

Preparatory Study and Impact Assessment support study on tyres

Draft report
Tasks 1-4 of the Preparatory study
Version 1.0

Not for publication

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September – 2025



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*

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Draft report
Tasks 1-4 of the Preparatory study
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Submitted by:



In collaboration with:



Manuscript completed in September 2025

<Revised/Corrected/nth> edition

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Luxembourg: Publications Office of the European Union, 2025

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

Project Information

| Title | Preparatory Study and Impact Assessment support study on tyres |
|----------------------------|--|
| Framework Contract No | ENV.B.4/FRA/2023/0018 Lot 1 |
| Specific Contract No | 2025/4500082801/ENV.B4/GROW |
| Service Request No | 8 |
| Project Duration | 30 months |
| Starting Date | 01/03/2025 |
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Partners

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

Deliverable information

| Deliverable No | D2 |
|---------------------------|--|
| Version of Deliverable* | 1.0 |
| Task | 2: Preparatory Study (PS) Phase 1 |
| Sub-task | 2.2 PS Tasks 1-4 |
| Main author(s) | Yifaat Baron, Daniel Hinchliffe, Fred Adjei, Lucía Gascón Castellero, Diana Hay, Izabela Kosińska-Terrade, Felix Mayer (Oeko-Institut) Corina Haita-Falah, Lucia van den Boogaart (Trinomics) |
| Reviewers | Wai Chung Lam & Nele Kelchtermans (VITO) |
| Recipient(s) | Lie Heymans (DG-ENV-B4) & Anne Serra (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) |

| *Version | Date | Description |
|----------|------------|---|
| (D2) 0.1 | 31/03/2025 | Template for input |
| (D2) 0.2 | 05/09/2025 | Input provided - Version for internal review |
| (D2) 0.3 | 09/09/2025 | Version with QA-1 |
| (D2) 0.4 | 09/09/2025 | Reviewed version |
| (D2) 0.5 | 09/09/2025 | Version 0.5 sent to EC |
| (D2) 0.6 | 19/09/2025 | Version 0.6 with EC feedback |
| (D2) 0.7 | 25/09/2025 | Revised version 0.7 for internal review |
| (D2) 0.8 | 26/09/2025 | Version 0.8 with QA-2 |
| (DY) 1.0 | 26/09/2025 | Version 1 (Revised with QA-2) (D2) sent to Stakeholders |

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List of Abbreviations and definitions

| | |
|------------------|---|
| 3PMSF | Three-Peak Mountain Snowflake |
| ADAC | Allgemeiner Deutscher Automobil-Club |
| BAT | Best Available Technology |
| BNAT | Best Not (yet) Available Technology |
| BOM | Bill of Materials |
| CB | Carbon Black |
| CLP | Classification, Labelling and Packaging |
| CN | Combined Nomenclature |
| dGTR | Devulcanised Ground Tyre Rubber |
| DPP | Digital Product Passport |
| EAF | Electric Arc Furnaces |
| EEA | European Environmental Agency |
| EF | Environmental Footprint |
| ELT | End-of-Life Tyres |
| ELV | End-of-Life Vehicles |
| EPD | Environmental Product Declaration |
| EPREL | European Product Registry for Energy Labelling |
| EoL | End of Life |
| ESPR | Regulation (EU) 2024/1781 of 13 June 2024 establishing a framework for the setting of Ecodesign for Sustainable Products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC |
| EUT | End-of-Use Tyres |
| HICP | Harmonised Index of Consumer Prices |
| HS | Harmonised System |
| H ₂ S | Hydrogen Sulphide |

| | |
|-------|--|
| ICE | Internal Combustion Engine |
| IQR | Interquartile Range |
| JRC | Joint Research Centre |
| LCA | Life Cycle Assessment |
| LCC | Life Cycle Costs |
| LLCC | Least Life Cycle Costs |
| LHV | Lower Heating Value |
| NACE | Nomenclature of Economic Activities |
| MEErP | Methodology for Ecodesign of Energy-related Products |
| OE | Original Equipment |
| OEM | Original Equipment Manufacturer |
| PAH | Poly Aromatic Hydrocarbons |
| PCR | Product Category Rules |
| PEFCR | Product Environmental Footprint Category Rules |
| PET | Polyethylene Terephthalate |
| rCB | Recycled Carbon Black |
| RCC | Rolling Resistance Coefficient |
| RFT | Run-Flat Tyres |
| sCB | Sustainable Carbon Black |
| TaaS | Tyre-as-a-Service |
| TDF | Tyre Derived Fuel |
| TPG | Tyre Pressure Gauges |
| TPO | Tyre Pyrolysis Oil |
| TPMS | Tyre Pressure Monitoring Systems |
| ToR | Terms of Reference |
| V2X | Vehicle To Everything |

| | |
|------|--|
| WFD | Waste Framework Directive or Directive 2008/98/EC on waste |
| wt-% | weight percent (share based on mass) |
| ZnO | Zinc Oxide |

1. Executive summary

2 Background

3 This report is the first part of the Ecodesign for Sustainable Products Regulation (ESPR) study on
4 the product group tyres. The report represents an interim draft of part 1 of the preparatory
5 study. It was carried out according to the ‘Methodology for Ecodesign of Energy related
6 Products’ (MEErP), which follows a fixed structure of seven tasks that support gathering
7 sufficient information on the product group in order to evaluate potential regulation options. A
8 preparatory study also aims to inform stakeholders and policy makers on the product group
9 itself and on important aspects to be considered in assessments under ESPR.

10 The current report presents initial findings for the first four MEErP Tasks: Scope (Task 1), Markets
11 (Task 2), Users (Task 3) and Technologies (Task 4). These tasks provide the information to
12 support the development of base cases for the follow-up MEErP Tasks 5 to 7, in which a Life
13 Cycle Assessment (LCA) according to the Product Environmental Footprint methodology will be
14 carried out (Task 5), substances of concern will be analysed (Task 5), and design options (Task 6)
15 and different policy scenarios (Task 7) evaluated. The data and conclusions included in Tasks 1
16 to 4 do not represent decisions on final regulatory measures to be taken. See **Section 3** for a
17 description of the MEErP methodology.

18 This study has been conducted in consultation with stakeholders, who have been involved
19 through online stakeholder consultations, individual interviews and in-person site visits. In the
20 first stakeholder meeting, taking place in October 2025, the validity of the data obtained so far,
21 as well as missing data points will be discussed with stakeholders. For this purpose, questions
22 for stakeholders are highlighted throughout the document, and a summary is available on the
23 [ecodesign tyres project website documents section: https://ecodesign-tyres.eu/en/documents](https://ecodesign-tyres.eu/en/documents).

24 The research team has aimed to map and cover as many aspects as possible in these tasks within
25 the project time constraints. Tyres remain a highly complex composite product. At this stage of
26 the interim draft, some parts may therefore be incomplete. Input from stakeholders within the
27 deadlines of the study is therefore highly welcome and will be used to revise this report and the
28 data used for MEErP Tasks 5, 6 and 7, as well as the impact assessment supporting study, should
29 the EC decide to regulate tyres under ESPR. For an overview of the project timeline, see
30 <https://ecodesign-tyres.eu/en/project-plan>.

31 In the past, Ecodesign preparatory studies strongly focused on energy efficiency; however,
32 following the revision of the Ecodesign Directive, ESPR now looks at additional material
33 efficiency aspects, such as recyclability, circularity and repairability. Many features of tyres have
34 already been regulated within the EU for some time, including safety and performance
35 characteristics, minimum rolling resistance and consumer-facing information, such as the EU
36 tyres label. This preparatory study is one of the first to be prepared under the ESPR regime and
37 aims to identify areas where Ecodesign measures may improve the environmental performance

38 of tyres, bringing a stronger focus to as yet unregulated aspects, such as design for recycling,
39 retreading and material circularity aspects. The MEERp methodology was applied to tyres
40 wherever possible, but flexibility was required in some areas to address relevant aspects. The
41 following is a summary of the content and initial key conclusions of each task.

42 **Task 1: Scope**

43 In MEERp Task 1 examines existing tyre classifications, definitions, relevant regulations and test
44 standards.

45 Tyres can be classified in various ways, but the most relevant **classifications** from a regulatory
46 perspective are C1 (passenger car tyres), C2 (light commercial vehicle tyres) and C3 (heavy
47 commercial vehicles tyres) classifications, which are used in international tyre regulations. These
48 form the basis for the EU tyre energy label. From a materials perspective, other tyre types can
49 be of relevance, given that different tyre types may enter similar end-of-life (EoL) processes. This
50 study therefore considers an open scope, aiming to gather data where possible on additional
51 vehicle tyre types beyond the categories of C1, C2 and C3, including bicycle, motorcycle,
52 agricultural and industrial or aircraft tyres where possible and relevant.

53 There are many **definitions** already used in existing regulations; however, they provide no
54 definition on material circularity aspects. Several suggestions have been provided by ETRMA
55 which were used as a reference point in this study. These include terms such as durability,
56 retreading, etc. Various terms have been compared with additional sources revealing in some
57 cases, e.g. with the term recovery, room for further specification. Gaps relating to how end of
58 waste criteria are defined for tyres were identified, leading to potential confusion.

59 Once legislation comes into force at an international level, it shall then be transposed in EU law,
60 for example through EU type approval. Existing laws cover a wide range of technical
61 performance requirements across vehicle types and include performance and safety
62 characteristics, directions relating to repair and use-phase characteristics, amongst others.
63 Recent agreements at the international level aim to set limits on abrasion of tyres; currently,
64 testing standards are being defined and agreed on, which will form the basis for future
65 regulation under the EU EURO 7 regulation.

66 For end-of-life (EoL) aspects, the Waste Framework Directive provides generic provisions for
67 tyres; however, there is no sector-specific legislation at the EU level. Individual EU Member
68 States have implemented their own rules, which can lead to treatment challenges across
69 borders. Gaps were identified relating to improving re-use, recycling, and uptake of bio-based
70 or recycled content, and could support optimising the circularity of tyres.

71 A large number of existing test standards have been listed which support implementation of
72 regulations and defining performance characteristics. Here gaps were found relating to
73 circularity. Due to the fact that the potential of a tyre to be retreaded can only be assessed after
74 the use phase, no standards currently exist to define “retreadability”. While there are standards
75 on recycled content for other material streams, there is not yet a standardised way to report on
76 recycled or sustainable material content.

77 The functional unit proposed to be used in further analysis, is a tyre across all its life cycle stages.
78 A standard tyre lifetime, expressed as expected mileage or kilometrage, will be defined based
79 on the vehicle tyre to be analysed. Defining base cases for analysing life cycle impacts and life
80 cycle costing in later tasks of this study, could be limited to tyres of vehicle categories for which
81 sufficient data is available.

82 **Task 2: Markets**

83 In Task 2, data is compiled from various data sources on EU production, trade and sales, product
84 stock and market trends. This is complemented by a range of consumer expenditure data
85 relating to pricing of both new and re-treaded tyres, installation, maintenance and repair and
86 end-of-life disposal.

87 Data from Eurostat does not always supply a full picture, with some data entries missing at the
88 individual member state level and not being well-aligned with the categories of C1, C2 and C3.
89 At the EU level, ETRMA provides useful data on their share of the market, representing the major
90 European manufacturers (ca. 70 %). This has been used to triangulate and make inferences
91 about the broader market. Some data was found on the categories of bicycle and motorcycle
92 tyres on which Eurostat often reports jointly, as well as agricultural and off-the road tyres
93 (ETRMA and Eurostat).

94 The C1-C3 tyres market in Europe is made up of approximately 25 % sales to Original Equipment
95 Manufacturers (OEMs) who sell the tyres with the vehicle, and 75 % replacement sales driven
96 by consumers. EU sales of C1, C2 and C3 tyres together are around 90-95 % of the total tyres
97 sales on the EU market, with an annual sales growth showing a slightly increasing trend over the
98 last five years.

99 The tyres production industry is highly competitive and this has led to increased automation in
100 production as well as siting of factories in regions with lower labour costs. Most production takes
101 place in Central and Eastern European countries such as Romania, Poland and Slovakia, but also
102 in Southern member states (MSs) such as Italy and Spain, as well as in France and Germany.
103 Most imports of tyres come from Asia, with China covering more than half of the imports in the
104 EU for C1 and C2 tyres.

105 The market is trending towards more reinforced tyres to support heavier vehicles such as SUVs
106 and electric vehicles (EVs), as well as a large increase in the variability of dimensions and specific
107 models requested by OEMs to complement the performance of their vehicles. Budget imports
108 from Asia are gaining an increasing market share in all segments, increasing competition and
109 making retreaded C3 tyres less attractive compared to new tyres for some consumers. These
110 tyres can also be more challenging to retread due to narrower width and different materials
111 used in the casing. The energy label has supported a lowering of rolling resistance (and hence of
112 fuel consumption) over time.

113 More recent premium tyre innovations include noise reducing tyres which are of higher interest
114 for EV users, run-flat tyres (in the C3 segment), and self-sealing tyres.

115 The consumer price data can vary widely by price segment (budget, medium and premium tyres)
116 and tyre class (C1, C2 or C3), but do not differ significantly among the MS. While the usual price
117 for a tyre ranges from approximately EUR 20 to EUR 200, high-end tyres can cost up to several
118 thousand euros, especially for the C3 tyres class. Data received from stakeholders put the price
119 of a retreaded tyre between EUR 40 to EUR 400, with the C3 tyres having the highest price. The
120 EU Harmonised Index of Consumer Prices (HICP) has increased steadily over the past 10 years,
121 being around 30 % higher in 2024 relative to 2015. Other costs to consumers relate to the
122 lifetime of a tyre, i.e. installation and tyre maintenance. Installation costs vary between EUR 50
123 and 100.

124 Data supporting regulations is most consistently available for C1, C2 and C3 tyres, although
125 trade data does not differentiate clearly between C2 and C3 tyres. In the motorcycle and bicycle
126 segment, data are inconsistently reported, sometimes combined and sometimes separately,
127 making comparisons difficult. Moreover, based on the Eurostat data, tyres for aircraft are not
128 produced in the EU-27. Finally, the production of agricultural tyres in the EU is not significant,
129 while the production of other non-road vehicle tyres is not reported by EUROSTAT. Only trade
130 data of non-road vehicles are reported, but they are reported in the same figure together with
131 agricultural and forestry vehicle tyres, precluding their separation.

132 **Task 3: Users**

133 Task 3 of the MEErP requires a description of how the product group interacts with the
134 associated energy system. Tyres impact fuel consumption through the rolling resistance. Rolling
135 resistance coefficients and corresponding limits are set in UNECE Regulation No. 117, which have
136 been transposed at the EU level by EU type approval legislation (EU) 2019/2044. The limits have
137 increased over time, essentially providing the function of a typical Ecodesign regulation. For this
138 reason, the tyres have until now been the only product group to have an EU energy label but no
139 accompanying Ecodesign regulation.

140 The rolling resistance is influenced by the rubber compound, the driving behaviour and inflation
141 of the tyre, among other aspects. The energy label uses the rolling resistance coefficients from
142 UNECE R117 to define energy label classes as a proxy for fuel consumption from the tyre.
143 Meeting different performance requirements means addressing trade-offs in tyre production to
144 reach a tyre with best performance for a given application. For instance, altering rubber
145 compounds to reduce rolling resistance also reduces the grip of the tyre. For this reason, the
146 energy label includes wet grip, rolling resistance and noise together with severe snow or ice
147 pictograms to support consumer choice between features. Past consumer surveys on the energy
148 label indicate that consumers assign highest importance to safety (wet grip, 75.6 %), followed
149 by fuel consumption (64.0 %), indicating lower importance of external rolling noise (39.1 %).

150 In terms of environmental impacts, the use phase tends to dominate life cycle impacts of tyres
151 due to its impact on fuel consumption, while tyre abrasion is a major source of unintentionally
152 released microplastics, estimated to contribute from about one-third to half of total
153 microplastics released into the environment. Most tyre particles end up in soil, a considerable
154 amount reaches aquatic environments via runoff, and a small fraction becomes airborne. A
155 separate mapping of LCA studies on tyres has been carried out separately from this report to

156 support the application of the PEF methodology in Task 5. For this reason, in Task 3 relevant
157 impacts are given using results from a few exemplary LCA studies to give an indication of the
158 environmental impact during the use phase.

159 User driving behaviours and tyre choice have a large impact on the lifecycle of tyres. Choosing
160 the right tyre for different conditions and outcomes impacts how well that tyre will perform,
161 and whether or not it may or may not have a high quality casing for retreading. Different driving
162 and maintenance behaviours can directly influence the lifetime of the tyre, the rate of abrasion
163 of the tyre, and whether or not the tyre will be re-usable again at EoL. For instance, rapid
164 acceleration, under-inflation, uneven (over)loading, poor alignment and lack of tyre rotation can
165 all lead to premature tyre wear.

166 User attitudes to sustainable materials in tyres have not yet been widely researched, however,
167 it can be assumed that consumers would expect tyre safety and functional performance to
168 remain within similar ranges or exceed that of tyres they currently use, without major changes
169 to pricing. It is conceivable that consumers may respond to simple, trusted indicators (e.g., a
170 verified recycled content badge and an abrasion class) integrated into the existing label. Fleet
171 operators on the other hand are more interested in total cost of ownership (TCO), energy
172 savings, durability, retreadability, and maintenance impacts. Here, procurement criteria that
173 support retreadability and abrasion performance without impacting rolling resistance or wet
174 grip may be of interest. Some initial indications from manufacturers indicate that there could be
175 an interest from fleet operators and OEMs for tyres with sustainable materials to meet their
176 sustainability goals.

177 While collection rates in tyre waste management systems are currently high, concerns have
178 been raised by several stakeholders around exports of shredded and whole tyres for EoL
179 processing in countries with dubious treatment infrastructure outside the EU. Increasing market
180 demand for materials arising from tyre recycling and supporting increased re-use and retreading
181 may be a complementary way to support the EU tyres treatment market. There are currently
182 uneven rules around waste definitions and criteria for re-usable tyres across member states.

183 We conclude in Task 3 that, from the user perspective, any ESPR measures changing product
184 composition should be done in such a way that it does not affect functional performance of the
185 tyre. At this time it is unclear how much consumer demand there is for increased use of
186 alternative materials or higher recyclability, with other parameters driving user behaviour or
187 choice in the use phase at the present time.

188 **Task 4: Technologies**

189 The aim of Task 4 is to gather information on the technical aspects of tyres throughout their life
190 cycle. This includes detailed information on tyre composition in the form of a bill of materials
191 (BOM), as well as descriptions of best available technologies (BAT) and best not (yet) available
192 technologies (BNAT). The production and distribution of tyres, as well as their end-of-life phase,
193 are also within the scope of the task. C1, C2 and C3 tyres are in focus, while other tyre types are
194 also covered, but in less detail. The aim of Task 4 is to support an understanding of how these

195 technologies can be applied in practice, what design options may be possible, and to define the
196 relevant parameters to be used in the LCAs to be performed in Task 5.

197 The “average” tyre

198 Tyres are among the most complex mass-produced composite products. They contain many
199 components, including natural and synthetic rubber, steel, textiles, carbon black, silica, and
200 various additives. Due to the wide variety of tyre models on the market, it is challenging to define
201 an 'average' tyre. Initially, the characteristics of different tyres were mapped. Then, an analysis
202 was carried out on models uploaded to the European Product Registry for Energy Labelling
203 (EPREL) over the past five years (around 130,000 models) to determine the most common
204 dimensions and performance characteristics.

205 Best Available and Best Not (yet) Available Technologies

206 The aim of defining a BAT or BNAT stems from the MEErP methodology, which typically focuses
207 on energy efficiency performance. Unlike electrical appliances, it is very difficult or even
208 impossible to define a BAT for tyres. A key issue is the inherent trade-off between different
209 properties: reducing rolling resistance, for instance, can improve fuel efficiency but may
210 negatively impact grip. Standard improvement options for tyres include optimised tread designs,
211 refined rubber compounds, and tyre pressure monitoring and maintenance systems. In the
212 context of tyres, BAT refers to established technologies that improve rolling or abrasion
213 resistance or reduce noise, while BNAT covers more advanced innovations, such as sensor-
214 equipped 'smart tyres', the use of biobased polymers or recycled carbon black.

