the report.

1. Methodology for Ecodesign of Energy-related Products (MEErP) Task 6 – Design Options

1.1. Objectives of MEErP Task 6

The aim of Task 6 in the MEErP is to identify and evaluate Design Options (DOs) for tyres. The assessment of the DOs builds on the results of MEErP Tasks 1-5, in particular the problem drivers and the relevant environmental impact and improvement potentials identified during the Life Cycle Assessment (LCA). It also takes into account the monetary consequences in terms of Life cycle costs (LCC) to the customer, their environmental costs and benefits, and the search for the Least Life Cycle Cost (LLCC) solution and DOs reflecting Best Available Technology (BAT).

The design options refer to the respective categories of tyres as defined in MEErP Task 1 (scope): C1, C2 and C3 tyres. These categories are used for analytical purposes, as they group together ranges of tyres considered to be reasonably functionally equivalent. The categories exhibit distinctive design features, components, and/or material composition. They are technically specified in the form of Base Cases (BCs), which allow quantification of input parameters to assess the environmental and cost impacts (MEErP Task 5) as well as the evaluation of DOs.

The objective of assessing DOs is to identify measures for addressing the hotspots of environmental impacts identified in MEErP Task 5, which lead to potential environmental improvements. Possible approaches to redesigning tyres are considered based on information gathered from literature and stakeholder consultation conducted throughout the preparatory study. The DOs refer to technological and operational innovations that aim to improve specific performance aspects influencing the overall sustainability, compared to the current BAT. The DOs considered in MEErP Task 6 are evaluated from the perspective of their possible environmental impact, their technical and economic feasibility. This means that only such DOs are considered that are deemed plausible by stakeholders or have been identified in literature, patents and communications of companies that manufacture tyres or components thereof.

The analysis in Task 6 intends to inform the formulation of policy options in MEErP Task 7 rather than to predetermine future legal requirements.

Introduction to the evaluation of Design Options using the MEErP

The MEErP provides a structured and comprehensive framework for assessing the environmental, economic, and technical performance of product DOs. At its core, the MEErP facilitates a life-cycle-based evaluation that integrates environmental impact assessments with techno-economic analysis to identify the LLCC and BAT. This ensures that design decisions not only meet regulatory requirements but also promote sustainability and cost-effectiveness.

The evaluation of DOs within MEErP is prepared by several tasks, including the definition of product scope (MEErP Task 1), market analysis (MEErP Task 2), use-stage, and technical analysis of existing products (MEErP Task 3 and Task 4), as well as the LCA and LCC in the succeeding (MEErP Task 5). The revised MEErP (Eynard et al., 2024) introduces refinements to better align the methodology with the EU's Green Deal objectives, emphasising aspects related to climate neutrality, circularity, and SoCs related to the product group under study. The work process for

80 developing DOs remains structured around seven core tasks, with MEERP Task 6 playing a pivotal
81 role in identifying and evaluating improvement potentials.

82 The MEERP normally requires first that DOs be mapped and evaluated, taking stakeholder input
83 into account, and then assessed, usually using the Ecoreport Tool (ERT). The ERT helps to
84 quantify the improvement potential of environmental impact compared to the base cases. This
85 structured approach enables policymakers and stakeholders to compare alternatives objectively
86 and select the most sustainable and economically viable solutions. Thus, the MEERP ensures that
87 product innovations are aligned with broader environmental goals, such as reducing greenhouse
88 gas emissions, improving energy efficiency, and adopting a circular economy. In the current
89 study, instead of using the ERT, environmental impact assessment is based on the far more
90 rigorous Product Environmental Footprint (PEF) methodology. The ERT is still used to calculate
91 the least lifecycle cost.

92 According to the MEERP, Task 6 of the preparatory study encompasses in principle the following
93 aspects:

- 94 • Introduction and Objectives: explanation of task 6, environmental hotspots and problem
95 drivers identified in Tasks 1-5;
- 96 • Overview of DOs: Based on the insights from MEERP Tasks 1–5 of this study, DOs that
97 could help improving resource consumption, material use, recyclability, or durability are
98 mapped and grouped into pathways;
- 99 • Analysis of DOs not taken forward for further quantitative analysis: due to regulation
100 elsewhere, or lack of clear quantitative impacts;
- 101 • Technical analysis of DOs taken forward for quantification of environmental impacts:
102 the prioritised DOs are assessed and assumptions on their potential impacts on the
103 different lifecycle stages compared to the Base Case are determined;
- 104 • Overview of DO input parameters: for calculation of LCA and LLCC;
- 105 • Analysis of PEF and LLCC for the DOs: results from the modelling of the Design Options
106 are provided;
- 107 • Discussions on DOs: documentation of any trade-offs between environmental and
108 economic performance;
- 109 • Conclusions: The chapter provides a summary of relevant findings which will then be
110 used to define policy options and scenarios in MEERP Task 7.

111 1.2. Specific environmental objectives

112 1.2.1. Environmental hotspots

113 The preliminary results of the LCA undertaken in MEERP Task 5 indicate that the majority of the
114 environmental impact of tyres across the analysed base cases is in the use phase, with raw
115 materials being the next highest impact area.

116 In the use phase, particulate emissions from fuel combustion are the largest contributors.
117 However, these are already regulated via UN R117 (rolling resistance) and Euro 7 (abrasion). The

118 remaining use phase impact is attributed to emissions arising from fuel extraction. While the use
119 phase dominates, it should also be considered that rolling resistance will always occur due to
120 the tyre, so the improvement potentials in the use phase are limited and dependent on the
121 highest possible rolling resistance and fuel requirements of the vehicle. Microplastic emissions
122 are also only possible to minimise, rather than fully eliminate, with 1.6 kg of wear assumed over
123 the lifetime of the base case C1 tyre and 12.3 kg of wear assumed over the lifetime of the base
124 case C3 tyre.

125 Amongst raw materials, preliminary results show larger impacts coming from synthetic rubber,
126 silica, carbon black (CB), benzothiadiazole and P-phenylene diamine compounds, cobalt salts,
127 steel, and polyester/nylon content.

128 The sensitivity analyses indicate that

- 129 • Tyre raw materials have a higher importance for electric vehicles, where related fuel
130 impacts are lower, particularly when running on renewable electricity. This is reflected
131 in the raw material stage contribution to the total Climate Change impact, increasing
132 from 7% in the baseline scenario to 12 %, with a corresponding decrease in the use
133 phase contribution from 90 % to 83 %;
- 134 • For retreaded tyres, achieving a rolling resistance similar to the RR of a tyre in its first
135 life is important to ensure that use phase impacts do not outweigh the retread material
136 savings. In the C3 retread price bracket, a good retread will strongly outperform a
137 similarly priced budget tyre that has higher rolling resistance and a shorter lifetime;
- 138 • If 20 % of tyres are exported to low- and middle-income countries, it can be expected
139 that a majority end up in open burning or environmentally uncontrolled pyrolysis¹. This
140 leads to a significant increase in the end-of-life (EoL) stage impact (PEF single score) of
141 up to 121 % for C1 tyres;
- 142 • When rubber sourcing is associated with deforestation, a difference ranging between 1
143 % and 4 % can be observed across base cases.

144 1.2.2. Problem drivers

145 In **Tasks 1-4**, the following problem drivers were identified that could be addressed under
146 Ecodesign.

147 **Design Features that Hinder Recycling (Inhibitors of Circularity)**

148 Certain tyre design innovations implemented for performance or comfort actively disrupt
149 mechanical and chemical recycling processes at their EoL:

- 150 • Self-Sealing Tyres: Viscous gels applied to plug punctures clog and foul shredder blades
151 in mechanical recycling, increasing maintenance costs for recyclers and contaminating
152 output fractions, or alternatively, meaning these tyres should ideally be sorted out and
153 incinerated instead of recycled;

¹ Though pyrolysis facilities in the EU have been developed that apply emissions control and prevent polluting outputs to the environment, in developing countries, some pyrolysis facilities are similar to open burning in terms of the emissions control applied.

- 154 • Silent/Noise-Reduction Tyres: The polyurethane foam glued inside to dampen cavity
155 noise produces excess fluff during granulation, contaminating the recyclate and
156 negatively affecting the market value of recycling outputs;
- 157 • Tyre pressure management systems (TPMS): These systems contain lithium-ion
158 batteries, which can cause thermal runaway, explosions, and severe fires if not removed
159 prior to shredding;
- 160 • Aramid Fibres: High shares of specific reinforcing materials like aramid fibres cannot be
161 easily cut by standard shredder blades.

162 **Underutilised Retreading Potential**

163 Tyres have a leading circularity success story in the form of the retreading of tyres, which may
164 enable the casing of a tyre to be reused up to 3 times. Provided the retreader uses a high-quality
165 tread for the retreading, such a retreaded tyre can meet similar rolling resistance values to the
166 original tyre. The retreading of tyres results in one third of the waste, enables reuse, and
167 importantly, reduces dependency on critical supply chains outside the EU. In the past three
168 decades. However, cheap single-use tyres have overwhelmed the retreading market for C1 and
169 C2 tyres (currently around 1-2 %, whereas this practice used to be common in the 1990s), and
170 decimated the retreading market for C3 tyres, increasingly challenging and reducing it from 40 %
171 to ~ 20 % in the last decade.

172 While retreading is established for heavy commercial tyres (C3) and offers significant
173 environmental benefits (up to 70 % material savings), it faces major barriers in other segments:

- 174 • Market Competition: A flood of low-cost, lower-quality budget imports (often with
175 narrower widths and lighter casings to reduce rolling resistance) makes retreading
176 economically unviable for passenger (C1) and light truck (C2) tyres, and increasingly this
177 competition is pushing C3 retreaders out of business;
- 178 • Lack of Standardisation: The wide variety of tyre dimensions and casing geometries
179 makes adapting retreading plants technologically and logistically difficult for C1 and C2
180 tyres;
- 181 • No Predictive Testing: There are currently no standardised testing methods or design
182 criteria to pre-assess whether a new tyre's carcass will be suitable and durable enough
183 for retreading after its first life.

184 **Presence of Substances of Concern (SoC)**

185 Legacy and active chemicals in tyres pose risks to human health, the environment, and the
186 viability of secondary raw materials:

- 187 • Polycyclic Aromatic Hydrocarbons (PAHs): Though restricted in extender oils, they are
188 still introduced into the tyre material flow via CB. Their presence restricts the use of
189 recycled rubber in various secondary applications (like playgrounds or turf);
- 190 • 6PPD: Used as an antioxidant/antiozonant, this additive is essential to ensure that a tyre
191 maintains functional performance during its life and that the rubber does not crack
192 when exposed to UV. However, some of its transformation products, such as 6PPD-
193 Quinone, have been linked to acute aquatic toxicity (e.g., mass mortality in salmon);

- 194 • Halobutyl Rubbers: Chlorobutyl and bromobutyl are used in tyre inner liners and cause
195 extensive corrosive damage during tyre pyrolysis as well as lowering the quality of Tyre
196 Pyrolysis Oil (TPO).

197 **Low Uptake of Recycled and Bio-Based Materials**

198 At present, the EU does not have adequate capacity to manage the recycling of all tyre waste,
199 resulting in large volumes being incinerated (co-processing in cement kilns) or exported outside
200 the EU.

- 201 • Mechanical recycling of rubber mostly results in open-loop recycling (e.g., turf infill,
202 asphalt) rather than closed-loop recycling back into new tyres. Planned bans on the
203 usage of downcycled rubber products in children's playgrounds, etc., mean that
204 recyclers expect to have no outlet for around 30% of mechanically recycled rubber in
205 the coming years;
- 206 • Quality Constraints: Pyrolysis produces oil and char, which can be used for CB
207 production:
- 208 - CB from TPO: called sustainable carbon black (sCB), which has a high chance of
209 meeting quality targets and is already used in tyres;
- 210 - CB from char: called recovered carbon black (rCB). Quality is poor as char
211 accumulates ash and other impurities. In addition, it takes a large effort to clean it
212 to make it viable for use in new tyres;
- 213 • Devulcanisation is the closest technology to closed-loop recycling. However, as a
214 relatively recently commercialised technology, capacities are still limited. Here,
215 standards are required to improve quality comparison and uptake across the industry,
216 whilst also avoiding problems with legacy substances;
- 217 • Lack of harmonisation of End of Waste Criteria between countries makes the problems
218 more complex, meaning that recycled rubber products may remain classified as waste,
219 preventing their export across borders for reuse in manufacturing.

220

221 **Supply Chain Risks**

- 222 • The European Union is 100 % dependent on natural rubber imports, which is sourced
223 heavily from smallholder farmers in Southeast Asia and West Africa. This foundational
224 supply faces additional complexity from the strict traceability mandates of the EU
225 Deforestation Regulation (EUDR), which risks creating supply bottlenecks and price
226 inflation;
- 227 • The embargo on Russian CB, which historically supplied approximately 40 % of the EU's
228 total capacity, has severely fractured the supply chain. To bridge this gap, the EU has
229 pivoted towards seaborne imports from China and India, exposing the manufacturing
230 base to global maritime logistics volatility and freight premiums;
- 231 • The EU (+UK) currently exports up to one-third of its collected End-of-Life Tyres (ELTs)
232 to non-OECD nations like India. These exports are largely fed into highly polluting,
233 unregulated, and outdated batch-pyrolysis furnaces and, in some cases, even open

234 burning, while the EU is losing the secondary raw materials (CB, elastomers, steel) it
 235 needs to offset its strategic vulnerabilities.

236 **Information Asymmetry and Lack of Traceability**

- 237 • Recyclers and retreaders currently lack access to information about the chemical
 238 composition or specific design features of an EoL tyre (e.g., knowing if it contains a
 239 battery, sticky gel or aramid fibres, foam, or restricted chemicals). This leads to
 240 contaminated recyclate streams, safety hazards, and increased maintenance costs in
 241 waste management facilities;
- 242 • End-users lack reliable, standardised metrics such as tyre durability, expected mileage,
 243 and abrasion rates to make environmentally informed choices. Tyre replacement
 244 purchase decisions are often driven by costs, not by rolling resistance performance and
 245 related savings in fuel consumption.

246 **Competition with single-use budget tyres**

247 Tyres sold in the budget, single-use segment have risen strongly in the EU in recent years, with
 248 strong increases in imports. While these tyres meet minimum market entry and safety
 249 requirements, compared to a more expensive tyre, they may have a range of deficiencies:

- 250 • Higher abrasion rates, increasing microplastics emitted to the environment;
- 251 • Lower quality casings make retreading difficult or impossible after first life, reducing
 252 circularity options;
- 253 • Lower classes of rolling resistance and/or wet grip performance, leading to higher use
 254 phase emissions;
- 255 • Lower service lifetime, durability, or reliability requiring earlier replacement, leading to
 256 higher waste generation.

257 **1.3. Overview of Design Options**

258 The design options were determined based upon the initial circularity assessment and the
 259 findings from tasks 1-4 relating to BAT, substances and components known to be problematic
 260 for different recycling routes and addressing the problem drivers listed in §1.2.2.

261 According to the standard MEERP Methodology, the BAT and Best Not (yet) Available Technology
 262 (BNAT) form the basis for the Design Options. As discussed in Task 4, it is challenging to define
 263 BAT for tyres, since they are normally optimised for specific applications. Design options were
 264 defined based on the potential to address the problem drivers listed above. These design options
 265 were shared with stakeholders for commenting and the collection of views.

266 **Table 1-1: Overview of considered design options.**

Design option no.	Short title	Brief description of the design option
DO-01	Recycled Content Targets	Mandate a minimum percentage of recycled materials in new tyres.

Design option no.	Short title	Brief description of the design option
DO-02	Design for Recycling - restriction of hindering materials	Restrict or phase out materials that contaminate recycling streams or pose safety risks during shredding: Self-sealing gels, Silent tyre foams, TPMS batteries, Aramid fibres, Bromobutyl and chlorobutyl rubber.
DO-03	Design for Recycling - information on materials that affect recycling options	Disclosure of materials in tyre (DPP) to enable sorting for suitable recycling routes for devulcanisation, pyrolysis, mechanical recycling: Substance ratio: rich or poor in silica, rich or poor in chlorobutyl (possibly also bromobutyl) rubber, presence of components from DO-02 (yes/no): self-sealing gels, silent tyre foams, TPMS batteries, aramid fibres. Grade of antioxidant/antiozonant. Introduce binding maximum content thresholds for Pb and Cd from ZnO suppliers
DO-04	Removal of extrusion spikes before sale	Mandate the removal of extrusion spikes from tyre tread prior to sales. Apply this DO to all tyres sold in the EU (not only C1, C2 and C3).
DO-05	Minimum Bio-based/Renewable Content	Set targets for the inclusion of bio-based materials to replace fossil-based synthetic rubbers and fillers with bio-based alternatives, such as silica from rice husk and alternative bio-rubbers.
DO-06	Rolling Resistance Limits	Tighten the minimum threshold for Rolling Resistance Coefficients (RCC), effectively banning the lowest energy classes (e.g., banning current Class E or D).
DO-07	Abrasion Limits (Microplastics)	Set maximum abrasion limits (mg/km) for tyres to reduce microplastic pollution and implicitly extend tyre life. Euro 7 will introduce abrasion limits. The 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 (ESPR) could set more ambitious tiers or complementary requirements.
DO-08	Support Retreading of C3 Tyres	Introduce the following measures for C3 tyres which support the uptake of high-quality retreading vs. budget tyres in the same price segment.
DO-09	Standardisation of C1/C2 tyre Dimensions for Retreading	Limit the number of non-standard tyre sizes or harmonise dimensions to facilitate retreading in C1 and C2 markets, where there are currently over 1,200 dimensions.
DO-10	Mileage Extension	Introduce a lifetime rating added to the label based on initial tread depth and abrasion indicator
DO-11	Criteria for Reuse	Set strict performance criteria for a tyre to be sold as "second-hand" in the EU. This would formalise the reuse market and clearly distinguish it from waste.
DO-12	DPP	Mandate a DPP tracking of substances of concern and use-phase events. This is the enabler for declaring substances for sorting, recycling and supporting retreading. It could also support reuse and export controls.

Design option no.	Short title	Brief description of the design option
DO-13	Substances of Concern (Chemicals)	Information requirements, substitution or restriction of various chemicals that pose problems in recycling or reuse processes (e.g. Bromobutyl rubber, 6PPD (Registration, Evaluation, Authorisation and restriction of Chemicals (REACH) underway), PAH limits in CB, cobalt salts (Critical Raw Material dependency), labelling of legacy substances in DPP.
DO-14	Design for Repair	Inner liners must be compatible with standard cold/hot vulcanisation patches; ban internal sealants that prevent patch adhesion.

267 The new ESPR methodologies propose to consider Design Options under five dimensions to
 268 enable capturing changes to the tyre product-service system, rather than focusing primarily on
 269 energy consumption during the use phase (as is the case in the original MEErP) (Magrini et al.,
 270 2025). These dimensions are as follows:

- 271 1. Product Material (e.g. substituting or removing hazardous substances, increased use of
 272 recycled or bio-based content);
- 273 2. Product Architecture (e.g. easy removal of components, retreadable tyres);
- 274 3. Product Service (e.g. offering extended warranties or retreading/regrooving services);
- 275 4. Product Business Model (e.g. tyres as a service per km driven);
- 276 5. Product Ecosystem (e.g. take-back and recycling infrastructure).

277 These dimensions are considered with the individual design options to ensure that possible
 278 trade-offs or conflicts are spotted early and taken into account. The design options should then
 279 be grouped into pathways, where design options in one pathway do not come into conflict with
 280 each other. The Design Options are therefore categorised under the following pathways:

281 **Path A: Closing the loop**

- 282 • DO-01 Recycled Content Targets;
- 283 • DO-02 Design for Recycling - restriction of hindering materials;
- 284 • DO-03 Design for Recycling - information on hindering materials.

285 **Path B: Bio-Transition**

- 286 • DO-05: Minimum Bio-Based / Renewable Content

287 **Path C: Lower impacts in the use phase**

- 288 • DO-04 removal of extrusion spikes at first use;
- 289 • DO-06 Rolling Resistance (Out of Scope);
- 290 • DO-07 Abrasion Limits (Out of Scope);
- 291 • DO-14 Design for Repair (low quantification priority).

292 **Path D: Life Extension**

- 293 • DO-08 Retreadable Tyres;
- 294 • DO-09 Standardisation of C1/C2 Tyre Dimensions for Retreading;

- 295 • DO-10 Extended Mileage through Potential Mileage Index indicator;
296 • DO-11 Criteria for reuse (low quantification priority).

297 **Enablers:** DO-12 DPP across all life stages, DO-13 SoC Information Requirements (low
298 quantification priority).

299 1.4. Design Options not considered in quantitative 300 assessment

301 According to the MEErP Methodology, it is necessary to prioritise Design Options for the
302 quantitative assessment.

303 In the overview list shown in Table 1-1, a large number of design options and related measures
304 can be implemented to target identified problem drivers, however, their impact is not always
305 straightforward to quantify. In addition, some of the design options are already (or in the course
306 of being) regulated under existing legislation making it important to avoid duplication of
307 requirements under ESPR. In a first step, design options were therefore analysed based on their
308 potential for regulation under ESPR based on:

- 309 • Effectiveness and existence of other legislation targeting same issue,
310 • Falling under the mandate of Ecodesign (when placed on market),
311 • Possibility to define quantitative impacts to the Bill of Materials and lifecycle stages.

312 In cases where it was concluded that the DO is already covered by other legislation, where it
313 would be more appropriate for the DO to be covered by other legislation or where the DO could
314 not be covered by ESPR, an initial analysis explaining why has been included in this section.

315 Several of the gaps identified here may still be relevant for the definition of specific measures
316 to be undertaken and assessed under Task 7, with highest relevance being the Digital Product
317 Passport which is assessed in more detail in section 2. Nonetheless, as quantification of impacts
318 would not be practical they have been included in this section.

319 1.4.1.1. DO-06 Rolling resistance limits

320 The LCA modelling in Task 5 confirms that the highest environmental impacts occur in the use
321 phase. Consequently, regulating rolling resistance under design options emerges as a priority.
322 Rolling resistance is, however, currently already regulated under UN R117 (UNECE R117, 2025),
323 and the current limits for C1, C2, and C3 tyres are being advanced at the current time. To
324 determine whether or not further design options could be appropriate here, it is necessary to
325 analyse whether:

- 326 • Existing limits under UN R117 go far enough;
327 • Any relevant gaps appear under UN R117.

328 In the EU, stage 1 limits on rolling resistance have applied since 2011. From November 1st, 2020,
329 all vehicle tyres were required to meet stage 2 obligations of UN Regulation No. 117 complying

330 with the RRC limits shown in **Table 1-2**. This essentially removed tyres with label E from the
 331 market but provided provisions for 1 N/kN higher for snow tyres, which could then still have an
 332 E label.

333 **Table 1-2: Stage 2 Limits under UN Regulation No. 117.**

Tyre Class	Max Value RRC (N/kN)	Corresponding EU Tyres Label Class
C1	10.5	D: $9.1 \leq \text{RRC} \leq 10.5$
C2	9.0	D: $8.1 \leq \text{RRC} \leq 9.0$
C3	6.5	D: $6.1 \leq \text{RRC} \leq 7.0$

334 Source: (UNECE R117, 2016) Article 6.3 <https://eur-lex.europa.eu/eli/reg/2025/1453/oj/eng>, (EU Regulation
 335 2020/740, 2020) Annex 1 Part A: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32020R0740>. For
 336 snow tyre that is classified as tyre for use in severe snow conditions, the limits shall be increased by 1 N/kN.

337 The 04 series of amendments to UN R117 entered into force on 10 January 2025. These
 338 introduced stage 3 limits for rolling resistance, as shown in **Table 1-3**.

339 **Table 1-3: Stage 3 Limits under UN Regulation No. 117.**

Tyre Class		Max Value RRC (N/kN)	Corresponding Label Class	Application Date	
C1	Load capacity index < 87	10.5	D: $9.1 \leq \text{RRC} \leq 10.5$	From 7 th July 2026	
	Load capacity index ≥ 87	Tyres other than Run Flat Tyres or Extended Mobility Tyres			9.0
		Tyres with a nominal aspect ratio ≤ 40 and suitable for speeds ≥ 300 km/h			10.0
		Run Flat Tyres or Extended Mobility Tyres			10.0
	Special use tyres	10.0			
C2	Tyres other than Traction tyres	8.5	D: $8.1 \leq \text{RRC} \leq 9.0$	From 1 Sep 2028	
	Traction tyres	9.0			

Tyre Class		Max Value RRC (N/kN)	Corresponding Label Class	Application Date
C3	Tyres other than tyres marked with “C”, “CP” or “LT”	6.0	5.1 ≤ RRC ≤ 6.0 D: 6.1 ≤ RRC ≤ 7.0	From 1 Sep 2028
	Tyres marked with “C” or “CP” as suffix to the tyre-size designation or with “LT” either as prefix or suffix to the tyre-size designation or with “LT” placed after the service description	6.5		

340 Source: (UNECE R117, 2016)Article 6.3 <https://eur-lex.europa.eu/eli/reg/2025/1453/oj/eng>, (EU Regulation
341 2020/740, 2020) Annex 1 Part A: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32020R0740>. For a
342 snow tyre that is classified as a tyre for use in severe snow conditions, the limits shall be increased by 1 N/kN.

343 As can be seen in **Table 1-3**, once Stage 3 shall apply on 7th July 2026 for C1, mainstream
344 passenger-car tyres (Load Index ≥ 87, not run-flat/extended mobility) shall need to have RRC
345 that would be EU label class C or better. For C2 and C3 tyres, stage 3 will apply from September
346 1st, 2028, bringing the maximum rolling resistance into the mid-point of the current D class for
347 the majority (non-traction) of C2 tyres, and bringing C3 tyres into the current C class for C3 tyres.

348 Current testing provisions on rolling resistance under UN R117 only test the tyre when new,
349 which generally gives an indication on the rolling resistance performance over its lifetime. As
350 the tyre gets worn done, rolling resistance usually decreases. Changes to the rubber during aging
351 processes may affect this. Of more importance is the safety performance when worn, and the
352 04 series amendments introduced testing of wet grip performance in a worn state to ensure
353 safety throughout the lifecycle.

354 These regulatory processes are well established and internationally approved, while significant
355 new limits on rolling resistance are scheduled to enter into force during the next two years. For
356 this reason, it is concluded that the current Regulation under R117 is sufficient and it is
357 unnecessary to pursue tighter use phase rolling resistance limits for new C1, C2, C3 tyres under
358 ESPR.

359 A gap was identified relating to retreaded tyres. Currently, retreaded tyres are subject to safety
360 requirements under UN Regulation No. 108 (C1 tyres) and UN Regulation No. 109 (C3 tyres).
361 There are no corresponding requirements to test rolling resistance. Several manufacturers and
362 retreaders do test rolling resistance and have shown that their retreads meet similar rolling
363 resistance to the original tyre. Here, the casing rolling resistance is of the highest importance,
364 followed by the tread and to a lesser extent, the retreading process itself. Over the past several
365 years, a study has been carried out to establish a retreading tyre label, which would provide
366 transparency for buyers in the retreading market². Without this in place, retreaders are currently
367 at a disadvantage since public procurement may be required to take tyres in a certain label class.

368 Once a retreading label is determined, retreaded tyre rolling resistance requirements might be
369 developed. At the current time, such requirements would likely be counterproductive, since the

² Results on the retreading label have not been published. The latest information is available here: <https://www.retreadedtyrelabel.eu/>.