215 Bill of materials and tyre weight

216 The weight and composition of tyres vary significantly across categories C1, C2 and C3. For each
217 category, the weight distribution of the tyres is given, as well as their average composition
218 considering the most relevant components by mass. The table below summarises the findings.

219 **Table 1-1: overview of production parameters and lifetime data.**

| Parameter | C1 | C2 | C3 |
|--|-------------------------|-------------------------|------------------------|
| weight (min and max in brackets) [kg] | 10 (5-29) | 13 (5-45) | 55 (22-148) |
| average wet grip class (shares of tyre models reported in the EPREL database in reference years 2020-2024 in brackets) | B (35.9 %) - C (37.2 %) | B (32.8 %) – C (42.8 %) | B (40.6 %) – C(49.1 %) |
| average rolling resistance class (shares of tyre models reported in the EPREL database in reference years 2020-2024 in brackets) | C (45.8 %) - D (39.1 %) | C (45.9 %) -D (43.7 %) | C(34.4 %)-D(47.5 %) |

| Parameter | | C1 | C2 | C3 |
|--|------------------------|------------|------------|------------|
| average external noise class (shares of tyre models reported in the EPREL database in reference years 2020-2024 in brackets) | | B (90.9 %) | B (93.3 %) | B (93.3 %) |
| share of tyres apt for severe snow | | 38 % | 43 % | 64 % |
| share of reinforced tyres | | 63 % | - | - |
| elemental composition [wt-%] | natural rubber | 19.10 % | 20.20 % | 34.90 % |
| | synthetic rubber | 24.10 % | 22.80 % | 10.50 % |
| | carbon black | 20.30 % | 19.10 % | 21.70 % |
| | silica | 7.30 % | 6.40 % | 2.50 % |
| | sulphur | 1.30 % | 1.10 % | 1.70 % |
| | zinc oxide | 1.90 % | 1.70 % | 2.70 % |
| | plasticisers | 6.20 % | 4.40 % | 1.70 % |
| | Other additives/agents | 3.80 % | 5.70 % | 3.00 % |
| | steel | 12.00 % | 12.50 % | 21.20 % |
| | textiles | 4.00 % | 6.10 % | 0.00 % |

220 Tyre production and distribution

221 The tyre manufacturing process, alongside all production steps is detailed. Energy demands for
 222 the manufacturing are quantified. Primary production waste is described qualitatively (i.e. which
 223 waste is generated), but precise data on waste quantities remain limited. Packaging and
 224 transport logistics are assessed. Finally, the technical product lifetime, which is closely linked to
 225 mileage and wear behaviour under real-world driving conditions is assessed. While reliable data
 226 on mileage is available for C1 tyres, similar data for C2 and C3 tyres is missing. The table below
 227 summarises the findings.

228 **Table 1-2: overview of production parameters and lifetime data.**

| Parameter | C1 | C2 | C3 |
|--|--------------------------|------------------------|-------------------------|
| Energy demand [kWh/kg tyre] | 2-3 | | |
| Primary waste production (solid waste) [kg/t tyre] | 40-80 | | |
| Water consumption [m ³ /t tyre] | 5-7 (excluding seawater) | | |
| Packaging material | Mainly negligible | | |
| Product lifetime (based on km) | 40 000 (25 000-65 000) | 55 000 (40 000-70 000) | Highly dependent on use |

229 **End-of-life aspects and circularity**

230 With more than 2.5 million end-of-life tyres (ELT) arising every year within the EU-27, end-of-life
 231 aspects and circularity are an important focus of the project. ELT mainly undergo preparation
 232 for reuse, material recycling or energy recovery. Preparation for tyre reuse primarily involves
 233 retreading. Retreading is established for heavy-duty C3 tyres but remains marginal for other tyre
 234 types, such as passenger car tyres (C1). With regard to tyre recycling, mechanical shredding and
 235 granulation is the most important technology. Additionally, tyre pyrolysis is an emerging
 236 technology, already treating several 100 000 tonnes per year but still faces some technical and
 237 economic barriers as well as environmental concerns. Finally, the majority of ELT is treated
 238 within cement kilns for energy and material recovery.

239 As part of the circularity aspects, critical raw materials in tyres and potential substances of
 240 concern, including those that may hinder recyclability are assessed. In addition, alternative
 241 materials—both recycled and biobased—are explored as part of ongoing innovation in the
 242 sector. The following table gives an overview of critical raw materials, potential substances of
 243 concern as well as alternative materials that are investigated in connection with tyres.

244 **Table 1-3: overview of materials assessed in the study.**

| Critical raw materials | Potential substances of concern | Recycled/recovered materials | Bio-based/renewable materials |
|---|---|---|---|
| Cobalt (Cobalt salts are used as adhesion promotor between rubber and steel) | Poly Aromatic Hydrocarbons (PAH) | Micronised vulcanised rubber powder (<450 µm) | Bio-based synthetic rubber |
| Magnesium (MgO is used as vulcanisation cure activator, acid neutralising agent and crosslinker) | Foams and noise absorbing materials in silent tyres | Devulcanised rubber | Bio-based butadiene |
| | Viscous gel materials used in self-sealing tyres | Recovered carbon black (rCB) | Natural rubber from Guayule |
| | Aramid fibres used for reinforcement | Sustainable carbon black from TPO (sCR) | Natural Rubber from Dandelion |
| | Silica or other non-volatile additives | Tyre pyrolysis oil (TPO) | Fig tree milk |
| | Halobutyl from the inner liner | r-PET yarns | Medium-chain-length polyhydroxyalkanoates (mcl-PHA) |
| | Lithium-ion battery from tyre mounted sensors | r-PET cords | Bio-oils (vegetable oils, e.g. palm, soybean, castor, sunflower, linseed, rape seed oils) |
| | Diphenylguanidine (DPG) is used as a vulcanisation accelerator | | Rice husk ash |
| | Benzothiazoles (BTHs), guanidines, and p-phenylenediamines (PPDs) | | Biochar and biowaste-derived silica |

| Critical raw materials | Potential substances of concern | Recycled/recovered materials | Bio-based/renewable materials |
|------------------------|---------------------------------|------------------------------|---|
| | | | Bio-based carbon black (e.g. tall oil or bio-feedstock) |
| | | | Bio-based PA56 (from e.g. starch, straw, and corn) |
| | | | Lyocell fibre |

245 Finally, to enhance circularity, Digital Product Passport (DPP) concepts are also discussed as a
246 way to improve traceability, transparency and information sharing across the tyre value chain.

247 Preliminary Conclusions Task 4

248 **C1, C2, and C3 tyres should be the primary regulatory focus**, as they share similar structures,
249 components, performance indicators and standardised testing methods, making them
250 technically and practically suitable for regulatory measures. By contrast, other tyre types have
251 more variable designs and operating conditions, complicating consistent evaluation.

252 **Retreading** emerges as a priority within the waste hierarchy, offering clear environmental and
253 cost benefits by extending tyre life and conserving resources. However, its success depends on
254 durable carcass design, legal quality requirements and the development of standardised testing
255 methods to determine carcass suitability. Retreading is already common for C3 tyres, but further
256 assessment is needed for C1 and C2 tyres. **Recycling** provides additional circularity
257 opportunities. Pyrolysis may enable recovery of carbon black and other materials but faces
258 unresolved technical, economic and regulatory barriers, while mechanical recycling often leads
259 to downcycling into lower-performance products. Other recovery options, such as
260 devulcanisation, show potential for closed-loop recycling but are not yet fully developed.

261 **Material choices** are another key factor. Incorporating recycled and bio-based inputs can reduce
262 environmental impact but requires long development cycles, rigorous testing to ensure
263 performance and safety, and careful regulatory design to define feasible and verifiable targets.
264 Decisions must also account for which components to target, whether to apply requirements
265 per tyre or across a manufacturer's portfolio, and how to ensure reliable measurement and
266 control of declared material contents. An LCA (Task 5) will be critical to evaluate the
267 environmental benefits of alternative materials and EoL options.

268 **Certain design features** (e.g. TPMS batteries, self-sealing gels, foam layers, or high shares of
269 specific reinforcing materials) **can complicate end-of-life treatment** and may require restrictions
270 if costs outweigh the benefits they provide. The **DPP** could enhance transparency and circularity
271 by providing detailed information on tyre composition, hazardous substances and recyclability.
272 For effective implementation, the DPP must address data updating, intellectual property
273 protection and technical solutions, such as standardised RFID tags, while being developed
274 collaboratively across the value chain to ensure practicality and adoption.

275 2. Introduction



282 This draft document represents the first phase of the preparatory study to
283 assess the product group tyres as part of the regulatory process under the
284 Ecodesign for Sustainable Products Regulation (ESPR). It covers the first four
285 tasks of Scope, Markets, Users and Technologies under the Methodology for
286 Ecodesign of Energy-related Products (MEErP) from 2011 (Kemna, 2011). It
287 also takes into account the 2024 revision of MEErP (Caldas et al., 2022) and
288 is complemented by elements of the DPP methodology. The aims and objectives of the project
289 and a general methodological overview are detailed below.

284 This preparatory study is carried out by the consortium of VITO, Öko-Institut, Trinomics and
285 Ecomatters. The initial investigation phase will take place from March 2025 to May 2026.
286 Dependent on the results, an impact assessment may be launched by the EU Commission
287 thereafter. For an overview of project planning, please refer to the project website:
288 <https://ecodesign-tyres.eu/en/project-plan>

289 The current interim draft represents a work in progress, which will be revised and added to
290 following the stakeholder meeting on 15th October, 2025.

291 2.1. Political context

292 The Ecodesign for Sustainable Products Regulation (ESPR) (EU) 2024/1781 entered into force on
293 18th of July 2024. The ESPR Regulation builds on the previously existing Ecodesign Directive
294 2009/125/EC, expanding the Ecodesign requirements for specific product groups as it enables
295 the setting of performance and information requirements for almost all categories of physical
296 goods placed on the EU market. The framework allows setting a wide range of requirements,
297 including on:

- 298 • product durability, reusability, upgradability and reparability
- 299 • presence of substances that inhibit circularity
- 300 • energy and resource efficiency
- 301 • recycled content
- 302 • remanufacturing and recycling
- 303 • carbon and environmental footprints
- 304 • information requirements, including a DPP

305 The ESPR already mentions tyres as a possible priority group for future ESPR legislation under
306 Article 18 (Prioritisation and planning). This product group was thus investigated in several
307 studies that were performed to support the Commission in the preparation of the first ESPR
308 working plan.

309 With the anticipation that working plan(s) would need to be prepared for the new ESPR, the
310 Joint Research Centre (JRC) assessed several product groups and horizontal requirements
311 identified as suitable candidates for prioritisation under the first ESPR working plan. The JRC
312 study focused on ‘new’ priorities – i.e., products and horizontal requirements that were not in
313 the scope of the previous Ecodesign Directive 2009/125/EC but that are in the scope of the ESPR
314 (Faraca & Palma, 2024).

315 From an initial list of 33 product groups referenced in recent policy documents, 18 products (11
316 final and 7 intermediate products) were initially shortlisted based on environmental, market and
317 policy considerations. The shortlisted product groups were then assessed in terms of
318 environmental relevance (i.e., impacts and improvement potential) for 10 impact categories
319 addressing the main climate, environmental and energy objectives of the EU: water effects; air
320 effects; soil effects; biodiversity effects; waste generation and management; climate change;
321 life-cycle energy consumption; human toxicity; material efficiency; and lifetime extension
322 (Faraca et al., 2024).

323 Tyres were investigated for passenger cars (C1), light-duty vehicles (C2) and heavy-duty vehicles
324 (C3). The assessment ranked tyres as high priority for further action, with some of the highest
325 impacts across the environmental categories air (emissions) and strategic autonomy, moderate
326 impacts in almost all other impact categories and an EU market size of 45 billion EUR (Faraca et
327 al., 2024).

328 On the 16th of April 2025 the ESPR Working Plan for 2025-2030 was published (COM(2025) 187)
329 and referred to tyres as a priority, specifying 2027 as an indicative timeline for adoption of ESPR
330 legislation. The following was specified as the improvement potential: “Though already
331 regulated by other pieces of EU legislation (including the Tyre Labelling Regulation (EU)
332 2020/740), potential to improve recyclability and recycled content and to mitigate risks related
333 to waste management of end-of-life tyres” (EU ESPR, 2025).

334 2.2. Objectives of this preparatory study

335 In March 2025, the European Commission (Directorate-General Environment) launched this
336 preparatory study on tyres to assess the environmental impacts and feasibility of proposing ESPR
337 requirements for this product group. This includes aspects listed in Article 5 of Regulation (EU)
338 2024/1781 such as durability, reliability, reusability, upgradeability, reparability. This study will
339 provide the necessary information for the identification of design and policy options.

340 Overall, the objectives of the study can be summarised as follows:

- 341 • analysing the technical, economic, environmental, market and societal aspects of tyres.
- 342 • establish the problems and problem drivers to be addressed by the intervention, and
- 343 • develop possible design options that have the potential to improve the environmental
344 performance of tyres in view of possible ESPR requirements, including a DPP,

345 • or alternatively, consider the use of the tyres labelling and the EPREL database for this
346 purpose (in synergy with the review of the Tyres Labelling Regulation taking place in
347 parallel), and mandatory public procurement criteria (if appropriate).

348 Aspects for which ESPR requirements can be set include the following and consists of a
349 possible focus for the study to be considered under the following tasks:

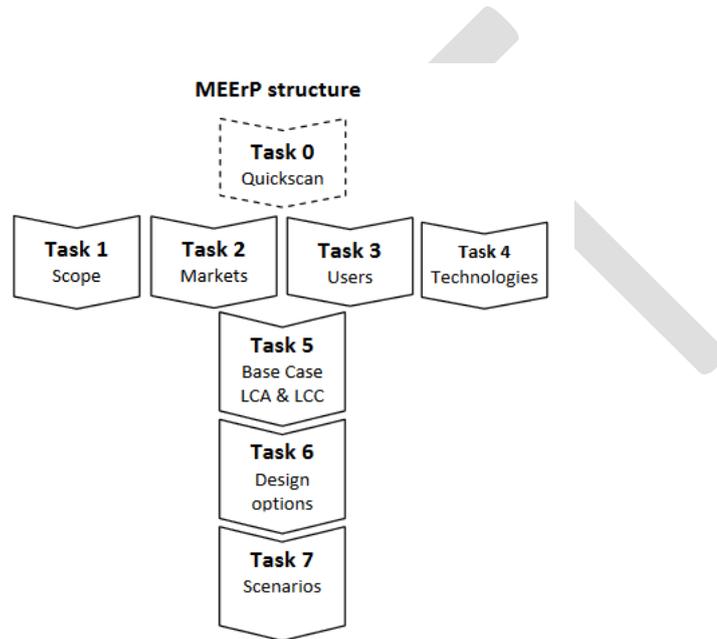
- 350 • product durability, reusability, upgradability and reparability
- 351 • presence of substances that inhibit circularity
- 352 • energy and resource efficiency
- 353 • recycled content
- 354 • remanufacturing and recycling
- 355 • carbon and environmental footprints
- 356 • information requirements, including a DPP

357 The current report covers MEER Tasks 1 to 4 (Scope, Market, Users, Technologies) and shall
358 serve as input for the first stakeholder meeting and following stakeholder consultation, before
359 starting on the second phase of the preparatory study with MEER Tasks 5-7.
360 Based on the findings of the preparatory study, the European Commission will decide whether
361 to develop a draft proposal for an ESPR Delegated Act for tyres, in which case an Impact
362 Assessment support study shall be carried out at a later stage.

363 3. Methodology

364 3.1. Methodology background

365 The preparatory study follows the MEErP methodology, which has been applied to around 40
 366 groups of energy-related-products in the framework of the Ecodesign Directive 20109/125/EC
 367 and shall also be applied in the context of preparatory studies under the ESPR. The MEErP
 368 consists of seven tasks:



369

370 **Figure 3-1: The seven tasks of the MEErP (Kemna, 2011).**

371 Following the coming into force of the ESPR, the MEErP methodology has recently been updated
 372 (Eynard et al., 2024) after the last update that took place in 2011 (Kemna, 2011). The intention
 373 of the revised MEErP is to incorporate material efficiency and environmental aspects more
 374 systematically and to update the EcoReport tool. The 2024 MEErP method considers the 16
 375 impact categories used in the Environmental Footprint (EF) method, in an effort to harmonise
 376 the EcoReport tool with the Product Environmental Footprint Category Rules (PEFCRs).
 377 Additional potential environmental impacts can be included and by default, the primary energy
 378 consumption is included since the methodology is used to analyse energy-related products in
 379 which energy consumption plays a vital. For instance, recyclability and recycled content will be
 380 input parameters and can be modelled in the end-of-life (EoL) scenario. Furthermore, material
 381 efficiency aspects are planned to be modelled consistently and systematically by introducing a
 382 discrete scoring system where the specific values are calculated. The new additions to the
 383 methodology impact Tasks 5 to 7 only, leaving Tasks 1-4 unchanged.

384 The preparatory study includes the following seven tasks (Eynard et al., 2024; Kemna, 2011):

- 385 • **Task 1 (Scope):** Define the product category and system boundaries to ground realistic
 386 design options, testing and calculation methods, and potential measures; review

- 387 existing EU/national measures and global benchmarks, and assess whether accurate,
388 reproducible test methods exist or need improvement.
- 389 • **Task 2 (Markets):** Position the product group within EU industry and trade, provide
390 market and cost inputs, capture trends relevant to Ecodesign measures, and assemble
391 price/rate data for life cycle cost (LCC) calculations.
 - 392 • **Task 3 (Users):** Characterise real-world user behaviour to quantify parameters that drive
393 environmental impact and LCC—identifying social, cultural, and infrastructural
394 barriers—and adjust from standard test conditions to actual use patterns.
 - 395 • **Task 4 (Technologies):** Analyse current EU-market products and technologies from
396 state-of-the-art to best available technology (BAT) and best near available technology
397 (BNAT) to inform Base Case definition (Task 5) and identify improvement potential (Task
398 6).
 - 399 • **Task 5 (Base Case, LCA & LCC):** Define a representative EU Base Case (using real-life
400 performance via multipliers from standard values) as the foundation for environmental
401 and LCC analyses, while checking through impact/sensitivity analysis that the
402 abstraction remains valid across segments. Data from previous tasks and literature is
403 used to model the product’s environmental footprint throughout its life cycle and
404 identify hotspots for improvement. This is done on using key impact categories (e.g.
405 energy use, greenhouse gas emissions, resource use, waste generation). In addition, a
406 review of relevant substances of concern is now included into this task as a result of the
407 revision of the MEErP Methodology.
 - 408 • **Task 6 (Design options):** Identify design options, based on the hotspots identified in Task
409 5, quantify their environmental impacts and consumer LCC, determine least life cycle
410 costs (LLCC) and BAT (with BNAT as long-term potential), and interpret the LLCC–BAT
411 gap as room for competitive differentiation and policy targeting. Assesses technical,
412 economic, and market feasibility of improvement measures (e.g. design changes,
413 material substitutions) and estimate the potential benefits (environmental, economic,
414 social) of these improvements. Looking into a design option of introducing a DPP to
415 cover information requirements was included into this task following the revision of the
416 MEErP Methodology and a design option related to substances of concern is also to be
417 included.
 - 418 • **Task 7 (Scenarios):** Integrate results to propose suitable policy instruments, build
419 scenarios (e.g. to 2030/2050) versus business-as-usual (BAU), model the effects of
420 different policy scenarios (e.g. BAU, Ecodesign requirements, voluntary agreements),
421 quantify the expected environmental, economic, and social impacts of each scenario at
422 the EU level and compare with EU targets and societal costs, assess impacts on
423 consumers and industry, and test robustness via a sensitivity analysis aligned with
424 sectoral design cycles. Choose the most effective and practical regulatory approach.
- 425

426 3.2. Approach of this preparatory study

427 The above-mentioned methodology has been developed for energy related products. Tyres
428 influence the fuel/energy consumption of vehicles indirectly, through the rolling resistance.
429 Tyres have had an Energy Label since 2009 covering wet grip, rolling resistance and external
430 noise (current Regulation (EU) 2020/740), with rolling resistance limits set by type approval,
431 largely derived from the international UNECE R117 regulation. The scope of this preparatory
432 study is therefore focused on unregulated material-related aspects, making it one of the first
433 times that the MEERp methodology is applied under the new framework of ESPR to target such
434 aspects. Since the original MEERp targets energy consumption, it is likely that the methodology
435 applied in this study shall need to deviate in some places from the original MEERp methodology
436 to ensure that all relevant aspects are included in the investigation at an appropriate level.

437 3.2.1. Stakeholder consultation

438 To collect data and exchange with stakeholders, the following means of consultation have been
439 implemented in this study so far.

- 440 • An online platform was established to allow sharing information on the study with
441 stakeholders. This platform can be found under <https://ecodesign-tyres.eu/en>. Among
442 others, a registration option was provided to stakeholders on the platform to be
443 involved with and follow project updates. Three online consultations were launched at
444 the beginning of June 2025 to collect data for the study.
 - 445 - The first aimed to collect data for the preparation of Tasks 1-4 of the preparatory
446 study. It was initially launched for 4 weeks until 30 June 2025 but was extended until
447 15 July 2025. 13 contributions were received from manufacturers and their
448 associations, retreaders and their associations, waste operators and their
449 associations, an environmental non-governmental organisation (NGO) and a few
450 additional related stakeholders from chemical and testing industries.
 - 451 - A second consultation was launched to collect data for life-cycle assessment and
452 was held until 5th September 2025. Three contributions were made by two
453 associations and by an environmental NGO.
 - 454 - The third consultation was launched to collect data on substances of concern with
455 the same timeline as the second consultation. However, it was extended by a further
456 two weeks until 19th September 2025. Three contributions were made by an
457 association, a Member State and a material manufacturer.
- 458 • In addition to the stakeholder consultations, interviews were held with the various
459 stakeholders throughout the summer of 2025, including interviews with manufacturers,
460 waste operators, retreaders and processors who take-up recycled material and prepare
461 it for use in new applications.
- 462 • Finally, the European Tyre and Rubber Manufacturers' Association (ETRMA)
463 representing the EU tyre industry organised a visit to a European facility active in
464 manufacturing, reclaiming and retreading

465 A first stakeholder meeting is planned to be held on 15 October 2025 in Brussels to discuss and
466 collect feedback on the first results. The meeting will focus on the preliminary results of MEERP
467 Tasks 1-4 and shall look at data gaps and areas that are still not completely clear. In the various
468 tasks, some questions have been included in this respect which shall be discussed during the
469 meeting.

470

DRAFT

471 4. MEErP Task 1 – Scope

472 4.1. Objectives of MEErP Task 1

473 The aim of MEErP Task 1 is to define the product category and the system boundaries of the
474 ‘playing field’ for Ecodesign. It aims to provide a detailed overview of existing legislation,
475 voluntary schemes and standards for tyres with the aim to define the functional unit of the
476 product group and the possible scope of a potential regulation. MEErP Task 1 is a very important
477 step in a preparatory study. It defines the scope and possible exemptions from the scope. It also
478 provides or proposes definitions of the subject matter of the study, ideally based on existing
479 standards, links it to existing legislation and identifies prevailing gaps to be filled by the
480 delegated acts to be drafted.

481 In addition, this study should address a range of different aspects related to the life cycle phases
482 of tyres (see detail in **Section 2.2** above). Most of them are understood to be aspects in the main
483 focus of the study (e.g. material related aspects, recyclability and recycled content). However,
484 microplastic emissions, noise emissions and tyre reliability are already covered (or to be covered
485 in the future) by UNECE Regulation No. 117 (does not apply to all kinds of tyres) and are also
486 transposed (or to be transposed) in EU legislation. In this respect, it was agreed at the beginning
487 of the study that these topics would be investigated far enough to consider if additional
488 measures to be introduced under ESPR would have a synergetic, antagonistic or neutral effect
489 on these aspects.

490 4.2. Product scope

491 4.2.1. Product definition and boundaries

492 Though there are many legislations and standards that refer to tyres, most of these do not define
493 this product nor provide explanations for what a tyre is. Many consumers refer to tyres and
494 wheels interchangeably, however, these terms describe different components of a vehicle.
495 While the wheel is the solid and often steel part that is attached to the vehicle axis and that
496 rotates when driving, the tyre is the casing that is fitted around the wheel rim and provides the
497 only point of contact between the vehicle and the road or ground (Tyre Safe, 2024).

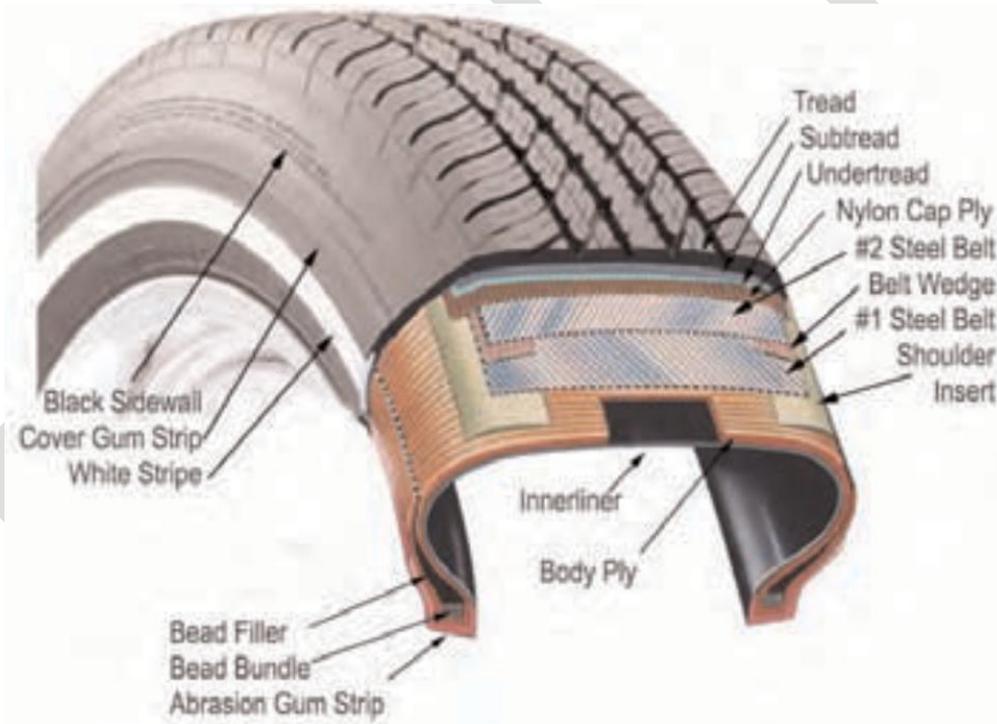
498 A tyre is composed of multiple components which are in turn composed of a large number of
499 materials and compounds. Rodgers refers to the modern radial tyre as the most complex
500 composite produced in mass production. This has to do with the wide variety of chemicals,
501 fabrics and types of steel going into its production, but is also a result of the complexity of
502 material blends or compounds used in the tyre. During production all of the components are
503 manufactured and put together, taking into consideration the type of vehicles for which the tyre
504 will be used and its typical use patterns, performance parameters that the tyre design needs to

505 achieve and handling characteristics (Rodgers, 2021). In this sense, production is a complex
506 process, and each plant has a different set-up.

507 According to (Gent, A.N. & Walter J.D, 2006) there are 20 or more components, with 15 or more
508 rubber compounds, assembled in a typical radial passenger car tyre. **Figure 4-1** presents a
509 schematic overview of a radial tyre to clarify the terms used throughout this study and their
510 location within the tyre. These include among others:

- 511 • Tread – top surface contacting the road.
- 512 • Under-tread cushion – rubber layer beneath tread.
- 513 • Belt package – typically steel belts that reinforce the tread region.
- 514 • Body plies – cords forming the carcass.
- 515 • Sidewall – the flexible region between bead and shoulder.
- 516 • Bead assembly – steel wire bundle ensuring rim seal and support.

517 A further schematic overview is provided in **Figure 4-2**.



518

519

Figure 4-1: Schematic construction of a radial tyre.

520

Source: (Gent, A.N. & Walter J.D, 2006)

521

522



1. Tread
2. Tread grooves
3. Crown belts
4. Cushion
5. Sidewall
6. Radial plies
7. Bead wire
8. Inner liner
9. Carcass belt
10. Shoulder

Figure 4-2: Schematic construction of a radial tyre.

Source: (European Commission, n.d)

523

524

525 A tyre has different belts and wires. The carcass belt is applied in the sidewall, adding stability
526 and preventing tyre deformation when inflation pressure is added. The bead wire keeps the tyre
527 seated to the rim and in some cases multiple beads are used for this purpose (Hyttinen, 2023a).

528 Nowadays on the global market, two types of tyres are common that differ in construction: the
529 Bias Ply construction (also termed cross ply) and the Radial construction. Though both are
530 constructed using similar components, the main differentiation is in how the fabric plies are
531 applied (Rodgers, 2021).

532 • In a bias ply tyre the fabric is applied diagonally, extending from bead to bead and with
533 the fabric cords oriented at an angle of between 20-40° to the centreline. Each further
534 layer of fabric is the applied in the opposite direction, creating a composite network of
535 layers running in opposite directions. This construction was introduced at the beginning
536 of the tyre industry and is still used in some places for heavy duty trucks (used for on/off
537 road applications or where road conditions are less developed) agricultural vehicles and
538 aircraft tyres (due to the prohibitive cost of radial tyre certification).

539 • Radial tyres were first developed in the 50s, commercialised in the 70s and have by now
540 largely replaced the bias ply construction in markets with fully developed road networks.
541 The casing construction is not as rigid as that of bias ply tyres and the ply cords extend
542 transversely and not radially between beads, meaning that they are at a 90° angle to the
543 tyre centreline.

544 A tyre has different functions. Primarily, it provides the interface between a vehicle and the road
545 or surface on which the vehicle is situated. The tyre supports the load of the vehicle, causing the
546 tyre to deflect until the average contact area pressure is balanced by the internal air pressure of
547 the tyre. The tyre's contact with the road or surface results in friction between the vehicle and
548 the surface which ultimately supports the vehicle's ability to start, stop and turn. Furthermore,
549 the tyre absorbs the irregularities of the road or surface, enabling the vehicle to drive through
550 different conditions of terrain and weather (Gent, A.N. & Walter J.D, 2006). A tyre must provide

551 these functions while also ensuring safety and reliability over time. More detail is provided on
552 the various functions to explain them further:

553 **Load support** – the tyre must support the load or weight of the vehicle and all persons or goods
554 that it carries. Tyre support is relevant both when driving and parking and under different road
555 and weather conditions.

556 A tyre's contact with the road creates friction and influences **tyre traction, propulsion, steering**
557 **and handling**. The vehicle's ability to start, stop and turn is a result of this friction and enables
558 vehicle accelerating, braking and steering (directional control). How the tyre tread is constructed
559 will influence the tyre's abilities to fulfil these functions on different road surfaces as well as
560 under varying weather conditions.

561 Tyres **absorb the irregularities of the road**, meaning that they need to be flexible on one side
562 but also to retain internal pressure when driving on various surfaces. This offers comfort to
563 passengers during the ride and protects vehicle components, passengers and carried goods from
564 shocks that would occur through direct contact with the road.

565 The tyre must be designed to provide all these functions over time, while remaining **safe and**
566 **reliable**. This means that it needs to remain durable and resist wear that is caused by a
567 combination of the road surfaces on which it drives, weather and climate conditions of use,
568 driving behaviour and additional aspects.

569 All these affect the tyre's level of noise and air emissions as well as its ability to push away water
570 from the tread surface (to avoid aquaplaning) to ensure a good grip of the road under different
571 driving conditions.

572 4.2.2. Subgrouping and classification

573 Tyres can be classified in many different ways, sometimes overlapping, depending on whether
574 the classification needs to reflect technical parameters, policy objectives, functionality or market
575 aspects. In the following sections, a few possible categorisations are presented.

576 4.2.2.1. Categorisation by vehicle type – based on UNECE 117, and EU type 577 approval

578 The most widely used categorisation for tyres is shown in **Table 4-1** according to the EU
579 Regulation 661/2009 (Regulation (EC) 661/2009 of the European Parliament and of the Council
580 of 13 July 2009 Concerning Type-Approval Requirements for the General Safety of Motor
581 Vehicles, Their Trailers and Systems, Components and Separate Technical Units Intended , n.d.)
582 and Regulation 2020/740 (EU Regulation 2020/740, 2020). This categorisation covers the tyres
583 of passenger cars, trucks, buses and their trailers.

584 **Table 4-1: Tyre categorisation according to relevant European regulations.**

| Tyre category | Typical vehicle category |
|---------------|---|
| C1 | M1, N1, O1, O2 |
| C2 | M2, M3, N, O3, O4 with load capacity index ≤ 121 , speed symbol \geq 'N' |
| C3 | M2, M3, N, O3, O4 with load capacity index ≥ 122 or load index ≤ 121 and speed symbol \leq 'M' |

585 Legend: M1 = passenger cars, N1 = light commercial vehicles, O1/O₂ = light trailers, M2/M3 = buses, N = commercial
586 vehicles and O3/O4 = heavy trailers; speed symbol N = maximum speed up to 140 km/h; speed symbol M = maximum
587 speed up to 130 km/h

588
589 Source: (EC Regulation 661/2009, 2009; EU Regulation 2020/740, 2020; UNECE R30, 2008; UNECE R54, 2008; UNECE
590 R108, 1998; UNECE R109, 1998; UNECE R117, 2016)

591 A tyre may be classified in more than one class if it meets the requirements for those classes.
592 This means that a tyre can be used in multiple vehicle tyre classes. For example, a 215/65 R16
593 tyre is sold for both SUVs (M1 category) and light vans (N1 category). When fitted on a passenger
594 SUV (M1), it falls under the C1 class. Whereas, when the same tyre construction is approved for
595 a light commercial vehicle (N1), it is treated as a C2 class tyre. Manufacturers sometimes seek
596 approval in both categories, because the casing and load index allow the tyre to function in both
597 roles.

598 This classification is fundamental for determining which technical and regulatory requirements
599 apply to each tyre type in the EU. The UNECE Regulations R30 (UNECE R30, 2008), R54 (UNECE
600 R54, 2008), R108 (UNECE R108, 1998) and R109 (UNECE R109, 1998) categorise tyres using the
601 same vehicle categories as the EU regulations mentioned above and below (M, N, O).
602 Specifically, R30 applies to new passenger car tyres (M1 and O), R54 to new commercial vehicle
603 tyres (M2, M3, N and O), R108 to retreaded passenger car tyres (M1 and O), and R109 to
604 retreaded commercial vehicle tyres (M2, M3, N and O).

605 Stakeholders refer to C1, C2 and C3 tyres as the most relevant for regulation because they have
606 the highest market shares and volumes. However, this categorisation does not apply to other
607 types of vehicle tyres, namely tyres of e.g. agricultural vehicles, aircraft, motorcycles, scooters,
608 and bicycles.

609 Tyre classes or categorisations that apply to these other types of vehicles have not been
610 identified; however, looking at vehicle type approval and the vehicle classifications against the
611 vehicle types specified in **Table 4-1** above clarifies that other tyre types are not covered. A
612 compilation of vehicle classifications based on the EU type approval legislation is given in the
613 table below.

614

615

Table 4-2: vehicle classification based on EU Type Approval legislation.

| Vehicle type | Vehicle classification | Source | Tyre class |
|--|---|-----------------------------|--|
| Category M consists of motor vehicles designed and constructed primarily for the carriage of passengers and their luggage | | | |
| Passenger cars | M1: 8 seats or less | Regulation (EU) 2018/858 | ≤3.5 t: C1 |
| Buses | M2: More than 8 seats, maximum mass = 5 tonnes or less | | ≤3.5 t: C2 >3.5 t: C3 |
| Buses | M3: More than 8 seats, maximum mass = more than 5 tonnes | | ≤3.5 t: C2 >3.5 t: C3 |
| Category N consists of motor vehicles designed and constructed primarily for the carriage of goods | | | |
| Trucks | N1: maximum mass = 3.5 tonnes or less | Regulation (EU) 2018/858 | C1 |
| | N2: maximum mass exceeding 3.5 tonnes but not exceeding 12 tonnes | | C2: load capacity index ≤ 121, speed symbol ≥ 'N' |
| | N3: maximum mass exceeding 12 tonnes | | C3: load capacity index ≥ 122 or load index ≤ 121 and speed symbol ≤ 'M' |
| Category O consists of trailers | | | |
| | O1: maximum mass not exceeding 0.75 tonnes | Regulation (EU) 2018/858 | C1 |
| | O2: maximum mass exceeding 0.75 tonnes but not exceeding 3.5 tonnes | | C1 |
| | O3: maximum mass exceeding 3.5 tonnes but not exceeding 10 tonnes | | C2: load capacity index ≤ 121, speed symbol ≥ 'N' |
| | O4: maximum mass exceeding 10 tonnes | | C3: load capacity index ≥ 122 or load index ≤ 121 and speed symbol ≤ 'M' |
| Bicycles, mopeds, motorcycles | L type vehicles | Regulation (EU) 168/2013 | unknown |
| Agricultural or forestry vehicle | T vehicle | Regulation (EU) 2019/519 | unknown |
| Agricultural trailer | R vehicle | Regulation (EU) No 167/2013 | unknown |
| Agricultural towed equipment | S vehicle | | unknown |
| Offroad vehicle | G vehicle | | unknown |

| Vehicle type | Vehicle classification | Source | Tyre class |
|---------------------------|---|---------------------------|------------|
| Non-road mobile machinery | Art. 3(1): (1) 'non-road mobile machinery' means any mobile machine, transportable equipment or vehicle with or without bodywork or wheels, not intended for the transport of passengers or goods on roads, and includes machinery installed on the chassis of vehicles intended for the transport of passengers or goods on roads; | Regulation (EU) 2016/1628 | unknown |
| Aircraft | unknown | unknown | unknown |

616 Legend: speed symbol N = maximum speed up to 140 km/h; speed symbol M = maximum speed up to 130 km/h

617 Product Category Rules (PCR) stipulate the rules for quantifying and declaring the carbon
 618 footprint of a product, serving as the basis for preparing an Environmental Product Declaration
 619 (EPD). Specifically for tyres, the core PCR¹ are established by the UL Environment (*ULE 10006*,
 620 2022). This document (**Section 2.1**) categorises tyres as follows and as such refers also to tyres
 621 beyond the C1, C2 and C3 classes:

- 622 • Passenger car tyre
- 623 • Light truck tyre
- 624 • Pick-up and delivery truck tyre
- 625 • Long haul truck tyre
- 626 • Regional/city truck tyre
- 627 • Mixed service truck tyre
- 628 • Pick-up bus tyre
- 629 • City bus tyre
- 630 • School bus tyre
- 631 • Regional/inter-city coach bus tyre
- 632 • Long-haul coach bus tyre
- 633 • Motorcycle tyre
- 634 • Off-the-road tyre
- 635 • Aircraft tyre

636 The tyres of each of the vehicle groups differ in dimensions, composition and their properties.
 637 This is related to vehicle weight and expected load as also to typical use behaviour (e.g. typical
 638 driving surfaces, high speed or slow driving, carriage of heavy goods, etc.). For instance, a tyre
 639 developed for agricultural vehicles will be developed to better suit off-road conditions. For

¹ i.e. the foundational, primary set of PCR that defines the baseline methodology and requirements for creating EPDs for tyres. This set can be adopted and supplemented by other PCR documents or programs and serves to ensure consistency across EPDs while allowing region/program-specific additions.

640 passenger cars, some tyres will be better designed for road use while others will be suitable for
 641 both on and off-road conditions.

642 Stakeholder question
 643 T1-1: Are you aware of further tyre classes aside from C1, C2 and C3, i.e. classes that
 644 apply to tyres of other than M, N and O vehicles?

645 **4.2.2.2. Categorisation by construction type**

646 As already explained above, tyres can be classified based on their construction type. Two main
 647 sub-groups exist which can be broken down into further sub-groupings.