370 industry is under fierce market pressure caused by budget imports and not all retreads are used
371 in situations where rolling resistance plays a significant role (e.g. waste collection fleets).

372 1.4.1.2. DO-07 Abrasion limits

373 Another key area that has been regulated already is abrasion performance, via the Euro 7
374 regulation. This applies only to C1, C2, and C3 tyres, which also form, for now, the main base
375 cases. Since abrasion is already regulated, further abrasion requirements under ESPR would be
376 a duplication.

377 1.4.1.3. DO-11 Criteria for Reuse

378 In Task 3, it was found that currently there are no unified criteria across Europe on selling tyres
379 for reuse. While some countries have voluntary standards or some basic rules in place, much
380 happens in unregulated markets. A clearer definition of re-usable tyres could formalise the reuse
381 market to improve tyre lifetimes by setting strict performance criteria for a tyre to be sold as
382 "second-hand" in the EU. This would formalise the reuse market and clearly distinguish it from
383 waste and could support avoiding exports of waste tyres as "re-usable".

384 However, setting requirements at the reuse stage may not be compatible with the ESPR legal
385 framework, which regulates only products when they are "PoM". Second-hand products were
386 already PoM as new in the past and are not "PoM" again when sold as used. In which case, this
387 should be addressed under an End-of-Waste criterion, possibly unified at the EU level.

388 Nevertheless, through the DPP sorting and assessment, reuse could be logged in the tyre's life-
389 cycle status. It could be envisaged, for example, that after an accident, a tyre is logged as not fit
390 for reuse or that a tyre has been assessed and sent to reuse. Upon export, customs officials could
391 also scan the tyre; if the digital status is 'EoL', export could be blocked regardless of visual
392 appearance.

393 Logging such an event in the DPP could be linked to the application of a reuse standard at
394 certified reuse assessment and sorting centres. Due to the likely difficulties in regulating a used
395 product under ESPR, criteria for reuse are provisionally considered out of scope for the
396 quantitative assessment of the design option. However, the option to include such requirements
397 in the DPP development lifecycle shall be assessed with the DPP DO (see **Section 2**).

398 1.4.1.4. DO-12 Digital Product Passport

399 In the design options, the DPP is implicitly incorporated as an enabler for lifecycle stages,
400 supporting the other Design Options. It is therefore deemed unnecessary to quantify specific
401 impacts from the DPP and see instead the other Design Option savings as being facilitated by
402 the DPP. In particular the DPP can play a role in:

- 403 • Supporting Market Surveillance across all life stages;

- 404
- 405
- Tracking lifetime events such as casing age, repair, or accidents during use phase, sorting for reuse, retreading, and end of life pathways;
- 406
- Content Declaration: List presence of substances that are relevant for recycling (silica/aramid fibres/self-sealing gels/TPMS) to aid recyclers in sorting for devulcanisation, pyrolysis, granulation, or co-processing in cement kilns;
- 407
- 408
- Reuse and/or Retreadability Status: Digital log of casing age and previous repairs, or accidents to validate safety for retreading;
- 409
- 410
- Substances of Concern: Flagging specific additives (e.g., 6PPD) that might restrict EoL applications.
- 411
- 412

413 It is expected that any DPP solution, should it come forward, would be addressed via a radio-
414 frequency identification (RFID) chip. This would mean a minor change in the BoM but is not
415 significant enough to warrant full modelling.

Question to stakeholders:

Is it possible that an RFID chip can hinder any recycling techniques (mechanical, pyrolysis, devulcanisation)?

To what degree are alternative data carriers considered appropriate (e.g., labelling on inner tyre sidewall)?

416

417 **1.4.1.5. DO-13 Substances of Concern (Chemicals)**

418 Design Option DO-13 aims to determine potential measures that could apply to substances of
419 concern from a chemical perspective, while the design for recycling DO-2 and DO-3 focus on
420 materials and components that hinder recycling.

421 In task 5, the substances of concern assessment (see task 5 annex) considers all substances in
422 tyres from different perspectives. Under ESPR, the following SoCs are relevant:

423 According to Article 2(27) of the ESPR, a ‘Substance of Concern’ means:

424 “A substance that:

- 425
- a. meets the criteria laid down in Article 57 of Regulation (EC) No 1907/2006 [REACH] and is identified in accordance with Article 59(1) of that Regulation;
- 426
- b. is classified in Part 3 of Annex VI to Regulation (EC) No 1272/2008 [Classification, Labelling and Packaging Regulation] under relevant categories.
- 427
- 428
- c. is regulated under Regulation (EU) 2019/1021 [Persistent Organic Pollutants Regulation]; or
- 429
- d. negatively affects the reuse and recycling of materials in the product in which it is present.”
- 430
- 431
- 432

433 Article 7(5) sets out requirements on tracking potential SoCs throughout the product lifecycle.
434 For a full analysis of the relevant chemicals, please see the SoC assessment in the separate Task
435 5 report annex. Measures that could be taken forward on chemicals apply to information
436 requirements on the following to support tracking through the lifecycle (via DPP):

437 Table 1-4: Overview of SoC measures (Chemicals)

SoC	DO Description	Detail	Proposed action	Challenges
SoC-01	Restriction or Phase-out of Bromobutyl Rubber	Halobutyls (chlorobutyl/bromobutyl) are used in inner liners for air retention. Problem: They cause "extensive damage via corrosion" to pyrolysis reactors and contaminate TPO, making it harder to use as a chemical feedstock.	Proposed Action: A stakeholder explicitly suggested "prohibiting the bromobutyl compounds which are more problematic" while minimizing chlorobutyls to the essential minimum.	Banning bromobutyl and reducing concentrations of chlorobutyl might affect the air retention capability of the tyre (impacting safety and rolling resistance).
SoC-02	Substitution of 6PPD (Anti-degradant)	6PPD is used to prevent tyre cracking. Its transformation product (6PPD-quinone) is linked to "acute mortality" in aquatic species (e.g., coho salmon).	While a REACH restriction is in progress, ESPR could incentivise uptake of "non-toxic anti-ozonants" to accelerate the shift to alternatives, as this is currently a major environmental hotspot for tyre wear particles.	Current alternatives to 6PPD are still under development and a full substitution is likely not possible immediately. 6PPD performs essential functions relating to protecting rubber during tyre lifecycle from UV degradation - lack of a viable alternative could lead to tyres that crack and fail faster (safety risk).
SoC-03	PAHs in CB	Current REACH restrictions limit PAHs in extender oils but not strictly in CB inputs. Consequently, recycled rubber often fails to meet strict PAH limits for consumer products (e.g., playground infill) because the original tyre contained "compliant" but high levels of PAHs.	Set a maximum PAH threshold for all CB used in new tyres to ensure the resulting EoL granulate is safe for downstream recycling. Possibly action is necessary under REACH Regulation instead of ESPR (i.e., revision of REACH Annex XVII entry 50).	Ensures recycled rubber (granulate) is safe for use in consumer products (e.g., playgrounds), preventing "legacy substance" recirculation.

SoC	DO Description	Detail	Proposed action	Challenges
SoC-04	Cobalt Salts	Cobalt is a Critical Raw Material and a potential SoC used to bond rubber to steel cords. Cobalt salts are currently investigated under REACH for a possible restriction.	Incentivise or mandate the use of alternative adhesion systems (e.g., resin-based or novel coatings) to reduce dependency on a critical and potentially hazardous raw material.	Though substitutes are understood to be in development, market readiness is not ensured. A restriction would affect tyre functionality.
SoC-05	Hazard Flagging of Legacy Substances in DPP	By the time a tyre becomes waste (5-10 years later), substances allowed at the time it was PoM might be banned. Recyclers currently cannot identify these "legacy substances".	Mandate that the DPP includes a "Substances of Concern Declaration" that is retroactively updated once a substance is restricted, in the DPP of all tyres PoM that contained that substance when newly manufactured. If a substance is restricted in the future, the DPP flag updates, warning the recycler to divert that specific tyre from material recycling (e.g., to energy recovery).	Threshold values need to be defined.
SoC-06	Restriction of use of substances used in sticky gel sealing materials	Sticky gels used in self-sealing tyres damage shredding equipment and affect the quality of recycling outputs. Run-flat tyres (RFT) provide the same safety function without creating the operational and safety issues, demonstrating that viable alternatives exist.	Restrict the use of constituents in sticky gel that lead to the gels causing damage to equipment and affecting recycle quality.	Though an alternative technology is available, it needs to be reviewed if RFT can provide equivalent function and how this would impact consumer costs and tyre performance (e.g., lifetime).

439 Under the new ESPR methodology, measures that ban certain substances must suggest
440 appropriate substitution options. These do not yet appear to be feasible for chemicals such as
441 6PPD, while the actual amount of chemicals left in such tyres at the end of life can be highly
442 variable. In a few cases, regulatory action is under consideration under REACH, which is
443 understood to be the proper legislation as for these cases, action is argued based on chemical
444 safety. For bromobutyl rubber and constituents of sticky gel sealing materials, a restriction is
445 proposed and considered under DO-02. Similarly, for chlorobutyl rubber, amounts used in
446 rubber liners should be reduced to a minimum, suggesting that a maximum content threshold
447 is determined to ensure minimum functionality is maintained. These measures are considered
448 under DO-03.

449 Information requirements suggested here are proposed to be limited to binary information
450 requirements where possible (contains yes/no, which component) and to apply to Article
451 27(2)(a,c and d) SoCs. In a few cases, a threshold shall be defined for specifying if a tyre is rich
452 or poor in relation to the content of a specific substance (i.e., silica, chlorobutyl). Since
453 information requirements would be implemented under a possible DPP, and likely do not
454 strongly alter material composition, the quantitative impacts are not modelled further here.
455 Further discussion and explanation of potential requirements are covered in the Task 5 annex
456 SoC report.

457 1.4.1.6. DO-14 Design for Repair

458 In discussions with stakeholders in tasks 1-4, repair did not come up as the major driver for tyre
459 lifetime extension in current practice. For more robust C3 tyres, repairs may be carried out
460 during the lifetime of the tyre or as part of the retreading process.

461 Potential design options might be:

- 462 • inner liners must be compatible with standard cold/hot vulcanisation patches;
- 463 • ban internal sealants that prevent patch adhesion;
- 464 • promote use of self-sealing gels.

465 It is not clear to what extent C1 and C2 tyres are currently repaired rather than exchanged for
466 new tyres upon the occurrence of damaging events. Such measures may require the definition
467 of "repairability" for a tyre.

468 A potential conflict occurs through the fact that "Self-sealing" tyres technically improve
469 "repairability" (functional recovery) but hinder "recyclability". In discussions with stakeholders,
470 some also indicated that self-sealing gels can be more of a temporary solution and warned that
471 end users may not notice punctures and keep driving when it is not safe to do so.

472 It is assumed that any impacts from reparability measures would be to increase the lifetime of
473 the tyre by a certain percentage, whilst also raising lifetime servicing costs.

Question to stakeholders:

Is there a need to improve reparability at the current time for C1, C2 or C3 tyres?

By what percentage could this affect the lifetime of an average tyre in the market?

474

475 **1.5. Technical Analysis of Quantifiable Design Options**

476 The remaining design options are considered to be of relevance for modelling impacts in the LCA
477 since they do not duplicate existing provisions in other legislation, or the modelling of such
478 impacts can be better quantified. The quantifiable input parameters for the LCA modelling are
479 via changes to the Base Case BoM (production inputs), the use phase, or EoL pathways. Market
480 impacts, standards, verification methods and ambition levels are analysed/modelled in Task 7
481 where relevant.

482 **1.5.1. Path A: Closing the Loop**

483 In this pathway, design options are considered that support improved recycling and uptake of
484 recyclates in new tyres.

485 **1.5.1.1. DO-01 Recycled Content**

486 This design option would require tyre manufacturers to meet mandatory minimum
487 recycled-content levels. It would entail incorporating devulcanised rubber and recovered
488 Carbon Black (CB) from tyre pyrolysis into the rubber compound and using recycled polyethylene
489 terephthalate (PET) or steel in reinforcing components, while still complying with all applicable
490 performance and safety standards.

491 **Environmental benefit:** Recycled materials can deliver significant environmental benefits in the
492 manufacturing and end-of-life stages. The environmental performance of each recyclate is
493 material-specific, and recycled content is not inherently more sustainable than virgin inputs.
494 Evaluation through an LCA is therefore essential.

495 **Rationale:** A range of recycled materials is already available for tyre manufacturing and,
496 provided supply and quality are sufficient, can substitute substantial portions of virgin raw
497 materials. In total, up to approximately 30–40 % of the rubber compound in an average C1, C2
498 or C3 tyre can theoretically be replaced with recycled material, comprising around 20–25 % from
499 rCB/sCB and 10–15 % from devulcanised rubber. These values represent theoretical upper limits
500 under current technological conditions, and actual feasible rates will depend on material quality
501 and supply stability. There is currently insufficient demand within the EU for recycled tyre
502 materials (granulate, steel, pyrolysis oil), making it cheaper to export waste tyres than to recycle
503 them domestically. By mandating that new tyres sold in the EU must contain, for example, 20 %
504 post-consumer recycled content (e.g., recovered CB or recycled rubber), ESPR supports

505 utilisation of the ELT waste stream. This should give ELT recycling outputs a monetary value in
506 Europe, incentivizing domestic retention and processing rather than export.

507 **Proposed implementation:** Separate post-consumer recycled-content targets are set for rubber
508 compounds and reinforcement materials, starting modestly and increasing over time³:

- 509 • Reinforcement (steel, textiles, etc.), e.g.: 50 % in 2032; 60 % by 2035; 80 % by 2040;
- 510 • Rubber compound, e.g.: 5 % in 2032; 10 % by 2035; 20% by 2040.

511 **Challenges & Trade-offs:** Achieving these targets requires managing feedstock availability,
512 purity variations, and potential cost premiums.

513 **Quantification of impacts**

514 The following assumptions for the modelling of this design option were made for rubber
515 compounds:

- 516 • Devulcanised Rubber: a partial substitute for virgin elastomer (rubber polymer), while it
517 may only partly and inconsistently offset some filler and process oil demand and
518 generally does not reliably replace the controlled curing system and other additives
519 needed to meet performance and safety specs;
- 520 • Micronised Powder: Assumed to act as a Diluent (Filler) only, not replacing active
521 polymer network;
- 522 • Reclaimed Rubber: partial substitute for rubber polymer, with a small and uncertain
523 potential to offset filler and process oil demand. Does not reliably replace the curing
524 system and other additives.

³ See Task 7 for an analysis of target setting.

525 Table 1-5: Overview of tyre recyclates and their composition impacts.

Recycled Input Type	Primary Target Component	Technology Readiness Level (TRL) (1-3= Research; 4-6=Development; 7-9 Deployment)	Max. Technically feasible by 2030 (% by weight, single tyre)	Active assumed impact on BoM entries (given a tyre compound composition of 60 % rubber, 30 % filler and 10 % additives)	Impact on performance (quantify, if possible, e.g. on RCC /durability /grip)
Devulcanised Rubber	Tread: up to 20 % Sidewall: up to 10 % Body ply: up to 30 % Bead base: up to 40 %	Deployment	Up to 20 % of the rubber compound, especially for post-industrial rubber compounds; post-consumer ELT may contain legacy contamination	1 kg Devulcanised Rubber substitutes: • 0.50–0.60 kg of virgin polymer, depending on the incoming stream (Natural Rubber / Styrene-Butadiene Rubber / Butadiene Rubber mix) • 0.20–0.30 kg of CB, representing rCB carried over from the original compound	No impact expected, provided compounds are properly rebalanced.
Reclaimed Rubber	Inner Liner / Apex	Deployment	<5 % of rubber compound	1 kg Reclaimed Rubber substitutes: 0.50 kg virgin rubber polymer 0.2-0.30 kg filler 0.025 kg process oil 0 kg of other additives/curatives	Potential Risk: Reinforcement consistency.
Micronised Rubber Powder (<450µm)	Filler (General)	Deployment	<5 % of rubber compound	Acts as inert filler (diluent).	Potential Risk: Tensile strength reduction.
rCB (sCB and potentially rCB)	Sidewall / Carcass	sCB: Development/Deployment rCB: Research	Up to 100 % of CB if quality allows (<i>N600/N700 grades</i>)	1:1 Carbon Black	Potential Risk: Thermal stability / Heat generation.

Recycled Input Type	Primary Target Component	Technology Readiness Level (TRL) (1-3= Research; 4-6=Development; 7-9 Deployment)	Max. Technically feasible by 2030 (% by weight, single tyre)	Active assumed impact on BoM entries (given a tyre compound composition of 60 % rubber, 30 % filler and 10 % additives)	Impact on performance (quantify, if possible, e.g. on RCC /durability /grip)
Recycled Steel (Electric Arc Furnace route)	Bead Wire / Steel Belts	Deployment	up to 100 % of steel	1:1 Steel	Potential Risk: Fatigue resistance (wire breakage).
Recycled Polyester (r-PET)	Carcass Plies / Capping	Deployment	up to 100 % of textiles	1:1 Polyester / other textiles	Potential Risk: Thermal stability / Heat generation.

526

527 Table 1-6: BoM assumptions for a C1 tyre meeting recycled content targets 5 % rubber compound, 50 % reinforcement materials.

Material	Material Composition (kg)							
	Original Composition	devulcanised rubber	CB	micr. rubber	recl. rubber	rPET	Recy. steel	adjusted composition
Rubber Compound Primary Materials								
Natural Rubber	1.408	-0.049			-0.003			1.355
Synthetic Rubber	2.031	-0.071			-0.005			1.955
Silica	1.082	-0.024			-0.002			1.056
CB. virgin	1.408	-0.0746	-0.08	-0.017	-0.006			1.226
Zinc Oxide (ZnO)	0.123							0.123
Sulfur	0.096							0.096
Stearic Acid	0.057							0.057

Material	Material Composition (kg)							
	Original Composition	devulcanised rubber	CB	micr. rubber	recl. rubber	rPET	Recy. steel	adjusted composition
Benzothiazoles-sulfonamides (DBCS. CBS. TBBS. CTP. TQM)	0.089							0.089
Amines and plasticisers (6PPD. DPG. BENPAT. DMBC)	0.167							0.167
Oils	0.247				-4E-04			0.247
Waxes	0.077							0.077
Alkylphenols (PTOP. PTBP)	0.011							0.011
Phenolic resins. including resorcinol. HMT	0.019							0.019
Cobalt Organic Salts	0.017							0.017
Reinforcement Materials								
Steel Belts. (0.5 % of weight from coating: 66 % Copper. 34 % Zinc)	0.663						-0.43	0.234
Steel Bead wire (0.5 % of weight from coating: 98 % Brass. 2 % Tin)	0.327						-0.21	0.116
Polyester cord fabric	0.182					0.04		0.146
Rayon cord fabric	0.086							0.086
Nylon cord fabric	0.088							0.088
Aramid cord fabric	0.001							0.001
Recycled Material Variant								

Material	Material Composition (kg)							
	Original Composition	devulcanised rubber	CB	micr. rubber	recl. rubber	rPET	Recy. steel	adjusted composition
dev. rubber		0.219						0.219
rCB			0.084					0.084
micr. rubber				0.017				0.017
recl. rubber					0.017			0.017
rPET						0.036		0.036
recy steel							0.64	0.640
Total	8.179							8.179
recycled content. reinforcement								50 %
recycled content. rubber compound								4.9 %

Draft for

529 The table above shows an example of how a recycled content rate of 5 % for the rubber
 530 compound and 50 % for the reinforcement materials could be met for a C1 tyre. Calculation
 531 basis for 20 %/80 % targets and for C3 tyres are provided in the annex. In this instance, the
 532 following shares of recycled materials were taken:

- 533 • Devulcanised rubber replaces 3.2 % of the rubber compound (closed loop);
 - 534 • Micronised rubber replaces 0.25 % of the rubber compound (closed loop);
 - 535 • Reclaim rubber replaces 0.25 % of the rubber compound (closed loop);
 - 536 • sCB replaces 6 % of virgin material with recycled material (closed loop);
 - 537 • rPET replaces 20 % of polyester cord fabric (open loop);
 - 538 • recycled steel replaces 65 % of primary steel.
- 539 - These recycled content rates could feasibly be reached through different
 540 combinations of rubber compounds and documented through mass flow
 541 verification or on a global level for a company. The table below shows the options
 542 that were calculated to define recycled content targets of 5 % and 20 % rubber
 543 compound and 50 % or 80 % reinforcement criteria for the base cases C1 and C3.

544 **Table 1-7: Comparison of C1 and C3 assumed recycled content targets via recycling**
 545 **pathways.**

Recycled Content Target	C1		C3	
	5 % Rubb., 50 % Reinf.	20 % Rubber, 80 % Reinf.	5 % Rubb., 50 % Reinf.	20 % Rubber, 80 % Reinf.
devulcanised rubber closed loop	3.2 %	16.0 %	3.2 %	16.0 %
sCB closed loop	6 %	15 %	5.0 %	12 %
rPET open loop	20 %	70 %		-
micronised rubber closed loop	0.25 %	0.5 %	0.3 %	0.5 %
reclaimed rubber closed loop	0.25 %	0.5 %	0.3 %	0.5 %
recycled steel open loop	65 %	96 %	50.0 %	81 %

546 -
 547 The table below shows the percentage of the weight of the recycled content derived from the
 548 recycled steel and polyester in the reinforcement materials and the rubber compound
 549 substitution.

550 **Table 1-8: Base case targets as a percentage of tyre weight.**

Tyre category	Base Case	Recycled content in reinforcement [weight-%]	Recycled content in rubber compound [weight-%]	Total recycled content by weight of tyre
C1-tyre	2032-target: 5 % compound 50 % reinf.	8.3 %	4.1 %	12.4 %
	2040-target: 20 % compound 80 % reinf.	13.1 %	16.7 %	29.8 %
C3-tyre	2032-target: 5 % compound 50 % reinf.	10.2 %	3.9 %	14.1 %
	2040-target: 20 % compound 80 % reinf.	16.5 %	15.9 %	32.4 %

551 To achieve these levels of recycled content, a minimum EoL material throughput is required.
552 Based on the available ELT in Europe and output process efficiency, the following impacts on the
553 EoL pathways were calculated versus the current EoL scenario to meet the C1 targets:

554 **Table 1-9: EoL pathways required to meet recycled content targets (C1, C3 – weighted**
555 **average).**

EoL Pathway	Status Quo (2025)	5 %, 50 % Target	20 %, 80 % target
Mechanical recycling (granulation) ⁴	40.1 %	~35 %	~25 %
Incineration in cement kiln	48.8 %	~45 %	~25 %
Pyrolysis	7.2 %	~10 %	~20 %
Devulcanisation	0.5 %	~5 %	~30 %
Micronised rubber	0.0 %	<0.5 %	<1 %
Reclaimed rubber	0.0 %	<0.5 %	<1 %
Civil engineering/backfilling/public works	3.3 %	3.3 %	3.3 %

556 Closing the loop on rubber compounds requires large changes in supply coming from
557 devulcanisation. Increasing the supply capacity of devulcanised rubber may initially be
558 constrained by the limited availability of suitable recycled rubber feedstock, particularly
559 materials with a relatively high natural rubber content.

⁴ Not including mechanical pre-treatment required for pyrolysis, devulcanisation, micronised/reclaimed rubber.

560 At present, the ELT recycling market has largely developed to meet the demand of other
561 downstream applications (e.g. rubber granulates and powders for civil engineering, sports
562 surfaces, or other material recovery uses). As a result, existing collection, sorting and processing
563 practices are not always optimised to produce recycled rubber streams specifically suited for
564 devulcanisation.

565 Although devulcanisation technologies have reached a reasonable level of technical maturity,
566 the absence of widely recognised technical standards remains a barrier to broader industrial
567 adoption. In particular, the lack of reference specifications for devulcanised rubber (e.g. quality
568 parameters, performance characteristics, or testing methods) makes it more difficult for tyre
569 and compound manufacturers to integrate these materials into tyre formulations with
570 confidence. This situation also reflects a broader knowledge and skills gap along the value chain,
571 including among compound manufacturers, who need to further develop expertise in the
572 formulation and optimisation of rubber compounds incorporating devulcanised materials.

573 In the short term, a rapid increase in demand for devulcanisation-grade feedstock could
574 therefore lead to a temporary supply constraint. However, this limitation is mainly structural
575 and market-driven rather than technical. It could be addressed through improved sorting and
576 logistics for ELTs and related rubber waste streams. For example, selective processing of certain
577 tyre categories (e.g. truck and bus tyres – C2) or improved collection and segregation of
578 retreading buffing material could significantly increase the availability of suitable feedstock.
579 These adjustments are currently limited mainly by weak market demand but could be
580 implemented relatively quickly if demand increases.

581 In terms of impacts for the use phase, current BAT shows the ability to develop tyres using these
582 materials, which have a high rating for rolling resistance and wet grip, making it likely that
583 technical innovations can achieve equivalent performance to existing tyres.

584 1.5.1.2. DO-02/DO-03 Design for Recycling - restriction or information 585 requirements on materials that hinder recycling

586 This design option aims to support recycling through restricting the presence of materials that
587 hinder the recycling of tyres or where not possible for safety reasons, introduction of
588 information requirements on presence, location and in some cases also instructions for easy
589 removal of materials and substances that hinder recycling.

590 DO-02 considers a restriction on the use of such materials, while DO-03 aims for information
591 requirements to support sorting for recycling.

592 **Environmental benefit:** Information on the inclusion of materials and components in tyres that
593 obstruct recycling supports the sorting out of such tyres from certain waste treatment routes
594 and where feasible, restriction of use of such materials or their removal from the tyre prior to
595 further processing. This is expected to decrease environmental risks related to the unintended
596 shredding and processing of such elements (environmental impacts of fires, damage to
597 equipment, loss of resources related to damage and maintenance and downtime of equipment,
598 but also impacts related to contamination of waste fractions when such elements remain in the
599 waste flow). Where the restriction of use of materials and components that obstruct recycling

600 is implemented, it shall eliminate the above impacts while also avoiding the fact that such tyres
601 are sorted out of ELT flows sent to recycling. In other words, an increase in the number of tyres
602 available for recycling is expected, as well as an increase in quantity and/or an improvement in
603 the quality of tyre recycling outputs.

604 **Economic benefits:** Elements that obstruct recycling can cause equipment
605 downtime/destruction, resulting in costs of repair and maintenance but also loss of income as a
606 result of increased downtimes. In the case of batteries, these can result in explosions and fires
607 and have an adverse impact on the feasibility of insuring against such events and avoiding
608 related costs incurred by the operator. Sticky gel sealants can also cause heat to build up in
609 shredders, leading to fires. The presence of bromobutyl and chlorobutyl in pyrolysis equipment
610 leads to corrosion and damage to such equipment. When the above materials remain in tyres
611 and tyre granules are sent to treatment, they also affect the quality of recycled output materials,
612 affecting their revenues and, in extreme cases, reducing the marketability of such materials.
613 Avoiding such costs would increase the economic efficiency of waste operations as well as
614 revenues from sales of recycled output materials.

615 **Rationale:** The use of alternatives that are not associated with the above risks (or their
616 development and implementation) should be supported by the legislator, while also creating a
617 disincentive to develop and increase the market of new systems that hold similar risks.