- 648 • Pneumatic tyres are tyres filled with air, however a few sub-categorisations exist:
 - 649 - Radial – see **Section 4.2.1**. The market trend has shifted towards the use of radial
 650 tyres and in Europe this type of tyre construction has become predominant on the
 651 market (Rodgers, 2021).
 - 652 - Bias-ply (cross-ply) – see **Section 4.2.1**. Such tyres are still used for heavy duty
 653 vehicles in countries with underdeveloped road networks, for certain off-road
 654 applications and for aircraft (Rodgers, 2021). In the EU it is assumed that only niche
 655 applications are relevant for such tyres.
 - 656 - Tube vs. tubeless – most people will be familiar with the use of tubes to support the
 657 structure of tyres of bicycles however this technology was also common in the past
 658 for other types of tyres. Based on exchange with stakeholders, nowadays, however
 659 in the C1, C2 and C3 classes tubeless tyres are the norm.
- 660 • Non-pneumatic tyres - such tyres are not filled with air and until recently only concerned
 661 solid tyres. Their main advantage is that through the use of elasticity, they avoid the
 662 need to monitor tyre air pressure and to inflate the tyre when the pressure decreases.
 - 663 - Solid tyres – According to a manufacturer’s website, such tyres have a high loading
 664 capacity and are optimised for slow vehicles or ones with a high risk of impact and
 665 damage. Typical application areas include forklift trucks, airport vehicles, heavy-
 666 duty transport vehicles, platform trucks and other industrial vehicles. There are
 667 different types of solid tyres, depending on how they are constructed, including
 668 cushion tyres, press-on bands and super elastic tyres (Our Solid Tyres, n.d).
 - 669 - Experimental airless designs – more recently research has been carried out into the
 670 development of air-less tyres (e.g. Michelin Tweel but also scholars like the Polymer
 671 Research Center in Madison, Wisconsin or Nanjing University of Aeronautics and
 672 Astronautics). These differ from solid tyres mainly in the attempt to develop designs
 673 that could replace pneumatic designs with a tyre that does not need to be inflated
 674 and that lacks the risk of a blow-out. At present these are considered to be niche
 675 applications (Y. Deng et al., 2023).

676

677 Questions for stakeholders:
678 T1-2: What applications is the bias ply tyre still used for in the EU aside from
679 agricultural tyres?
680 T1-3: Can you confirm that these tyres are handled at EoL together with other
681 pneumatic tyres?
682 T1-4: Is it correct to assume that the use of tubes in the various vehicle tyre types
683 and classes is uncommon aside for bicycle tyres and agricultural tyres?
684 T1-5: Where used, are tyre tubes disposed of through the same waste management
685 routes as tyres?
686 T1-6: Is it practical to subject solid tyres and pneumatic tyres to the same waste
687 management?

688 4.2.2.3. Categorisation by functional performance of seasonal application

689 Within the various classes, different tyres have been developed to be more appropriate for use
690 under certain environmental conditions or to deal with specific use cases.

691 First and foremost, this refers to tyres developed to better suit specific seasons or rather the
692 weather conditions expected in the different season.

- 693 • All-season tyres for driving in all weather conditions such as rain, heat and cold, but not
694 intended for driving in areas where ice and snow tend to accumulate on roads. “They
695 have a wider and deeper tread profile than other tyre types which means that they
696 provide more grip and traction on the roads” (Tyre Safe, 2024). A manufacturer specifies
697 these tyres for safe use in temperatures ranging from -10 °C to +30 °C, explaining that
698 they are suitable in places that experience mild summers and winters and only
699 occasional snowfall (Michelin UK, n.d).
- 700 • Summer tyres are better designed for use in warmer weather months or all years in
701 places that do not experience winter weather (e.g. cold temperatures, snow). According
702 to a manufacturer website, such tyres are designed for months where the temperature
703 can reach 40 °C and deliver optimal performance in temperatures above 7 °C. They are
704 designed with a shallower tread pattern and with stiffer, stickier tread compounds to
705 ensure good grip on both dry and wet surfaces (Michelin UK, n.d).
- 706 • Winter tyres are specifically designed for driving in cold, icy or snowy conditions. Legally
707 they are termed snow tyres (see **Section 4.2.4.22**). “With a unique tread compound and
708 multi-sipe tread patterns, these tyres provide more traction, better handling and shorter
709 stopping distances in icy conditions” (Tyre Safe, 2024). Promotional data of a tyre
710 manufacturer explains that they are designed temperatures below 7 °C. Compared to
711 summer tyres, winter tyres have a deeper tread and additional grooves and the
712 materials used will not stiffen as will summer tyres when exposed to cold temperatures
713 (Michelin UK, n.d).

714 Furthermore, some tyres are designed to better suit specific road or surface conditions, to deal
715 with events that can occur during use or to mitigate certain environmental impacts of the tyre
716 during use. This includes for example:

717 • 4 X 4 Tyres are designed for vehicles that are expected to drive more in off-road
718 conditions on rugged, uneven surfaces and varying terrain. “Generally these tyres have
719 a deeper tread, a higher rubber ratio and reinforced sidewalls to prevent punctures”
720 (Tyre Safe, 2024). Legally speaking such tyres are called special use tyres, for example in
721 UNECE Regulations (see **Section 4.2.4.23**).

722 • Self-sealing tyres are filled with a material which in the case of a puncture, fills and
723 gauges the area of the puncture so that the vehicle can continue to be driven without
724 seeking immediate roadside repairs. ASDA Tyres explain that typically sticky gel
725 materials are used and will seal a puncture of up to 5mm in diameter, without losing air
726 pressure or affecting driving. In the case of a puncture, the gel instantly surrounds and
727 plugs small holes caused by nails, screws, or sharp debris. The technology relies on the
728 sealant to prevent air from escaping, so that in some case the driver may not even realise
729 that a puncture occurred (ASDA Tyres, 2025).

730 • Run-flat tyres are tyres that have reinforced sidewalls which will hold the weight of the
731 vehicle even when the internal pressure drops after a puncture of the tyre. The
732 reinforcing is not aimed to extend the service life despite the puncture but just to ensure
733 the vehicle can safely drive to a place where the tyre can be repaired or replaced.
734 According to (ASDA Tyres, 2025) this method type of tyre typically allows safe driving for
735 around 50 miles (~80 km) after a puncture. Tyre Safe (2024) refer to run-flat-tyres which
736 are explained to be “be fitted with a tyre pressure monitoring system”.

737 • Electric vehicle tyres are designed to be compatible with the electric vehicles, because
738 these tend to be heavier than conventional vehicles. Similarly, “these tyres are heavier
739 than conventional ones and are crafted with reinforced sidewalls, distinctive tread
740 patterns and rubber compounds to cope with the higher torque output of electric
741 vehicles” (Tyre Safe, 2024). That said, from exchange with tyre manufacturers, it is
742 understood that tyres developed for combustion engine vehicles are also suitable for
743 use with EVs. In that sense, the question is rather whether EV tyres are better suited for
744 higher loads and if this subsequently will ensure higher durability in this respect.

745 • Noise reduction tyres are equipped with a foam layer which absorbs some of the noise
746 emitted during driving and thus reduces the noise level of and within the vehicle.
747 According to Mathis (Mathis, Omar, 2023), as cars have gotten less noisy, more
748 development efforts are aimed at reducing noise generated by tyres. Though most noise
749 reduction tyres use a foam insert to absorb the noise, new developments are looking at
750 serrated films designed to disturb air flow and reduce noise within the tyre.

751 4.2.2.4. Categorisation by market or product life cycle

752 As discussed in the next tasks, a few categories can be distinguished when considering how tyres
753 are marketed and sold. To begin with, a distinction between new tyres and used tyres can be
754 made; however, in each of these groups additional sub-groupings are common.

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- Tyre tiers: Regardless of whether new or used tyres are concerned, manufacturers refer to a few main tiers or market positions for which they design tyres. Usually this includes Premium tyres, Mid-tier tyres, and Budget tyres. Some stakeholders refer also to a fourth tier. There is no standardisation of the tyre tiers and according to an association exchanged with, each manufacturer uses different definitions to categorise tyres into the various tiers within its product portfolio. Generally speaking, the higher the tier, the more expensive the tyre and thus in the higher tiers more investment in research and development can be expected as well as specification of unique characteristics or elements. Similarly, the lower tiers will be more concerned with complying with minimum regulation requirements while ensuring less expensive pricing.
- 765
- A distinction relevant for new tyres is whether they are sold to OEMs or to end-consumers.
- 766
- OEM tyres are the first tyres to be fitted on a vehicle and with which it will be placed on the market. From exchanges with tyre manufacturers, it can be understood that OEMs can have unique specifications for a tyre, resulting in a higher variety of tyre dimensions and properties for OEM tyres than is typical for end-user tyres. This can translate to specific tyres being developed for a certain OEM model. “Car makers often set specific requirements for the featured tyre, involving e.g. specificities in design of belts, in the chemistry of tread compound, etc.”(European Commission, n.d). OEM tyres have an OE (Original Equipment) marking on the tyre which indicates that it was designed by the tyre manufacturer and approved to be fitted as original equipment for a vehicle brand or in some cases even for specific vehicles (European Commission, n.d).
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- Replacement tyres is the term used for tyres sold to end-users as they are purchased once the vehicle tyres in use on a vehicle are worn and need to be replaced. Though different end-users will have different preferences in terms of tyre tiers and characteristics, the diversity of tyres purchased as replacement tyres is generally smaller than OEM tyres. This is probably related to the choice of tyres that dealers make available to their clients, which to some degree dictates consumer choice.
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- Looking at secondary market operations, a few use cases are apparent:
- To a lesser degree, some sales of part worn tyres are observed. These can be sold by private consumers as 2nd hand tyres, however in the waste management of EoL vehicles, where tyres must be dismantled at initial stages, it is not uncommon to identify tyres that are still in good shape and sell them for reuse.
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- Retreaded tyres are tyres that have reached their EoL but have been identified as having a casing that is still in good shape and that can allow a form of refurbishment to return the tyre to use. During the retreading process, the casing is checked and where suitable, the tread (and sometimes also the part of the sidewall) is replaced. The current practice practically gives the casing a second life, with retreaders claiming that retreads are comparable in terms of performance with new tyres.
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795 4.2.2.5. Categorisation by technical parameters - size / load / speed rating

796 Tyres can be distinguished based on various technical parameters, with some of these being
797 specified on the tyre and in some cases also compliant with standards or legislation. Some of
798 these parameters are particularly important when replacing tyres, i.e., in order to ensure
799 interchangeability with the tyre to be replaced.

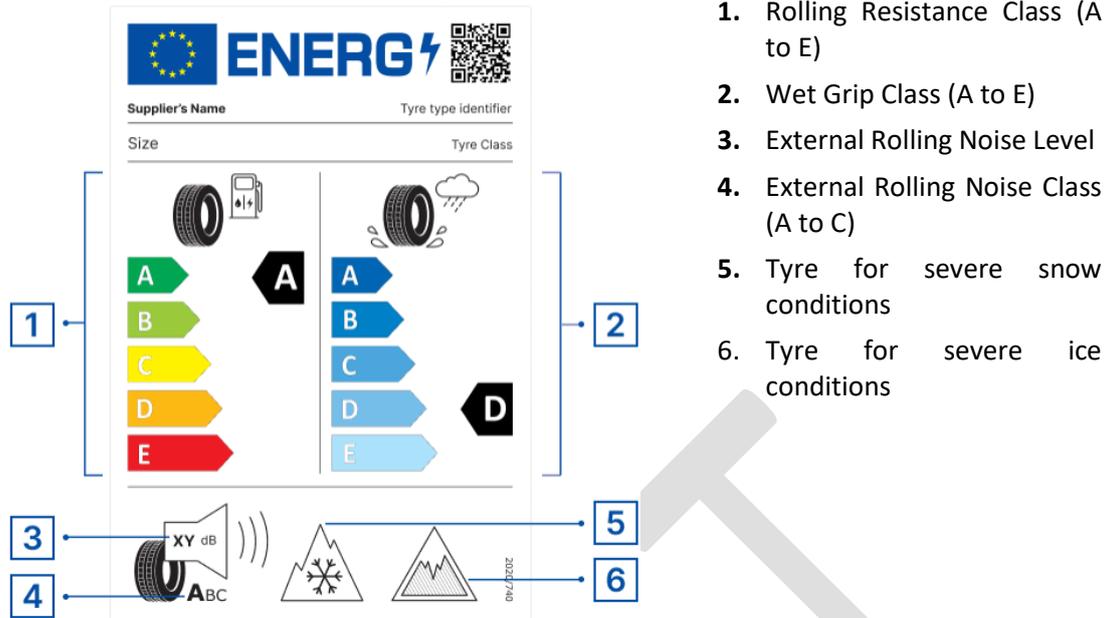
800 A replacement tyre needs to match the “tyre size” and to a lesser degree also the “service
801 description”. The following describes these parameters for C1 tyres (European Commission, n.d)
802 and is followed by an example to demonstrate how this is detailed in a tyres dimension code:

- 803 • Tyre size combines the following parameters:
 - 804 - Section width is measured in mm from sidewall to sidewall;
 - 805 - Aspect ratio is the ratio of the section height and of the section width of a tyre,
806 expressed as percentage;
 - 807 - Construction (or structure) meaning tyre construction (see **Section 4.2.2.2**),
808 whereas R stands for radial and B stands for bias;
 - 809 - Rim diameter represents the total rim diameter, and is given in inches;
- 810 • Service description
 - 811 - Load index is an assigned number corresponding with the load-carrying capacity of
812 a tyre. The heavier a vehicle, the higher the load index;
 - 813 - Speed index: is the letter that follows the load index and indicates the maximum
814 speed the tyre can service. The rated speed must exceed the maximum speed
815 homologated for the vehicle, though for winter tyres national legislation may permit
816 a lower index.

817 Looking at an example dimension code of a tyre “205/55 R16 91V”, it specifies, section width
818 (205 mm), aspect ratio (55), construction (R), rim diameter (16”), load index (91) and the speed
819 rating (V).

820 4.2.2.6. Categorisation by regulatory/labelling category

821 The Tyre Labelling Regulation (EU Regulation 2020/740, 2020) comprises of information
822 requirements for consumers that are provided through a label. Among others, the label includes
823 a few parameters which are addressed through categorisation or classes. This on the one side
824 has allowed removing the worst performers from the market but also provides end-users with
825 a system that allows them to understand how a specific tyre performs in relation to a given
826 category. According to the Commissions webpage, for rolling resistance and wet grip the classes
827 have decreased since the introduction of the label from 7 to 5 (meaning that tyre performance
828 improved leaving two empty classes) and restrictions that have applied from 2024 shall further
829 reduce the scale to 4 classes. For noise, there are 3 classes though here too, only the two higher
830 classes are actually populated. **Figure 4-3** shows the information specified on the label and how
831 the classes are categorised.



1. Rolling Resistance Class (A to E)
2. Wet Grip Class (A to E)
3. External Rolling Noise Level
4. External Rolling Noise Class (A to C)
5. Tyre for severe snow conditions
6. Tyre for severe ice conditions

Figure 4-3: Understanding the Tyres Label.

Source: (European Commission, 2023)

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4.2.2.7. Conclusions on the scope of tyres addressed in this study and relevant categorisations

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836 The above sections show that there are multiple ways in which tyres could be categorised. Many
837 of the aspects that are to be considered for regulation under ESPR are related to the materials
838 used in tyre manufacture and how they behave throughout the life cycle of tyres (e.g. emissions
839 during use and waste phase, recyclability). Though tyres of various vehicles differ in terms of
840 specific composition, dimensions, typical use and technical parameters, from a material
841 perspective they have many similarities. All tyres are composed of the same main materials, and
842 in this sense, material aspects related to the different life cycle phases have similarities.
843 Categorisations according to vehicle type are thus of interest. Though tyre classes are specified
844 in legislation and standards for the tyre classes C1, C2, C3, other categories are not as well
845 defined though also addressed to some degree in legislation. Looking at the information in tasks
846 2, 3 and 4 also shows a much higher data availability for tyre classes C1, C2 and C3, which shall
847 make the analysis of these classes easier than those of other vehicle categories.

848 Though construction categories are relevant, the radial construction is the more dominant on
849 the market. Also, from a material perspective, though the construction differs, materials and
850 components are understood to be similar and at least in the case of radial and bias ply tyres, so
851 is waste management. The relevance of tubes and of non-pneumatic structures to this study is
852 still unclear due to their limited use and unclear waste management.

853 Though functional performance is of importance, looking again at the issues in focus suggests
854 that the implementation of new requirements to be developed under ESPR should ensure that
855 tyre functionality would remain comparable to its current state. This is particularly true for
856 aspects that are already regulated by other legislation such as abrasion, noise, safety and

857 reliability. Furthermore, tyre sub-categories that are optimised for different purposes or seasons
858 are not well defined in legislation as shall become clear from the next sections. For example,
859 from exchange with manufacturers it could be understood that there is no standardisation that
860 clearly defines which tyres are in the various tiers (budget, mid-tier and premium). Each
861 manufacture defines the tiers differently

862 Market related categorisations are of interest insofar as it is clear that at the time of purchase,
863 a tyre should achieve the same performance level regardless of whether it is a new tyre (OEM
864 or replacement) or a retreaded one. Looking at tyre classes in combination with whether the
865 tyre is new or retreaded could thus be of relevance. Though it could be argued that a minimal
866 performance could be considered also for second hand tyres to increase consumer certainty on
867 the quality of such tyres and thus to promote reuse, the sales of such tyres are assumed to have
868 a small market share and to be more difficult to control (e.g. when sales are between private
869 consumers). The current study shall thus not focus on part worn tyres.

870 The categorisations based on technical parameters and on regulatory/labelling classes are of
871 relevance to the end-user, in particular when purchasing replacement tyres. However, these are
872 of less relevance as categories for assessing tyres in the context of this study, except in relation
873 to ensuring here too the implemented ESPR requirements do not result in non-compliance with
874 other legislation.

875 Questions for stakeholders to clarify the relevance of part worn tyres to the scope:
876 T1-7: Can you confirm that most part worn tyres are sold as second hand tyres either
877 by end-users or by vehicle authorised treatment facilities?
878 T1-8: Are part worn tyres also sold by end-of-life tyres (ELT) operators and if so what
879 share of the ELTs collected are sold and to who?
880 T1-9: How do the sales of part worn tyres correlate with the exports of ELTs beyond
881 EU borders?

882 4.2.3. System boundaries

883 As compared to former Ecodesign, the ESPR framework newly allows setting a wide range of
884 requirements, including on:

- 885 • product durability, reusability, upgradability and reparability
- 886 • presence of substances that inhibit circularity
- 887 • energy and resource efficiency
- 888 • recycled content
- 889 • remanufacturing and recycling
- 890 • carbon and environmental footprints
- 891 • information requirements, including a DPP

892 From the above, energy efficiency is considered by the consultant to be covered through the
893 reference to fuel efficiency and rolling resistance under UNECE R117 and the EU Regulation

894 661/2009/EC and Regulation 1222/2009/EC. The remaining aspects listed above, suggest that
895 this study shall focus on different aspects related to materials used in tyre manufacture and their
896 behaviour throughout the tyre life cycle. Therefore, all **life cycle stages** are to be considered,
897 including raw materials (sourcing, environmental footprint), manufacturing, distribution, use,
898 and end-of-life.

899 It is obvious that a study related to EU legislation shall include the EU 27 in its **geographical**
900 **scope**. That said, a significant share of tyres are imported to the EU from other countries and
901 though unrelated, a significant share of tyres is currently also exported at end-of-life (see task
902 2). The potential interplay with the UK market may also be of interest. It is still to be considered
903 how such aspects could be considered in the study and, in particular, in the analysis of base
904 cases to be performed in the next stages.

905 Considering the temporal scope, the study is to consider the development of tyres in coming
906 years and how this is to change should certain requirements be implemented. That said, at the
907 tyre level, it shall be necessary to consider what comprises an average tyre lifetime, given that
908 changes to material composition that could be a result of ESPR requirements should not result
909 in a reduction in tyre durability and reliability.

910 4.2.4. Relevant definitions

911 This section reproduces definitions used in various standards and legislation with the purpose
912 of developing a list of terms and definitions that are accepted by tyre related stakeholders and
913 that could be applied in future legislation to be developed under ESPR. Where multiple
914 definitions could be found, they are discussed, and conclusions are made to allow proposing a
915 definition to be used throughout this study and any resulting legislation. Definitions appear in
916 alphabetic order. It should be noted that technologies that relate to some of the definitions are
917 not explained here but rather under task 4 (see **Section 7**).

918 Definitions already specified under the ESPR (e.g. durability, substance of concern) and under
919 the Waste framework Directive (WFD) (e.g. 'reuse', 'recovery', 'preparing for reuse' and
920 'recycling') shall be used should tyres be addressed under ESPR legislation and are not
921 reproduced here. The study team was kindly provided with a list of suggested definitions by
922 ETRMA, which have been used as a useful reference point throughout this section.

923 4.2.4.1. Casing

924 "The worn tyre comprising the carcass, remaining tread and sidewall material. This worn tyre is
925 the component that undergoes processes like buffing and repair to be prepared for retreading"
926 (UNECE R108, 1998; UNECE R109, 1998).

927 4.2.4.2. Carbon black – various

928 The following definitions have been identified in relation to carbon black and a few of its sources.

929 • Recovered carbon black (rCB): A material, primarily carbon, recovered from End-of-Life
930 Tyres (ELTs) through processes like pyrolysis and subsequent purification, intended for
931 use as a substitute for virgin carbon black in manufacturing, particularly in the
932 production of new tyres and other rubber products” ETRMA specifies the source as
933 derived from CORDIS - EU research results and other sources. (ETRMA, 2025d).

934 • Sustainable carbon black (sCB): carbon black that is produced through methods with
935 better environmental performance than the traditional production process. Claims of
936 improved environmental performance should be substantiated through evidence
937 compliant with ISO 14040 and 14044 standards.” ETRMA specifies the source as adapted
938 from: From waste to worth – novel extraction of carbon black from used tyres |
939 CBreCYCLE Project | Results in Brief | H2020 | CORDIS | European Commission. (ETRMA,
940 2025d).

941 Though not addressed in the above definition, sCB has been explained by stakeholders to be
942 produced from pyrolysis oils rather than from solid char. The combustion process is better
943 controlled than in the case of production of most virgin CB imported into the EU and is thus said
944 to result in less emissions to air. Stakeholders thus refer to this material as more sustainable
945 than virgin carbon black.

946 • “Renewable Carbon Black: Carbon black alternative from a renewable bio-derived
947 feedstock, such as agricultural waste.” ETRMA specifies the source as: Ricardo –
948 Environmentally optimal breaks and tyres. (ETRMA, 2025d).

949 The consultant understands renewable carbon black as carbon black produced by combusting a
950 renewable, bio-based feedstock. It does not include alternative filler materials that can replace
951 carbon black but are not derived from char.

952 4.2.4.3. Carcass

953 "Carcass" means that part of a tyre other than the tread and the rubber sidewalls which, when
954 inflated, bears the load (UNECE R108, 1998; UNECE R109, 1998).

955 4.2.4.4. Devulcanisation

956 The following definitions have been found for devulcanisation:

957 • “Devulcanisation: Process of decomposition of chemical cross-links in cured rubber
958 typically focusing on selective scission of cross-linking bonds.” ETRMA states that this
959 definition has been “adapted from ASTM D6814 (Standard Test Method for
960 Determination of Percent Devulcanization of Crumb Rubber)”. (ETRMA, 2025d).

961 • “Devulcanization: A chemical process that breaks the bonds of vulcanised rubber
962 without shortening the carbon chains. Devulcanization is a recovery method for material
963 recovery.” (WBSCD -Tire Industry Project, 2023).

964 Both definitions refer to the breaking or cutting of the chemical bonds of cured or vulcanised
965 rubber which appear equivalent, however each definition has additional details. Should a

966 definition be necessary in future ESPR legislation the context would need to be consulted to
967 determine the appropriateness of one of these options or of possible adaptations.

968 Devulcanisation and reclaiming are sometimes used interchangeably but differ as explained
969 under **Section 4.2.4.13** on reclaimed rubber.

970 4.2.4.5. Durability

971 At the beginning of this section reference is made to existing definitions within the ESPR and the
972 WFD that shall probably apply, should an ESPR legislation be developed for tyres. ESPR defines
973 durability as follows:

- 974 • “Durability’ means the ability of a product to maintain over time its function and
975 performance under specified conditions of use, maintenance and repair;” (EU ESPR,
976 2025).

977 The same term is defined in Standard EN45552-2020 as follows:

- 978 • “durability < of a part or a product > - ability to function as required, under defined
979 conditions of use, maintenance and repair, until a limiting state is reached
- 980 - Note 1 to entry: The degree to which maintenance and repair are within the scope
981 of durability will vary by product or product-group.
- 982 - Note 2 to entry: The user of this document must define the criteria for the transition
983 from limiting state to EoL. For more information see Figure D.1.
- 984 - Note 3 to entry: Durability can be expressed in units appropriate to the part or
985 product concerned, e.g. calendar time, operating cycles, distance run, etc. The units
986 should always be clearly stated ”(CEN/CENELEC, 2020).

987 Though the EN45552-2020 definition has been developed for energy related products, it makes
988 a few references which are of interest. The reference to “a limiting state” could be understood
989 to mean the end of the product lifetime, however the standard refers to a limiting state as an
990 “occurrence which results in a primary or secondary function no longer being delivered”
991 referring among others to a wear-out failure as an example. The failure of a tyre could result in
992 an accident and would rather be considered to be a limiting state that should not be reached.
993 However, the consultants assume that as additional examples could apply, the specification of
994 a condition of wear, such as the legal tread depth threshold in the EU, which is 1.6 mm for
995 passenger car tyres, as an indication for tyre replacement could be specified for the case of tyres
996 as the limiting state. This would be in line with Note 2 of the standard that requires the user of
997 the document (or rather definition) to specify criteria for the transition from a limiting state to
998 EoL.

999 Note 3 refers to the need to specify durability in appropriate units for the product concerned.
1000 For tyres a reference to mileage or rather kilometrage in the EU is common, though various
1001 stakeholders have emphasised that the actual durability depends on multiple factors of the real
1002 use conditions (e.g. exposure to weather, tyre pressure, driving behaviour, etc.).

1003 In this respect, ETRMA explained that while the tyre tread abrasion rate does not predict tyre
 1004 life which is the total service mileage, it is a relevant indicator for it, which was explained with a
 1005 simple example: Two tyres can cover the same mileage yet shed very different amounts of tread.
 1006 For instance, over 50,000 km, Tyre A (6 mm tread depth) loses 20 mg/km, while Tyre B (9 mm
 1007 tread depth) loses 50 mg/km. The better-performing tyre is the one that loses less material over
 1008 the same distance—in this example, Tyre A. Therefore, mileage alone is not a meaningful
 1009 indicator of environmental performance; the key metric is tyre abrasion rate, which should be
 1010 as low as possible. The durability of a tyre relates to both structural integrity/robustness AND
 1011 Tread Abrasion (ETRMA, 2025d).

1012 From exchanges with various stakeholders on the practice of retreading, it has been understood
 1013 that the level of wear of some tyres when they reach EoL prohibits their retreading. However,
 1014 this has not been specified so far in terms of quantifiable parameters.

1015 Questions for stakeholders:
 1016 T1-10: What limiting state is relevant in the case of tyres?
 1017 T1-11: What criteria could be used to define the point of transition from the limiting
 1018 state to EoL?
 1019 T1-12: What criteria could be used to define the point of transition from the limiting
 1020 state to the state at which a tyre should be sent to retreading?
 1021 T1-13: Can the tyre tread abrasion rate be considered a relevant indicator for tyre
 1022 service mileage and thus indirectly also to tyre durability?

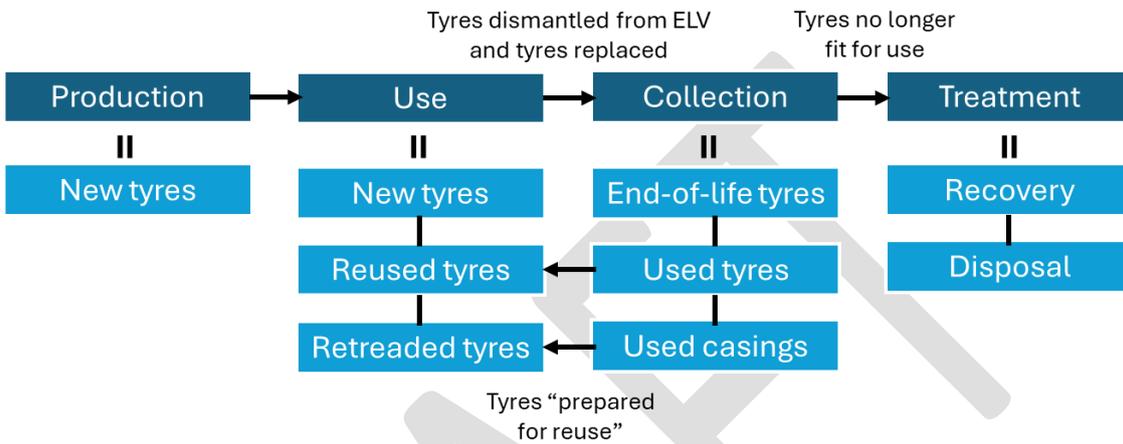
1023 4.2.4.6. End-of-life tyre

1024 The following definitions have been found for ELTs and originate from various sources.

- 1025 • “Tyre no longer suitable for its original purpose” (CEN/CENELEC, 2010; *EN 17188:2024*,
 1026 2024).
- 1027 • “A tyre that has reached the end-of-use stage that can no longer be used for its original
 1028 purpose, it is taken out of use, and its resources are either recovered or disposed of”
 1029 (ETRMA, 2025d).
- 1030 • “A tyre that can no longer serve its original purpose on a vehicle. This excludes tyres that
 1031 are retreaded, reused or exported in used cars” Taken from the glossary of the World
 1032 Business Council for Sustainable Development (WBSCD -Tire Industry Project, 2023).

1033 By excluding the cases of retreading, reuse and exports from the EN standard definition, the
 1034 WBSCD makes clear that even if a tyre is subjected to these operations after it has been collected
 1035 as an ELT that it would not be viewed as an ELT. Though this definition may make sense, as it
 1036 attempts to exclude tyres that can still be used in one way or another, it is not clear how this
 1037 would relate to “end-of-waste” criteria. Should a definition in this direction be considered for
 1038 future ESPR legislation, that would need to be clarified to avoid the creation of incoherencies
 1039 between Union legislations.

1040 In the consultant’s opinion, the ETRMA definition also takes head of this misalignment by
 1041 clarifying that the tyre is taken out of use. This would also exclude tyres that are reused or
 1042 retreaded (the fact that the casing is reprocessed to enable its remaining in use does not conflict
 1043 with this understanding) or exported when the tyre ends up remaining in use. In parallel the
 1044 consultants interpret this definition to clarify that a tyre exported and then recovered or
 1045 disposed of would still be considered an ELT. The reference to the destiny of ELTs as either
 1046 recovered or disposed is further understood to cover all other possible routes of a tyre once it
 1047 has been collected. Please see **Figure 4-4** in this respect.



1048

1049 **Figure 4-4: The scope of tyre that are collected and their possible routes handling.**

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 1052

Source: own illustration

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Questions for stakeholders:
 T1-14: Do you agree that the ETRMA definition would cover all possible routes of tyres collected from vehicle dismantlers and tyre dealers while excluding those tyres sorted out to routes that enable them to remain in use?

1057 **4.2.4.7. End-of-use tyre**

1058 “A tyre on which the functional and legal requirements and standards are no longer met and
 1059 that has been made available for collection” (ETRMA, 2025d).

1060 **4.2.4.8. Ground rubber**

1061 “Ground rubber: Ground rubber is produced by grinding ELTs into different sized pieces. Metal
 1062 and fabric can be removed and the granules are sized for specific applications”(WBSCD -Tire
 1063 Industry Project, 2023).

1064 **4.2.4.9. New tyre**

1065 “Tyre that has not been used and is not a retread tyre” (*ISO 4223-1*, 2017).

1066 **4.2.4.10. Normal tyre**

1067 The following definitions have been identified:

- 1068 • “Normal tyre: Tyre intended for highway (or public highway) use which does not require
1069 “M+S” (or other variations) or severe snow or special use (3.1.2) tyre designations” (*ISO*
1070 *4223-1*, 2017).
- 1071 • “‘Normal tyre’ is a tyre intended for normal road use only” (UNECE R108, 1998; UNECE
1072 R109, 1998).

1073 The various definitions differ in terms of their reference to the surface on which tyres are
1074 expected to be driven. Seeing as a tyre of a road vehicle will not only be used on highways, the
1075 UNECE definition is considered to be more appropriate.

1076 **4.2.4.11. Off-road professional tyre**

1077 “‘Off-road professional tyre’ means a special use tyre primarily used in severe off-road
1078 conditions” (EC Regulation 661/2009, 2009).

1079 **4.2.4.12. Pyrolysis**

1080 Though many forms of pyrolysis are applied by industry for various purposes, the following
1081 definitions are of relevance for the context of its application in ELT waste management.

- 1082 • “Pyrolysis: The decomposition of ELT material into oil, gas, steel and char in different
1083 proportions. The process includes the application of pressure, high temperatures and
1084 usually the absence of oxygen. Carbonization, gasification and thermolysis are related
1085 recovery methods” (WBSCD -Tire Industry Project, 2023).
- 1086 • “Tyre Pyrolysis - A thermochemical recycling process where valuable materials are
1087 recovered from tyres or parts of tyres by decomposition of the organic part in the
1088 absence of oxygen (i.e. not combustion)” (ETRMA, 2025d).

1089 Both definitions refer to a decomposition process, usually without oxygen, of ELT material, with
1090 the one being more detailed in terms of the process and its potential products. Should a
1091 definition be necessary in future ESPR legislation the context would need to be consulted to
1092 determine the appropriateness of one of these options or of possible adaptations.

1093 **4.2.4.13. Reclaimed rubber**

1094 The following definitions have been identified:

1095 “Reclaimed rubber: Devulcanised rubber that has been thermally, mechanically, and/or
1096 chemically plasticised for use as a rubber diluent, extender, or processing aid. The process of
1097 reclaiming rubber includes main chain degradation.” ETRMA state that the definition is adapted
1098 from (ETRMA, 2025d; Wiśniewska et al. & Wiśniewska, P., Wang, S. & Formela, K., 2022).

1099 “Reclamation/reclaimed rubber: The conversion of vulcanised rubber waste into a state in which
1100 it can be mixed, processed and vulcanised again. Reclamation usually involves a chemical
1101 process. It is considered a method of material recovery” (WBSCD -Tire Industry Project, 2023).

1102 The definitions have various differences and could be used to develop a definition for future
1103 ESPR legislation for tyres should the term need to be included.

1104 Devulcanisation and reclaimed rubber are often used interchangeably; however, Wiśniewska et
1105 al. explain that “Rubber devulcanization can be considered as a selective scission of cross-linking
1106 bonds in order to breakdown three-dimensional structure, while rubber reclaiming is
1107 combination of main chain degradation and cross-linking bond scission” (Wiśniewska et al. &
1108 Wiśniewska, P., Wang, S. & Formela, K., 2022).

1109 4.2.4.14. Reinforced tyre

1110 “‘Reinforced tyre’ or ‘extra load tyre’ means a C1 pneumatic tyre structure in which the carcass
1111 is designed to carry a greater load than the corresponding standard tyre” (EC Regulation
1112 661/2009, 2009).

1113 4.2.4.15. Retreaded tyre

1114 “Retreaded tyre: Used tyre that has been reconditioned to extend the useful life of the tyre with
1115 the replacement of the tread rubber only or replacement of tread and sidewall rubbers.

1116 Note 1 to entry: It covers the following process methods.

- 1117 • “Top capping” – replacement of the tread.
- 1118 • “Re-capping” – replacement of the tread and with the new material extending over part
1119 of the sidewall.
- 1120 • “Bead to bead” – replacement of the tread and sidewall rubber including all or part of
1121 the lower area of the tyre” (ISO 4223-1, 2017).

1122 ETRMA provided the following definitions related to retreaded tyres (ETRMA, 2025d):

- 1123 • “Retreading - Generic term for refurbishing a used tyre by replacing the worn tread with
1124 new material. It may also include renovation of the outermost sidewall surface and
1125 replacement of the crown plies or the protective breaker”.
- 1126 • “Retreadability - The capability of a tyre to be refurbished through the process of
1127 retreading, allowing it to be reused for its original purpose”.

- 1128 • “Retreadable tyre - A worn tyre comprising the carcass, remaining tread and sidewall
1129 material that is considered suitable for effective retreading by a tyre industry specialist
1130 following an inspection”. The source is specified as UNECE regulations 108 & 109.

1131 The WBSCD refers to retreading as follows:

- 1132 • “Also known as recapping or remolding. The process of tyre renewal for reuse by
1133 replacing worn-out rubber belts and treads with new ones”(WBSCD -Tire Industry
1134 Project, 2023).

1135 In the consultant’s opinion, the various definitions for retreading are similar in their reference
1136 to various options for retreading in terms of the tyre component that is replaced. Though not all
1137 refer explicitly to the process being applied to a used tyre, this is clear in all formulations. The
1138 definition given in ISO 4223-1, 2017 is considered to be the most complete, though neither of
1139 the definitions refers to the different retreading processes that are applied in practice, i.e., cold
1140 retreading and hot retreading.

1141 It is noted that the ETRMA definition for a “retreadable tyre” refers to “the carcass, remaining
1142 tread and sidewall material” as the parts comprising the worn tyre to be retread. This is aligned
1143 with the definition given under UNECE Regulation No 108 and UNECE Regulation No 109 for a
1144 casing, which refers to “The worn tyre comprising the carcass, remaining tread and sidewall
1145 material” as the component “to be prepared for retreading.” (UNECE R108, 1998; UNECE R109,
1146 1998).

1147

Questions for stakeholders:

1148

T1-15: In your opinion, is it necessary to include reference of the various retreading
1149 practices that are applied in practice to the definition of retreading?

1150

T1-16: If tyres are required to be retreadable in future ESPR legislation, do both need
1151 to be possible?

1152 4.2.4.16. Recycled/recovered/renewable/bio-based material

1153 In various discussions with stakeholders where the practicability of a recycled content target for
1154 tyres was discussed, manufacturers often raised their preference for a mutual target for both
1155 recycled and renewable content. In the context of recycled materials, it is also relevant to clarify
1156 if the material is of pre- or post-consumer source. ETRMA has provided a few related definitions.
1157 These are compared with definitions specified in the Waste Framework Directive which is the
1158 framework referred to in the ESPR for several definitions related to the waste phase.

1159 The WFD does not define the term recycled material, however it specifies the following
1160 definition in Article 3(17) for the term:

- 1161 • ‘Recycling’: “any recovery operation by which waste materials are reprocessed into
1162 products, materials or substances whether for the original or other purposes. It includes

1163 the reprocessing of organic material but does not include energy recovery and the
1164 reprocessing into materials that are to be used as fuels or for backfilling operations”
1165 (Waste Framework Directive (WFD), 2008).

1166 • “Recycled material - A material (post-consumer or pre-consumer) that has been
1167 reprocessed from a discarded material by means of a manufacturing process and made
1168 into a final product or a component for incorporation into a product”. ETRMA states that
1169 the above definition is “Adapted and simplified from WBCSD TIP - Circular definitions for
1170 the tire industry and in line with European (WFD) regulation” (ETRMA, 2025d).

1171 Despite differences in formulation and in the term itself, the definition that ETRMA provides is
1172 aligned with the definition given in the WFD, though not specifying operations that are excluded
1173 in the WFD definition. As ETRMA refer to a recycled material and as backfilling is not considered
1174 a material but rather an operation, the lacking reference in this case can be understood.
1175 However, when considering energy recovery and in particular use as fuels, an explicit exclusion
1176 from the ETRMA definition would ensure that fuel, which can be viewed as a product, is not
1177 interpreted as a recycled material.