618 The presence of *polyurethane foams* in the ELT recycling mix can lead to clogging, bridging, or
619 jamming of shredding and grinding machines and thus to increased downtime for
620 cleaning/maintenance at recycling plants. In addition, the foam is taken up in the textile fraction,
621 increasing the share of ELT material that cannot be recycled and reducing the overall recycling
622 rate. Where PU particles remain in the rubber fraction, this negatively affects the quality and
623 market value of recycled materials. Though most noise reduction tyres use a foam insert to
624 absorb the noise, new developments are looking at serrated films designed to disturb air flow
625 and reduce noise within the tyre. There are also some companies manufacturing tyre rims that
626 are looking into the development of perforated and textured tyre rims to reduce noise. In
627 parallel, a design to enable quick removal of the foam would not just enable removing PU foams
628 from tyres prior to processing but would also have a positive effect on tyre repair, which cannot
629 be performed in noise reduction tyres without the removal of the foam.

630 *Sticky gel and elastomer self-sealants* adhere to shredding and grinding equipment and lead to
631 increased downtimes for cleaning and replacing blades, as well as to heating up of treated
632 fractions that can result in fires. They further contaminate crumb rubber and can complicate
633 devulcanisation and pyrolysis processes. *Aramid fibres* used in reinforced tyres have similar
634 problems. Alternatives to gels and aramid fibres exist, like solid polymer or film liners, multi-
635 layer membranes and self-healing rubber that may affect the composition of recyclates but are
636 not associated with impacts on shredding equipment. FRT also ensures that a tyre can be used
637 until the driver reaches a tyre dealer and can have the tyre repaired or replaced and does not
638 exhibit the same problems as long as it is not reinforced with aramid fibres.

639 The presence of *lithium batteries* in tyres sent to shredding can induce explosions and fires in
640 shredders, creating heavy damage to equipment, resulting in downtime and related losses.
641 However, in most TPMS, the battery is not in the tyre but rather attached to the tyre valve. It is
642 presumed that such batteries remain in treated fractions when the TPMS sensor is not safely

643 removed from the valve at the depollution stage of end-of-life vehicles. This suggests that
644 information on the location of such batteries and information facilitating easy dismantling could
645 help ensure early removal of such components, avoiding related problems to begin with.

646 *Silica* (HDS) is used as a filler material in tyres for reducing rolling resistance and can reduce tyre
647 abrasion. Some alternatives to HDS and CB exist but are still at a low technological maturity level.
648 Nonetheless, the provision of information on the share of silica content could help in sorting and
649 batching of tyres for specific treatment processes.

650 **Proposed implementation:**

651 DO-02 Performance requirements (Restrictions or phase out):

- 652 • For sticky gel sealing materials used in self-sealing tyres, a prohibition of use is under
653 consideration. This could be associated with SoC if the substances could be identified.
654 Alternatively, a ban on self-sealing tyres should be considered. This is recommended
655 due to the understanding that RFT provides the same safety function without creating
656 the operational and safety issues associated with self-sealing sealants, demonstrating
657 that viable alternatives exist;
- 658 • Chlorobutyl rubber and bromobutyl rubber are both used in inner liners of tyres.
659 Bromobutyl has been referred to as more problematic than chlorobutyl and is proposed
660 to be restricted for use in tyres. The concentrations chlorobutyl in tyre materials should
661 be limited as far as possible. A preliminary threshold of 3 % is proposed as an upper limit
662 for use in new tyres;
- 663 • To minimise the content of cadmium and lead compounds in tyres, it is proposed to
664 introduce a binding maximum content threshold for Pb and Cd from ZnO suppliers.

665 All performance requirements should apply after 2030. Should alternatives not be available,
666 providing the same safety level as these components, or where easy removal can be proven and
667 verified by waste management operators, an information requirement could be introduced
668 instead, starting in 2028, requiring the indication of the component in the tyre, its localisation,
669 and instructions for easy removal. To support the latter, it may be necessary to develop technical
670 guidance on designs considered to allow easy removal.

671 DO-03 Information Requirements:

- 672 • Disclosure of presence of Article 27(2)(a, c, and d) SoC in tyre (e.g., through DPP) above
673 a threshold of 0.1 % w/w, to enable sorting for suitable recycling routes for
674 devulcanisation, pyrolysis, and mechanical recycling;
- 675 • Silica ratio: rich or poor in silica according to the threshold relevant for pyrolysis (poor:
676 <5 %, rich: ≥5 %);
- 677 • Chlorobutyl ratio: rich or poor in chlorobutyl according to the threshold relevant for
678 pyrolysis (poor: <3 %, rich: ≥3 %);
- 679 • Presence of components (yes/no) and easy removal instructions for DO-02
680 components/materials: self-sealing gels, silent tyre PU foams, TPMS batteries;
- 681 • Declaration of textile class: Standard (Nylon/Poly) or Advanced (Aramid). Aramid fibres
682 cling to rubber particles and require additional process steps.

683 **Challenges & Trade-offs:** Assuming the existing alternatives provide a similar function, the
684 trade-off depends on the materials applied in potential substitutes and, in particular, on their
685 comparative redesign (one-time costs) and purchase (operative costs). In general, noise
686 reduction tyres and self-sealing tyres currently represent only a small share of the market and
687 thus, impacts would be low to negligible at the market level. The prohibition on allowing the use
688 of batteries in the tyre itself could prohibit the introduction of "smart tyre" technologies.
689 However, it seems that these are still new on the market and impacts are assumed to be
690 negligible. The use of batteries in systems installed in the wheel is assumed beyond the control
691 of tyre manufacturers and thus may need to be addressed through other legislation with
692 information requirements. The use of silica is important to achieve good rolling resistance and
693 should not be prohibited at this stage, but the potential for prohibition in the future may
694 incentivise further development of alternatives currently understood to lack maturity. While
695 bromobutyl is to be restricted, the possibility of using chlorobutyl instead is already practiced
696 and impacts are not expected as long as the maximum concentration threshold for chlorobutyl
697 is sufficient to control inner liner gas permeability.

698 **Quantification of impacts**

699 For sticky gels used in self-sealing tyres (to be restricted) and foams used in noise reduction tyres
700 (to be removed), impacts are based on the assumption that a larger share of tyres is delivered
701 to recycling and used to produce secondary raw materials. The share of such tyres has been
702 assumed to be 2 %, and they are assumed to shift from the "civil engineering/backfilling public
703 works" route to a route where they would be shredded into rubber granules and then split
704 evenly between pyrolysis, devulcanisation and mechanical recycling routes. Though for self-
705 sealing tyres, a restriction could mean that end-users of such tyres will be subjected to higher
706 repair costs, the fact that such tyres currently have such a small market share suggests that such
707 impacts shall be negligible when viewed from the market perspective. It is further noted that
708 impacts are only expected in the C1 market segment, where such technologies are assumed to
709 be more prevalent than for C2 and C3.

710 Estimating the environmental impact of batteries not removed from tyres that enter the ELT
711 waste management and result in damages to shredding facilities is not straightforward. As a
712 proxy, costs related to such damages are used as a means of reflecting avoided damages in a
713 quantified (and in this case monetarised) manner. To quantify the potential benefit of
714 introducing information requirements for TPMS batteries, a report published by EURiC on the
715 problem of Li-battery-related fires in Waste Electrical and Electronic Equipment is referred to.
716 At the time, the report used data from 2018 and estimated that per facility, an average of
717 190,000 € of costs would be incurred due to battery related incidents. These costs refer to
718 damages where WEEE batteries are not removed from the equipment in which they are
719 contained and are processed together with such equipment as waste. Though the costs do not
720 reflect the case of batteries in TPMS and their processing with tyres, risks of thermal runaway
721 and related explosions and fires are similar, in particular given that tyre material burns easily
722 and can contribute to event severity. Related incidents such as fires and explosions that damage
723 equipment, can lead to injuries of employees, are associated with downtime of machinery and
724 loss of the waste that is burned during the fire and respective secondary materials that would
725 otherwise be produced and marketed. Increases in insurance premiums are also mentioned.
726 This cost was said to be significant, given that most waste operators are SMEs (EuRIC, 2021).

727 1.5.2. Path B: Bio-Transition

728 1.5.2.1. DO-05 Minimum Bio-based/Renewable Content

729 Introduction of targets to increase the share of renewable, bio-based materials in tyre
730 manufacturing. The objective is to displace fossil-derived components (such as synthetic rubber,
731 petroleum oils, and mineral silica) with bio-based alternatives (e.g., vegetable oils, bio-resins,
732 rice husk silica, and biopolymers) without competing with food supply chains.

733 **Environmental benefit:** Shifting to bio-based materials can reduce reliance on finite fossil
734 resources and may lower environmental burdens—most notably the carbon footprint (Global
735 Warming Potential). An LCA is needed to confirm that the benefits of replacing fossil inputs with
736 bio-based materials are not outweighed by added agricultural impacts (e.g., land and water use,
737 biodiversity loss) or higher burdens in processing and production.

738 **Rationale:** Tyres already contain a substantial share of bio-based materials—especially natural
739 rubber (Hevea), cellulosic rayon (viscose) and typically bio-based stearic acid from natural fats
740 and oils—together accounting for around 20 % of tyre mass in C1 and C2 tyres and >30 % in C3
741 tyres. Further decarbonisation, therefore, depends on reducing the remaining fossil-derived
742 fraction. While there may be some environmental savings from bio-based materials, they also
743 have a potential value in reducing supply chain risks and improving the EU's open strategic
744 autonomy. Materials based on fossil fuels (CB, synthetic rubber) are exposed to petrochemical
745 supply chain risks such as sanctions on Russia and other global shocks affecting the oil price and
746 maritime delivery routes.

747 The focus of this Design Option is on "New" or "Alternative" Bio-based content that goes beyond
748 the industry's standard usage of Natural Rubber. Implementing bio-based feedstocks means
749 accounting for materials that are already bio-based, then prioritising high-TRL physical
750 drop-in/near drop-in options (with possible minor recipe tweaks and no mass-balance needed).
751 Finally, some inputs—especially inorganics and complex synthetics—may have no credible bio-
752 route, so opportunities may instead lie in bio-based precursors/raw materials, the bio-based
753 share of organic fractions, and bio-based conversion/process chemicals upstream.

754

755 **Table 1-10** below summarises which material (groups) could potentially be replaced fully or
756 partly with bio-based alternatives. Based on availability and TRL, the need for compound
757 adjustments (drop-in vs. non-drop-in), and whether substitution is full or partial (including the
758 role of allocation procedures), materials are assigned to Tier 1 or Tier 2. Materials with
759 substantial technical constraints or intrinsically fossil-/mineral-linked pathways are assigned to
760 Tier 3. The Tiers are defined as follows:

761 • **Inherently Bio-based:** Materials are today already bio-based / mainly produced by using
762 bio-based materials;

763 • **Tier 1 bio-based substitution:** Near drop-in using bio-feedstocks (no mass balance
764 allocation or similar necessary). The tyre recipe may need adjustment. The material in
765 the tyre is physically derived from biomass; additionally, high TRL;

766 • **Tier 2 bio-based substitution:** Materials that meet one or more of the following criteria:

767 - replaced either via the mass-balance approach (drop-ins),

768 - replaced through functionally equivalent alternatives, i.e. non-drop-ins (differing
769 chemical structures with similar performance),

770 - For non-drop-ins, adjustments to the tire compound (recipe) and new technical
771 validation cycles are required.),

772 - are only partly bio-based – drop in, but medium TRL and/or medium availability;

773 • **Tier 3 Technically Constrained /mineral-linked:** Inorganic elements (metals) or complex
774 synthetics where bio-routes are non-existent, unproven, or functionally inferior, or
775 where TRL is low.

776 **Table 1-10: Overview of bio-based material classifications.**

Compartment	Material (group)	Inherently bio-based	Tier 1 bio-based substitution	Tier 2 bio-based substitution	Tier 3 Technically Constrained /mineral-Linked	TRL (1-3= Research; 4-6=Development; 7-9 Deployment)
Rubber	Natural Rubber	X				Deployment
	Synthetic Rubber			X		Development
Filler	CB				X	Research
	Silica		X			Deployment
Rubber compounding additives	Oils			X		Deployment
	Sulfur				X	Research
	Cobalt Organic Salts			X ⁵		Development
	other additives			X		Development/ Research
	Stearic Acid	X				Deployment
	ZnO				X ⁶	
Steel	Steel Belts and bead wire				X	Not applicable
Fabric	Rayon cord fabric	X				Deployment
	other fabrics (polyester, nylon, aramid)			X	Development	

777

⁵ Organic part can be bio-based.

⁶ Chemicals for conversion can be bio-based.

778 Natural rubber is already a bio-based material (Hevea). Beyond Hevea as a source for natural
779 rubber, alternative natural-rubber feedstocks such as guayule (*Parthenium argentatum*) and
780 Russian dandelion (*Taraxacum koksaghyz*) have progressed into pilot/demonstration tyre
781 initiatives, indicating technical feasibility. While natural rubber is proposed to be excluded from
782 initial bio-based targets, a target or bonus based upon local rubber supply could be more
783 interesting to develop sources of natural rubber in Europe and reduce dependency on imports.

784 Synthetic rubber materials - including styrene–butadiene rubber (SBR), polybutadiene rubber
785 (BR), butyl rubber (IIR), and isoprene rubber (IR, polyisoprene)- can generally be produced via
786 bio-based monomers that are then polymerised using largely the same established elastomer
787 chemistry. In particular, the ethanol route (dehydration of bioethanol to ethylene, followed by
788 conversion to butadiene) is close to commercialisation for the production of BR and SBR. The
789 butanol route (fermentation of sugars to butanol, followed by dehydration) is also considered
790 promising. Alternatively, bio-attributed (mass-balance) approaches can be used, in which bio-
791 based feedstocks are co-processed with fossil feedstocks in existing petrochemical assets, with
792 the bio-based share allocated to the resulting polymers.

793 CB is produced by the pyrolysis of a hydrocarbon feedstock. This dominant industrial route
794 (furnace black) can, in principle, also be run with bio-based hydrocarbons (e.g. bio-oils), although
795 this has not been commercialised. In furnace-black production, bio-oils can be less apt than
796 mineral oils (higher inherent water/oxygen contents / overall different composition affects yield
797 and nanostructure). Drying and/or upgrading is likely essential and achieving conventional yields
798 may require modified process conditions.

799 HDS used in tyres is today typically produced without bio-based materials. Silica accounts for
800 13 % (C1-tyres), 6 % (C2-tyres) and 4 % (C3-tyres) of a tyre's mass. Many tyre companies feature
801 premium products that partly or fully contain silica derived from rice husk ash. Rice husks are an
802 agricultural byproduct that contains high concentrations of silicon dioxide. When incinerated to
803 generate energy, the resulting ash becomes a source of silica. Silica is not an organic material,
804 and it does not contain biogenic carbon. In this context, "bio-based" is best understood as bio-
805 derived sourcing of the precursor/energy and circular use of an agricultural residue, rather than
806 an increase in the tyre's bio-based (biogenic-carbon) content.

807 Oils on the basis of bio-based material, such as soybeans, rapeseed or orange peels have already
808 been introduced in various tyres. The technical "saturation point" for bio-oils is a limiting factor
809 in their adoption. Beyond an equilibrium saturation point, further incorporation of bio-oil leads
810 to leaching. Other constraints of bio-based oils in comparison to mineral oil include increased
811 oxidative ageing, overall incompatibility with other tyre compounds or performance loss.

812 Sulphur is not "bio-based" in a chemical sense. Most supply is a by-product of oil refining and
813 natural gas processing. Desulphurisation of biogas would also yield high-quality sulphur, but it is
814 not reported that it is used as a tyre compound.

815 Cobalt organic salts: Bio-based substitution is constrained because the cobalt is inorganic; the
816 organic ligand sourcing could be bio-based.

817 Other rubber additives include adhesion systems, antidegradants/stabilisers, and vulcanisation
818 accelerators and retarders. For several of these additives, biomass-containing drop-in

819 alternatives can in principle be introduced, including via bio-attributed (mass-balance) supply
 820 chains. Examples include TMQ, MBT, and CBS. Alternatively, also bio-based substitutes, that
 821 often require an adaptation in the tyre formula (e.g. Polyethyleneimine, Phosphoryl
 822 polysulphide or Caprolactam Disulfide as a substitute for DPG) are commercially available. For
 823 other rubber additives, bio-based alternatives/compounds have been investigated but have not
 824 been commercialised, e.g. alkylphenols.

825 Stearic acid is commonly produced from natural fats and oils (often animal fats such as tallow
 826 and/or vegetable oils).

827 Zinc itself is not a mineral. However, chemicals for conversion can be bio-based.

828 Steel is not of relevance for bio-based substitution.

829 Rayon (viscose) tyre cords are also bio-based in origin because they are cellulosic fibres used in
 830 tyre reinforcement systems.

831 Bio-based polyamides and bio-based PET are available on the market, and bio-based polyamides

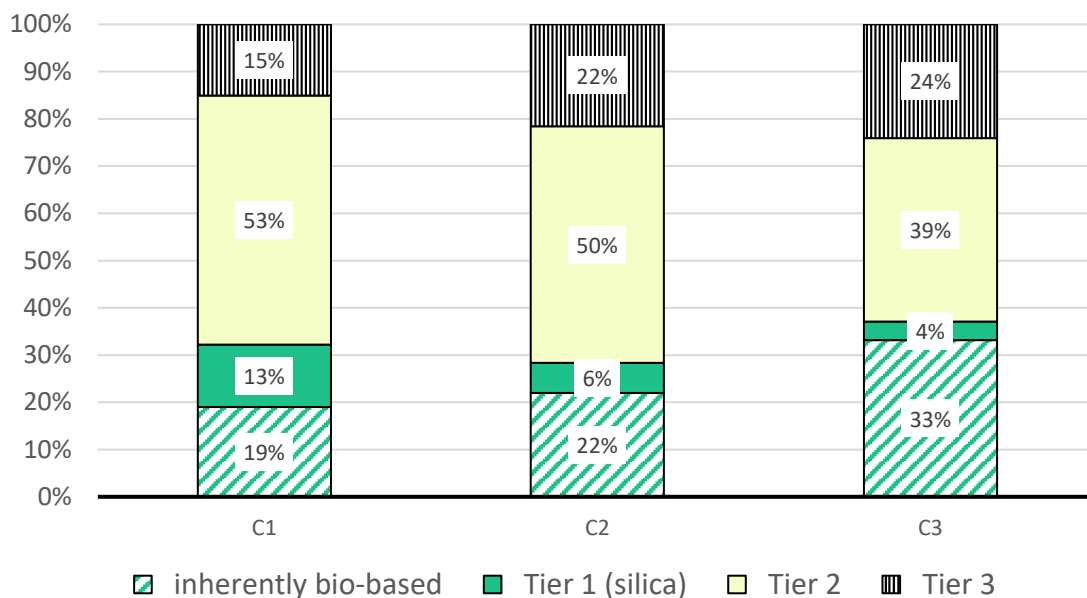


Figure 1-1: Share of materials suitable for a bio-based substitution of C1, C2 and C3 tyres.

832 have been explored as candidates for more sustainable tyre reinforcement materials. In
 833 practice, major tyre manufacturers currently highlight recycled PET as a scalable near-term
 834 option for polyester reinforcement textiles in tyres, while broader adoption of bio-based
 835 alternatives depends on meeting stringent tyre-cord performance and qualification
 836 requirements.

837 **Proposed implementation:** Given differences in tyre composition, separate bio-based content
 838 targets are proposed for C1, C2 and C3 tyres.

839 It is proposed that natural rubber be excluded from any such target to encourage genuine
 840 innovation rather than business-as-usual compliance and false incentives. If a target was set for
 841 e.g. 20 % including natural rubber, then certain tyres may already meet the target and others

842 may be incentivised to increase natural rubber content, rather than substituting other materials
 843 for bio-based compositions. Natural rubber is currently entirely sourced from outside the EU
 844 and also entails other supply risks (deforestation regulation must be applied).

845 Eligible bio-based content includes materials that are physically derived from biomass, including
 846 non-carbon materials produced from bio-sources (e.g., silica derived from rice husk ash), not
 847 only materials containing bio-based carbon. Minimum requirements start modestly and increase
 848 over time:

- 849 • 2030: 2 % (C1), 1.5 % (C2), 1 % (C3) of tyre mass;
- 850 • 2035: 5 % (C1), 3 % (C2), 2 % (C3) of tyre mass;
- 851 • 2040: 15 % (C1), 7 % (C2), 5 % (C3) of tyre mass.

852 **Challenges and trade-offs:** A wide range of bio-based materials could, in principle, be introduced
 853 into tyres, but they rely on vastly different feedstocks and production routes. Most options are
 854 not drop-in or near drop-in substitutes and therefore require adjustments to the tyre
 855 formulation. For certain material groups, only partial substitution is feasible (e.g., oils), and some
 856 “bio-based” claims may be based on allocation approaches (e.g., mass balance) rather than the
 857 physical share of biomass-derived material in the tyre. Finally, availability, technical
 858 performance, and cost impacts can constrain implementation, particularly at scale.

859 **Quantification of impacts**

860 There are few available reliable datasets for bio-based materials that can be used to calculate
 861 the environmental impacts, making the quantification of impacts challenging. Initial rough
 862 calculations also show limited impacts to the LCA from bio-based materials. For this reason, it is
 863 proposed to determine initial impacts by bio-based substitution of 10 % by weight of the tyre
 864 applied to synthetic rubber and 10 % substitution by weight of tyre is applied to bio-based
 865 content in silica in the C1 tyre base case. For C3 tyres, a larger proportion is already bio-based
 866 due to larger shares of natural rubber, the amount of non-substitutable reinforcement materials
 867 (steel) is higher, and in the base case the silica content is low. For this reason, only a 10 % bio-
 868 based substitution of the synthetic rubber is modelled. The overview of these quantification
 869 impacts is shown in the table below.

870 **Table 1-11: assumed bio-based substitution quantifications.**

Tyre Material		Weight in reference tyre (kg)	10 % bio-based substitution of tyre weight (kg)	Remaining non-bio-based material (kg)	Amount of material substituted
C1	Synthetic Rubber	2.031	0.818	1.22	40 %
	Silica	1.082	0.818	0.26	73.3 %
C3	Synthetic Rubber	9.25	6.41	2.84	69 %

871

872

873

Question to stakeholders:

874

Are there alternative proxies for bio-based content that can be used to better model bio-based content impacts or is using a silica / synthetic rubber approach considered close enough to understand the broad impacts?

875

876

877

1.5.3. Path C: Reduction of impacts in the Use Phase

878

As detailed in section 1.4, most of the use phase impacts relating to rolling resistance and abrasion limits have already been regulated elsewhere. However, one potential market entry requirement was identified relating to abrasion of extrusion spikes.

879

880

881

1.5.3.1. DO-04 Removal of extrusion spikes before sale

882

Beyond tread wear during the use phase, an additional contributor to wear emissions is extrusion spikes (vent spews) present on new tyres that do not contribute to the tyre performance but are a result of the manufacturing process. Upon use, they are worn off the tyre surface and land in the environment in the first few hundred km, contributing to impacts related to microplastics and particulate matter. As larger wear particles, they act as long-term reservoirs for leaching toxic additives into the environment, account for larger parts of soil/road run-off particles and may be more likely to be ingested by small organisms. Removal would entail an increase in production costs. Still, it would stop an avoidable share of pollution from the total tyre wear loss related to tyre use and subsequent impacts on the environment. Furthermore, removed spikes are expected to be collected by manufacturers and recycled, as is the case when a tyre is buffed in preparation for retreading.

883

884

885

886

887

888

889

890

891

892

893

Under Euro 7, two test methods have now been approved for use to measure tyre wear losses. These are either the convoy method or a drum test, where abrasion is measured. No specific measures have been listed on extrusion spikes in these test methods, and it is unclear whether manufacturers might shave these off before the test to avoid additional abrasion emissions.

894

895

896

897

Where technically and economically feasible, BAT includes the use of reduced-vent or micro-vent mould designs, improved mould geometry, and optimised air-evacuation systems (including vacuum-assisted moulding) that minimise or eliminate the need for conventional vent holes. Such design approaches materially reduce the formation of vent spews and avoid the need for downstream finishing. Where vent formation cannot be fully avoided through mould and process optimisation, BAT includes integrated in-line removal within the component manufacturing process. These solutions are incorporated directly into extrusion, calendaring, or pre-assembly lines.

898

899

900

901

902

903

904

905

Such a measure could be applied to an open scope, i.e. also to bicycle tyres, motorcycle, agricultural and off-road tyres.

906

907

908

909 **Quantification of impacts**

910 The number of spikes is thought to range from around 600 for a bicycle tyre, 1,200 for a C1
911 passenger car tyre, to 2,500 for a C3 truck tyre. Spikes have weights of $\approx 5\text{mg}$ per spike (0.5 mm
912 radius, 5 mm length, density of 1.15 g/cm^3). This leads to 3 g, 5.4 g, or 11.3 g preventable
913 microplastic pollution per respective tyre type, or roughly 5 %, 0.25 % or 0.15 % of expected tyre
914 wear.

915 **1.5.4. Path D: Life Extension**

916 **1.5.4.1. DO-08 Support Retreading of C3 tyres**

917 This design option aims to introduce requirements that support retreadability of C3 tyres. Any
918 such measures would be aligned with provisions arising from the retreading label investigations
919 currently in progress.

920 **Rationale:** Currently, retreading suffers from high competition with budget tyres, which
921 undercut the price and simultaneously lower the availability of high-quality casings on the
922 market. Making it clearer which tyres are retreadable and which are not, can support sorting
923 facilities in directing retreadable tyres to retreaders.

924 Following the new ESPR methodologies along the five dimensions of product material,
925 architecture, service, business model, and ecosystem, it is possible to define a number of
926 measures that could support retreading:

- 927 a) Application of a retreadability standard to determine if a new tyre could in theory be
928 retreaded (based on shearography after strenuous accelerated use phase tests to
929 determine robustness of casing – belt tread). Such a standard does not currently exist
930 and would need to be deferred to standardisation bodies for development and later
931 uptake;
- 932 b) Labelling of regroovability;
- 933 c) Information requirements on tread width, buffing radius, rolling resistance of casings to
934 be added to European Product Registry for Energy Labelling (EPREL);
- 935 d) Ban single use C3 tyres;
- 936 e) Green public procurement (GPP) requirement to give priority in public purchasing to
937 retreaded/retreadable tyres;
- 938 f) GPP requirements on tyres as a service.

939 All of these were suggested to stakeholders in the design options stakeholder consultations.
940 However, Task 6 design options are predominantly concerned with technical and economic
941 feasibility, while options (b) - (f) are in fact policy options that would affect the retreading market
942 rather than the design of a tyre. These options are therefore analysed together in Task 7. Point
943 (a) is a question of being able to define a retreadable tyre. Here, the consideration is therefore
944 based upon whether or not a retreaded tyre has any measurable impact on the BoM, use phase
945 and EoL phase for C3 tyres.

946 **Environmental benefit:** retreaded tyres can be retreaded to achieve similar rolling resistance
947 performance to new tyres, provided that high-quality casings are available in the correct
948 dimensions. A high-quality retreadable tyre can be retreaded two times or more, reducing waste
949 generation and material production impacts. **Challenges and Trade-Offs:** It is of high importance
950 that retreaded tyres do not have a much poorer rolling resistance than the tyres with which they
951 are competing. The casing is responsible for around 50 % of the rolling resistance, while the
952 tread and process contribute to the rest. High-quality casings and application of high-quality
953 treads are therefore important contributors to retreadability. At the moment, rolling resistance
954 of retreaded tyres is not required by UN R109 and therefore not measured consistently across
955 the market, leading to a lack of comparability between retreaded tyres. The industry has
956 proposed retread labels and the EU Commission is conducting a study to assess the potential to
957 develop a retreading label.

958 **Retreadable tyres**

959 It is challenging to define a retreadable tyre, since this is dependent on the way the tyre is used
960 and how it then enters end of life.