1178 ETRMA does not provide a definition for the term “recovered material, despite referring for
1179 example to “recovered carbon black”. In Article 3(15) of the WFD:

1180 • ‘recovery’ is defined as “any operation the principal result of which is waste serving a
1181 useful purpose by replacing other materials which would otherwise have been used to
1182 fulfil a particular function, or waste being prepared to fulfil that function, in the plant or
1183 in the wider economy. Annex II sets out a non-exhaustive list of recovery operations;”
1184 (Waste Framework Directive (WFD), 2008).

1185 In a later amendment, Article 3(15a) was added defining:

1186 • ‘material recovery’ as “any recovery operation, other than energy recovery and the
1187 reprocessing into materials that are to be used as fuels or other means to generate
1188 energy. It includes, inter alia, preparing for re-use, recycling and backfilling” (Waste
1189 Framework Directive (WFD), 2008).

1190 Material recovery as defined by the WFD could apply in the consultant’s opinion, both to
1191 products and to materials recycled from waste, meaning for example that tyre retreading could
1192 be considered as material recovery as it comprises of the preparing for reuse of tyre casing
1193 recovered from ELT.

1194 The consultants understand a recovered material to generally refer to “materials extracted from
1195 waste products.” In the context of tyres, this primarily refers to recovered carbon black (rCB),
1196 which is obtained through the pyrolysis of ELTs. While rCB is a recovered material, it may also
1197 be considered a recycled material if it is reprocessed and used in a new product (refers to **Section**
1198 **4.2.4.2**) as this would be in line with the WFD definition for recycling as well as the definition
1199 provided by ETRMA.

1200 “Post-consumer recycled material – Material generated by households or by commercial,
1201 industrial and institutional facilities in their role as end users of the product which can no longer
1202 be used for its intended purpose. This includes returns of material from the distribution chain.”

1203 ETRMA provides the source for this definition as “ISO14021 and WBCSD TIP – Circular definitions
1204 for the tire industry” (ETRMA, 2025d).

1205 “Pre-consumer recycled material – Material diverted from the waste stream and recycled during
1206 a manufacturing process. Excluded is reutilisation of materials such as rework, regrind or scrap
1207 generated in a process and capable of being reclaimed within the same process that generated
1208 it. “ ETRMA states that this definition is “Adapted from ISO 14021 and WBCSD TIP – Circular
1209 definitions for the tyre industry” (ETRMA, 2025d).

1210 “Renewable material is defined as bio-based resources that return to their previous stock levels
1211 by natural growth or replenishment processes at a rate in line with use cycles. Therefore, they
1212 are replenished/regrown at a faster rate than harvested/extracted” ETRMA provides the source
1213 for this definition as “WBCSD TIP - Circular definitions for the tire industry” (ETRMA, 2025d).

1214 “Bio-based materials - Resource derived from biomass excluding any materials embedded in
1215 geological formations or transformed to fossilised material. Examples include trees, crops,
1216 grasses, algae, microorganisms, animals and wastes of biological origin (e.g. manure)”. ETRMA
1217 provides the source for this definition as “ISO 59004:2024” (ETRMA, 2025d).

1218 4.2.4.17. Regrooving

1219 “Removing rubber from the layer of existing rubber of the tire to restore tread pattern depth
1220 and extend the lifetime of a tyre. Optional: it is a refurbishing operation”. ETRMA refers to the
1221 following source: WBCSD TIP Circular definitions & metrics (ETRMA, 2025d).

1222 4.2.4.18. Rubber powder

1223 “Rubber powder: Micronised rubber powder (MRP) is categorised as a dry powdered
1224 elastomeric crumb rubber in which the majority of the particles are < 1000 µm” (WBCSD -Tire
1225 Industry Project, 2023).

1226 4.2.4.19. Run-flat tyre

1227 “‘Run-flat tyre’ or ‘Self-supporting tyre’ describes a pneumatic tyre structure provided with any
1228 technical solutions (for example, reinforced sidewalls, etc.) allowing the pneumatic tyre,
1229 mounted on the appropriate wheel and in the absence of any supplementary component, to
1230 supply the vehicle with the basic tyre functions, at least, at a speed of 80 km/h (50 mph) and a
1231 distance of 80 km when operating in flat tyre running mode” (UNECE R30, 2008).

1232 The same regulation also provides the following definition:

1233 ‘Run flat system’ or ‘Extended mobility system’ describes an assembly of specified functionally
1234 dependant components, including a tyre, which together provide the specified performance
1235 granting the vehicle with the basic tyre functions, at least, at a speed of 80 km/h (50 mph) and
1236 a distance of 80 km when operating in flat tyre running mode”(UNECE R30, 2008).

1237 **4.2.4.20. Second-hand or part-worn tyres**

1238 "Second-hand or part-worn tyres are used tyres that are still intended for use on public road,
1239 provided they meet specific legal requirements. A 'second-hand tyre' is a used tyre that remains
1240 suitable and legally compliant for its original purpose on a vehicle, having previously been used
1241 by another owner holder." ETRMA provides this definition stating that it is adapted from Used
1242 Tyre Recovery: An introduction to applicable regulations in England and Wales. Used Tyre
1243 Working Group.

1244 **4.2.4.21. Sidewall**

1245 "'Sidewall' means the part of a tyre between the tread and the area designed to be covered by
1246 the rim flange" (UNECE R108, 1998; UNECE R109, 1998).

1247 **4.2.4.22. Snow tyre**

1248 The following definitions have been identified:

- 1249 • "Snow tyre: Tyre whose tread pattern, tread compound or structure is primarily
1250 designed to achieve in winter conditions, e.g. snow, a performance better than that of
1251 a normal tyre with regard to its ability to initiate or maintain vehicle motion.
1252 - Note 1 to entry: It is identified by a combination of the letters "M" and "S", e.g. M+S,
1253 M&S" (ISO 4223-1, 2017).
- 1254 • "Snow tyre" means a tyre whose major features including tread pattern are primarily
1255 designed to achieve in mud and/or snow conditions a performance better than that of
1256 a normal tyre with regard to its ability to initiate and control vehicle motion (UNECE
1257 R108, 1998).

1258 The definitions are more or less equivalent aside from the reference to tyre identification.

1259 **4.2.4.23. Special use tyre**

1260 The following definitions have been identified:

- 1261 • "Tyre intended for mixed use both on- and off-road or for other special duty and
1262 primarily designed to initiate and maintain the vehicle in motion in off-road condition"
1263 (ISO 4223-1, 2017).
- 1264 • "Special use tyre" means a tyre intended for mixed use, both on- and off-road or for
1265 other special duty. These tyres are primarily designed to initiate and maintain the
1266 vehicle in motion in off-road conditions" (UNECE R108, 1998; UNECE R109, 1998).

1267 The definitions are equivalent.

1268 **4.2.4.24. Tread**

1269 The following definitions have been identified:

1270 "Tread' means that part of a tyre which comes into contact with the ground, protects the
1271 carcass against mechanical damage and contributes to ground adhesion" (UNECE R108, 1998;
1272 UNECE R109, 1998).

1273 "Tyre tread: part of a pneumatic tyre that normally comes in contact with the ground" (CEN/TS
1274 17045:2020, 2020).

1275 The definitions are similar, however the one referred to in UNECE 108 and 109 is not limited
1276 only to pneumatic tyres, while also detailing functions of the tread, making it more complete.

1277 UNECE also refers to the following definition:

1278 "Tread used for retreading process" means either a pre-cured tread or the specification of the
1279 major features of the tread used for mould cure process." Article 2.59 of (UNECE R108, 1998).

1280 **4.2.4.25. PRODCOM/COMEXT categories (Eurostat)**

1281 PRODCOM provides statistics on the production of manufactured goods by enterprises in EU
1282 countries. **Table 4-3** specifies tyre-related categories used as codes in the PRODCOM
1283 classification of industrial products (NACE class 22.11) and their corresponding COMEXT codes.
1284 NACE stands for Nomenclature of Economic Activities. It is the statistical classification system
1285 used by the EU to categorise economic activities and collect/analyse economic data. COMEXT
1286 provides the EU statistics for international trade in goods. It uses the Harmonized System (HS)
1287 and Combined Nomenclature (CN) codes.

1288 **Table 4-3: Products linked to NACE 22.11: Manufacture of rubber tyres and tubes; retreading**
1289 **and rebuilding of rubber tyres and corresponding COMEXT codes.**

| PRODCOM | COMEXT | Description | Observations |
|--|-------------------|---|--|
| CPA 22.11.11: New pneumatic tyres, of rubber, of a kind used on motor cars | | | |
| 22.11.11.00 | 401110 | New pneumatic rubber tyres for motor cars (including for racing cars) | Classification assumed to reflect C1 tyres in task 2 |
| CPA 22.11.12: New pneumatic tyres, of rubber, of a kind used on motorcycles or bicycles | | | |
| 22.11.12.00 | 401140, 401150 | New pneumatic rubber tyres for motorcycles or bicycles | |
| CPA 22.11.13: New pneumatic tyres, of rubber, of a kind used on buses, lorries or aircraft | | | |
| 22.11.13.55 | 401120 | New pneumatic rubber tyres for buses or lorries with a load index ≤ 121 | Classification assumed to reflect C2 tyres in task 2 |
| 22.11.13.57 | 401120 | New pneumatic rubber tyres for buses or lorries with a load index > 121 | Classification assumed to reflect C3 tyres in task 2 |

| PRODCOM | COMEXT | Description | Observations |
|---|--|--|--|
| 22.11.13.70 | 401130 | New pneumatic rubber tyres for aircraft | MS level production data is not reported for this code |
| CPA 22.11.14 Agrarian tyres; other new pneumatic tyres, of rubber | | | |
| 22.11.14.00 | 401160, 401161, 401162, 401163, 401169, 401170, 401180, 401190, 401193, 401193, 401199 | Agrarian tyres; other new pneumatic tyres, of rubber | |
| CPA 22.11.15 Inner tubes, solid or cushion tyres, interchangeable tyre treads and tyre flaps, of rubber | | | |
| 22.11.15.30 | 401290 | Solid or cushion rubber tyres; interchangeable rubber tyre treads | Assumed to reflect components rather than tyre types |
| 22.11.15.50 | 401290 | Rubber tyre flaps | |
| 22.11.15.70 | 401310 | Inner tubes, of rubber | |
| CPA 22.11.16 Camel-back strips for retreading rubber tyres | | | |
| 22.11.16.00 | 401290 | Camel-back strips for retreading rubber tyres | Assumed to reflect components for retreading |
| CPA 22.11.20 Retreaded pneumatic tyres, of rubber | | | |
| 22.11.20.30 | 401211 | Retreaded tyres of rubber of a kind used on motor cars | Assumed to reflect C1 retreaded tyres |
| 22.11.20.50 | 401212 | Retreaded tyres of rubber of a kind used on buses and lorries | Assumed to reflect C2 and C3 retreaded tyres |
| 22.11.20.90 | 401213 | Retreaded tyres of rubber (including of a kind used on aircraft; excluding of a kind used on motor cars; buses or lorries) | Assumed to reflect all other retreaded tyres |

Source: (PRODCOM List 2024 - EU Vocabularies - Publications Office of the EU, 2024)

1290

1291 There are PRODCOM codes for different vehicle types including motor cars (assumed to reflect
 1292 passenger cars), buses and lorries, motorcycles, bicycles, aircraft and other. Though the
 1293 PRODCOM code descriptions can be associated to some degree with specific vehicle type tyres
 1294 and in some cases with characterisations of the classes C1, C2 and C3, the consultants observe
 1295 that they do not strictly follow the same classifications and are also not always used in the
 1296 reported data.

1297 **4.2.4.26. Categories according to EN- or ISO-standard(s)**

1298 EN and ISO standards categorise tyres by intended vehicle use, construction type, service type,
 1299 and key markings (size, load, speed). The main categorisation is by vehicle/application type and
 1300 includes the categories shown in Error! Reference source not found..

1301 **Table 4-4: Tyre categories according to vehicle/application type in EN-/ISO Standards.**

| Category | ISO | EN |
|-----------------------|--------------------------|---------------|
| Passenger Car | 4000, 10191 | 1420-1, 10844 |
| Light Truck | 4209, 10191 | 1420-1 |
| Truck/Bus | 4209, 15222 | 1420-1 |
| Motorcycle | 10231 | - |
| Bicycle | 5775 | - |
| Agricultural/Forestry | 4251, 7867, 8664 | - |
| Industrial/Earthmover | 4250, 3739, 18807, 18808 | - |
| Aircraft | 3324 | - |
| Other/Special | 4223-1, 3877 | 10844 |

1302

1303 Source: Own compilation

1304 Further categorisations (sometimes also integrated as sub-categorisations) are by tyre
 1305 construction (e.g. radial/bias, tubeless/tube-type), intended use (normal, snow, traction),
 1306 detailed size/load/speed ratings, and tread pattern.

1307 **4.2.4.27. Labelling categories (EU Energy Label or Eco-label), if not defined by**
 1308 **the above**

1309 The European Commission (EU Regulation 2020/740, 2020) only includes provisions for the C1,
 1310 C2 and C3 categorisation in the Labelling of Tyres Regulation. The following tyre categories are
 1311 excluded from its scope:

- 1312 • Off-road professional tyres;
- 1313 • Tyres designed to be fitted only on vehicles registered for the first time before 1 October
 1314 1990;
- 1315 • T-type temporary-use spare tyres (such as the mini-spare tyre);
- 1316 • Tyres whose speed rating is less than 80 km/h;
- 1317 • Tyres whose nominal rim diameter does not exceed 254 mm or is 635 mm or more;

- 1318 • Tyres fitted with additional devices to improve traction properties, such as studded
 - 1319 tyres;
 - 1320 • Tyres designed only to be fitted on vehicles intended exclusively for racing;
 - 1321 • Second-hand tyres, unless such tyres are imported from a third country.
- 1322 No ecolabels for tyres were found in the European market.

1323 **4.3. Legislation (EU, Member State and third country level)**

1324 Tyre legislation forms the legal framework that governs the safety, environmental performance,
 1325 and market placement of tyres across different jurisdictions. At the EU level, harmonised
 1326 regulations establish mandatory requirements on aspects such as type approval, labelling, noise,
 1327 rolling resistance, and wet grip, ensuring a consistent standard for all Member States. National
 1328 legislation within individual Member States may complement or reinforce these EU provisions,
 1329 particularly in areas such as enforcement, inspection, and market surveillance.

1330 The case of tyres is somewhat unique as in many cases, legislation is first introduced at the
 1331 international level by UNECE Regulations. These are then transposed into the legislation of all
 1332 countries that are signatories of such regulations. In the case of the EU, such legislation is
 1333 transposed into EU legislation and thus applies in all EU Member States.

1334 Beyond Europe, third countries apply their own legislative systems, which can vary significantly
 1335 in scope and stringency, influencing international trade and compliance obligations for
 1336 manufacturers. In the case of tyres, it is however very common that such legislation is a
 1337 transposition of the international UN Regulations.

1338 This section outlines the key legislative frameworks at EU, Member State, and third country
 1339 levels, highlighting their role in shaping tyre design, testing, and market access.

1340 **Table 4-5** shows an overview of the legislations that might be of relevance in the framework of
 1341 this study.

1342 **Table 4-5: Relevant regulations applicable to tyres.**

| Geographic scope of legislation | Legislation |
|---------------------------------|---|
| International regulation | <ul style="list-style-type: none"> - UNECE Regulations No 30, No 54 and No 117 regarding Tyre safety and environmental performance, - UNECE Regulation No 64 on spare wheels and run-flat systems, - UNECE Regulation No. 108 and 109 on retreaded tyres, - UNECE Regulation No 141 on light duty vehicle tyre pressure, - UNECE Regulation No 142 on tyre installation, and - UNECE Regulation No 124 on wheel replacement |

| Geographic scope of legislation | Legislation |
|---------------------------------|---|
| European legislation | <ul style="list-style-type: none"> - Regulation (EU) 2020/740 on the labelling of tyres - Regulation (EU) 2019/2144 on type-approval requirements for motor vehicles and their trailers - Regulation (EU) 2015/208 on vehicle functional safety requirements for the approval of agricultural and forestry vehicles - Regulation (EU) 2018/858 on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles - Regulation (EU) 2024/1257 (EURO 7 Regulation), which indicates a need to measure and limit non-exhaust emissions² consist of particles emitted by tyres and brakes of vehicles either by UN Regulation or Commission’s delegated act - Regulation (EU) 2023/1115 on deforestation-free products, under which any operator or trader who places these commodities on the EU market, or exports from it, must be able to prove that the products do not originate from recently deforested land or have contributed to forest degradation. - Additional legislations affecting vehicles, where tyres are also affected by some requirements, e.g. Directive 2000/53/EC (ELV) and Directive 2005/64/EU (3R Type Approval), Directive 2008/98/EC (WFD), Regulation 1907/2006 (REACH), Regulation 1272/2008 (CLP) - Upcoming Circular Economy Act (CEA) |
| Member state regulation | - See Annex I |
| Third country regulation | - See Annex II |

1343 Source: Own compilation

1344 **4.3.1. International legislation**

1345 **4.3.1.1. UNECE Regulations No. 30³, 54⁴ and 117⁵ regarding Tyre safety and**
 1346 **environmental performance**

1347 UNECE Regulation No. 30 (UNECE R30, 2008) regulates new pneumatic tyres primarily for
 1348 passenger cars (i.e., class C1), establishing requirements for tyre dimensions, load capacity,

² These non-exhaust emissions for tyres are particularly microplastics. Improved materials and designs that reduce wear will help meet the new regulatory requirements. The intention is to introduce binding emission limits for tyres sold on the EU market.

³ Pneumatic tyres for motor vehicles and their trailers (Class C1)

⁴ Pneumatic tyres for commercial vehicles and their trailers (Classes C2 and C3)

⁵ Tyres with regard to rolling sound emissions, adhesion on wet surfaces and rolling resistance (Classes C1, C2 and C3)

1349 speed rating, structure (radial, bias-ply, etc.), and mandatory markings. The regulation includes
1350 performance requirements such as a load/speed endurance test, which ensures that tyres can
1351 withstand specific loads at their rated speeds without structural failure (such as tread separation
1352 or cord breakage). It also mandates the presence of tread-wear indicators and specifies the
1353 minimum tread depth, ensuring a basic level of safety and durability for passenger car tyres.

1354 UNECE Regulation No. 54 (UNECE R54, 2008) covers new pneumatic tyres for commercial
1355 vehicles (i.e., Class C2 and C3). Like Regulation No. 30, it sets out requirements for tyre
1356 dimensions, load and speed ratings, structure, and markings, but also includes performance
1357 tests, especially a load/speed endurance test, to verify that tyres for trucks and buses can safely
1358 carry their designated loads at specified speeds. The regulation ensures that tyres for
1359 commercial vehicles meet minimum safety and durability standards, which is highly relevant for
1360 the product scope as it defines what constitutes a compliant tyre for these vehicle categories.

1361 UNECE Regulation No. 117 (UNECE R117, 2016) introduces environmental and safety
1362 performance requirements beyond those of Regulations No. 30 and No. 54. It applies to new
1363 pneumatic tyres of classes C1, C2, and C3, and sets maximum limits for three main aspects:
1364 rolling sound emissions, wet grip, and rolling resistance. The regulation also defines specific
1365 criteria for snow tyres and special use tyres, with adjusted requirements where appropriate.

1366 4.3.1.2. UNECE Regulation No. 64 on spare wheels and run-flat systems

1367 UNECE Regulation No. 64 (UNECE R64, 2010) sets out uniform provisions concerning the
1368 approval of vehicles with regard to their equipment, specifically focusing on temporary-use
1369 spare units, run-flat tyres and systems, and tyre pressure monitoring systems (TPMS). The
1370 regulation applies to passenger cars and light commercial vehicles when equipped with any of
1371 these systems or components.

1372 For tyres, the most relevant aspects regulated under UNECE R64 include the requirements for
1373 temporary-use spare tyres (often called “space-saver” spares), run-flat tyres, and TPMS. The
1374 regulation ensures that if a vehicle is equipped with a temporary-use spare unit, the tyre used
1375 must be approved under UNECE Regulation No. 30 and must meet specific load and speed
1376 requirements.