961 In discussions with stakeholders from the retreading industry, it was mentioned several times
962 that experienced retreading staff can quickly identify which tyres can be retreaded or not when
963 they come in for retreading. However, the specific criteria which apply cannot easily be
964 determined. Several manufacturers have stated that a retreadable tyre cannot be determined,
965 since whether or not it is retreadable depends on the product life.

966 In theory, any tyre is retreadable, but in practice single use budget tyres often do not have a
967 casing that is robust enough for safe retreading at the End of Life. In general, it appears that
968 there are some technical features that lead to retreadability, these are:

- 969 • Robustness of the bead wire, steel belts, and sidewall cords,
- 970 • Depth of undertread and tread width geometries,
- 971 • a clearly defined "buffer zone" (the layer of rubber between the bottom of the tread
972 grooves and the steel belts),
- 973 • Quality of adhesives and interlocking compounds.

974 Giving information on the undertread and related geometries is, however, strictly guarded IP of
975 manufacturers.

976 Several attempts are under development to determine a retreadability standard based on
977 destructive testing under an adapted UN No. R54. However, an agreement needs to be reached.
978 A standardised lab test would in this case need to prove the steel belts, sidewall cords, and bead
979 wire can survive a minimum number of heavy-load cycles beyond the life of the original tread.

980 If such a method can be defined, then the European Commission or CEN (the European
981 Committee for Standardisation) could undertake to develop a unified testing method for "Casing
982 Retreadability", and manufacturers could then test their C3 tyres and declare the results in the
983 DPP. Tyres meeting a threshold performance are declared retreadable, or an index is developed
984 to assign a "Retreadability Class" (e.g., A to E).

985

986 **Quantification of impacts**

987 It is expected that higher tensile steel and some alterations to the build of the tyre casing are
 988 needed to reach retreadability. This likely means some minor changes in the composition of the
 989 tyre. However, since no specific criteria could be defined in discussions with stakeholders to
 990 determine a retreadable tyre, it is assumed that there are no specific changes to the BoM used
 991 in the base case.

992 In the use phase, a retreadable casing likely increases the rolling resistance unless no
 993 countermeasures are taken to compensate for this. Since tyres are on the market that reach low
 994 rolling resistance ratings whilst also being retreadable, there were also no changes quantified
 995 here.

996 At end of life, the most relevant change is that a retreadable tyre enters a retreading process
 997 and is prepared for reuse, rather than sent to a waste treatment process. Here, there are no
 998 expected changes in the EoL pathways, but a change in the percentage of tyres entering
 999 retreading may occur – this is accounted for in Task 7 scenario modelling.

1000 **Questions for stakeholders**

1001 How would a retreadable tyre affect BoM, costs and affordability for consumers/fleet
 1002 operators?

1003 **1.5.4.2. DO-09 Standardisation of C1/C2 tyre Dimensions for Retreading**

1004 This design option considers limiting the number of non-standard tyre sizes or harmonising
 1005 dimensions to facilitate automated retreading. Over 600 dimensions exist for C1 tyres on the
 1006 market, and this is increasing, making the viability of retreading C1 difficult. For C2 the number
 1007 of dimensions is higher than C3 and also increasing.

1008 **Rationale:** The vast variety of dimensions complicates the use of rigid moulds in hot retreading,
 1009 increasing costs. Achieving a higher level of standardisation in C1 and C2 casing dimensions
 1010 would improve options for retreading of these tyres. Linking such retreads to possible green
 1011 public procurement targets may improve outcomes.

1012 Dimensions requirements are driven by the Original Equipment Manufacturer (OEM) for vehicle
 1013 manufacturers. Criteria to limit the number of casing dimensions that can be applied by OEM
 1014 manufacturers to new tyres, for example:

- 1015 1) 70 % of C1 fleet should be within 50 standard casing dimensions;
- 1016 2) Take advantage of stronger extra load (XL) and High Load (HL) tyres for EVs to define
 1017 European Tyre and Rim Technical Organisation (ETRTO) universal EV green casing:
 1018 underlying casing geometry (the bead, the sidewall thickness, the undertread
 1019 radius) would be standardised across brands. When the tyre goes to a retreader, it
 1020 fits into a universal curing mold;
- 1021 3) Add tread width information entered into EPREL.

1022

1023 **Quantification of impacts**

1024 Similar to DO-08 on retreading, these design options are rather market instruments that would
 1025 cause changes to the retreading market, to be modelled in Task 7 scenarios. Improved
 1026 retreading rate of high quality C1 and C2 tyres leads to savings in rolling resistance in use phase,
 1027 less waste and lower material waste compared with similarly priced budget tyres. This may
 1028 depend on having equivalent label classes for effective comparison between retreads and new
 1029 tyres.

1030 **1.5.4.3. DO-10 Mileage Extension**

1031 To determine options for mileage extension, two options were considered.

- 1032 I. Introduction of minimum mileage requirement
- 1033 II. Introduction of information requirements on expected mileage

1034 Under the Euro 7 regulation, abrasion limits are currently being defined and test methods are
 1035 being explored to introduce a service life indicator linked to tyre abrasion test performance. In
 1036 March 2026, both the drum test method and the convoy testing method were approved for
 1037 testing mileage performance under Euro 7. These test methods are contentious as the convoy
 1038 test is expensive to conduct, while the drum test can produce different results. At the same time,
 1039 only limited data on mileage performance exists currently, with Allgemeiner Deutscher
 1040 Automobil-Club (ADAC) testing providing the largest range of data on the market, using a
 1041 different test method.

1042 **I. Minimum Mileage Performance Requirement**

1043 This Design Option considers the introduction of mandatory minimum mileage performance
 1044 requirements for C1, C2 and C3 tyres, ensuring that all tyres PoM meet or exceed a defined
 1045 threshold under standardised test conditions. Manufacturers would be required to demonstrate
 1046 compliance through harmonised mileage-test protocols (potentially similar to the abrasion test
 1047 protocol to be introduced under the EURO 7 norm). All regulatory performance and safety
 1048 requirements must be maintained.

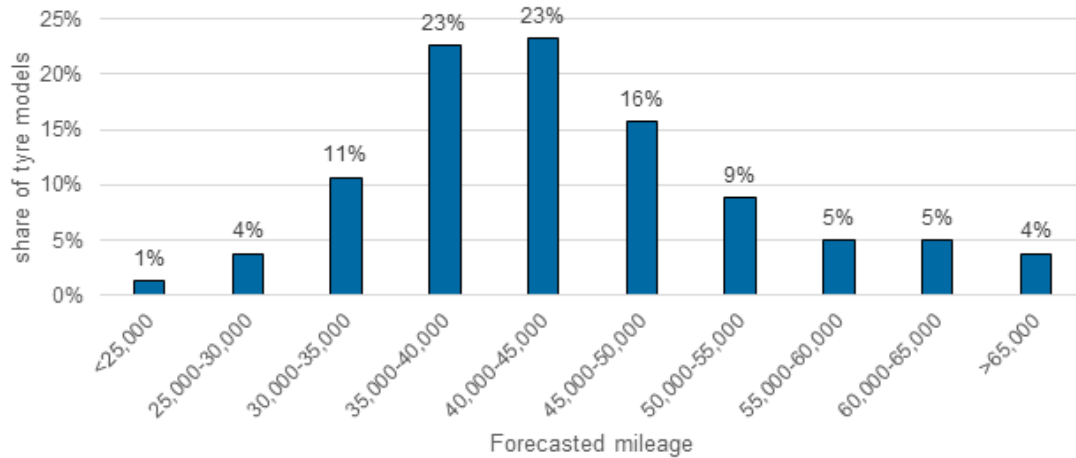
1049 **Relevance for ESPR:** The measure directly supports the following Article-5 objectives:

- 1050 • Durability;
- 1051 • Resource efficiency;
- 1052 • Reduced environmental impacts;
- 1053 • Reduced expected waste generation.

1054 **Environmental benefit:** Higher tyre mileage reduces the total number of tyres manufactured,
 1055 distributed, and discarded over a vehicle's lifetime.

1056 **Rationale:** Tyre mileage is assumed to vary significantly across the EU market. Reliable test data
 1057 from the ADAC test protocol are available for C1 tyres. Based on these data, mileage values for

1058 159 C1 tyre models were forecasted by the ADAC, as shown in the graph below.⁷ The results
 1059 show a characteristic distribution representing a Gaussian curve. .



1060

1061 **Figure 1-2: Distribution of mileage performance of 159 C1 tyres tested under ADAC.**

1062 While most models are forecast to be in the 35,000 – 45,000 km range, the testing data does
 1063 not show the sales numbers of the tested models. Since it is known that budget models
 1064 represent a large market share, it can be expected that models at the lower end of the market
 1065 represent a higher proportion of sales.

1066 Standardised durability requirements can help eliminate the lowest performing products and
 1067 reduce environmental burdens associated with replacements, thus increasing the average
 1068 mileage of tyres. The higher the limit, the higher will be the average mileage.

1069 **Table 1-12: Impacts of minimum mileage requirements on models’ distribution (not sales**
 1070 **weighted).**

Minimum mileage requirement	Average mileage [km] Method 1 ⁸	Average mileage [km] Method 2 ⁹	Increase in overall mileage
No limit	43,903	43,903	Reference
30,000	44,085	44,831	+0.4 up to 2.1 %
35,000	44,498	46,270	+1.4 up to 3.2 %
40,000	45,850	49,492	+ 4.4 up to 7.0 %

1071 It can be seen that increasing the limit based upon a market weighting of the tyres according to
 1072 the ADAC tests leads to limited increases in overall average mileage in the market. A sales-
 1073 weighted approach would likely show a larger percentage change. However, with no reliable
 1074 sales data on the tyres tested this is not possible to calculate reliably.

⁷ It should be noticed that the testing method does not follow any international standards.

⁸ Tyres with a forecasted mileage below the respective threshold are excluded from the dataset, reflecting a regulatory ban that prevents such products from entering the market. The average is therefore calculated only from tyres compliant with the minimum mileage requirement.

⁹ Tyres with a measured mileage below the respective threshold are retained in the dataset but their mileage is adjusted upward to the regulatory minimum.

1075 Conflicts and Trade-offs

1076 Improving the durability of tyres hits strong trade-offs in wet grip performance. One of the
1077 cheapest ADAC tyres tested achieved the highest mileage performance, whilst the wet grip
1078 performance was considered too dangerous to recommend the use of the tyre. Setting minimum
1079 mileage requirements may therefore push the budget tyre segment towards designs with poorer
1080 grip performance and thereby inhibit safety aspects. At the same time, this does not capture
1081 reliability, which may still display premature failure in budget tyres due to other reasons than
1082 performance alone (e.g. structural damage after 2 years). Given the lack of data on sales per
1083 model currently available, it is unclear what the impact on the market would be, while testing
1084 methods also need to be set up and run under Euro 7 on abrasion first to determine feasibility.

1085 II. Introduction of potential mileage index

1086 The tyres energy label and Euro 7 abrasion framework consider options for a service life index
1087 on tyres. Under Euro 7, an abrasion index is proposed (agreement on test methods still pending).
1088 In alignment with these two directives, a service life indicator may be added to EPREL or the
1089 DPP, or a lifetime rating added to the label based on initial tread depth and abrasion indicator.
1090 This index is under development outside of ESPR (Giechaskiel, B. et al., 2025). However, a tread
1091 depth information requirement is proposed to be added to EPREL. A review clause under ESPR
1092 could set a minimum service life indicator. A classification of the lifetime from the index could
1093 be given (A-E).

1094 The environmental benefits are less easily quantifiable compared to a market minimum
1095 performance requirement, since this measure would inform consumers about expected tyre
1096 longevity relative to a reference tyre (e.g., via a visible mileage index). Longer-lasting tyres
1097 reduce tyre consumption over the vehicle lifecycle by decreasing replacement frequency; this
1098 may entail a minor increase in high-performance/durable materials per tyre.

1099 Overall manufacturing output, material demand, and the quantity of materials reaching EoL are
1100 expected to decrease in proportion to the lifetime extension, while use-phase fuel consumption
1101 should ideally remain unchanged (i.e., no adverse effect on rolling resistance). Any measure
1102 must be implemented without compromising safety, maintaining at least the minimum Wet Grip
1103 requirements under UN R117.

1104 Quantification of impacts

1105 Based on the mileage distribution of C1 tyres (tests by ADAC), setting a minimum threshold of
1106 35,000 km for C1 tyres (i.e., tyres below this value are not allowed) increases the average
1107 mileage from ~44,000 km to ~46,500 km, corresponding to an uplift of ~2,500 km or ~5 %.

1108 For the LCA calculations, it is assumed that introducing a measure on mileage (either I. minimum
1109 requirement or II. visible mileage index), supported by appropriate legislation and test methods,
1110 shifts purchasing towards longer-lifetime tyres, increasing the base case lifetime by 10 %.

1111 1.6. BAT for specific DOs

1112 1.6.1.1. DO-01: Recycled Content; DO-05: Minimum Bio-Based / Renewable 1113 Content; DO-06 Rolling Resistance; DO-07 Abrasion limits

1114 - Beyond the numerous specified design options, DO-01 (recycled content) and DO-
1115 05 (bio-based content) —together with DO-06 (rolling resistance) and DO-07
1116 (abrasion) (even though out of scope) —must be demonstrated as technically
1117 feasible not only individually, but also when implemented in combination. The
1118 example below illustrates technical feasibility.

1119 The development of high-performance and environmentally improved tyres remains technically
1120 challenging, as several performance aspects compete with one another. Tyres are foremost a
1121 safety-critical product, and wet grip performance must not be compromised when increasing
1122 sustainability characteristics. Other performance criteria regulated under the EU tyre label—
1123 namely rolling resistance and external rolling noise—are comprehensively documented through
1124 the EPREL database.

1125 While triple-A-rated tyres (A/A/A for wet grip, noise and rolling resistance) do exist on the
1126 market, achieving this combination is demanding¹⁰, as improvements in rolling resistance can
1127 negatively affect wet grip, and noise optimisation can conflict with tread design requirements.

1128 With regard to material composition, many of the leading tyre manufacturers have developed
1129 high-performing demonstrator models and some C1 tyres are currently offered commercially in
1130 the EU market with significant shares of bio-based and recycled materials. One example is the
1131 Continental UltraContact NXT, which declares a total of 65 % “sustainable materials”, comprising
1132 renewable, recycled, and ISCC PLUS mass-balance certified circular feedstocks. The stated
1133 composition can be summarised as follows:

- 1134 • Renewable materials: natural rubber, bio-silica, and bio-resins (likely the largest share);
- 1135 • Recycled materials: recycled rubber, recycled steel, and recycled PET textile (via
1136 ContiRe.Tex technology);
- 1137 • ISCC PLUS circular materials: synthetic rubber and polymers manufactured through
1138 mass-balance processes using circular feedstock.

1139 Even when excluding natural rubber (typically 15–20 % of total tyre mass), the remaining
1140 combination of recycled and bio-based materials still lies in the range of approximately 45–50
1141 %. This suggests that, at least in principle, such tyres could already exceed the maximum
1142 material-related targets proposed in DO-01 (recycled content) and DO-05 (bio-based content).
1143 However, Continental does not disclose the exact internal breakdown of the 65 % share, so
1144 compliance with these targets cannot be conclusively verified at this stage.

1145 Regarding durability, mileage data for the UltraContact NXT itself are not yet available, but the
1146 closely related standard Continental UltraContact achieves 55,900 km in the ADAC test series.

¹⁰ In the EPREL database only ~500 C1-C3 models PoM between 2020 and 2024 (which corresponds to 0.03 %) are AAA tyres.

1147 Given that the UltraContact NXT is based on the same tyre architecture, and exhibits even lower
1148 rolling resistance, it is reasonable to assume a comparable mileage, which is significantly above
1149 average performance levels (see DO-06 rolling resistance).

1150 Similarly, abrasion values for the standard UltraContact fall into the lower range, with
1151 52.5 mg/km/t reported (DO-07 abrasion limits), indicating favourable performance in terms of
1152 particulate emissions from tyre wear. Although no specific abrasion measurements have been
1153 published for the UltraContact NXT, its design relationship to the UltraContact suggests similar
1154 behaviour.

1155 1.6.1.2. DO-02 Design for Recycling - restriction of hindering materials

1156 BAT for end-of-life tyres should be able to handle all materials intentionally added during tyre
1157 design. In principle, components such as sealants, aramid fibres, PU foams, or batteries could be
1158 compatible with BAT-level recycling. This is, however, only possible if proven technologies exist
1159 that can reliably separate or process them without reducing recycling yields, contaminating
1160 secondary products, or leading to fire hazards.

1161 For PU foams, there are claims that they can be handled in standard ELT recycling, but this is not
1162 supported by transparent data or operational demonstrations. In fact, one stakeholder claims
1163 the opposite: PU is typically removed with the textile fraction, increasing non-recyclable
1164 outputs, and residual fragments can contaminate rubber granulates, lowering their quality.

1165 Because BAT requires demonstrated, scalable solutions rather than theoretical assumptions,
1166 materials that introduce unverified separation challenges cannot be considered
1167 BAT-compatible. Until effective recycling processes for PU-containing tyres are proven, these
1168 materials must be regarded as hindering circularity and may justifiably be subject to design
1169 restrictions or further assessment.

1170 1.6.1.3. Other design options

1171 The design options DO-08 (retreading) to DO-14 (design for repair) are not included in the BAT
1172 assessment. They are not process-technology measures, but rather market, design, information,
1173 or regulatory enablers.

1174 1.7. Stakeholder consultation process

1175 To support development of assumptions on the design options, interviews were held with the
1176 following stakeholder groups:

- 1177 • Retreading/waste management network association;
- 1178 • Independent Retreader;
- 1179 • Premium EU manufacturer with retreading business;
- 1180 • Tyre additives producer;

- 1181 • Devulcanisation operator;
- 1182 • Tyres manufacturer association;
- 1183 • Experts working for the EU Commission on tyre retreading label and abrasion
- 1184 methodologies;
- 1185 • Vehicle OEM.

1186 The full list of design options with description and estimated impacts/relevance for the
1187 environment was sent to all registered stakeholders in high detail on March 4th, 2026, to enable
1188 provision of feedback in the run-up to the second stakeholder meeting planned on June 8th,
1189 2026. The questionnaire aims to verify assumptions on material compositions and viability,
1190 whilst at the same time to gather information on technical viability and costing impacts. 7
1191 Stakeholders returned the questionnaire within 4 weeks, and some of their inputs have been
1192 considered in the drafting of this study. Due to the timings of the quantification of the impacts
1193 in the PEF LCA, a full re-run of the impacts will be conducted following feedback from the second
1194 stakeholder meeting (from July 2026).

1195 The analysis presented in the preceding chapters closely resembles that provided in the
1196 stakeholder questionnaire, with the addition of a quantitative analysis step.

1197 **1.8. Input parameters design options per base case**

1198 In this section, the key input parameters for all base cases and their design options are
1199 presented. The BoM for each base case and the modifications introduced by each design option
1200 are detailed, alongside consumption data for energy, water, and other resource use, as well as
1201 the adjusted LCC inputs. These parameters serve as the basis for calculating both the
1202 environmental and LCC impacts.

1203 1.8.1. BC1: C1 Tyre

1204 1.8.1.1. Bill of materials

1205 Table 1-13: BoM assumed changes by Design Option for Base Case 1 (C1 tyre).

BoM - Base Case C1	Reference Tyre		DO-01 A	DO-01 B	DO-05
			Recycled Content 5 % rubber compound, 50 % reinforcement materials	Recycled Content, 20 % recycled compound, 80 % reinforcement materials	Bio-based target 10 % rice husk ash for silica, 10 % bio-based synthetic rubber
Material	Value Kg/tyre	Reference	Absolute Numbers	Absolute Numbers	Percentage compared
			kg/tyre	kg/tyre	to 100 % reference
Natural Rubber	1.408	100 %	1.36	1.15	100 %
Synthetic Rubber	2.031	100 %	1.95	1.67	60 %
Silica	1.082	100 %	1.06	0.96	24 %
CB	1.408	100 %	1.23	0.78	100 %
ZnO	0.123	100 %	0.12	0.12	100 %
Sulfur	0.096	100 %	0.10	0.10	100 %
Stearic Acid	0.057	100 %	0.06	0.06	100 %
Benzothiazoles-sulfonamides (DBCS, CBS, TBBS, CTP, TQM)	0.089	100 %	0.09	0.09	100 %

BoM - Base Case C1	Reference Tyre		DO-01 A	DO-01 B	DO-05
			Recycled Content 5 % rubber compound, 50 % reinforcement materials	Recycled Content, 20 % recycled compound, 80 % reinforcement materials	Bio-based target 10 % rice husk ash for silica, 10 % bio-based synthetic rubber
Amines and plasticisers (6PPD, DPG, BENPAT, DMBC)	0.167	100 %	0.17	0.17	100 %
Oils	0.247	100 %	0.25	0.25	100 %
Waxes	0.077	100 %	0.08	0.08	100 %
Alkylphenols (PTOP, PTBP)	0.011	100 %	0.01	0.01	100 %
Phenolic resins, including resorcinol, HMT	0.019	100 %	0.02	0.02	100 %
Cobalt Organic Salts	0.017	100 %	0.02	0.02	100 %
Steel Belts, Coating (66 % Copper, 34 % Zinc)*	0.663	100 %	0,23	0.03	100 %
Bead wire (98 % Brass, 2 % Tin)*	0.327	100 %	0.12	0.01	100 %
Polyester cord fabric	0.182	100 %	0.15	0.05	100 %
Rayon cord fabric	0.086	100 %	0.09	0.09	100 %
Nylon cord fabric	0.088	100 %	0.09	0.09	100 %
Aramid cord fabric	0.001	100 %	0.00	0.00	100 %
Bio-based CB / Silica - Rice Husk Ash as Proxy	0	0 %	0.00	0.00	0.818 %
Bio-based synthetic rubber	0	0 %	0.00	0.00	0.818 %
devulcanised rubber	0	0 %	0.219	1.093	0 %
rCB	0	0 %	0.0845	0.211	0 %

BoM - Base Case C1	Reference Tyre		DO-01 A	DO-01 B	DO-05
			Recycled Content 5 % rubber compound, 50 % reinforcement materials	Recycled Content, 20 % recycled compound, 80 % reinforcement materials	Bio-based target 10 % rice husk ash for silica, 10 % bio-based synthetic rubber
micronised rubber	0	0 %	0.0171	0.0342	0 %
reclaimed rubber	0	0 %	0.0171	0.0342	0 %
rPET	0	0 %	0.0364	0.127	0 %
recycled steel**	0	0 %	0.640	0.946	0 %
Total product weight	8.18	100 %	8.18	8.18	8.18 %

1206

Draft for SHI

1207 1.8.1.2. Consumption data

1208 Table 1-14: Use phase impacts assumed from design options.

Use phase data - Base Case C1				DO-10 Mileage Improvement
Parameters for energy consumption due to rolling resistance and acceleration resistance	Value	Unit	Reference	Percentage compared
				to 100 % reference
RCC	8.4	kg/ton	100 %	100 %
Reference Service Life	40,000	km	100 %	110 %
Tyre Wear Loss	1.6	kg	100 %	95 %
Outer Radius	31.6	cm	100 %	100 %
Seat Radius	20.3	cm	100 %	100 %
Tread Depth	0.775	cm	100 %	105 %
Treadwear Indicator Height	0.167	cm	100 %	100 %
Tread Length	196.114	cm	100 %	100 %
Density	1.196	g/cm ³	100 %	100 %
Contact Width	15.8	cm	100 %	100 %
Void ratio	0.29	-	100 %	100 %
Weight of new tyre	8.18	kg	100 %	102 %

1209 It is assumed that the following design options make no change to the use phase on rolling
1210 resistance or lifetime, while the base case weight and geometry is maintained consistent for
1211 comparability purposes:

- 1212 • DO-01 Recycled content: could change the rolling resistance of service life if the
1213 compound performs differently;
- 1214 • DO-02/03 Design for recycling: self-sealing tyres and TPMS may have a longer service
1215 life on average. TPMS tyres containing batteries may have on average an improved
1216 rolling resistance during the lifetime in real use. Noise reduction tyres may have an
1217 impact on weight. Since it is expected that restrictions are only implemented where
1218 substitutes exist providing a similar level of functionality, no changes to use phase are
1219 quantified here;
- 1220 • DO-05 Bio-Based materials: could change the rolling resistance of service life if the
1221 compound performs differently;

1222 DO-09 Standardisation of Tyre Dimensions: this would change possibly some average
 1223 dimensions of a tyre on the market but could be arranged so that it does not change
 1224 performance characteristics.

1225 **1.8.1.3. End of Life Pathways**

1226 **Table 1-15: EoL pathways impacts by design option.**

BC 1 EoL	status quo	DO-01 A	DO-01 B	DO-2	DO-03	DO-09
End-of-life treatment process	%	Recycled Content 5 % rubber, 50 % reinforcement	Recycled Content 20 % rubber, 80 % reinforcement	Restriction of Substances that hinder recycling	Declaration of materials that hinder recycling	Standardisation of casings
Retreading market	1.0 %					+2 %
Mechanical recycling (granulation)	40.1 %	37.3 %	23.2 %	+1 %	-2 %	-
Incineration in cement kiln	48.8 %	44.8 %	23.2 %	+1 %	+1 %	-
Pyrolysis	7.2 %	8.0 %	20.1 %			-
Devulcanisation	0.5 %	5.7 %	28.5 %			-
Micronised rubber	0.0 %	0.4 %	0.9 %			
Reclaimed rubber	0.0 %	0.4 %	0.9 %			
Civil engineering/back filling/public works	3.3 %	3.3 %	3.3 %	-2 %	+1 %	-

1227 **1.8.1.4. Life cycle costing data**

1228 For the initial Life cycle costing analysis, limited data was available and so no cost differential
 1229 was incorporated in the calculations for C1 and C3 tyres for recycled content, bio-based
 1230 materials or retreadable tyres. For lifetime analysis, a longer lifetime leads to lower costs per
 1231 km, while restrictions on self-sealing gels is expected to affect lifetimes of the small part of the
 1232 market that uses these. The cost impacts of bio-based, recycled content and retreadable tyres
 1233 will be adjusted and incorporated following stakeholder feedback in the second stakeholder
 1234 meeting. It is known that impacts occur in the following ways:

- 1235
- 1236
- 1237
- 1238
- 1239
- 1240
- 1241
- 1242
- 1243
- 1244
- 1245
- 1246
- 1247
- 1248
- 1249
- 1250
- 1251
- 1252
- 1253
- 1254
- 1255
- 1256
- 1257
- 1258
- 1259
- 1260
- 1261
- 1262
- 1263
- The price of natural rubber is subject to periodic fluctuations that directly impact the price of SBR. Also considering the implementation of the EUDR regulation, an increase in the price of the polymer fraction is expected in the coming years.
 - Recycled PET and steel is thought to be cost competitive.
 - Carbon black is tied to the price of oil but could be partially decoupled from this by systematic use of pyrolysis oils.
 - The price of devulcanised rubber is essentially based on that of the recycled rubber from which it is obtained and is less subject to market fluctuations. Considering 1 kg of devulcanised rubber as a substitute for 0.95 kg of virgin rubber compound, i.e., 0.5-0.6 kg of polymer and 0.2-0.3 kg of CB, the price of devulcanised rubber is approximately 50-60% of the price of the replaced materials. In case of substitution of highly performing compounds, or in case of Natural Rubber shortage, the price equivalence can be as low as 40% (devulc-price vs. virgin compound).
 - Currently, bio-based materials often come with a price premium compared with virgin materials. Renewable raw materials remain more expensive than fossil based alternatives, with costs strongly dependent on feedstock type, conversion technology and the extent of renewable energy use. There is therefore no single cost benchmark. Cost levels also differ significantly depending on whether production is physically segregated or implemented via a mass balance chain of custody, with distinct logistical, verification and cost implications. Non fossil materials are generally more expensive during market introduction; costs are expected to decrease over time through scale up, operational learning effects and the introduction of mandatory targets that drive optimisation and investment.
 - It is expected that retreadable tyres are generally more expensive to produce than non-retreadable tyres, due to more robust construction and utilisation of more steel and longer-lived rubber (also e.g. use of larger amounts of anti-degradants in sidewall rubber). If non-retreadable tyres were subject to market restrictions based on retreadability, this would likely lead to higher costs for purchasing new tyres for consumers.

1264 **Table 1-16: Comparison of cost impacts by design option.**

Lifecycle Costing Parameters				DO-02 Design for Recycling	DO-10 Mileage Extension
LCC parameters	Value	Unit	Reference	Percentage compared to 100 % reference	Percentage compared to 100 % reference
Average expected initial life time	4	years	100 %	-	110 %
Assumed purchase price	388	Euro/unit	100 %	-	-
Installation/acquisition costs (if any)	18.75	Euro/unit	100 %	-	-
Repair & maintenance costs	58.75	Euro/unit	100 %	101 %	110 %

1265 **1.8.2. BC2: Modelling Pending**

1266 The C2 modelling will take place following the second stakeholder meeting.

Draft for SH meeting 2

1267 1.8.3. BC3: C3 Tyre

1268 1.8.3.1. Bill of materials

1269 Table 1-17: Comparison of BoM impacts by design option for Base Case 3 (C3 tyre).

BoM - Base Case C3	Reference Tyre		DO-01 A	DO-01 B	DO-05	DO-10
			Recycled Content 5 % rubber compound, 50 % reinforcement materials	Recycled Content, 20 % recycled compound, 80 % reinforcement materials	Bio-based target 10 % rice husk ash for silica, 10 % bio-based synthetic rubber	Mileage improvement
Material	Absolute Number Kg/tyre	Reference %	Absolute Numbers	Absolute Numbers	Percentage compared	Absolute Numbers
			kg/tyre	kg/tyre	to 100 % reference	kg/tyre
Natural Rubber	20.8	100 %	20.14	17.62	100%	21.23
Synthetic Rubber	9.25	100 %	8.96	7.83	31%	9.68
Silica	2.53	100 %	2.46	2.19		2.53
CB	13	100 %	11.50	7.75	100%	13.43
ZnO	1.3	100 %	1.30	1.30	100%	1.30

BoM - Base Case C3	Reference Tyre		DO-01 A	DO-01 B	DO-05	DO-10
			Recycled Content 5 % rubber compound, 50 % reinforcement materials	Recycled Content, 20 % recycled compound, 80 % reinforcement materials	Bio-based target 10 % rice husk ash for silica, 10 % bio-based synthetic rubber	Mileage improvement
Sulfur	0.774	100 %	0.77	0.77	100%	0.77
Stearic Acid	0.462	100 %	0.46	0.46	100 %	0.46
Benzothiazoles-sulfonamides (DBCS, CBS, TBBS, CTP, TQM)	0.739	100 %	0.74	0.74	100 %	0.74
Amines and plasticisers (6PPD, DPG, BENPAT, DMBC)	0.811	100 %	0.81	0.81	100 %	0.81
Oils	0.42	100 %	0.42	0.41	100 %	0.42
Waxes	0.216	100 %	0.22	0.22	100 %	0.22
Alkylphenols (PTOP, PTBP)	0.0177	100 %	0.02	0.02	100 %	0.02
Phenolic resins, including resorcinol, HMT	0.419	100 %	0.42	0.42	100 %	0.42
Cobalt Organic Salts	0.0791	100 %	0.0791	0.0791	100 %	0.08
Steel Belts, (Coating: 66% Copper, 34% Zinc)*	9.8	100%	4.92	1.95	100 %	9.80
Bead wire (coating: 98% Brass, 2% Tin)*	3.47	100 %	1.74	0.69	100 %	3.47
Nylon cord fabric	0.0192	100 %	0.02	0.02	100 %	0.02
Bio-based synthetic rubber	0	0 %	0.00	0.00	6,4107 %	0.00
devulcanised rubber	0	0 %	1.63	8.13	100 %	0.00

BoM - Base Case C3	Reference Tyre		DO-01 A	DO-01 B	DO-05	DO-10
			Recycled Content 5 % rubber compound, 50 % reinforcement materials	Recycled Content, 20 % recycled compound, 80 % reinforcement materials	Bio-based target 10 % rice husk ash for silica, 10 % bio-based synthetic rubber	Mileage improvement
rCB	0	0 %	0.65	1.56	100 %	0.00
micronised rubber	0	0 %	0.13	0.25	100 %	0.00
reclaimed rubber	0	0 %	0.13	0.25	100 %	0.00
rPET	0	0 %	0.00	0.00	100 %	0.00
recycled steel**	0	0 %	6.60	10.63	100 %	0.00
Total product weight	64.11	100 %	64.11	64.11	64.11 %	65.39

1270

Draft for

1271 1.8.3.2. Consumption data

1272 Table 1-18: Use phase impacts by design option base case 3 (C3 tyre).

Use phase data - Base Case C3				DO-08 Retreadability	DO-10 Mileage Improvement
Parameters for energy consumption due to rolling resistance and acceleration resistance	Value	Unit	Reference	Percentage compared to 100 % reference	Percentage compared to 100 % reference
RCC	5.270	kg/ton	100 %		
Reference Service Life	253,410	km	100 %	110 %	110 %
Tyre Wear Loss	12.306	kg	100 %		95 %
Outer Radius	50.630	cm	100 %		
Seat Radius	28.580	cm	100 %		
Tread Depth	1.720	cm	100 %		105 %
Treadwear Indicator Height	0.186	cm	100 %		
Tread Length	312.714	cm	100 %		
Density	1,140	g/cm ³	100 %		
Contact Width	26.790	cm	100 %		
Void ratio	0.160	-	100 %		
Weight of new tyre	64.107	kg	100 %		102 %

1273 DO-08 Retreadable tyre: this would likely change certain aspects relating to steel belt
1274 construction, reinforcement materials, and tread width. However, stakeholders were not able
1275 to state what the specific differences between a retreadable and a non-retreadable tyre are.
1276 Changing the casing leads to changes in the rolling resistance, but this can be compensated for
1277 through changes to tread and compound design. It is expected that a higher quality casing in
1278 general would lead to a 10% higher lifetime compared to the reference tyre.

1279 DO-10 Mileage improvement: For the base case, a lifetime representing a premium tyre
1280 (253,000 km) was taken as the reference point, which may need to be adjusted in a follow-up
1281 calculation to more accurately model an “average C3 tyre” on the market. The lifetime of the
1282 tyre is considered to be achieved through a combination of improved abrasion performance
1283 and/or greater tread depth. Changes to the abrasion performance tend to increase the durability
1284 of the rubber and reduce rolling resistance, while a deeper tread depth tends to increase rolling

1285 resistance until the tyre again reaches the same tread depth as the reference tyres. Since the
 1286 base case aims to model an average tyre, it is considered here that 5% tread depth addition
 1287 leads to 2% additional tyre weight, while better abrasion performance leads to 5% less tyre wear
 1288 over the tyre lifetime. Together, the effects cancel out changes in rolling resistance. The main
 1289 variable under consideration here is to determine the impact of a 10% increase in lifetime on
 1290 the environmental performance and replacement rate of tyres.

1291 It is assumed that the following design options make no change to the use phase on rolling
 1292 resistance, while the base case weight and geometry are maintained consistent for
 1293 comparability purposes:

- 1294 • DO-01 Recycled content: could change the rolling resistance of service life if the
 1295 compound performs differently;
- 1296 • DO-02/03 Design for recycling: self-sealing tyres and TPMS may have a longer service
 1297 life on average, TPMS tyres containing batteries may have, on average, an improved
 1298 rolling resistance during the lifetime in real use. Noise reduction tyres may have an
 1299 impact on weight. Since it is expected that restrictions may be difficult and information
 1300 requirements would be the starting point, no changes to the use phase are quantified
 1301 here;
- 1302 • DO-05 Bio-Based materials: could change the rolling resistance of service life if the
 1303 compound performs differently.

1304 **1.8.3.3. End of Life Pathways**

1305 **Table 1-19: Assumed impact on EoL pathways by design option (C3 tyre).**

BC 3 EoL		DO-01 A	DO-01 B	DO-2	DO-03	DO-08
End-of-life treatment process	status quo	Recycled Content 5 % rubber, 50 % reinforcement	Recycled Content 20 % rubber, 80 % reinforcement	Restrictions that hinder recycling	Declaration of materials that hinder recycling	Support for retreading
Mechanical recycling (granulation)	40.1%	37.5 %	24.5 %			
Incineration in cement kiln	48.8%	45.1 %	24.5 %			
Pyrolysis	7.2%	7.9 %	18.9 %			
Devulcanisation	0.5%	5.4 %	27.0 %			
Micronised rubber	0.0%	0.4 %	0.8 %			
Reclaimed rubber	0.0%	0.4 %	0.8 %			

BC 3 EoL		DO-01 A	DO-01 B	DO-2	DO-03	DO-08
Civil engineering/backfilling/public works	3.3%	3.3 %	3.3 %			

1306

1307 **1.8.3.4. Life cycle costing data**

1308 See section 1.8.1.4 for analysis on C1 and C3 costings (these will be adjusted more thoroughly
1309 following second stakeholder meeting).

1310 **Table 1-20: Comparison of cost impacts by design option (C3 base case).**

Lifecycle Costing Parameters				DO-08 Retreadability	DO-10 Mileage improvement
LCC parameters	Value	Unit	Reference	Percentage compared to 100 % reference	Percentage compared to 100 % reference
Average expected initial lifetime	3	years	100 %	110 %	110 %
Assumed purchase price	410	Euro/unit	100 %		
Installation/acquisition costs (if any)	18.75	Euro/unit	100 %		
Repair & maintenance costs	58.75	Euro/unit	100 %		110 %

1311 **1.9. Environmental & life cycle costing impact of design**
1312 **options per base case**

1313 This section covers the calculated environmental benefits and impacts of the previously
1314 identified design options for each base case. All relevant changes to input parameters per option
1315 are examined using the LCA model to assess how each option affects the output values across
1316 all PEF impact categories. Additionally, the LCC changes for each design option are considered.
1317 By comparing the results for the design options against the previously calculated results in Task
1318 5, we can assess the environmental impact and costs of each option. This comparison will help
1319 identify trade-offs that should be considered moving forward with each design option.

1320 **1.9.1. BC1: C1 Tyre**

1321 The environmental impact and LCC impact of each design option for the C1 tyre base case (BC1) are presented in this section.

1322 **1.9.1.1. Environmental impact**

1323 **Table 1-21** presents the environmental impact of all design options, along with their comparison to the original base case results (reference). The difference is
 1324 expressed in percentages. The results are provided for the full lifetime of the product, thus including lifetime increase (DO-10).

1325 **Table 1-21: Environmental impact per design option (full lifetime) compared to BC1.**

PEF Impact categories	unit	Original base case	DO-01A Recycled content	DO-01B Recycled content	DO-02 Restriction of substances that hinder recycling	DO-03 Declaration of materials that hinder recycling	DO-05 Biobased materials	DO-10 Mileage improvement
Acidification	mol H+ eq	9.13E-01	9.04E-01	8.89E-01	9.13E-01	9.13E-01	9.08E-01	9.89E-01
	% difference	0 %	-0.9 %	-2.7 %	0.0 %	0.0 %	-0.6 %	8.3 %
Climate change	kg CO2 eq	3.03E+02	3.01E+02	2.98E+02	3.02E+02	3.03E+02	3.02E+02	3.31E+02
	% difference	0 %	-0.6 %	-1.6 %	0.0 %	0.0 %	-0.2 %	9.3 %
Climate change - Biogenic	kg CO2 eq	4.10E-02	4.02E-02	3.83E-02	4.10E-02	4.10E-02	3.97E-02	4.28E-02
	% difference	0 %	-2.1 %	-6.7 %	0.0 %	0.0 %	-3.1 %	4.3 %
Climate change - Fossil	kg CO2 eq	3.02E+02	3.01E+02	2.97E+02	3.02E+02	3.02E+02	3.02E+02	3.31E+02

PEF Impact categories	unit	Original base case	DO-01A Recycled content	DO-01B Recycled content	DO-02 Restriction of substances that hinder recycling	DO-03 Declaration of materials that hinder recycling	DO-05 Biobased materials	DO-10 Mileage improvement
	% difference	0 %	-0.6 %	-1.6 %	0.0 %	0.0 %	-0.2 %	9.3 %
Climate change - Land use and LU change	kg CO2 eq	4.28E-02	3.79E-02	3.56E-02	4.28E-02	4.28E-02	4.22E-02	4.42E-02
	% difference	0 %	-11.3 %	-16.8 %	0.0 %	0.0 %	-1.5 %	3.4 %
Ecotoxicity, freshwater	CTUe	4.14E+02	4.20E+02	4.08E+02	4.14E+02	4.14E+02	4.23E+02	4.30E+02
	% difference	0 %	1.4 %	-1.5 %	0.0 %	0.0 %	2.3 %	3.8 %
Ecotoxicity, freshwater - inorganics	CTUe	3.06E+02	2.79E+02	2.67E+02	3.06E+02	3.06E+02	2.82E+02	3.20E+02
	% difference	0 %	-8.8 %	-12.6 %	0.0 %	0.0 %	-7.8 %	4.4 %
Ecotoxicity, freshwater - organics	CTUe	1.10E+02	1.42E+02	1.42E+02	1.10E+02	1.10E+02	1.43E+02	1.12E+02
	% difference	0 %	29.9 %	29.4 %	0.0 %	0.0 %	30.5 %	2.3 %
Particulate matter	disease inc.	1.15E-05	1.14E-05	1.10E-05	1.15E-05	1.15E-05	1.15E-05	1.19E-05
	% difference	0 %	-1.4 %	-4.8 %	0.0 %	0.0 %	-0.4 %	2.8 %
Eutrophication, marine	kg N eq	2.07E-01	2.06E-01	2.03E-01	2.07E-01	2.07E-01	2.08E-01	2.24E-01
	% difference	0 %	-0.4 %	-2.2 %	0.0 %	0.0 %	0.2 %	8.3 %
Eutrophication, freshwater	kg P eq	1.10E-02	1.01E-02	1.04E-02	1.10E-02	1.10E-02	1.06E-02	1.14E-02

PEF Impact categories	unit	Original base case	DO-01A Recycled content	DO-01B Recycled content	DO-02 Restriction of substances that hinder recycling	DO-03 Declaration of materials that hinder recycling	DO-05 Biobased materials	DO-10 Mileage improvement
	% difference	0 %	-7.8 %	-5.5 %	-0.4 %	-0.3 %	-3.2 %	3.3 %
Eutrophication, terrestrial	mol N eq	2.94E+00	2.92E+00	2.88E+00	2.94E+00	2.94E+00	2.94E+00	3.20E+00
	% difference	0 %	-0.6 %	-2.0 %	0.0 %	0.0 %	-0.1 %	8.8 %
Human toxicity, cancer	CTUh	3.42E-08	3.83E-08	3.86E-08	3.42E-08	3.42E-08	3.71E-08	3.60E-08
	% difference	0 %	11.8 %	12.8 %	-0.1 %	0.1 %	8.4 %	5.2 %
Human toxicity, cancer - inorganics	CTUh	1.18E-08	1.38E-08	1.45E-08	1.18E-08	1.18E-08	1.14E-08	1.26E-08
	% difference	0 %	17.4 %	23.3 %	0.0 %	0.0 %	-3.0 %	7.0 %
Human toxicity, cancer - organics	CTUh	2.03E-08	2.24E-08	2.23E-08	2.03E-08	2.03E-08	2.35E-08	2.12E-08
	% difference	0 %	10.2 %	10.0 %	-0.2 %	0.2 %	15.9 %	4.2 %
Human toxicity, non-cancer	CTUh	2.37E-06	2.52E-06	2.53E-06	2.37E-06	2.37E-06	2.35E-06	2.57E-06
	% difference	0 %	6.2 %	6.5 %	0.0 %	0.0 %	-1.1 %	8.1 %
Human toxicity, non-cancer - inorganics	CTUh	8.73E-07	1.03E-06	1.06E-06	8.73E-07	8.73E-07	8.44E-07	9.27E-07
	% difference	0 %	17.6 %	21.9 %	0.0 %	0.0 %	-3.3 %	6.1 %

PEF Impact categories	unit	Original base case	DO-01A Recycled content	DO-01B Recycled content	DO-02 Restriction of substances that hinder recycling	DO-03 Declaration of materials that hinder recycling	DO-05 Biobased materials	DO-10 Mileage improvement
Human toxicity, non-cancer - organics	CTUh	1.30E-06	1.31E-06	1.30E-06	1.30E-06	1.30E-06	1.31E-06	1.43E-06
	% difference	0 %	0.1 %	-0.1 %	0.0 %	0.0 %	0.2 %	10.0 %
Ionising radiation	kBq U-235 eq	4.44E+00	4.46E+00	4.68E+00	4.44E+00	4.44E+00	4.33E+00	4.58E+00
	% difference	0 %	0.5 %	5.4 %	0.0 %	0.0 %	-2.6 %	3.1 %
Land use	Pt	4.02E+03	3.88E+03	3.34E+03	4.02E+03	4.02E+03	4.02E+03	4.19E+03
	% difference	0 %	-3.6 %	-17.0 %	0.0 %	0.0 %	-0.1 %	4.1 %
Ozone depletion	kg CFC11 eq	1.25E-05	1.18E-05	1.03E-05	1.25E-05	1.25E-05	1.25E-05	1.31E-05
	% difference	0 %	-5.0 %	-17.8 %	0.0 %	0.0 %	-0.1 %	5.2 %
Photochemical ozone formation	kg NMVOC eq	1.71E+00	1.70E+00	1.68E+00	1.71E+00	1.71E+00	1.71E+00	1.87E+00
	% difference	0 %	-0.5 %	-1.9 %	0.0 %	0.0 %	-0.2 %	9.3 %
Resource use, fossils	MJ	4.17E+03	4.14E+03	4.06E+03	4.17E+03	4.17E+03	4.16E+03	4.55E+03
	% difference	0 %	-0.7 %	-2.7 %	0.0 %	0.0 %	-0.4 %	9.1 %
Resource use, minerals and metals	kg Sb eq	3.62E-04	3.14E-04	2.65E-04	3.62E-04	3.62E-04	3.17E-04	3.69E-04
	% difference	0 %	-13.0 %	-26.8 %	0.0 %	0.0 %	-12.4 %	2.1 %

PEF Impact categories	unit	Original base case	DO-01A Recycled content	DO-01B Recycled content	DO-02 Restriction of substances that hinder recycling	DO-03 Declaration of materials that hinder recycling	DO-05 Biobased materials	DO-10 Mileage improvement
Water use	m3 depriv.	1.57E+01	1.49E+01	1.31E+01	1.57E+01	1.57E+01	1.53E+01	1.61E+01
	% difference	0 %	-4.9 %	-16.1 %	0.0 %	0.0 %	-2.1 %	2.8 %

1326 1.9.1.2. LCC impact

1327 **Table 1-22** presents the LCC impact of all design options, along with their comparison to the original base case results (reference). The difference is expressed
 1328 in percentages. Costs, as calculated in the ERT, are expressed per year, with the exception of the product price, which is also reported over the total lifetime.

1329 **Table 1-22: LCC impact per design option compared to BC1.**

Cost category	Unit	Original base case	DO-01A Recycled content	DO-01B Recycled content	DO-02 Restriction of substances that hinder recycling	DO-03 Declaration of materials that hinder recycling	DO-05 Biobased materials	DO-10 Mileage improvement
Product price	EUR	71	71	71	71	71	71	71
	EUR/year	18	18	18	18	18	18	16
	% difference/year	0 %	0 %	0 %	0 %	0 %	0 %	-9.1 %
Installation costs	EUR/year	4.7	4.7	4.7	4.7	4.7	4.7	4.3
	% difference	0 %	0 %	0 %	0 %	0 %	0 %	-9.1 %

Cost category	Unit	Original base case	DO-01A Recycled content	DO-01B Recycled content	DO-02 Restriction of substances that hinder recycling	DO-03 Declaration of materials that hinder recycling	DO-05 Biobased materials	DO-10 Mileage improvement
Fuel (Euro-super 95) costs	EUR/year	32	32	32	32	32	32	31
	% difference	0 %	0 %	0 %	0 %	0 %	0 %	-0.7 %
Repair & maintenance costs	EUR/year	14.7	14.7	14.7	14.8	14.7	14.7	14.7
	% difference	0 %	0 %	0 %	1.0 %	0 %	0 %	0 %
Total	EUR/year	68.8	68.8	68.8	68.9	68.8	68.8	66.5
	% difference	0 %	0 %	0 %	0.2 %	0 %	0 %	-3.3 %

1330 1.9.2. BC2: Results pending

1331 1.9.3. BC3: C3 Tyre

1332 The environmental impact and LCC impact of each design option for the C3 tyre base case (BC3) are presented in this section.

1333 1.9.3.1. Environmental impact

1334 **Table 1-23** presents the environmental impact of all design options, along with their comparison to the original base case results (reference). The difference is
 1335 expressed in percentages. The results are provided for the full lifetime of the product, thus including lifetime increase (DO-08).

1336 Table 1-23: Environmental impact per design option (full lifetime) compared to B3.

PEF Impact categories	unit	Original base case	DO-01A Recycled content	DO-01B Recycled content	DO-05 Biobased materials	DO-08 Support retreading	DO-10 Mileage improvement
Acidification	mol H+ eq	3.25E+01	3.24E+01	3.23E+01	3.25E+01	3.56E+01	3.52E+01
	% difference	0 %	-0.3 %	-0.7 %	-0.1 %	9.5 %	8.5 %
Climate change	kg CO2 eq	5.69E+03	5.68E+03	5.65E+03	5.69E+03	6.24E+03	6.18E+03
	% difference	0 %	-0.3 %	-0.7 %	0.0 %	9.6 %	8.6 %
Climate change - Biogenic	kg CO2 eq	4.31E-01	4.25E-01	4.17E-01	4.25E-01	4.60E-01	4.58E-01
	% difference	0 %	-1.4 %	-3.2 %	-1.3 %	6.8 %	6.4 %
Climate change - Fossil	kg CO2 eq	5.69E+03	5.68E+03	5.65E+03	5.69E+03	6.24E+03	6.18E+03
	% difference	0 %	-0.3 %	-0.7 %	0.0 %	9.6 %	8.6 %
Climate change - Land use and LU change	kg CO2 eq	4.83E-01	4.33E-01	4.08E-01	4.79E-01	5.07E-01	5.05E-01
	% difference	0 %	-10.2 %	-15.5 %	-0.8 %	4.9 %	4.6 %
Ecotoxicity, freshwater	CTUe	4.26E+03	4.20E+03	4.07E+03	4.29E+03	4.50E+03	4.48E+03
	% difference	0 %	-1.4 %	-4.7 %	0.7 %	5.5 %	5.2 %
Ecotoxicity, freshwater - inorganics	CTUe	3.28E+03	3.06E+03	2.94E+03	3.14E+03	3.49E+03	3.47E+03
	% difference	0 %	-6.7 %	-10.4 %	-4.1 %	6.4 %	5.9 %
Ecotoxicity, freshwater - organics	CTUe	1.01E+03	1.17E+03	1.15E+03	1.18E+03	1.04E+03	1.04E+03
	% difference	0 %	15.5 %	13.8 %	16.2 %	2.3 %	2.7 %
Particulate matter	disease inc.	1.96E-04	1.95E-04	1.91E-04	1.96E-04	2.10E-04	2.07E-04

Preparatory Study and Impact Assessment support study on tyres

PEF Impact categories	unit	Original base case	DO-01A Recycled content	DO-01B Recycled content	DO-05 Biobased materials	DO-08 Support retreading	DO-10 Mileage improvement
	% difference	0 %	-0.8 %	-2.4 %	-0.1 %	7.1 %	5.8 %
Eutrophication, marine	kg N eq	1.49E+01	1.49E+01	1.48E+01	1.49E+01	1.63E+01	1.62E+01
	% difference	0 %	-0.1 %	-0.4 %	0.0 %	9.7 %	8.6 %
Eutrophication, freshwater	kg P eq	1.23E-01	1.13E-01	1.13E-01	1.19E-01	1.28E-01	1.28E-01
	% difference	0 %	-8.0 %	-7.7 %	-2.5 %	4.6 %	4.4 %
Eutrophication, terrestrial	mol N eq	1.63E+02	1.63E+02	1.62E+02	1.63E+02	1.79E+02	1.77E+02
	% difference	0 %	-0.1 %	-0.4 %	0.0 %	9.7 %	8.6 %
Human toxicity, cancer	CTUh	3.92E-07	4.15E-07	4.19E-07	4.05E-07	4.17E-07	4.15E-07
	% difference	0 %	5.7 %	6.7 %	3.2 %	6.3 %	5.8 %
Human toxicity, cancer - inorganics	CTUh	1.37E-07	1.57E-07	1.69E-07	1.33E-07	1.48E-07	1.47E-07
	% difference	0 %	15.0 %	23.8 %	-2.5 %	7.8 %	7.1 %
Human toxicity, cancer - organics	CTUh	2.24E-07	2.27E-07	2.23E-07	2.40E-07	2.38E-07	2.36E-07
	% difference	0 %	1.3 %	-0.6 %	7.1 %	6.3 %	5.6 %
Human toxicity, non-cancer	CTUh	2.23E-05	2.37E-05	2.40E-05	2.20E-05	2.37E-05	2.37E-05
	% difference	0 %	6.3 %	7.7 %	-1.3 %	6.6 %	6.5 %
Human toxicity, non-cancer - inorganics	CTUh	1.13E-05	1.28E-05	1.35E-05	1.10E-05	1.20E-05	1.20E-05
	% difference	0 %	13.2 %	19.3 %	-2.6 %	6.1 %	6.0 %
Human toxicity, non-cancer - organics	CTUh	8.05E-06	8.04E-06	8.02E-06	8.05E-06	8.83E-06	8.75E-06

PEF Impact categories	unit	Original base case	DO-01A Recycled content	DO-01B Recycled content	DO-05 Biobased materials	DO-08 Support retreading	DO-10 Mileage improvement
	% difference	0 %	-0.1 %	-0.4 %	0.0 %	9.8 %	8.7 %
Ionising radiation	kBq U-235 eq	4.45E+01	4.48E+01	4.68E+01	4.37E+01	4.66E+01	4.65E+01
	% difference	0 %	0.8 %	5.3 %	-1.7 %	4.8 %	4.7 %
Land use	Pt	5.92E+04	5.74E+04	5.07E+04	5.91E+04	5.95E+04	6.06E+04
	% difference	0 %	-3.0 %	-14.4 %	0.0 %	0.6 %	2.5 %
Ozone depletion	kg CFC11 eq	1.46E-04	1.45E-04	1.45E-04	1.45E-04	1.58E-04	1.56E-04
	% difference	0 %	-0.1 %	-0.6 %	-0.1 %	8.3 %	7.4 %
Photochemical ozone formation	kg NMVOC eq	4.89E+01	4.88E+01	4.87E+01	4.89E+01	5.37E+01	5.31E+01
	% difference	0 %	-0.2 %	-0.6 %	0.0 %	9.7 %	8.6 %
Resource use, fossils	MJ	7.42E+04	7.39E+04	7.33E+04	7.40E+04	8.12E+04	8.05E+04
	% difference	0 %	-0.3 %	-1.1 %	-0.2 %	9.5 %	8.5 %
Resource use, minerals and metals	kg Sb eq	2.66E-03	2.10E-03	1.77E-03	2.22E-03	2.74E-03	2.76E-03
	% difference	0 %	-21.2 %	-33.4 %	-16.7 %	2.9 %	3.4 %
Water use	m3 depriv.	1.39E+02	1.32E+02	1.19E+02	1.37E+02	1.45E+02	1.45E+02
	% difference	0 %	-5.6 %	-14.9 %	-1.4 %	3.7 %	4.1 %

1337 1.9.3.2. LCC impact

1338 **Table 1-24** presents the LCC impact of all design options, along with their comparison to the original base case results (reference). The difference is expressed
 1339 in percentages. Costs, as calculated in the ERT, are expressed per year, with the exception of the product price, which is also reported over the total lifetime.