1377 For run-flat tyres and systems, the regulation requires that vehicles equipped with these must
1378 also have a run-flat warning system (or a TPMS that meets the regulation’s requirements), which
1379 alerts the driver when a tyre is operating in a flat condition.

1380 The regulation also sets out detailed performance requirements for TPMS. These systems must
1381 detect a loss of tyre pressure (such as from a puncture) and alert the driver within 10 minutes if
1382 the pressure drops by 20 .% or more, or falls below 150 kPa, whichever is higher. The TPMS must
1383 also detect system malfunctions and alert the driver within 10 minutes.

1384 **4.3.1.3. UNECE Regulation No. 108 and 109 on retreaded tyres**

1385 UNECE Regulations No 108 (UNECE R108, 1998) and UNECE No. 109 (UNECE R109, 1998) set out
1386 the technical and performance requirements for retreaded tyres for passenger cars (UNECE
1387 R108) and commercial vehicles (UNECE R109). They establish the baseline for the safety, quality,
1388 and performance of retreaded tyres, ensuring that these products can be placed on the market
1389 with a level of assurance comparable to new tyres.

1390 Both regulations specify that only casings from tyres that were originally type-approved can be
1391 used for retreading, ensuring that the structural integrity of the casing is suitable for a second
1392 life, which is a critical aspect for both safety and environmental performance.

1393 The regulations detail the processes and quality management systems required for retreading
1394 production units, including requirements for inspection, preparation, repair, and the application
1395 of new tread material. The regulations also specify minimum material thicknesses for new tread
1396 and, in the case of passenger car tyres, set a maximum age for the casing (seven years) to ensure
1397 reliability.

1398 Performance requirements are a key part of both regulations. Retreaded tyres must pass a
1399 load/speed endurance test, which is designed to ensure that the retreaded tyre can safely carry
1400 the specified load at the designated speed without exhibiting failures such as tread separation,
1401 ply separation, or broken cords. Both regulations require that retreaded tyres be marked with
1402 clear information, including the brand, size, structure, service description (load index and speed
1403 symbol), date of retreading, and the word "RETREAD." They must also carry the international
1404 approval mark, ensuring traceability and market surveillance.

1405 **4.3.1.4. UNECE Regulation No 141 on light duty vehicle tyre pressure**

1406 UNECE Regulation No. 141 (UNECE R141, 2018) regulates the performance of TPMS fitted to M1
1407 vehicles up to 3,500 kg and N1 vehicles with single tyres on all axles. It sets the minimum
1408 functional performance of systems that monitor tyre inflation pressure in use, the test methods
1409 to verify this performance, and the driver warning requirements. In practice, it links vehicle
1410 approval to tyre inflation safety outcomes and therefore affects the in-use safety, energy
1411 efficiency and durability performance associated with tyres. The Regulation requires that TPMS
1412 must operate from 40 km/h up to the vehicle's maximum design speed and remain robust to
1413 electromagnetic interference as evidenced by compliance with UNECE R10. It lays down three
1414 core performance requirements that are verified on-road: detection of incident-related pressure
1415 loss (puncture), detection of significant under-inflation due to diffusion or gradual loss, and
1416 malfunction detection.

1417 The Regulation also specifies standardised test conditions and procedures, including ambient
1418 temperature, dry high-adhesion road, speed ranges for puncture and diffusion tests, pressure
1419 measurement accuracy, and detailed driving sequences and deflation targets, as well as
1420 procedures to simulate malfunctions.

1421 These requirements create a baseline level of in-use tyre inflation monitoring in the EU vehicle
1422 fleet, complementing tyre-specific UNECE regulations on tyre construction and performance
1423 (e.g. UNECE R30/54 and UNECE R117) and reducing safety risks and potential excess rolling
1424 resistance from under-inflation.

1425 4.3.1.5. UNECE Regulation No 142 on tyre installation

1426 UNECE Regulation No 142 (UNECE R142, 2021) governs how tyres must be installed on approved
1427 vehicles. It ensures that vehicles are fitted only with tyres that are correctly dimensioned,
1428 appropriately rated for load and speed, compatible with the approved rim configurations, and
1429 compliant with the tyre performance and construction regulations that apply to type-approved
1430 tyres.

1431 The regulation's core relevance lies in the performance and fitment requirements that indirectly
1432 constrain tyre characteristics on vehicles placed on the EU market. First, every tyre installed on
1433 a vehicle must fulfil the technical and transitional requirements⁶ of UNECE R30, UNECE R54 and
1434 UNECE R117, meaning the installed tyres must be type-approved for dimensions, load/speed
1435 capability, and, where applicable, wet grip, rolling sound and rolling resistance per UNECE R117.
1436 Second, tyre fitment rules enforce homogeneity and adequate clearances: all normally fitted
1437 tyres (excluding temporary-use spares) must share the same structure; tyres on a given axle
1438 must be of the same type; and wheel housings must allow unrestricted movement for the
1439 declared maximum tyre envelope across suspension/steering ranges, verifiable physically or by
1440 agreed virtual methods.

1441 4.3.1.6. UNECE Regulation No 124 on wheel replacement

1442 UNECE Regulation No. 124 (UNECE R124, 2006) regulates the type-approval of replacement
1443 wheels for passenger cars and their trailers. It governs key wheel characteristics that directly
1444 condition which tyres can be safely and legally fitted, and it imposes performance tests that
1445 interact with tyre fitment, inflation, and service conditions.

1446 The regulation applies to replacement wheels for vehicles in categories M1 (passenger cars),
1447 M1G (off-road passenger cars), O1 (light trailers), and O2 (medium trailers). It excludes original
1448 equipment (OE) wheels and special wheels, which remain subject to national approval. The
1449 regulation sets out requirements for wheel design, manufacturing, and installation, ensuring
1450 that replacement wheels are compatible with the tyres they are intended to support.

1451 The regulation specifies rigorous testing procedures for wheels, which indirectly affect tyre
1452 performance.

⁶ A transitional requirement is the set of time-bound administrative rules embedded in a UN Regulation (or its series of amendments) that manage the shift from an older to a newer set of technical requirements.

1453 The regulation also requires wheels to meet specific load capacity and inflation pressure
1454 standards, which align with tyre performance requirements. This ensures that tyres are not
1455 subjected to stresses beyond their design limits.

1456 4.3.2. EU legislation

1457 The following section provides summaries of EU legislations dealing with tyres and their main
1458 focus.

1459 4.3.2.1. Regulation (EU) 2020/740 on the labelling of tyres

1460 Regulation EU 2020/740 (EU Regulation 2020/740, 2020) provides a framework for harmonised
1461 information on the performance indicators of a tyre's behaviour under real conditions. The
1462 regulation establishes a label containing up to five symbols covering the fuel efficiency, external
1463 rolling noise as well as wet, snow and ice grip of tyres. It allows "end-users to make an informed
1464 choice when purchasing tyres". Standardised tests laid down in UNECE R117 are used to
1465 measure the performance aspects. Scales described in Annex I of the EU tyre labelling regulation
1466 are used to classify the tyres' performance with regard to fuel efficiency, wet grip and external
1467 rolling noise. UNECE R117 defines limits for rolling resistance, wet grip, and noise in successive
1468 stages (stage 1, 2 and 3), with each stage being stricter than the previous one and these are then
1469 reflected in the EU Regulation on the labelling of tyres.

1470 Regulation 2020/740 is currently under revision, with adoption planned for the second quarter
1471 of 2026. This initiative introduces new information requirements for retreaded tyres and
1472 amendments to the Regulation's Annexes to improve consumer information, extend the
1473 compliance data of the product database and improve legal certainty with regard to the format
1474 of advertising information and promotional material (European Commission, 2025e).

1475 Furthermore, the European Commission has initiated work to develop a label for retreaded C3
1476 tyres, following an industry proposal received in October 2022 (Viegand Maagøe, 2025).

1477 For further detail on the parameters addressed in the Regulation, see **Sections 4.2.2.6 and 7.3.2.**

1478 4.3.2.2. Regulation (EU) 2019/2144 on type-approval requirements for 1479 motor vehicles and their trailers

1480 Regulation 2019/2144 (EU Regulation 2019/144, 2019) sets EU type-approval rules that directly
1481 affect tyres through both the vehicle-side system requirements and tyre performance
1482 requirements. It requires vehicles to be equipped with an accurate TPMS that can warn the
1483 driver of pressure loss across a wide range of road and environmental conditions, and that is
1484 designed to avoid resetting or recalibration at a low tyre pressure. The Commission must set
1485 uniform procedures and technical specifications for TPMS type-approval via implementing acts.

1486 For tyres as products, the Regulation requires that all newly manufactured tyres placed on the
1487 EU market meet safety and environmental performance requirements set out in the relevant
1488 regulatory acts listed in Annex II, with the Commission empowered to adopt uniform procedures
1489 and technical specifications for tyre type-approval and installation. The Regulation also signals
1490 the replacement of prior EU tyre provisions with UN Regulations, notably UNECE R117 on rolling
1491 sound emissions, wet grip and rolling resistance, and encourages developing requirements that
1492 assess performance when tyres are worn so that tyres meet requirements throughout their life.

1493 **4.3.2.3. Regulation (EU) 2015/208 on vehicle functional safety requirements**
1494 **for the approval of agricultural and forestry vehicles**

1495 Commission Delegated Regulation (EU) 2015/208 (Commission Delegated Regulation (EU)
1496 2015/208, 2014) supplements Regulation (EU) 167/2013 on the EU type-approval of agricultural
1497 and forestry vehicles and is relevant to tyres insofar as it sets binding functional safety
1498 requirements for tyres fitted to tractors, tracked tractors and certain towed/interchangeable
1499 equipment within that framework. It does not regulate road vehicle replacement tyres generally,
1500 but it defines the approval regime for tyres used on agricultural/forestry vehicles and links EU
1501 approval to UNECE tyre regulations. Article 34 subjects tyres to approval testing and
1502 performance verification in accordance with Annex XXX (about requirements on tyres), while
1503 Annex I recognises the UNECE tyre regulations (notably UNECE R106 for agricultural tyres and
1504 UNECE R54 for certain tyre categories) that apply on an equal basis to EU legislation.

1505 The Regulation also sets test conditions that directly affect tyre specification and marking:
1506 maximum design speed tests must be performed with new pneumatic tyres having the greatest
1507 rolling radius intended by the manufacturer, at road-use pressures, with an explicit tolerance
1508 that includes a 5 % allowance for tyre-size variation; vehicles with maximum design speed above
1509 60 km/h must be equipped with adjustable speed limiters meeting UNECE R89, which constrains
1510 permissible tyre speed capability selections for such vehicles. The scope therefore captures tyre
1511 type-approval recognition (via UNECE R106 and UNECE R54 listed as applicable to relevant
1512 categories), vehicle-level conformity of the mounted tyres with the approved sizes, loads, and
1513 speed indices, and the verification that the tyre configuration supports measured maximum
1514 design speed and load/mass limits established elsewhere in the regulation.

1515 At vehicle level, compliance includes fitment of tyres matching approved dimensions, load
1516 indices, speed categories, and use conditions for on-road/off-road operation during type-
1517 approval testing.

1518 **4.3.2.4. Regulation (EU) 2018/858 on the approval and market surveillance**
1519 **of motor vehicles and their trailers, and of systems, components**
1520 **and separate technical units intended for such vehicles**

1521 Regulation (EU) 2018/858 (Regulation (EU) 2018/858, 2018) establishes the EU type-approval
1522 and market-surveillance framework for motor vehicles and their trailers, and for the systems,
1523 components, separate technical units, parts and equipment designed for such vehicles. Tyres
1524 fall within this framework as components/parts that can be fitted to approved vehicles. As such,

1525 tyres placed on the EU market must comply with the relevant regulatory acts listed under the
 1526 vehicle type-approval system, and national authorities may verify conformity both at type-
 1527 approval and in market surveillance. The Regulation also empowers controls on parts and
 1528 equipment that can significantly impair environmental protection or functional safety if fitted to
 1529 vehicles, which captures safety- and environment-critical tyre characteristics and replacement
 1530 tyres in the aftermarket.

1531 The Regulation requires that technical requirements for systems, components and separate
 1532 technical units (including tyres) be harmonised via referenced regulatory acts, notably UN
 1533 Regulations accepted under the UNECE 1958 Agreement and EU acts listed in Annexes.

1534 **4.3.2.5. Regulation (EU) 2024/1257 (EURO 7 Regulation) on type-approval**
 1535 **of motor vehicles and engines and of systems, components and**
 1536 **separate technical units intended for such vehicles, with respect to**
 1537 **their emissions and battery durability**

1538 Regulation (EU) 2024/1257 (EURO 7) (EU Regulation 2024/1257, 2024) explicitly brings C1, C2
 1539 and C3 class tyres (as per UNECE R117) into its scope, excluding ice grip tyres. It establishes
 1540 common technical requirements and administrative provisions for emission type-approval and
 1541 market surveillance of vehicles and related components, and it defines tyre abrasion as part of
 1542 non-exhaust emissions to be addressed within this framework.

1543 The Regulation indicates a need to measure and limit non-exhaust emissions that consist of
 1544 particles emitted by tyres and brakes of vehicles, either by UN Regulation or Commission’s
 1545 delegated act. These non-exhaust emissions for tyres refer in particular to microplastics.
 1546 Improved materials and designs that reduce wear will help meet the new regulatory
 1547 requirements. The intention is to introduce binding emission limits for tyres sold on the EU
 1548 market. For this purpose the Regulation empowers the Commission to set methods to measure
 1549 tyre abrasion and, if the World Forum for the Harmonization of Vehicle Regulation (UNECE
 1550 WP.29) does not adopt uniform provisions on tyre abrasion limits by set dates, to adopt EU
 1551 abrasion limits via a delegated act.

1552 Tyres are implicated through non-exhaust emissions policy: the Regulation recognises tyre-
 1553 derived microplastics as a major source and foresees measurement methods and potential limits
 1554 for abrasion as part of type-approval governance. It directs alignment with UN regulations where
 1555 appropriate (e.g. UNECE R117 and future UNECE WP. 29 outcomes) and allows incorporation of
 1556 UN abrasion limits into EU law once adopted. It also tasks the Commission, via implementing
 1557 acts, to establish detailed test methods, performance requirements for test equipment, and
 1558 compliance thresholds pertinent to monitoring and market surveillance, including for tyre
 1559 abrasion.

1560 **4.3.2.6. Regulation (EU) 2023/1115 (EU Deforestation Regulation)**

1561 Regulation (EU) 2023/1115 (EU Deforestation Regulation, 2023) directly addresses the supply
 1562 chain of rubber, which is a key component in tyre manufacturing. The primary objective of this

1563 regulation is to minimise the EU's contribution to global deforestation and forest degradation,
1564 thereby helping to reduce greenhouse gas emissions and biodiversity loss.

1565 Specifically concerning rubber, the regulation states that certain products, including new and
1566 retreaded pneumatic tyres, shall not be placed or made available in the EU market or exported
1567 unless they are deforestation-free. Being "deforestation-free" means that the rubber used in
1568 these tyres must have been produced on land that has not been subject to deforestation after
1569 31 December 2020. Additionally, these products must have been produced in accordance with
1570 the relevant legislation of the country of production, encompassing aspects such as land use
1571 rights, environmental protection, human rights, and labour rights.

1572 To ensure compliance, operators placing or exporting rubber-based products like tyres are
1573 mandated to establish and implement comprehensive due diligence systems. such systems
1574 involve three key elements: information requirements, such as collecting the geolocation of all
1575 plots of land where the rubber was produced; risk assessment, to determine if there is a non-
1576 negligible risk of non-compliance with the deforestation-free and legality criteria; and risk
1577 mitigation measures if a risk is identified, to ensure that only a negligible risk remains.

1578 Used commodities and products that have completed their life cycle and would otherwise be
1579 discarded as waste are generally excluded from the scope of the regulation, unless they are
1580 specific by-products of the manufacturing process.

1581 4.3.2.7. Directive 2008/98/EC (Waste Framework Directive)

1582 The European Waste Framework Directive (WFD) 2008/98/EC (Waste Framework Directive
1583 (WFD), 2008) forms the basis for waste management in the EU. Its aim is to minimise waste,
1584 conserve resources and protect the environment. It establishes a hierarchical waste
1585 management system prioritising waste prevention over other options:

- 1586 (a) prevention
- 1587 (b) preparing for re-use
- 1588 (c) recycling
- 1589 (d) other recovery, e.g. energy recovery
- 1590 (e) and disposal

1591 Although the WFD regulates waste management in general and is not focused on specific
1592 product groups, tyre pyrolysis is a recovery operation under the WFD, whose place in the waste
1593 hierarchy depends on its principal outcome. When pyrolysis reprocesses end-of-life tyres into
1594 materials used as products or feedstocks—such as recovered carbon black or pyrolysis oil used
1595 as a chemical/feedstock rather than burned—it can be considered recycling, because it
1596 constitutes reprocessing of waste into materials for original or other purposes and is not energy
1597 recovery nor the production of materials to be used as fuels (Article 3(17); Article 3(15)). If the
1598 main result is the production of fuels that are combusted for energy (e.g. pyrolysis gas), it can
1599 be considered as “other recovery” which ranks below recycling in the hierarchy set out in Article
1600 4 and reproduced above.

1601 The Directive calls on Member States to improve waste management and monitoring and
1602 provides for measures to promote the circular economy. Important aspects include schemes for
1603 extended producer responsibility, promoting waste separation, improving the recycling rate and
1604 ensuring that waste is treated in an environmentally friendly and healthy manner.

1605 Article 6 (1) and (2) of the WFD specifies “End-of-waste criteria” which are of relevance to
1606 remanufacturing, refurbishment and reuse operations of waste. The criteria specify when
1607 certain end-of-life products or components cease to be waste and become a product, or a
1608 secondary raw material. This is the case when certain specified waste has undergone a recovery
1609 operation (including recycling) and complies with specific criteria:

- 1610 • “The substance or object is to be used for specific purposes;
- 1611 • A market or demand exists for such a substance or object;
- 1612 • The substance or object fulfils the technical requirements for the specific purposes and
1613 meets the existing legislation and standards applicable to products; and
- 1614 • The use of the substance or object will not lead to overall adverse environmental or
1615 human health impacts” (Waste Framework Directive (WFD), 2008).

1616 These criteria were not initially included in the WFD but were added to remove obstacles for
1617 reuse of components and secondary materials from products that had been sent to waste
1618 management and that had thus reached the “waste” status. In other words, the criteria are of
1619 importance to promote reuse, refurbishment and remanufacture operations which are at a high
1620 level of the waste hierarchy.

1621 The Directive foresees developing specific end-of-waste criteria for certain products, explicitly
1622 mentioning tyres. For tyre recyclates (e.g. rubber granulate, recovered carbon black) and casings
1623 sent for retreading, this means that after appropriate recovery/preparing-for-re-use operations,
1624 outputs would need to demonstrate established uses and markets (e.g. as retread casings or
1625 material feedstocks), meet relevant technical and product standards, and comply with pollutant
1626 limits, with documented assurance that their intended use does not cause overall adverse
1627 impacts. Meeting these conditions, once they are set, would then enable consideration of such
1628 materials as products rather than waste (see more detail in task 4 under section 7).

1629 Among others, Article 8 about extended producer responsibility (EPR), states that: “Member
1630 States may take appropriate measures to encourage the design of products in order to reduce
1631 their environmental impacts and the generation of waste in the course of the production and
1632 subsequent use of products, and in order to ensure that the recovery and disposal of products
1633 that have become waste take place in accordance with Articles 4 [the waste hierarchy – see
1634 above] and 13 [ensuring that waste management does not endanger human health and the
1635 environment]” (Waste Framework Directive (WFD), 2008). This article supports the introduction
1636 of ESPR requirements that address design with the purpose of improving the waste management
1637 of products, e.g. increasing the number of tyres that can be prepared for reuse and increasing
1638 and/or improving the amount and quality of materials that can be recovered from ELT.