1340 **Table 1-24: LCC impact per design option compared to BC3.**

Life cycle costs	unit	Original base case	DO-01A Recycled content	DO-01B Recycled content	DO-05 Biobased materials	DO-08 Support retreading	DO-10 Mileage improvement
Product price	EUR	419	419	419	419	419	419
	EUR/year	140	140	140	140	127	127
	% difference/year	0 %	0 %	0 %	0 %	-9.1 %	-9.1 %
Installation costs	EUR/year	6.3	6.3	6.3	6.3	5.7	5.7
	% difference	0 %	0 %	0 %	0 %	-9.1 %	-9.1 %
Fuel (diesel) costs	EUR/year	698	698	698	698	694	686
	% difference	0 %	0 %	0 %	0 %	-0.6 %	-1.7 %
Repair & maintenance costs	EUR/year	20	20	20	20	18	20
	% difference	0 %	0 %	0 %	0 %	-9.1 %	0 %
Total	EUR/year	864	864	864	864	844	839
	% difference	0 %	0 %	0 %	0 %	-2.2 %	-2.9 %

1341

1342 1.10. Analysis of design options per base case

1343 In this section, both environmental impacts and LCC results are analysed to determine which
 1344 design options could be advanced as policy measures. Since these options address the product
 1345 aspects outlined in Article 5(1), the full range of environmental impacts must be evaluated to
 1346 ensure a balanced assessment. Incorporation of multiple aspects into the framework makes it
 1347 possible for a design option to perform significantly better in one impact category while
 1348 underperforming in others. A narrow focus on one or two categories would introduce bias into
 1349 the comparison and overlook trade-offs across the remaining impact categories.

1350 To address this, the PEF single-score methodology is applied, transforming the impact category
 1351 results (as previously shown) into a single, normalised, weighted indicator. By aggregating
 1352 climate change, toxicity, eutrophication, land use, and other life cycle impacts into one score,
 1353 design alternatives can be ranked according to their overall environmental performance.

1354 When these PEF single scores are plotted alongside their corresponding life-cycle costs, a clear
 1355 comparison against the base case is shown. Design options having the lowest PEF single scores
 1356 and the most favourable cost profiles may then be prioritised for inclusion in the new ESPR
 1357 requirements. Prior to presenting the analysis, the single-score method will be explained and
 1358 the scores for the Base Case and each design option will be reported.

1359 1.10.1. Calculation method PEF single score

1360 The PEF single score is calculated as follows:

$$1361 \text{ PEF single score} = \sum_{i=1}^{16} I_i * \frac{WFi}{NF_i}$$

1362 I = calculated impact for PEF impact category (e.g. Climate change, Acidification, etc)

1363 WF = Weighing factor for PEF impact category

1364 NF = Normalisation factor PEF impact category

1365 The weighting factor reflects the relative importance of the impact category, and the
 1366 normalisation factor anchors each impact to a per-capita baseline. The most recent set of
 1367 weighing and normalisation factors was released in 2023 by the Joint Research Centre (European
 1368 Commission. Joint Research Centre., 2023), which builds on the original factors in Annex I of the
 1369 Commission Recommendation (EU) 2021/2279 (European Commission, 2021) on the use of the
 1370 Environmental Footprint methods. The factors used for calculating the single score is included
 1371 in **Table 1-25** below.

1372

1373 **Table 1-25: PEF Single score normalisation factor and weighing factor per PEF impact**
 1374 **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 %
Resource use, fossils	MJ/person	6.50E+04	8.32 %

1375

1376 **1.10.2. PEF single score per base case and design option**

1377 The purpose of PEF single scores is to provide comparable weighted values across the main 16 PEF impact categories, where a higher single score indicates a
 1378 greater environmental impact (**Table 1-26**). Therefore, PEF single scores were calculated for each of the base cases, aggregating impacts across all life-cycle
 1379 stages over the product’s entire lifetime. In addition, the PEF single scores were calculated per km driven to consider lifetime extensions by design options. The
 1380 same scoring system was then applied to every design option for each base case, enabling a like-for-like comparison of overall environmental performance.

1381 **Table 1-26: PEF Single score per design option for each base case.**

Base Case		Original Base Case (Reference)	DO-01A Recycled content	DO-01B Recycled content	DO-02 Restriction of substances that hinder recycling	DO-03 Declaration of materials that hinder recycling	DO-05 Biobased materials	DO-08 Support retreading	DO-10 Mileage improvement
BC1: C1 Tyres	PEF Single Score total lifetime	2.12E-02	2.10E-02	2.05E-02	2.12E-02	2.12E-02	2.11E-02	n.a.	2.29E-02
	% difference	0 %	-0.9 %	-3.0 %	-0.02 %	-0.01 %	-0.52 %	n.a.	8.2 %
	PEF Single Score per km driven	5.29E-07	5.24E-07	5.14E-07	5.29E-07	5.29E-07	5.27E-07	n.a.	5.21E-07
	% difference	0 %	-0.9 %	-3.0 %	-0.02 %	-0.01 %	-0.52 %	n.a.	-1.6 %
BC3: C3 Tyres	PEF Single Score total lifetime	4.51E-01	4.49E-01	4.46E-01	n.a.	n.a.	4.50E-01	4.93E-01	4.88E-01
	% difference	0 %	-0.5 %	-1.3 %	n.a.	n.a.	-0.2 %	9.2 %	8.2 %
	PEF Single Score per km driven	1.78E-06	1.77E-06	1.76E-06	n.a.	n.a.	1.78E-06	1.77E-06	1.75E-06

Base Case	Original Base Case (Reference)	DO-01A Recycled content	DO-01B Recycled content	DO-02 Restriction of substances that hinder recycling	DO-03 Declaration of materials that hinder recycling	DO-05 Biobased materials	DO-08 Support retreading	DO-10 Mileage improvement
% difference	0 %	-0.5 %	-1.3 %	n.a.	n.a.	-0.2 %	-0.7 %	-1.6 %

1382 **1.10.3. Total yearly cost per base case and design option**

1383 Annual life-cycle costs are summarised in **Table 1-27** for convenience from the data previously presented in this report. The total annual costs are presented for
 1384 every design option within each base case, enabling a like-for-like comparison of annual life-cycle costs. Because discounting and present-worth conversion
 1385 occur within the tool, only the total annual cost figures are reported, as they offer the most accurate representation of life-cycle cost in the present.
 1386 Consequently, design alternatives can be ranked and prioritised based on these annualised cost values.

1387 **Table 1-27: Total yearly costs in EUR per design option for each Base Case.**

Base Case		Original Base Case (Reference)	DO-01A Recycled content	DO-01B Recycled content	DO-02 Restriction of substances that hinder recycling	DO-03 Declaration of materials that hinder recycling	DO-05 Biobased materials	DO-08 Support retreading	DO-10 Mileage improvement
BC1: C1 Tyres	EUR/year	68.8	68.8	68.8	68.9	68.8	68.8	n.a.	66.5
	% difference	0 %	0 %	0 %	0.21 %	0 %	0 %	n.a.	-3 %
BC3: C3 Tyres	EUR/year	864	864	864	n.a.	n.a.	864	844	839
	% difference	0 %	0 %	0 %	n.a.	n.a.	0%	-2 %-2.2 %	-2.91 %

1388

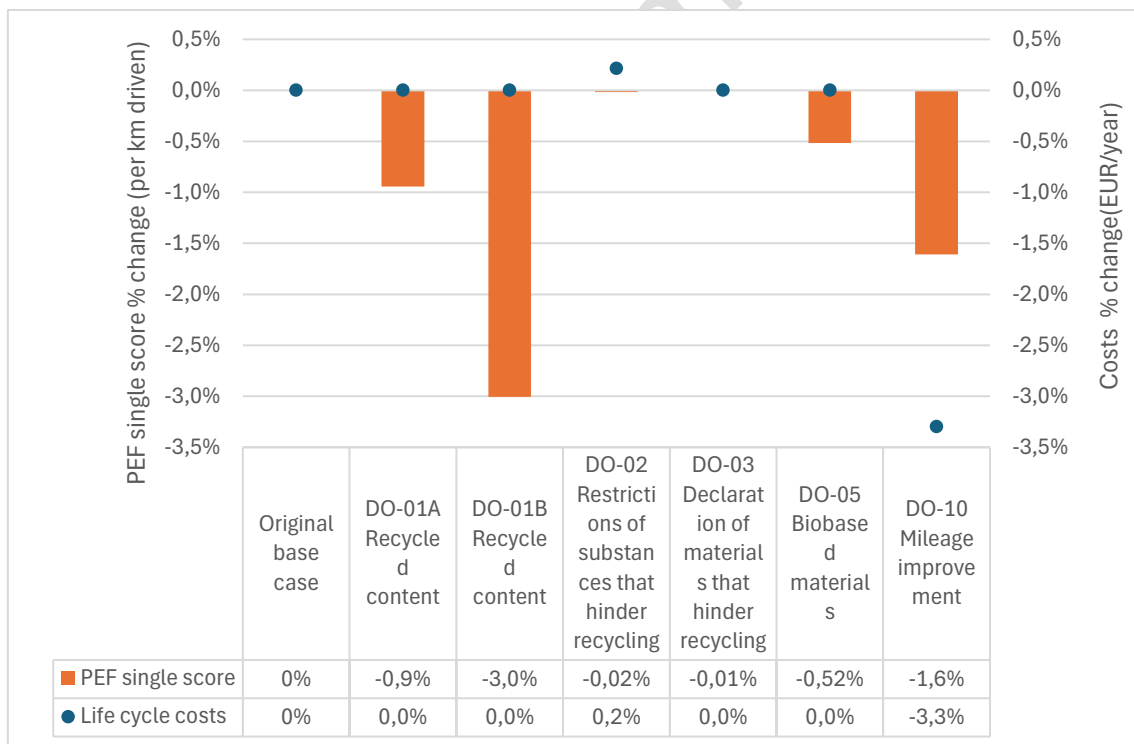
1389 **1.10.4. Evaluation of selected design options per base case**

1390 In this section, the environmental impact (PEF single score) and LCC of the individual design
 1391 options, as well as the cumulative results for the corresponding design option paths, are
 1392 presented. The cumulative impacts were calculated by aggregating the environmental impact
 1393 (PEF single score) and cost improvements of each design option one at a time, under the
 1394 assumption that each design option does not adversely affect the other.

1395 **Note: the pathways A (closing the loop (DO-01,02,03)), B (bio-transition (DO-05)) and D*
 1396 *(lifetime extension (DO-08,10) have been calculated separately here. According to the new*
 1397 *MEErP methodologies, DOs should be grouped into pathways where they do not conflict with*
 1398 *each other. While the cumulative LCA here only considers individual paths A, B, D, it is also*
 1399 *foreseeable that Path A, B and D can be combined together, despite some trade-offs.*

1400 **1.10.4.1. BC1: C1 Tyres**

1401 Below (**Figure 1-3**), the change in PEF single score of the base case per kilometre driven is shown
 1402 (left y-axis), together with the % change in costs per year (right y-axis).



1403

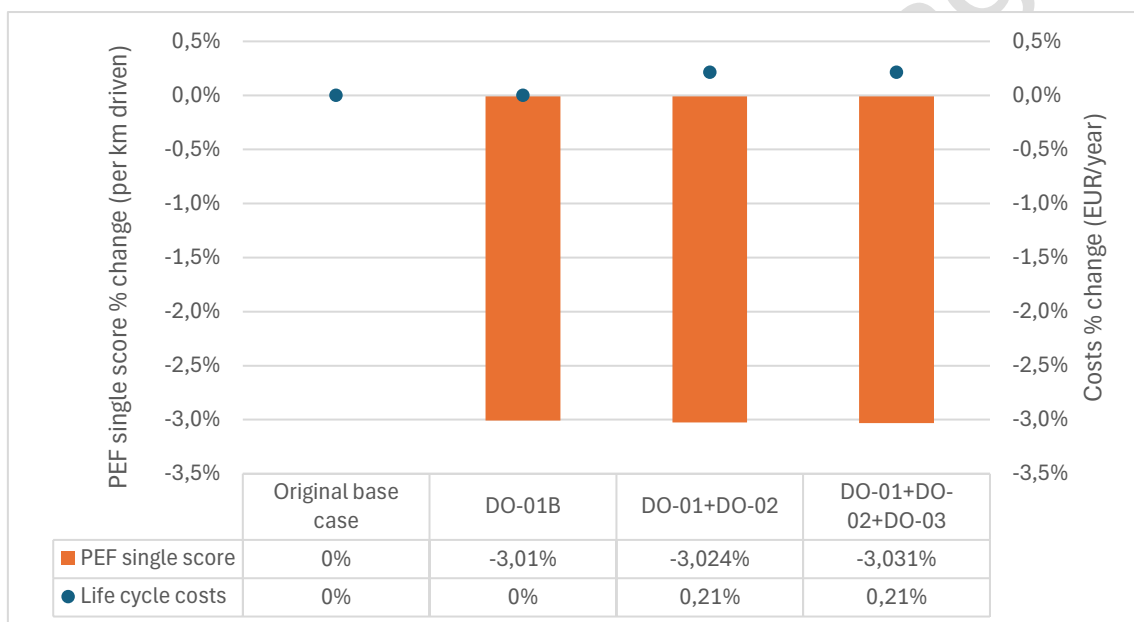
1404 **Figure 1-3: BC1 - PEF score change (in %) per design option per kilometre driven versus costs**
 1405 **change per year (in %).**

1406 DO-01A and DO-01B show a reduction in overall environmental impact (-0.9 % and -3 %
 1407 respectively), primarily due to the use of recycled materials, as well as an increased share of
 1408 tyres undergoing devulcanisation and pyrolysis as EoL treatment scenarios. No change is
 1409 observed in their LCC. DO-02 and DO-03 show a negligible reduction in PEF single score (-0.02 %

1410 and -0.01 %) as a result of changes in their EoL treatment scenarios. This is because the EoL life
 1411 cycle stage contributes only marginally to the overall impact, as identified in Task 5. The costs of
 1412 DO-02 increase slightly (0.2 %) due to higher maintenance costs.

1413 For DO-05, the environmental impact is reduced (-0.52 %) due to the use of bio-based materials
 1414 with lower associated impacts. DO-10 shows a lower PEF single score (-1.6 %) compared to the
 1415 original base case, as the total impact is distributed over a longer lifetime. Furthermore, its
 1416 annual costs decrease (-3.3 %), as the longer lifetime allows costs to be distributed over a greater
 1417 time period.

1418 Finally, the cumulative LCA and LCC results for Path A, expressed in change in PEF single score
 1419 per kilometre driven of the base case (left y-axis), together with the % change in costs per year
 1420 (right y-axis), are shown in **Figure 1-4**. For the cumulative impact calculation, DO-01B was
 1421 selected over DO-01A, as it represents an improved version of the same design option.



1422

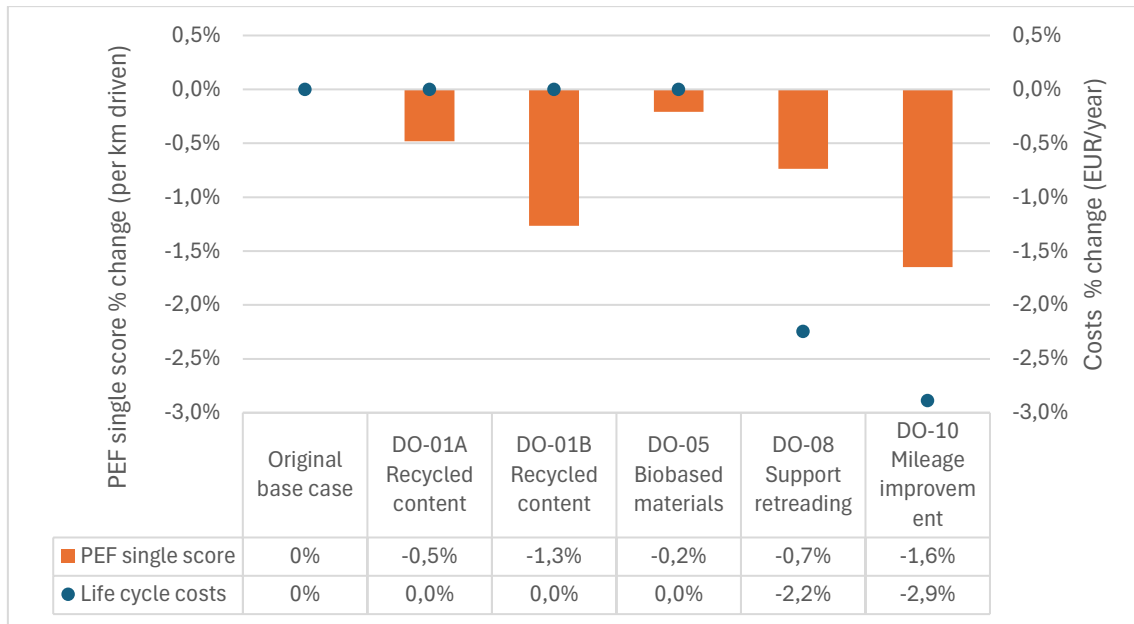
1423 **Figure 1-4: BC1 – Path A cumulative results: PEF score change (in %) per design option over**
 1424 **the full lifetime versus costs change per year (in %).**

1425 The cumulative results of the design options for Path A show a progressive improvement, with
 1426 the combination of the design options DO-01, DO-02 and DO-03 representing the best-
 1427 performing option (-3.031 % impact reduction). Costs increase by 0.21 % following the addition
 1428 of DO-02 but remain stable thereafter.

1429 **1.10.4.2. BC2: Results pending**

1430 **1.10.4.3. BC3: C3 Tyre**

1431 Below (**Figure 1-5**), the change in PEF single score of the base case per kilometre driven is shown
 1432 (left y-axis), together with the % change in costs per year (right y-axis).



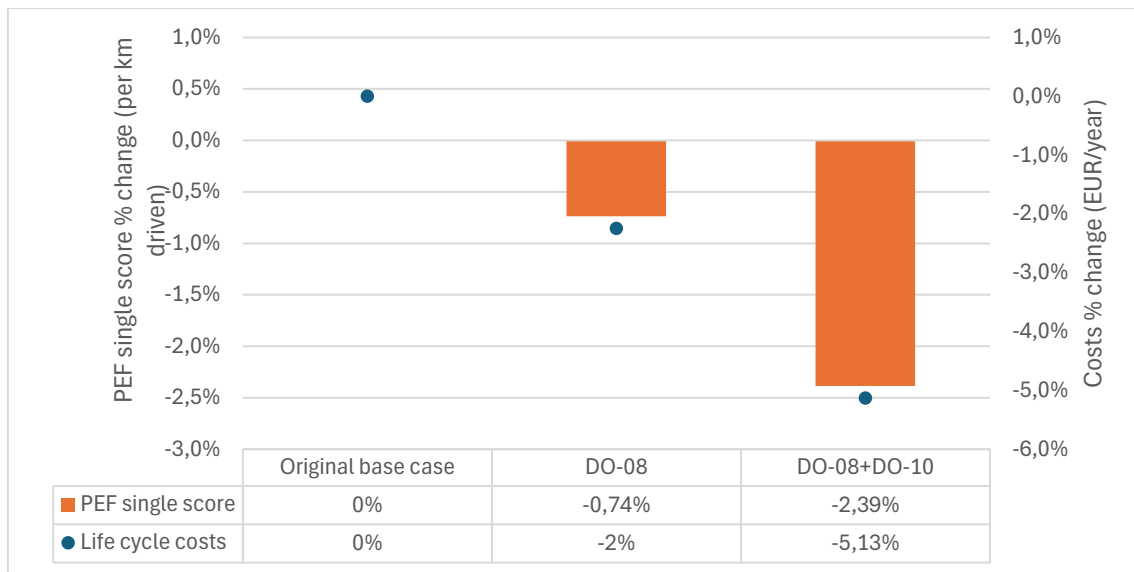
1433

1434 **Figure 1-5: BC3 - PEF score change (in %) per design option per kilometre driven versus costs**
 1435 **change per year (in %).**

1436 DO-01A and DO-01B have an overall lower environmental impact (0.5 % and 1.3 % respectively),
 1437 primarily due to the use of recycled materials, as well as an increased share of tyres undergoing
 1438 devulcanisation and pyrolysis as EoL treatment scenarios. No change is observed in their lifecycle
 1439 costs. For DO-05, the environmental impact is reduced (-0.2 %) due to the use of bio-based
 1440 materials with lower associated impacts.

1441 DO-08 shows a decrease in impact (-0.7%) compared to the original base case, as the total
 1442 impact is distributed over a longer lifetime. Furthermore, its LCC decreases (-2.2%), as the longer
 1443 lifetime allows costs to be distributed over a greater time period. Similarly, DO-10 shows a
 1444 reduction in both environmental impact and costs (-1.6% and -2.9%) compared to the original
 1445 base case. The observed reduction in impact and costs can be attributed to lifetime extension
 1446 as well as lower fuel consumption and tyre wear loss.

1447 Finally, the cumulative LCA and LCC results for Path D, expressed in change in PEF single score
 1448 per km driven of the base case (left y-axis), together with the % change in costs per year (right
 1449 y-axis), are shown in **Figure 1-6**.



1450

1451 **Figure 1-6: BC3 – Path D cumulative results: PEF score change (in %) per design option per km**
 1452 **driven versus costs change per year (in %).**

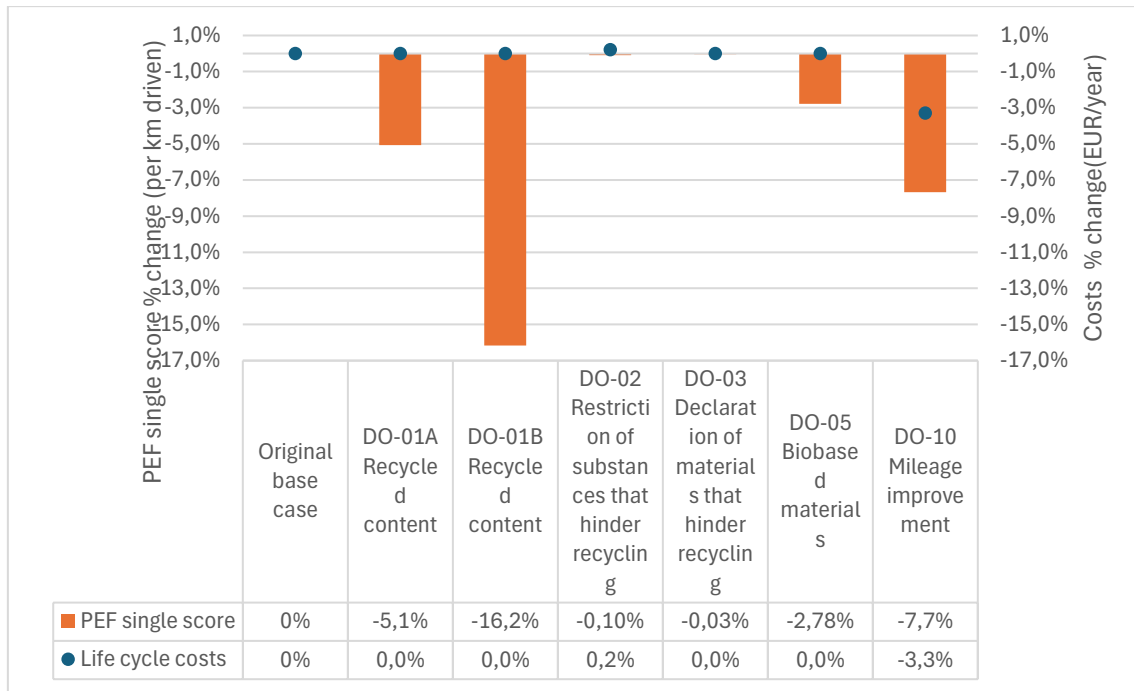
1453 The cumulative results per kilometre driven show a progressive improvement, with the
 1454 combination of the design options DO-08 and DO-10 representing the best-performing option
 1455 (2.39 % impact reduction). Similarly, a maximum cost reduction of -5.13 % is observed for the
 1456 DO-08 and DO-10 combination.

1457 **1.10.5. Evaluation of selected design options per base case, excluding**
 1458 **the use phase impact**

1459 As identified in Task 5, the use phase is the largest contributing life cycle stage. To better assess
 1460 the effects of each design option on the other life cycle stages, particularly raw materials, the
 1461 environmental impact (PEF single score) of the individual design options, as well as the
 1462 cumulative results for the corresponding design option paths, are presented, excluding the use
 1463 phase impact of the tyre. The cumulative impacts were calculated by aggregating the
 1464 environmental impact (PEF single score) and cost improvements of each design option one at a
 1465 time, under the assumption that each design option does not adversely affect the other.

1466 **1.10.5.1. BC1: C1 Tyres**

1467 **Figure 1-7** illustrates the change in PEF single score (excluding the use phase) of the base case
 1468 per kilometre driven (left y-axis), together with the % change in costs per year (right y-axis).



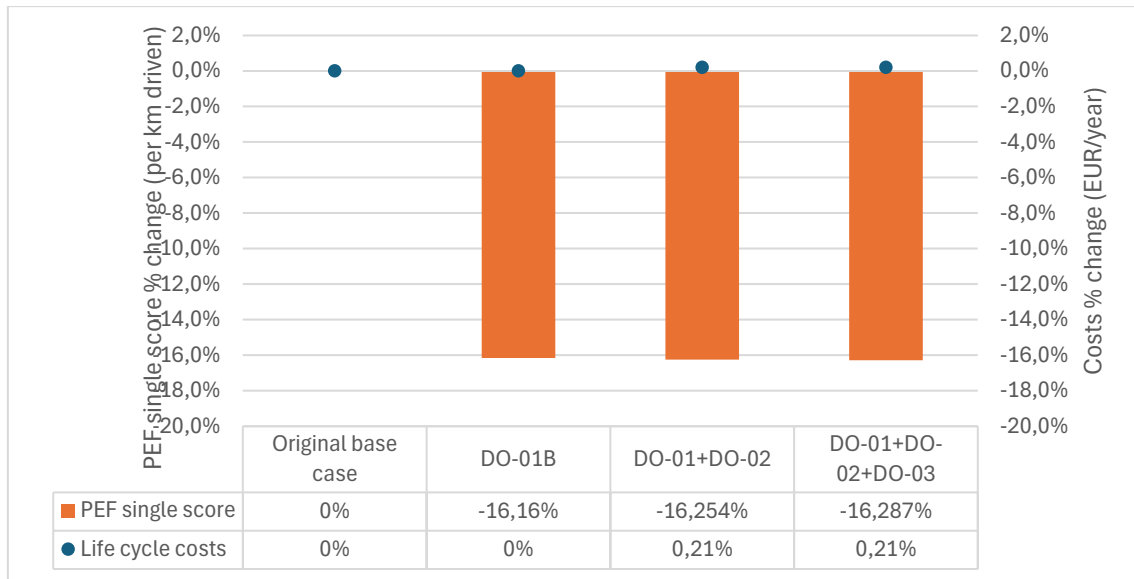
1469

1470 **Figure 1-7: BC1 - PEF score change excluding use phase (in %) per design option per kilometre**
 1471 **driven versus costs change per year (in %).**

1472 When the use phase is excluded, the impact reductions associated with each design option
 1473 become more evident. This effect can be specifically observed in design options involving
 1474 changes in raw materials, such as DO-01A, DO-01B and DO-05, where impact reductions of up
 1475 to 16.2 % are identified.

1476 The cumulative LCA and LCC results for Path A (excluding the use phase), expressed in change in
 1477 PEF single score per kilometre driven of the base case (left y-axis), together with the % change
 1478 in costs per year (right y-axis), are shown in **Figure 1-8**. For the cumulative impact calculation,
 1479 DO-01B was selected over DO-01A, as it represents an improved version of the same design
 1480 option.

1481



1482

1483
1484

Figure 1-8: BC1 – Path A cumulative results: PEF score change excluding use phase (in %) per design option versus costs change per year (in %).

1485
1486
1487
1488
1489

Similar to the cumulative full lifetime results shown in **Figure 1-4**, the Path A cumulative results excluding the use phase impact show a progressive improvement, with the combination of the design options DO-01, DO-02 and DO-03 representing the best-performing option (-16.287 % impact reduction). Costs increase by 0.21 % following the addition of DO-02 but remain stable thereafter.

1490

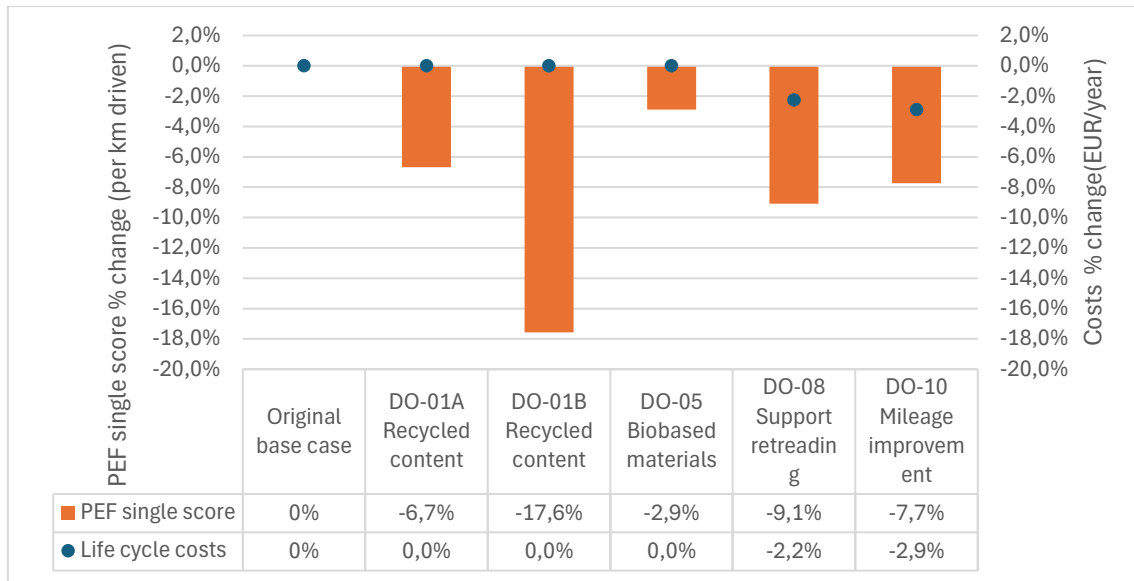
1.10.5.2. BC2: Results pending

1491

1.10.5.3. BC3: C3 Tyres

1492
1493

Figure 1-9 illustrates the change in PEF single score (excluding the use phase) of the base case per kilometre driven (left y-axis), together with the % change in costs per year (right y-axis).

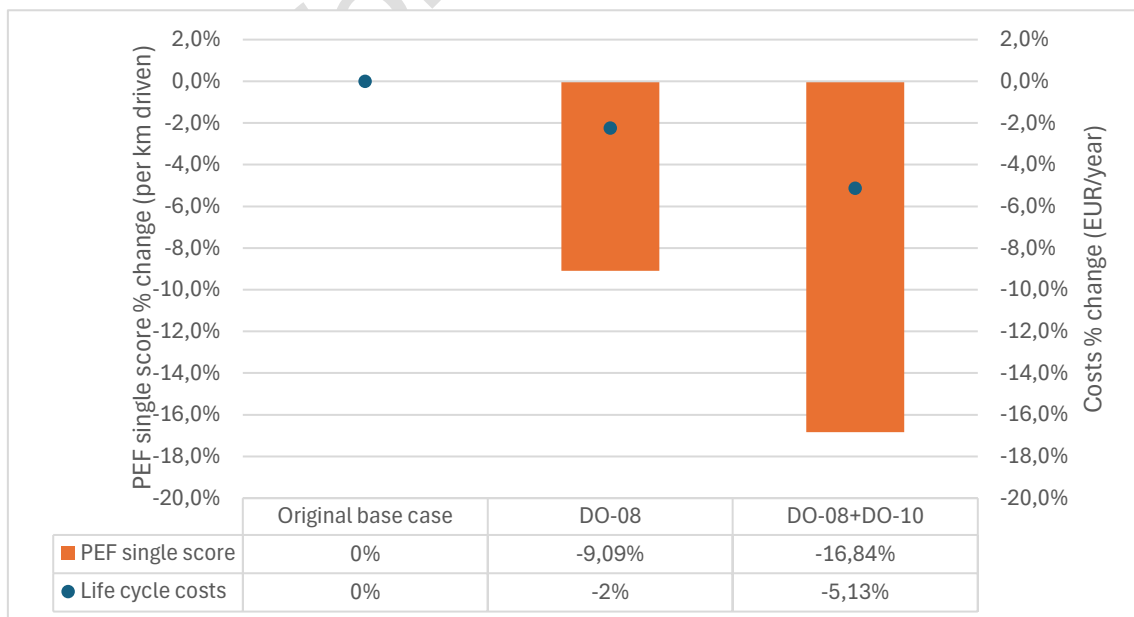


1494

1495 **Figure 1-9: BC3 - PEF score change excluding use phase (in %) per design option per kilometre**
 1496 **driven versus costs change per year (in %).**

1497 When the use phase is excluded, the impact reductions associated with each design option
 1498 become more evident. This effect can be specifically observed in design options involving
 1499 changes in raw materials, such as DO-01A, DO-01B and DO-05, where impact reductions of up to
 1500 17.6 % are identified.

1501 The cumulative LCA and LCC results for Path A (excluding the use phase), expressed in change in
 1502 PEF single score per kilometre driven of the base case (left y-axis), together with the % change
 1503 in costs per year (right y-axis), are shown in **Figure 1-10**. For the cumulative impact calculation,
 1504 DO-01B was selected over DO-01A, as it represents an improved version of the same design
 1505 option.



1506

1507 **Figure 1-10: BC3 – Path A cumulative results: PEF score change excluding use phase (in %) per**
 1508 **design option versus costs change per year (in %).**

1509 The cumulative results excluding the use phase impact show a progressive improvement, with
1510 the combination of the design options DO-08 and DO-10 representing the best-performing
1511 option (-16.84 % impact reduction). Similarly, a maximum costs reduction of -5.13 % is observed
1512 for the DO-08 and DO-10 combination.

1513 1.10.6. Conclusions

- 1514 • Looking at the per km driven results for BC1, the best performing DO is DO-01B mainly
1515 because of raw material impact reduction and increased shares of devulcanisation and
1516 pyrolysis as EoL treatment scenarios. Regarding the costs, DO-10 is the most efficient
1517 DO because of its increased lifetime despite the increase in maintenance costs: costs are
1518 distributed across a longer period of time/ more km, and therefore, fewer costs are
1519 allocated per km;
- 1520 • Looking at the per km driven results for BC3: the best performing DO in terms of
1521 environmental impact and lifetime costs is DO-10 due to its increased lifetime, lower
1522 fuel consumption, and lower tyre wear loss;
- 1523 • In the cumulative scenarios, Path A (BC1) has a greater reduction in comparison to Path
1524 D (BC3), although this might not be a fair comparison between base cases;
- 1525 • When the use phase impact is excluded, higher reduction percentages are observed
1526 across all design options.
- 1527 • As part of the MEErP it is necessary to consider the “product affordability” for the
1528 consumer. At the present time, only limited costing changes have been assumed to
1529 calculate the lifecycle costs. This leads to minimal changes calculated for C1 and C3 tyres
1530 from the original product price. Following stakeholder feedback at the second
1531 stakeholder meeting changes may be made here.

1532 2. Digital Product Passport Analysis

1533 2.1. Step A: Scope & Context

1534 2.1.1. A.1 Product scope

1535 The proposed scope for the DPP to start with builds upon existing regulatory classifications:

- 1536 • **C1** (Passenger cars);
- 1537 • **C2** (Light commercial vehicles);
- 1538 • **C3** (Heavy commercial vehicles/trucks and buses) categories.

1539 For the end-of-life stage and sorting, it may be beneficial to extend this scope to further tyre
1540 categories.

1541 Tyres are primarily classified as final products in the replacement market (sold directly to
1542 consumers or fleet operators). However, they also function as highly engineered intermediate
1543 products when supplied directly to OEMs for integration onto newly manufactured vehicles.

1544 2.1.2. A.2 Market context and stakeholder data roles

1545 The tyre value chain is highly consolidated at the point of manufacture but fragmented at EoL.

1546 Data Generators & Controllers:

- 1547 • **Manufacturers:** Generate and control the foundational Product Lifecycle Management
1548 (PLM) data, exact chemical compounding recipes, and structural geometry;
- 1549 • **Certification Bodies (e.g., ISCC):** Generate cryptographic tokens proving Mass Balance
1550 sustainability claims;
- 1551 • **Retreaders:** bring the product onto the market a second time with distinct
1552 characteristics (may be of different tread, tread depth);
- 1553 • **Sorting and recycling at EoL:** sorting centres and recyclers create data on tyre EoL flows
1554 – either to reuse, retreading, or recycling processes.

1555 Data Exchange Points & Standardisation Hubs:

- 1556 • **The Global Data Service Organisation (GDSO) Ecosystem:** The registry set up by the
1557 industry for tyre data exchange. They standardise the Application Programming
1558 Interface (API) and RAIN RFID parameters that allow the physical tyre to ping the
1559 manufacturer's cloud;
- 1560 • **ETRTO:** Sets the physical dimensional standards;
- 1561 • **National Extended Product Responsibility (EPR) schemes for Tyres:** Across the EU, tyre
1562 collection and recycling are managed by national, EPR management organisations (e.g.,

1563 Aliapur in France, Signus in Spain, Ecopneu in Italy). These national bodies already
 1564 possess databases tracking tyre collection rates, retreading diversion, and recycling
 1565 tonnages.

1566 **Data Users (Downstream):**

- 1567 • **Replacement Tyre Consumers:** at point-of-sale view information on label, possibly
 1568 deeper information available in EPREL;
- 1569 • **OEMs:** Interested to know high-level data for product optimisation purposes;
- 1570 • **Fleet Operators:** Consume Model-level durability data and Item-level lifecycle data in
 1571 their fleets to calculate Total Cost of Ownership (TCO);
- 1572 • **Maintenance and/or repair workshops:** identification of tyre type and whether worth
 1573 repairing.
- 1574 • **EoL sorting operators:** Rely on data on the substance composition of tyres and
 1575 identification of tyres that should not be sent to certain treatment routes;
- 1576 • **Retreaders:** Consume filtered, abstract structural data to safely process the asset;
- 1577 • **Recyclers:** divert tyres of different types to different recycling processes (may depend
 1578 on legacy substances).

1579 **2.1.3. A.3 Existing policy and legal context**

1580 The tyre industry is already subject to a large number of regulations. The goal of the DPP is not
 1581 to duplicate existing efforts, and may draw on or link up with existing databases.

- 1582 • **EPREL:** Currently collects detailed Model-level energy label data on Rolling Resistance,
 1583 Wet Grip, and external Rolling Noise. The DPP may not be needed if EPREL can achieve
 1584 the same ends, or it may replace or reference the existing EPREL Unique Identifier via
 1585 API; it should not create a duplicate entry point of additional data entry needs for the
 1586 user's system. The table below shows the data points currently required to be entered
 1587 into EPREL.
- 1588 • **Euro 7 Emission Standards:** Will legally mandate the testing and reporting of
 1589 microplastic abrasion indices (A-E limits). The DPP can potentially be used to indicate
 1590 the final index and the specific testing methodology (Drum vs. Convoy) required for
 1591 Market Surveillance authorities (MSA) auditing.
- 1592 • **REACH Regulation:** Governs the restriction of Substances of Very High Concern (SVHCs),
 1593 such as the impending restriction on the antioxidant 6PPD. SCIP is the database for
 1594 information on **Substances of Concern** In articles as such or in complex objects
 1595 (**Products**) established under the Waste Framework Directive (WFD). Companies
 1596 supplying articles containing substances of very high concern (SVHCs) on the Candidate
 1597 List in a concentration above 0.1% weight by weight (w/w) on the EU market have to
 1598 submit information on these articles to ECHA. The SCIP database ensures that the
 1599 information on articles containing Candidate List substances is available throughout the
 1600 whole lifecycle of products and materials, including at the waste stage. The information
 1601 in the database is then made available to waste operators and consumers.

- 1602 • **EUDR (Deforestation Regulation):** Requires strict geospatial traceability for natural
1603 rubber sourcing.
- 1604 • **National EPR schemes:** define what data must be collected for monitoring of EoL tyres
1605 and processing.
- 1606 • **Retreading Label (pending):** if implemented, will provide information on retreading
1607 rolling resistance performance via label classes.
- 1608 • At the end of 2025, the European Commission also launched consultations on the New
1609 Legislative Framework which governs CE markings, conformity assessment and
1610 harmonised technical rules; and on the Market Surveillance Regulation which sets the
1611 enforcement framework for non-food products. These are expected to come together
1612 in a new EU Product Act, that takes into account digitalisation, circularity and supply
1613 chain aspects.

1614 **Table 2-1: Current Data Fields Collected under EPREL**

Category	EPREL Data Field	Legal Basis in Regulation (EU) 2020/740
Identification	Supplier / brand name	Art. 4(1); Annex VII(1)
	Tyre type identifier	Annex II(2); Annex VII(2)
	Tyre category (C1/C2/C3)	Annex I, Part A (definitions & category tables)
	Tyre size (width, aspect ratio, rim)	Annex VII(3)
	Load-capacity index	Annex VII(3)
	Speed-category symbol	Annex VII(3)
	Reinforced / XL	Annex VII(3)
	Snow tyre designation (3PMSF ¹¹)	Annex II, Part D; Annex VII(4)
	Ice-grip tyre designation	Annex II, Part D; Annex VII(5)
Label Performance Data (Public)	Rolling resistance class (A–E)	Annex I, Part A; Annex II, Part A
	Wet grip class (A–E)	Annex I, Part B; Annex II, Part B
	External rolling noise class (A–C)	Annex I, Part C; Annex II, Part C
	External rolling noise (dB)	Annex I, Part C; Annex II, Part C
	Snow-grip pictogram	Annex II, Part D
	Ice-grip pictogram	Annex II, Part D
	QR code (link to EPREL)	Art. 4(5); Annex II(1)(b)
Technical Performance Values (Not on Label but Required in EPREL)	RCC	Annex IV(3)(a); Annex I Part A
	Wet grip index	Annex IV(3)(b); Annex I Part B
	Measured noise value (dB)	Annex IV(3)(c); Annex I Part C
	Snow-grip test value	Annex IV; Annex I Part D

¹¹ 3PMSF: Three-Peak Mountain Snowflake

Category	EPREL Data Field	Legal Basis in Regulation (EU) 2020/740
	Ice-grip test value	Annex IV; Annex I Part E
Compliance & Documentation	Date of placing on the EU market	Art. 4(1); implied in Annex VII obligations
	Declaration of conformity	Art. 4(9); Annex IV(1)
	Technical documentation (test reports, conformity evidence)	Art. 4(9); Annex IV(1–6)
	Test laboratory details / accreditation	Annex IV(3)
	Label template version	Annex II (as amended under Art. 11)
	QR-code consistency with EPREL entry	Annex II(1)(b)

1615 2.1.4. A.4 Data collection status quo

1616 Existing Data Initiatives and Pilot Projects

1617 Three initiatives are of high relevance for exploring how the DPP can be integrated into tyres:

- 1618 • **CIRPASS-2 (Collaborative Initiative for a Standards-based Digital Product Passport):**
1619 The most relevant ongoing initiative is the EU-funded CIRPASS-2 project, which is
1620 actively piloting the real-world deployment of the DPP across several sectors. It is a
1621 temporary consortium of over 40 partners, including tech companies, manufacturers,
1622 and NGOs. A subset of the consortium is currently executing a dedicated Tyre Lighthouse
1623 Pilot.
1624 This project is actively testing the physical-to-digital connector, finding that optical QR
1625 codes are insufficient for tyres and validating vulcanised RAIN RFID tags as the necessary
1626 standard. The DPP architecture may build upon the CIRPASS-2 semantic interoperability
1627 findings to ensure the passport functions in harsh, real-world retreading and recycling
1628 environments.
1629 The mandate of CIRPASS-2 is to prevent vendor lock-in. It is tasked with developing
1630 open, standardised semantic definitions and cross-sector interoperability protocols.
1631 RAIN RFID is a global, open standard governed by ISO/IEC 18000-63 and GS1 EPC Gen2.
1632 Any hardware manufacturer can produce RAIN RFID tags and readers.
1633
- 1634 • **GDSO (Global Data Service Organisation for Tyres) Ecosystem:** The GDSO is an industry-
1635 led, non-profit international association. It was founded by major tyre manufacturers
1636 (Bridgestone, Continental, Goodyear, Michelin, Pirelli) to standardise tyre data access.
1637 The GDSO itself operates on non-proprietary standards, acting as an open "phonebook"
1638 or resolver service, utilizing global GS1 standards to standardise how an RFID ping
1639 translates into a web query. The GDSO does not host a centralised database of its own.
1640 When the resolver receives a query, it routes that query directly to the specific
1641 manufacturer's proprietary cloud servers to fetch data.
1642 The Tyre DPP can potentially leverage this existing decentralised infrastructure to
1643 enforce ESPR Role-Based Access Control rules without duplicating data storage, while

1644 allowing companies to maintain total sovereign control over their proprietary IT
1645 infrastructure.

1646 • **Catena-X and Supply Chain Data Spaces:** Catena-X is a collaborative, federated data
1647 space specific to the global automotive value chain. It is governed by the Catena-X
1648 Automotive Network e.V. (an association), based on an open source, non-proprietary
1649 operating system. A federated data space is a decentralised data management
1650 architecture where independent organisations can securely share and access data
1651 without handing over control of that data to a single, centralised authority.

1652 Since tyres act as both final consumer products and intermediate components for
1653 vehicle OEMs, the DPP can align with broader automotive data spaces. Catena-X is used
1654 by European OEMs and premium tyre suppliers (like Continental and Pirelli) to track
1655 supply chain carbon footprints and material origin. By aligning the Tyre DPP's Batch-level
1656 data requirements (such as the Mass_Balance_Cert_ID) with Catena-X data models, it
1657 can be explored whether the industry could potentially verify recycled content quotas
1658 using existing B2B cryptographic ledgers, avoiding the need to build additional
1659 verification systems for the ESPR.

1660 **Current Data Quality & Granularity**

1661 A foundational pillar of the DPP methodological framework is the strict enforcement of logical
1662 data granularity. Assigning the precise granularity ensures that data is tracked at the most
1663 efficient network level, avoiding unnecessary duplication while simultaneously maintaining
1664 precise, legally defensible traceability.

1665 • **Model-Level data:** applies to the stock keeping unit (SKU) and represents engineering
1666 baseline data, theoretical performance metrics, chemical category classifications, and
1667 dimensional blueprints. This data is already maintained within corporate Product
1668 Lifecycle Management (PLM) systems and parts of it are shared in sanitised formats with
1669 regulatory bodies via EPREL.

1670 • **Batch-level:** tracking exists internally on the manufacturer's side but is rarely exposed
1671 externally. Batch data is needed for tracking material origin, quality control recalls, and
1672 the allocation of mass-balanced sustainable materials, such as recycled carbon black
1673 (rCB), recycled PET cords, or bio-based synthetic rubber synthesised from agricultural
1674 waste. Managing Batch-level data requires a moderate to extremely high IT effort. It
1675 necessitates deep, real-time API integrations between the factory floor MES hardware,
1676 the overarching corporate Enterprise Resource Planning (ERP) suite (typically SAP), and
1677 increasingly, external cryptographic public ledgers required to prove mass balance
1678 claims without double-counting.

1679 • **Item-level** represents the highest data resolution, requiring a unique digital identifier
1680 and lifecycle tracking for every single physical tyre. This is achieved via Radio Frequency
1681 Identification (RFID) technology, specifically passive Ultra-High Frequency (UHF) tags
1682 physically embedded into the tyre casing, usually near the bead, prior to high-pressure
1683 vulcanisation. These robust chips are encoded with a Serialized Global Trade Item
1684 Number (SGTIN-96). This unique identifier acts solely as a license plate, linking the
1685 physical rubber asset to the GDSO cloud architecture, a dataspace designed to facilitate
1686 standardised data retrieval via remote API execution. While item-level tracking is
1687 becoming a standard practice for high-value C3 commercial truck tyres—which are
1688 designed as capital assets meant to be retreaded multiple times to amortise their initial

1689 cost—imposing item-level read/write dynamic data tracking on millions of cheap,
1690 disposable C1 passenger tyres presents a large infrastructure effort where ROI and
1691 technological limitations may play a larger role. Passive RFID tags possess memory
1692 measured in bits, not megabytes, making them incapable of functioning as onboard hard
1693 drives for complex lifecycle data.

1694 Currently, data sharing is mostly siloed and supply chain data (like the percentage of recycled
1695 content) is verified mostly through highly manual, analogue, annual third-party audits.
1696 Manufacturers share compliance data with regulators, but B2B data sharing (e.g., giving a
1697 recycler the chemical makeup of a tyre) is virtually non-existent without proprietary, localised
1698 agreements.

1699 **Constraints & Barriers to Data Sharing:**

1700 To facilitate a pragmatic, industry-supported rollout of the DPP, the DPP methodology
1701 categorises proposed data attributes into distinct regulatory tiers. The Essential tier designates
1702 crucial data points that are mandatory for immediate, day-one policy enforcement, consumer
1703 safety verification, and basic circularity operations. These elements are obligatory and must be
1704 structurally present in the schema from the start of regulatory enforcement. Conversely, the
1705 Strongly Recommended tier encompasses advanced data points that offer transformative value
1706 to the broader circular ecosystem, but appropriately acknowledge the severe technological,
1707 financial, or infrastructural realities currently facing the manufacturing sector. These elements
1708 are highly prioritised but are often granted an official IT phase-in period to allow manufacturers
1709 the necessary time to upgrade internal legacy Enterprise Resource Planning (ERP) systems,
1710 adapt factory-floor manufacturing lines, or finalise complex third-party cryptographic
1711 verification integrations.

1712 **Intellectual Property Confidentiality:** the DPP must avoid requiring the public exposure of exact
1713 tyre recipes and compositions, making e.g. silica ratios sensitive. The same likely applies to exact
1714 sidewall geometry dimensions.

1715 **Lack of EoL IT Infrastructure:** While premium manufacturers can implement IT infrastructures,
1716 the independent shredding, pyrolysis, and sorting facilities at the end of the value chain
1717 frequently lack the hardware (RFID portal scanners) and software (API integration capabilities)
1718 required to actually read and utilise a dynamic DPP.

1719 **2.1.4.1. Use of EPREL or DPP Interfaces**

1720 Under the scope of this preparatory study, it is not predetermined whether the DPP should
1721 replace EPREL, be used in parallel to EPREL or EPREL may serve the functions of the DPP. The
1722 suitability of EPREL depends largely on the intended scope and functions of a DPP.

1723 EPREL has inherent limitations in that it is a centralised database and based on data entered at
1724 the model level, not the item or batch level which prevents tracking of lifecycle events.
1725 Currently, there is a public facing database, as well as a Market Surveillance Authority view
1726 which enables viewing of the entered datapoints for verification (e.g. test standards etc.).

1727 A DPP as envisioned by the CIRPASS-2 project can on the other hand provide item level tracking
1728 via a RAIN RFID, and point to any database via GS1 SGTIN resolvers. It would provide data at
1729 model, batch and item level that can be updated throughout the product lifecycle and in
1730 machine-or AI readable formats. Utilising data infrastructures set up under e.g. GDSO allows for
1731 decentralised governance of proprietary data for manufacturers, enables API-driven
1732 architectures, automation of data fields fulfilment via ERP systems and could provide read and
1733 write access for authorised stakeholders.

1734 The key distinction being: the EPREL database was primarily developed to support the energy
1735 label at model level, while the DPP can potentially have high impact for enabling the circular
1736 economy at item level. It is considered that building such a DPP on top of EPREL would require
1737 a full re-engineering of the EPREL system architecture, while a DPP in parallel to EPREL would
1738 potentially duplicate efforts from MSAs and manufacturers.

1739 Should additional requirements under ESPR only be of limited scope and ambition (i.e. no
1740 lifecycle tracking, simple information requirements), then EPREL may be a more suitable option.
1741 However, EPREL would quickly reach limits in delivering some of the use cases listed in the
1742 following section.

1743 **Question to stakeholders**

1744 Do you have a current opinion/preference for a separate DPP system, or extension of EPREL?
1745

1746 **2.2. Step B: Identifying use cases & data needs**

1747 **2.3. Step B.1: Specification of Use Cases**

1748 Following the DPP methodology, use cases for the DPP supporting the design options are to be
1749 elaborated.

1750 The design options elaborated in this report imply the following additional information
1751 requirements that could enter a DPP.

1752

1753

1754

1755 **Table 2-2: Potential DPP Information Requirements from Design Options**

Design Option	Information Requirement	Actor
DO-01 Recycled Content	Recycled content in the tyre	point of sale / EPREL
DO-02/03 Presence of substances that hinder recycling	Presence of: Self-sealing gels Noise reduction foams Aramid fibres Batteries ¹² Silica content (rich/poor)	Recyclers/sorting centres / EPREL
DO-04 Extrusions spikes	N/A	
DO-05 Bio-based content	Mass balanced bio-based content verification	point of sale / EPREL
DO-06 Rolling Resistance	Already included in EPREL/Label. Retreaded performance classification (A-E)	Point of sale / EPREL
DO-07 Abrasion Limits	Abrasion index measurement	Point of sale / EPREL
DO-08 Retreading Support	Retreadability (to be defined) Buffing Radius Tread Width Optimum Buffing Depth	Retreaders
DO-09 Standardised Dimensions	Yes/No – ETRTO standard needed	Retreaders / procurers
DO-10 Mileage Indicator	Tread Depth, Indicator calculated based on abrasion test results (to be defined by Euro 7 and not ESPR)	Point of sale / EPREL
DO-11 Criteria for reuse	Log assessment events	Retread, repair, maintenance operators
DO-12 DPP	N/A	
DO-13 SoC	Flag hazardous substances in tyre (6PPD, PAHs etc.)	Recyclers
DO-14 Design for Repair	N/A	Recyclers

¹² Batteries that are part of TMPS are often not installed in the tyre but rather in adjacency. Consequently, communication with a vehicle DPP may be needed to ensure that a waste operator is made aware of the need to ensure that the battery has been dismantled from the system mounted on tyre valves prior to sending an individual tyre to treatment.

1756 In the following, the use cases where these data could be utilised are proposed based on
 1757 different actions in the lifecycle, split into three stages.

1758 **Table 2-3: Overview of possible use cases for the DPP**

Use Case	Information Requirement	Actor	Granularity	Action
Active Life / Placing on the Market				
Primary Purchase	Label parameters, potentially also durability/mileage aspects, Green Public Procurement	Consumer / B2B / public authority	Model	READ
Recycled Content / Bio-Based Content	Material Composition information	Market Surveillance Authorities (MSA)	Batch / Item	READ
Regulatory Compliance	Parameters to meet, safety and performance requirements.	Market Surveillance Authorities (MSA)	Model	READ
End of First Life				
Centralised EoL Sorting	SoC for recycling, number of retreads, production date, retreadable	EPR scheme, sorting operator	Model, Item	READ
Lifecycle Events Tracking	Repair, retread, EoL status	Repair, retread, waste operators	Item	READ/WRITE
Customs Export Enforcement	EoL Status	Customs agents	Item	READ
2nd Hand Purchase	Safety / retread history	Consumer / B2B	Item	READ
Circular End of Life Processing				
Retreading	Retreadable, production date, tread width, buffing radius and depth	Retreaders	Model, Item	READ/WRITE
Mechanical Shredding	Presence of SoC that hinder shredding process	Recyclers	Model, Item	READ
Pyrolysis / Devulcanisation	Log assessment events	Recyclers	Model, Item	READ

1759 **2.3.1. Active Life / Placing on the Market**

1760 **2.3.1.1. Primary Purchase & Green Public Procurement (GPP)**

1761 • **Primary Actor:** Consumers, Corporate Fleet Managers, Public Authorities (e.g.,
1762 Municipal Bus Fleets).

1763 • **Secondary Actor:** Regulatory Labelling Systems (EPREL), B2B Procurement Software.

1764 • **Trigger:** A procurement cycle is initiated. A buyer evaluates new tyre models for
1765 purchase, or a public authority drafts a tender requiring strict adherence to Green Public
1766 Procurement (GPP) emission and durability thresholds.

1767 • **Step-by-Step Actions:**

1768 1. The buyer or their procurement software queries the DPP (via a web interface
1769 or API) for specific tyre models.

1770 2. The DPP provides the static, verified physical baselines, label parameters, and
1771 Euro 7 abrasion ratings.

1772 3. For Public Authorities, the system automatically cross-references these data
1773 points against mandatory GPP criteria (e.g., verifying falls within the required
1774 threshold for municipal fleets).

1775 4. The buyer executes the purchase based on verified Total Cost of Ownership
1776 (TCO) and compliance data.

1777 • **Granularity:** Model

1778 • **Data Access:** READ

1779 • **Conceptual Information Needs:** All label and public facing information parameters.

1780 **2.3.1.2. Verification of Recycled Content/Bio-Based Content (DO-01/05)**

1781 • **Primary Actor:** Market Surveillance Authority (MSA) / Regulatory Auditors

1782 • **Secondary Actor:** Certification Bodies (e.g., ISCC PLUS), Manufacturers

1783 • **Trigger:** An annual regulatory compliance audit to verify the manufacturer is meeting
1784 ESPR recycled content mandates (rCB, rPET).

1785 • **Data Interaction:** READ

1786 • **Step-by-Step Actions:**

1787 1. The MSA accesses the restricted regulatory view of the DPP;

1788 2. The auditor queries specific production batches rather than individual items;

1789 3. The DPP resolves the cryptographic token/credential linked to that batch;

1790 4. The MSA's auditing software takes that token and pings the external, third-party
 1791 certification ledger (e.g., the ISCC+ database) to verify its cryptographic
 1792 authenticity and confirm the volume of sustainable material allocated to that
 1793 batch.

1794 • Conceptual Information Needs: Mass_Balance_Cert_ID.
 1795

1796 2.3.1.3. Regulatory Compliance verification/auditing of parameters

1797 • Primary Actor: MSA / Environmental Regulators

1798 • Secondary Actor: N/A

1799 • Trigger: Routine market surveillance to verify the legitimacy of a manufacturer's public
 1800 declarations on label, e.g. RRC, Euro 7 Abrasion Index rating, SoC threshold reporting.

1801 • Data Interaction: READ

1802 • Step-by-Step Actions:

1803 1. The MSA queries the data attribute for a specific tyre model.

1804 2. The system reveals parameters, and any related standards applied or test results.

1805 3. The MSA verifies that information is correct for tyre in question.

1806 • Conceptual Information Needs: Various parameters required by regulations (e.g.
 1807 entered to EPREL currently).

1808 2.3.2. End of First Life (Read and Write)

1809 2.3.2.1. Centralised EoL Tyre Sorting and Routing

1810 • **Primary Actor:** EoL Collection & Sorting Facilities / EPR Operators.

1811 • **Secondary Actor:** OEM Manufacturers (accounting for waste), Downstream Recyclers.

1812 • **Trigger:** Mixed loads of unclassified End-of-Life (EoL) tyres arrive at a centralised sorting
 1813 facility from various municipal or commercial collection points.

1814 • **Data Interaction:** READ

1815 • **Step-by-Step Actions:**

1816 1. Tyres are loaded onto a high-speed, automated sorting conveyor (e.g., at speeds
 1817 of 3 tyres per second).

1818 2. Automated RFID portal arrays scan each tyre as it passes.

1819 3. The sorting software queries the DPP to instantly retrieve the aggregate physical
 1820 and chemical parameters of the tyre.

1821 4. The system's algorithms cross-reference this data to dynamically route the tyre
 1822 down specific conveyor channels:

1823 5. *To Retreading:* If *Retreadable_Casing* and < 2 previous retread events.

1824 6. *To Pyrolysis:* if *Silica_Ratio* is <10% and DO-02 contaminants are absent.

1825 7. *To Devulcansation*: if high natural rubber content and no legacy/contaminants
 1826 flagged.

1827 8. To High-Torque Mechanical Shredding: If Textile_Class is Aramid.

1828 • **Conceptual Information Needs:** This actor requires the information to route effectively:
 1829 Retreadable_Casing, production date, number of past retreads/repairs,
 1830 Silica_Ratio_Category, Textile_Class, and DO-02_Physical_Hindrances.

1831 2.3.2.2. Dynamic Lifecycle State & Event Log

1832 • **Primary Actor:** Authorized B2B Actors (Certified Mechanics, Retreaders, EoL Collection
 1833 Facilities).

1834 • **Secondary Actor:** MSAs / Customs (who will read the output), GDSO / Decentralized
 1835 Ledger (routing).

1836 • **Trigger:** A physical intervention occurs that permanently alters the tyre's operational
 1837 status—such as a successful retreading, a major vulcanised repair, catastrophic accident
 1838 damage, or final decommissioning for material recovery.

1839 • **Data Interaction:** READ / WRITE

1840 • **Step-by-Step Actions:**

1841 1. The authorised technician or facility operator scans the tyre's UHF RAIN RFID
 1842 tag to access the physical asset's DPP.

1843 2. The operator's terminal authenticates their legal corporate identity (via strict
 1844 Identity and Access Management) to unlock 'Write' permissions.

1845 3. The operator logs the specific intervention (e.g., "Retread Applied") OR updates
 1846 the overarching status from the standardised matrix (changing it from Active to
 1847 EoL_Critical_Damage or EoL_Material_Recovery).

1848 4. The software transmits a secure API 'Write' request to the GDSO
 1849 resolver/manufacturer cloud.

1850 5. The DPP updates instantly, ensuring the new Lifecycle_State is permanently
 1851 appended. This becomes visible to sorting facilities, second hand markets and
 1852 allows border control to mass scan tyre shipments.

1853 • **Conceptual Information Needs:** Lifecycle_State (Write access), Lifecycle_Event_Log
 1854 (Write access).

1855 Note: granting Write Access to a decentralised network requires an Identity and Access
 1856 Management (IAM) framework. If a repair shop patches a tyre or a retreader carries out a
 1857 retread, they must digitally sign that entry using a verifiable credential (proving they are a legally
 1858 certified workshop). Building the IT infrastructure to authenticate thousands of independent
 1859 European repair shops would require a multi-year phase-in.

1860 **2.3.2.3. Secondary Market Evaluation (Part-Worn & Retread Purchase)**

- 1861 • **Primary Actor:** Consumers, B2B Fleet Operators.
- 1862 • **Secondary Actor:** Second-hand Retailers, Certified Retreaders (who generated the
1863 data).
- 1864 • **Trigger:** A buyer is evaluating a physically used, part-worn, or remanufactured
1865 (retreaded) tyre for purchase.
- 1866 • **Step-by-Step Actions:**
 - 1867 1. The buyer scans the secondary data carrier (e.g., NFC tap with a smartphone or
1868 QR code scan) on the individual used tyre.
 - 1869 2. The interface queries the item-specific DPP ledger.
 - 1870 3. The buyer reviews the asset's specific history, verifying its precise age,
1871 confirming it has not been flagged as EoL_Critical_Damage (illegally salvaged
1872 from a scrapyard), and reviewing the Lifecycle_Event_Log to see who
1873 performed past vulcanised repairs or retreads.
 - 1874 4. If it is a retread, the buyer also can read (forthcoming) retreaded label
1875 performance ratings.
- 1876 • **Data Interaction:** READ
- 1877 • **Conceptual Information Needs:** Manufacturing_Date_Timestamp, Lifecycle_State,
1878 Lifecycle_Event_Log.

1879 **2.3.2.4. Customs Export Blocking & Waste Enforcement (DO-11)**

- 1880 • **Primary Actor:** MSA / Customs Agents
- 1881 • **Secondary Actor:** Certified EoL Collection Agencies (who initially update the status)
- 1882 • **Trigger:** A shipping container manifested as "used, roadworthy tyres" arrives at an EU
1883 port bound for export to a developing nation.
- 1884 • **Data Interaction:** READ
- 1885 • **Step-by-Step Actions:**
 - 1886 1. Customs agents perform a rapid, non-line-of-sight sweep of the shipping container
1887 using high-frequency UHF RFID portal arrays.
 - 1888 2. The scanner queries the DPP lifecycle ledger for all detected SKUs.
 - 1889 3. If the database returns a verified "End of Life" status for the assets, the system
1890 flags the shipment.
 - 1891 4. Customs agents legally embargo the container under EU waste shipment
1892 regulations, requiring "End of Life" status tyres to be removed.

- 1893
- **Conceptual Information Needs:** EoL_Status_Flag.

1894 **2.3.3. Circular Secondary Processing**

1895 **2.3.3.1. Automated Casing Intake for Retreading (DO-08)**

- 1896
- **Primary Actor:** Retreaders (B2B)
- 1897
- **Secondary Actor:** GDSO (Data Routing Network)
- 1898
- **Trigger:** A worn C1/C2/C3 casing arrives at a remanufacturing facility for intake
- 1899
- inspection.
- 1900
- **Data Interaction:** READ / WRITE
- 1901
- **Step-by-Step Actions:**
- 1902
1. Automated portal reads the tyre's embedded UHF RAIN RFID tag.
- 1903
2. The facility's ERP system queries the DPP via the GDSO network.
- 1904
3. Retrieval of retread parameters (buffing radius, tread width, retreadable)
- 1905
4. The system automatically rejects internally compromised/non-standard casings
- 1906
- to material recovery or accepts compliant casings and calibrates the buffing
- 1907
- machinery.
- 1908
- If Lifecycle Event updating is possible, then the retreader can also write to the DPP: new
- 1909
- retread parameters, or assign new status (destined for EoL).
- 1910
- **Conceptual Information Needs:** retreadable casing, buffing radius, tread width, optimal
- 1911
- buffing depth.
- 1912

1913 **2.3.3.2. Design for Recycling - Mechanical Shredding & Hazard Mitigation**
 1914 **(DO-02/03)**

- 1915
- **Primary Actor:** Mechanical Recyclers / Shredder Operators
- 1916
- **Secondary Actor:** Manual Dismantlers
- 1917
- **Trigger:** An EoL tyre drops onto the intake conveyor of an ambient or cryogenic
- 1918
- shredding facility.
- 1919
- **Data Interaction:** READ
- 1920
- **Step-by-Step Actions:**
- 1921
1. Intake scanner reads the RFID tag and alerts the operator's dashboard that the
- 1922
- tyre contains material that would disrupt shredding process;
- 1923
2. Operator checks for physical hindrances (e.g., TPMS Lithium-ion batteries, PU
- 1924
- foams, gels) and if possible physically extracts them to prevent facility fires or
- 1925
- other impacts. Alternatively divert to incineration in co-processing.

1926 3. Operator checks the textile class. If Aramid/Kevlar is present, the tyre is diverted
 1927 from standard steel blades to specialised high-torque shear shredders to prevent
 1928 catastrophic equipment damage;

1929 • **Conceptual Information Needs:** Textile_Class, DO-02_Physical_Hindrances.

1930 **2.3.3.3. Design for Recycling - Pyrolysis/Devulcanisation (DO-02/03)**

1931 • **Primary Actor:** Pyrolysis / Devulcanisation Operators

1932 • **Secondary Actor:** N/A

1933 • **Trigger:** EoL tyre batches are evaluated for high-temperature reactor feeding.

1934 • **Data Interaction:** READ

1935 • **Step-by-Step Actions:**

1936 1. Facility RFID arrays scan incoming material;

1937 2. The system queries the DPP to verify chemical compatibility;

1938 3. The system algorithmically flags and rejects tyres with high silica content (which
 1939 would contaminate the recovered CB with high ash in pyrolysis) or internal
 1940 gels/foams (which would poison the pyrolysis oil or contaminate devulcanisation);

1941 4. Automated systems use other composition data to optimise tyre batching for EoL
 1942 processes;

1943 5. Safe, compliant tyres are loaded into the thermal reactor.

1944 • **Conceptual Information Needs:** Silica_Ratio_Category, DO-02_Physical_Hindrances

1945

1946 Questions to stakeholders

1947 - Are the specified use cases accurate and complete?

1948 - Are the identified actors, triggers, and actions realistic and correctly represented?

1949 - Do the use cases reflect current or credible future practices across the value chain?

1950 - Are additional use cases or relevant variations missing?

1951 - What is the perceived value of the data required for each use case for industry
 1952 stakeholders (including EU-based and third-country producers) relative to the effort
 1953 required to generate, maintain, and share that data?

1954

1955

1956 *The next steps for the DPP analysis are to validate use cases with stakeholders, then to determine*
 1957 *specific data needs of these use cases and validate these. The data needs and governance*
 1958 *analysis takes place in Task 7.*

1959 **3. Annexes**

1960 **Table 3-1: BC1 Recycled Content Material Composition 20% Rubber Compound, 80% reinforcement materials.**

BC1 Material	Material Composition (kg) (Recycled Content: 20% Rubber compound, 80% Reinforcement Materials)							
	Original Composition	devulcanised rubber	CB	micr. rubber	recl. rubber	rPET	Recy. steel	adjusted composition
Rubber Compound Primary Materials								
Natural Rubber	1.408	-0.246			-0.007			1.155
Synthetic Rubber	2.031	-0.355			-0.010			1.666
Silica	1.082	-0.119			-0.004			0.960
CB. virgin	1.408	-0.373	-0.211	-0.034	-0.0125			0.777
Zinc Oxide (ZnO)	0.123							0.123
Sulfur	0.096							0.096
Stearic Acid	0.057							0.057
Benzothiazoles-sulfonamides (DBCS. CBS. TBBS. CTP. TQM)	0.089							0.089

BC1 Material	Material Composition (kg) (Recycled Content: 20% Rubber compound, 80% Reinforcement Materials)							
	Original Composition	devulcanised rubber	CB	micr. rubber	recl. rubber	rPET	Recy. steel	adjusted composition
Amines and plasticisers (6PPD. DPG. BENPAT. DMBC)	0.167							0.167
Oils	0.247				-0.000854			0.246
Waxes	0.077							0.077
Alkylphenols (PTOP. PTBP)	0.011							0.011
Phenolic resins. including resorcinol. HMT	0.019							0.019
Cobalt Organic Salts	0.017							0.017
Reinforcement Materials								
Steel Belts. (0.5 % of weight from coating: 66 % Copper. 34 % Zinc)	0.663						-0,63	0.030
Steel Bead wire (0.5 % of weight from coating: 98 % Brass. 2 % Tin)	0.327						-0,31	0.015
Polyester cord fabric	0.182					-0,13		0.055
Rayon cord fabric	0.086							0.086
Nylon cord fabric	0.088							0.088
Aramid cord fabric	0.001							0.001

BC1 Material	Material Composition (kg) (Recycled Content: 20% Rubber compound, 80% Reinforcement Materials)							
	Original Composition	devulcanised rubber	CB	micr. rubber	recl. rubber	rPET	Recy. steel	adjusted composition
Recycled Material Variant								
dev. rubber	0	1,093						1,093
rCB	0		0,21					0,211
micr. rubber	0			0,034				0,034
recl. rubber	0				0,034			0,034
rPET	0					0,127		0,127
recy steel	0						0,946	0,946
Total	8.179							8.179
recycled content. reinforcement								80 %
recycled content. rubber compound								20.1 %

1961

1962 **Table 3-2: BC3 Recycled Content Material Composition 5% Rubber Compound, 50% reinforcement materials.**

BC3 Material BOM	Material Composition (kg) (5% rubber compound, 50% reinforcement materials recycled content)							
	Original Composition	devulcanised rubber	carbon black	micr. rubber	recl. rubber	rPET	recy steel	adjusted composition
Recyclates								

BC3 Material BOM	Material Composition (kg) (5% rubber compound, 50% reinforcement materials recycled content)							
	Original Composition	devulcanised rubber	carbon black	micr. rubber	recl. rubber	rPET	recy steel	adjusted composition
dev. rubber	0	1.626						1.626
recycled carbon black	0		0.65					0.650
micr. rubber	0			0.127				0.127
recl. rubber	0				0.127			0.127
rPET	0					0		0.000
recy steel	0						6.601	6.602
Rubber Compound								
Natural Rubber	20.8	-0,619			-0,043			20,137
Synthetic Rubber	9.25	-0.275			-0.0195			8.955
Silica	2.53	-0.0662			-0.00517			2.459
Carbon Black, virgin	13	-0.666	-0.65	-0.127	-0.0551			11.502
Zinc oxide	1.3							1.300
Sulfur	0.774							0.774
Stearic Acid	0.462							0.462
Benzothiazoles-sulfonamides (DBCS, CBS, TBBS, CTP, TQM)	0.739							0.739
Amines and plasticisers (6PPD, DPG, BENPAT, DMBC)	0.811							0.811
Oils	0.42				-0.00318			0.417
Waxes	0.216							0.216
Alkylphenols (PTOP, PTBP)	0.0177							0.018
Phenolic resins. including resorcinol, HMT	0.419							0.419

BC3 Material BOM	Material Composition (kg) (5% rubber compound, 50% reinforcement materials recycled content)							
	Original Composition	devulcanised rubber	carbon black	micr. rubber	recl. rubber	rPET	recy steel	adjusted composition
Cobalt Organic Salts	0.0791							0.079
Reinforcement Materials								
Steel Belts, Coating (66% Copper, 34% Zinc)	9.8						-4.875	4.925
Bead wire (98% Brass, 2% Tin)	3.47						-1.726	1.744
Polyester cord fabric	-	-				0		0.000
Rayon cord fabric								0.000
Nylon cord fabric	0.0192							0.019
Aramid cord fabric								0.000
Total	64.107							64.107

1963

1964 **Table 3-3: BC3 Recycled Content Material Composition 20% Rubber Compound, 80% reinforcement materials.**

BC3 Material BOM	Material Composition (kg) (20% rubber compound, 80% reinforcement materials recycled content)							
	Original Composition	devulcanised rubber	carbon black	micr. rubber	recl. rubber	rPET	recy steel	adjusted composition
Recyclates								
dev. rubber	0	8.13						8.131
recycled carbon black	0		1.56					1.560
micr. rubber	0			0.254089				0.254
recl. rubber	0				0.254089			0.254
rPET	0	-				0		0.000

BC3 Material BOM	Material Composition (kg) (20% rubber compound, 80% reinforcement materials recycled content)							
	Original Composition	devulcanised rubber	carbon black	micr. rubber	recl. rubber	rPET	recy steel	adjusted composition
recy steel	0						10.6289	10.629
Rubber Compound								
Natural Rubber	20.8	-3.095			-0.0879			17.617
Synthetic Rubber	9.25	-1.376			-0.0391			7.834
Silica	2.53	-0.331			-0.0103			2.189
Carbon Black, virgin	13	-3.328	-1.56	-0.2541	-0.110			7.748
Zinc oxide	1.3							1.300
Sulfur	0.774							0.774
Stearic Acid	0.462							0.462
Benzothiazoles-sulfonamides (DBCS, CBS, TBBS, CTP, TQM)	0.739							0.739
Amines and plasticisers (6PPD, DPG, BENPAT, DMBC)	0.811							0.811
Oils	0.42				-0.00635			0.414
Waxes	0.216							0.216
Alkylphenols (PTOP, PTBP)	0.0177							0.018
Phenolic resins. including resorcinol, HMT	0.419							0.419
Cobalt Organic Salts	0.0791							0.079
Reinforcement Materials								
Steel Belts, Coating (66% Copper, 34% Zinc)	9.8						-7.849	1.950
Bead wire (98% Brass, 2% Tin)	3.47						-2.779	0.691
Polyester cord fabric	-	-				0		0.000

BC3 Material BOM	Material Composition (kg) (20% rubber compound, 80% reinforcement materials recycled content)							
	Original Composition	devulcanised rubber	carbon black	micr. rubber	recl. rubber	rPET	recy steel	adjusted composition
Rayon cord fabric								0.000
Nylon cord fabric	0.0192							0.019
Aramid cord fabric								0.000
Total	64.107							64.107

1965

1966

1967

Draft for SH meeting

1968

4. References

- 1969 Chawla, K., Chirvasuta, T., Wolf, M.-A., Wolf, K., Rongen, S. et al. (2026). *Methodology for*
1970 *defining data requirements for the Digital Product Passport under the ESPR framework*
1971 (No. JRC145830). Publications Office of the European Union.
1972 <https://data.europa.eu/doi/10.2760/451127>
- 1973 EuRIC. (2021). *Lithium battery fires in WEEE – An urgent problem* (The Innovation Platform 7, pp.
1974 126–130). https://euric.org/images/Position-papers/Issue_7_EuRIC_Part.pdf
- 1975 European Commission. (2021). *Commission Recommendation (EU) 2021/2279 on the use of the*
1976 *Environmental Footprint methods to measure and communicate the life cycle*
1977 *environmental performance of products and organisations*. European Commission.
1978 <https://eur-lex.europa.eu/eli/reco/2021/2279/oj/eng>
- 1979 European Commission. Joint Research Centre. (2023). *Updated characterisation and*
1980 *normalisation factors for the environmental footprint 3.1 method*. Publications Office.
1981 <https://doi.org/10.2760/798894>
- 1982 Eynard, U., Spiliotopoulos, C., & Blengini, G. A., Alfieri, F., Mathieux, F., Ardente, F., Gama
1983 Caldas, M., Mancini, L. (2024). *Review of the MEErP Methodology for ecodesign of*
1984 *energy-related products*. European Commission, Joint Research Centre.
1985 [https://op.europa.eu/en/publication-detail/-/publication/03ac5f5a-eb3b-11ee-bf53-](https://op.europa.eu/en/publication-detail/-/publication/03ac5f5a-eb3b-11ee-bf53-01aa75ed71a1)
1986 [01aa75ed71a1](https://op.europa.eu/en/publication-detail/-/publication/03ac5f5a-eb3b-11ee-bf53-01aa75ed71a1)
- 1987 Giechaskiel, B., Ferrarese, F., Grigoratos, T., & Franco, V. (2025). *Wear of Passenger Car C1 Tyres*
1988 *Under Regulatory On-Road Testing Conditions*. *Vehicles*, 7(3), 91.
- 1989 Magrini, C., Rodriguez, M. J., Gonzalez, T. M., Senatore, V., Gama, C. M., Kouloumpis, V., Maury,
1990 T., Amadei, A., & Venturelli, S. (2025). *Method for the ranking of potential requirements,*
1991 *based on expected impacts and costs*. JRC Publications Repository.
1992 <https://doi.org/10.2760/1478580>
- 1993 Regulation (EU) 2020/740 of the European Parliament and of the Council of 25 May 2020 on the
1994 Labelling of Tyres with Respect to Fuel Efficiency and Other Parameters, Amending
1995 Regulation (EU) 2017/1369 and Repealing Regulation (EC) No 1222/2009 (2020).
1996 <https://eur-lex.europa.eu/eli/reg/2020/740/oj/eng>
- 1997 Regulation No. 117 of the Economic Commission for Europe of the United Nations (UNECE);
1998 Uniform provisions concerning the approval of tyres with regard to rolling sound
1999 emissions and/or to adhesion on wet surfaces and/or to rolling resistance [2016/1350]
2000 (2016). [https://op.europa.eu/de/publication-detail/-/publication/48d3ed27-604f-](https://op.europa.eu/de/publication-detail/-/publication/48d3ed27-604f-11e6-9b08-01aa75ed71a1/language-en)
2001 [11e6-9b08-01aa75ed71a1/language-en](https://op.europa.eu/de/publication-detail/-/publication/48d3ed27-604f-11e6-9b08-01aa75ed71a1/language-en)
- 2002 UN Regulation No 117 – Uniform Provisions Concerning the Approval of Tyres with Regard to
2003 Rolling Sound Emissions and/or to Adhesion on Wet Surfaces and/or to Rolling
2004 Resistance [2025/1453], Pub. L. No. R117 (2025). [https://eur-](https://eur-lex.europa.eu/eli/reg/2025/1453/oj/eng)
2005 [lex.europa.eu/eli/reg/2025/1453/oj/eng](https://eur-lex.europa.eu/eli/reg/2025/1453/oj/eng)
- 2006

Getting in touch with the EU

In person

All over the European Union there are hundreds of Europe Direct centres. You can find the address of the centre nearest you online (european-union.europa.eu/contact-eu/meet-us_en).

On the phone or in writing

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),
at the following standard number: +32 22999696,
via the following form: european-union.europa.eu/contact-eu/write-us_en.

Finding information about the EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website (european-union.europa.eu).

EU publications

You can view or order EU publications at op.europa.eu/en/publications. Multiple copies of free publications can be obtained by contacting Europe Direct or your local documentation centre (european-union.europa.eu/contact-eu/meet-us_en).

EU law and related documents

For access to legal information from the EU, including all EU law since 1951 in all the official language versions, go to EUR-Lex (eur-lex.europa.eu).

EU open data

The portal data.europa.eu provides access to open datasets from the EU institutions, bodies and agencies. These can be downloaded and reused for free, for both commercial and non-commercial purposes. The portal also provides access to a wealth of datasets from European countries.