1639 **4.3.2.8. Directive 2000/53/EC (ELV Directive)**

1640 Directive 2000/53/EC (ELV Directive, 2000) on end-of-life vehicles (ELVs) regulates how vehicles,
 1641 their components and materials, are designed for end-of-life processing, collected, treated, and
 1642 recovered. The Directive sets binding, vehicle-level recycling and recovery targets that indirectly
 1643 but materially apply to tyres: economic operators had to reach by 1 January 2015 at least 85 %
 1644 reuse and recycling and 95 % reuse and recovery, which drives the removal and material
 1645 recycling of various materials rather than disposal or energy recovery.

1646 In accordance with Annex I of the ELV Directive, specific requirements apply to the handling of
 1647 tyres from end-of-life vehicles. If tyres are not separated during the shredding process in a way
 1648 that enables effective material recycling, they must be removed beforehand to facilitate proper
 1649 recovery. This de facto leads to all tyres being removed from ELVs and sent to separate waste
 1650 management unless they can be directed to reuse (e.g. 2nd hand sales or retreading). Treatment
 1651 facilities must further provide appropriate storage conditions for used tyres, with measures to
 1652 prevent fire hazards and avoid excessive stockpiling. These provisions aim to ensure the
 1653 environmentally sound management of tyres within the broader framework of end-of-life
 1654 vehicle treatment.

1655 The ELV Directive is in final stages of a revision, and a “Proposal for a Regulation on circularity
 1656 requirements for vehicle design and on management of end-of-life vehicles² was published in
 1657 2023 and is being negotiated. The proposal is to replace both the ELV Directive and the 2RTA
 1658 Directive (see next section). Aside from M1 and N1 vehicles to which the ELV Directive already
 1659 applies, it is proposed to extend the scope of the legislation to trucks, buses and motorcycles
 1660 and mopeds.

1661 **4.3.2.9. Directive 2005/64/EU (3RTA Directive)**

1662 Directive 2005/64/EC (Directive 2005/64/EC, 2005), also known as the 3R Type Approval
 1663 Directive, sets binding requirements at the vehicle type-approval stage to ensure that passenger
 1664 cars and light commercial vehicles are designed for high reuse, recycling and recovery at end of
 1665 life. This is directly relevant to tyres because, tyres are explicitly counted as recyclable in the
 1666 mandatory recyclability/recoverability calculations used at type-approval. Annex I states that
 1667 vehicles must be reusable and/or recyclable to at least 85 % by mass and reusable and/or
 1668 recoverable to at least 95 % by mass, and “for the purposes of calculations, tyres shall be
 1669 considered as recyclable.” This means tyre mass contributes toward the 85 % recyclability target
 1670 and, if necessary, the 95 % recoverability target, shaping how manufacturers account for tyre
 1671 end-of-life treatment in their compliance strategy.

1672 Furthermore, the Directive requires manufacturers to prepare and have assessed a
 1673 dismantling/recycling/recovery strategy based on proven technologies, supported by materials
 1674 data consistent with ISO 22628:2002. That strategy covers components including tyres and must
 1675 be coherent with the recyclability/recoverability calculations that treat tyres as recyclable;
 1676 approval authorities verify this coherence at type-approval.

1677 Directive 2005/64/EC implements, within the vehicle type-approval system, the recyclability and
1678 recoverability objectives anticipated by the ELV Directive. In other words, ELV sets the life cycle
1679 policy framework and treatment obligations, including explicit provisions for tyre storage and
1680 removal at treatment facilities, while Directive 2005/64/EC translates those ELV objectives into
1681 ex-ante vehicle design and approval requirements, counting tyres as recyclable for compliance
1682 and compelling manufacturers to plan and document tyre treatment within their overall
1683 reuse/recycling/recovery strategy.

1684 4.3.2.10. Regulation (EC) 1907/2006 (REACH Regulation)

1685 The Regulation (EC) No 1907/2006 (REACH Regulation, 2006) concerns the registration,
1686 evaluation, authorisation and restriction of chemical substances. Its purpose is to ensure a high
1687 level of protection of human health and the environment, as well as the free circulation of
1688 substances on the internal market while enhancing competitiveness and innovation. It lays down
1689 provisions on certain substances as well as mixtures. The provisions shall apply “to the
1690 manufacture, placing on the market or use of such substances on their own, in mixtures or in
1691 articles and to the placing on the market of mixtures”.

1692 The REACH regulation is directly relevant to tyres because it governs chemicals used to make
1693 tyre compounds and regulates tyres themselves as “articles.” Under REACH, manufacturers and
1694 importers of substances used in tyres—such as rubber polymers, process oils, curatives,
1695 antioxidants/antiozonants, fillers, and other additives—must register their substances, generate
1696 data, assess risks, and communicate risk management measures down the supply chain to tyre
1697 producers, enabling safe manufacture and use under foreseeable conditions. Tyres, being
1698 articles, trigger specific article-related obligations related to release of substance and presence
1699 of substances of very high concern (SVHC).

1700 REACH also enables EU-wide restrictions under Annex XVII, where tyres are targeted via the
1701 polycyclic aromatic hydrocarbon (PAH) restriction for extender oils and for tyres/treads
1702 themselves. See **Section 7.6.5** for further detail on PAHs.

1703 Finally, REACH requires robust supply-chain communication: safety data sheets and exposure
1704 scenarios convey conditions of safe use, and tyre producers must ensure their uses are covered
1705 or perform their own assessments, while passing safe-use information for tyres containing
1706 SVHCs to downstream users and consumers where applicable. Hazardous substances that are
1707 relevant for tyres will be analysed in Task 5 and Task 6.

1708 4.3.2.11. Regulation (EC) 1272/2008 (CLP Regulation)

1709 The Regulation (EC) No. 1272/2008 (EC Regulation 1272/2008, 2008) is the EU’s main legislative
1710 instrument for hazard communication of chemicals. Regarding tyres, it governs the
1711 classification, labelling, and packaging (CLP) of the chemicals and mixtures used to produce them
1712 and those released during their treatment or recycling. Tyres themselves are articles, so they
1713 are not CLP-labelled, but tyre makers and recyclers must comply with CLP via their raw materials
1714 and processing outputs.

1715 4.3.2.12. Critical Raw Materials Act (CRMA)

1716 Natural rubber has previously been identified by the European Commission as a Critical Raw
1717 Material (CRM). It was included in the 2017 CRM list and remained listed in the 2020 update,
1718 where it was highlighted as the only biotic material on the list at that time (Critical and Strategic
1719 Materials, n.d.). Although natural rubber was not included in the latest CRM list (2023), it
1720 continues to be among the materials regularly assessed for criticality in each cycle, reflecting its
1721 significant economic importance for European industry and exposure to supply risks tied to
1722 geographic concentration and climate or disease pressures. Given the triennial reassessment
1723 approach, its status could change in future iterations depending on updated data and
1724 methodology, including supply-demand dynamics and diversification trends.

1725 4.3.2.13. Upcoming Circular Economy Act (CEA)

1726 Due for adoption in 2026, the European Commission's proposed Circular Economy Act (CEA)
1727 aims to "establish a single market for secondary raw materials, increase the supply of high-
1728 quality recycled materials and stimulate demand for these materials in the EU" (Commission
1729 Launches Consultation for Upcoming Circular Economy Act, 2025). The CEA would matter for
1730 tyres mainly by harmonising how tyre waste becomes "secondary raw materials," strengthening
1731 extended producer responsibility (EPR) for tyres, clarifying end-of-waste criteria for tyre-derived
1732 materials (e.g. crumb rubber, pyrolysis oil/char, devulcanised rubber), and creating EU demand
1733 for recycled content via green public procurement.

1734 4.3.3. Member State legislation

1735 Across EU Member States, tyre-related regulation shows three clear clusters: metrology and
1736 safety of tyre pressure measurement; product performance and vehicle-tyre compatibility
1737 (including studded tyres and noise); and circular economy instruments governing end-of-waste
1738 status and extended producer responsibility (EPR) for tyres (see detailed list in **8.1 Annex I**).
1739 Several countries focus on legal metrological control of tyre pressure gauges used in public or
1740 commercial settings, often via detailed technical ordinances that set type-approval, verification,
1741 and test methods. Examples include Portugal's 2023 metrological control ordinance for tyre
1742 pressure gauges, Slovenia's 2024 rules on metrological requirements for tyre-pressure gauges,
1743 and a series of measures in Czechia (2011 and 2018 drafts) and Croatia (2016 draft) that lay
1744 down technical and verification requirements for legally controlled instruments.

1745 A second cluster addresses performance in specific operating conditions and compatibility with
1746 vehicle systems. Finland's instruments include a national regulation on technical requirements
1747 and type-approval for studded tyres (2020), and draft regulations (2024–2025) adjusting rules
1748 for tractors' propulsion systems, tyres, and rims. Italy's 2011 decree on wheel-tyre systems for
1749 cars, with a 2022 update on supplementary grip devices for light vehicle categories, likewise
1750 reflects detailed national management of fitment, grip aids, and seasonal or surface-specific
1751 safety needs. The Netherlands complements performance considerations with a voluntary
1752 "Covenant on quieter tyres" (2006).

1753 The third cluster is circular economy governance, where end-of-waste criteria and EPR
1754 frameworks are central. Lithuania’s 2021 measure establishing end-of-waste criteria for recycled
1755 tyres and a 2024 draft amendment, Portugal’s 2016 draft on end-of-waste criteria for rubber
1756 from used tyres, and Estonia’s 2018 specific requirements for tyre chips used in shale-oil
1757 production exemplify how Member States set quality and use conditions for ELT-derived
1758 materials. Finland’s 1995–1997 decisions on recovery and treatment of used tyres and the 2013
1759 draft decree on separate collection, reuse and recovery show long-running EPR and collection
1760 infrastructure building (see also task 4 under **Section 7**).

1761 4.3.4. Third country legislation

1762 Tyre-related regulations in non-EU countries show significant diversity but increasingly converge
1763 around international standards, especially those developed by the UNECE (see detailed list in
1764 **8.2 Annex II**). Though such regulation is heterogeneous it converges around three themes:
1765 safety and type-approval, performance and information (including TPMS and labelling-like
1766 elements), and end-of-life or environmental controls.

1767 According to the Automotive Regulatory Guide 2023, mature regulatory systems such as the
1768 United States and Canada rely on federal motor vehicle safety standards that specify tyre
1769 construction, testing, performance, selection and rim compatibility across vehicle classes.
1770 Several large emerging economies combine mandatory conformity assessment with detailed
1771 technical standards: Brazil uses INMETRO/CONMETRO schemes and CONTRAN requirements for
1772 new tyres, retreading, TPMS, and consumer information, alongside environmental obligations
1773 for collection and final disposal; China’s GB and GB/T standards govern testing for passenger
1774 and truck tyres and require certification; India’s mix of BIS standards and CMVR/AIS regulations
1775 covers a wide range of tyre quality and performance parameters (ACEA, 2023).

1776 Adoption of UNECE regulations is a major pathway for international alignment. Full or partial
1777 UNECE uptake is explicit in Japan, Malaysia, Singapore, Thailand, Vietnam, Myanmar and the
1778 Philippines. The UK’s pre-2021 framework was historically aligned with UNECE through EU type-
1779 approval; it also developed domestic instruments such as tyre age limits for certain vehicle
1780 classes and end-of-waste quality protocols for tyre-derived materials. In contrast, the US and
1781 Canada maintain their own performance-based frameworks rather than UNECE, and countries
1782 like Brazil, China, and India primarily use national standards and certification schemes, though
1783 they increasingly converge on similar performance dimensions (wet grip, rolling resistance,
1784 noise, TPMS) (ACEA, 2023).

1785 Environmental and circular-economy measures are expanding but vary widely. Brazil mandates
1786 collection and environmentally sound final disposal via IBAMA/CONAMA; Indonesia regulates
1787 SNI certification and tyre imports; Colombia, Ecuador and Mexico maintain national technical
1788 regulations and standards for tyres and related components; the UAE specifies conditions under
1789 which repair kits can replace spare tyres for certain vehicle categories. Several jurisdictions also
1790 regulate retreaded tyres explicitly (e.g. FMVSS 117 in the US; Thai TIS for retreads), reflecting
1791 safety considerations and circularity goals (ACEA, 2023).

1792 Overall, third-country legislation shows a strong global trend toward harmonisation with UNECE
1793 in many Asia-Pacific and Middle Eastern markets, while large economies maintain national
1794 regimes with increasing attention to performance (wet grip/rolling resistance), safety systems
1795 (TPMS), and end-of-life responsibilities.

1796 4.3.5. Comparative analysis of legislation

1797 Looking mainly at UNECE Regulations and EU legislations, these address already numerous
1798 aspects for tyres, including:

1799 For C1, C2 and C3 class tyres: requirements for tyre dimensions, load capacity, speed rating,
1800 structure (radial, bias-ply, etc.), and mandatory markings; performance tests; environmental
1801 and safety performance requirements (rolling sound emissions, wet grip, and rolling resistance);
1802 Provisions for special systems like run-flats, spare tyres and tyre pressure monitoring systems;
1803 regulation on retreaded tyres (detail processes and quality assurances, performance
1804 requirements, markings); tyre installation; replacement wheels; microplastics and abrasion.

1805 For agricultural vehicle tyres, identified legislation addresses functional safety requirements and
1806 performance testing.

1807 Looking at the materials used in tyre manufacture, these are addressed in general through
1808 various legislation on chemicals (restriction for PAHs), critical raw materials (rubber between
1809 2017-2020) and material supply chains (rubber), however these regulations are not sector
1810 specific and rarely address tyres specifically.

1811 Similarly, though waste management is addressed in general under the WFD and also applies to
1812 tyres, from various exchanges, the consultant understand that current extended producer
1813 responsibility organisations have only been developed for tyres of categories C1, C2 and C3.
1814 Though there are indications that other tyres are also collected and managed at EoL, the lack of
1815 formal systems means among others that little data exists on such practices to clarify their
1816 appropriateness. In addition, the WFD foresees the development of tyre specific end-of-waste
1817 criteria, however this is still outstanding.

1818 While the ELV Directive ensures that tyres are managed properly at end-of-life, this only applies
1819 to the tyres of M1 (passenger cars) and N1 (light vehicles) vehicles at EoL and not to tyres
1820 replaced during a vehicle's lifetime, meaning that they do not apply to most tyres. In connection
1821 with the ELV Directive, the 3RTA Directive requires vehicles manufacturers to submit evidence
1822 that a tyre can reach the ELV directive reuse, recycling and recovery targets when it is to arrive
1823 in the waste phase. The way that the accounting is done in this context to show compliance with
1824 the targets considers that tyres are 100 % recycled and contributes a significant share of the
1825 weight of a vehicle towards compliance with the targets. In practice, however, seeing as around
1826 50 % of tyres are recovered this accounting is misleading.

1827 In summary, though international and EU legislation account for many aspects related to tyre
1828 performance and safety, material aspects are only addressed by general legislation, not
1829 including tyre specific provisions, leaving room for ESPR to address such aspects.

1830
1831

Stakeholder question:
T1-17 Are you aware of any other gaps of relevance to ESPR?

1832

1833 **4.4. Test standards (EU, Member State and third country**
1834 **level)**

1835 The following section outlines the main national, European and international test standards
1836 relevant to tyres. Test standards ensure the safety, reliability, and environmental performance
1837 of tyres throughout their life cycle. By providing harmonised methods for evaluating key
1838 characteristics such as durability, grip, rolling resistance, noise, and material properties, these
1839 standards enable consistent product assessment and facilitate regulatory compliance across
1840 markets.

1841 **4.4.1. EN or ISO/IEC test standards**

1842 EN and ISO standards are internationally recognised frameworks that establish requirements
1843 and test methods for products and processes, including tyres. ISO standards are developed by
1844 the International Organization for Standardization and are intended for global application,
1845 providing harmonised technical specifications across countries. EN standards, or European
1846 Norms, are developed by European standardisation bodies and are oriented to the needs and
1847 regulatory context of the European market. Many EN standards adopt ISO standards directly (as
1848 EN ISO).

1849 IEC standards related to tyres were not found but is not surprising as the International
1850 Electrotechnical Commission (IEC) develops standards for the compatibility of electrical,
1851 electronic and related technologies.

1852 **Table 4-6** shows an overview of tyre-related ISO standards, many of which were adopted as EN
1853 ISO standards (e.g. ISO 4000:2024), by vehicle and/or application.

1854

Table 4-6: Tyre-related ISO standards by vehicle / application.

| ISO Standard | Year | Title | General tyre definitions | Standards by vehicle / application | | | | | | |
|-----------------|---------------|---|--------------------------|------------------------------------|-----------------------------------|----------------------|---|-------------------------|----------|--|
| | | | | Passenger car | Truck, bus and commercial vehicle | Motorcycle / bicycle | Agricultural, forestry and construction | Industrial and Off-road | Aircraft | Mobile cranes and specialised machines |
| 10191 | 2021 | Passenger car tyres — Verifying tyre capabilities — Laboratory test methods | | X | | | | | | |
| 10231 | 2025 | Motorcycle tyres — Test methods for verifying tyre capabilities | | | | X | | | | |
| 10454 | 1993 | Truck and bus tyres — Verifying tyre capabilities — Laboratory test methods | | | X | | | | | |
| 10571 | 2024 | Tyres for mobile cranes and similar specialised machines | | | | | | | | X |
| 10844 | 2021 | Acoustics — Specification of test tracks for measuring sound emitted by road vehicles and their tyres | | X | X | X | X | X | X | X |
| 11795 | 2018 | Agricultural tractor drive wheel tyres — Explanation of rolling circumference index (RCI) and speed radius index (SRI) and method of measuring tyre rolling circumference | | | | | X | | | |
| 13325 | 2019 | Tyres — Coast-by methods for measurement of tyre-to-road sound emission | | X | X | | | | | |
| 14040/1 4044 | 2006 | Environmental management — Life cycle assessment — Principles and framework / Requirements and guidelines | | X | X | X | X | X | X | X |
| 14067 | 2018 | Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification | | X | X | X | X | X | X | X |
| 14960 | 2023/ 2024 | Tubeless tyres. Valves and components. Clamp-in tubeless tyre valve. Test methods | | X | X | | | | | |
| 15222 | 2021 | Truck and bus tyres. Method for measuring relative wet grip performance. Loaded new tyres | | | X | | | | | |

| ISO Standard | Year | Title | General tyre definitions | Standards by vehicle / application | | | | | | |
|--------------|------|---|--------------------------|------------------------------------|-----------------------------------|----------------------|---|-------------------------|----------|--|
| | | | | Passenger car | Truck, bus and commercial vehicle | Motorcycle / bicycle | Agricultural, forestry and construction | Industrial and Off-road | Aircraft | Mobile cranes and specialised machines |
| 18106 | 2016 | Passenger car, commercial vehicle, truck and bus tyres — Methods for measuring snow grip performance — Loaded new tyres | | X | X | | | | | |
| 18164 | 2005 | Passenger car, truck, bus and motorcycle tyres — Methods of measuring rolling resistance | | X | X | X | | | | |
| 18807 | 2019 | Tyres and rims for logging and forestry service | | | | | X | | | |
| 18808 | 2021 | Agricultural tyres for construction machines | | | | | X | | | |
| 19447 | 2021 | Passenger car tyres — Method for measuring ice grip performance — Loaded new tyres | | X | | | | | | |
| 20908 | 2023 | Tyre sound emission test — Methods of drum | | X | X | | | | | |
| 22638 | 2024 | Rubber. Generation and collection of tyre and road wear particles (TRWP). Road simulator laboratory method | | X | X | X | X | X | X | X |
| 23671 | 2021 | Passenger car tyres — Method for measuring relative wet grip performance — Loaded new tyres | | X | | | | | | |
| 28580 | 2018 | Passenger car, truck and bus tyre rolling resistance measurement method — Single point test and correlation of measurement results | | X | X | | | | | |
| 3324 | 2013 | Aircraft tyres and rims. Specifications and Test methods for tyres | | | | | | | X | |
| 3739 | 2022 | Industrial tyres and rims. Pneumatic tyres (metric series) on 5 degrees tapered or flat base rims. Designation, dimensions and marking and Load ratings | | | | | | X | | |
| 3877 | 1997 | Tyres, valves and tubes - List of equivalent terms | X | X | X | X | X | X | X | X |

| ISO Standard | Year | Title | General tyre definitions | Standards by vehicle / application | | | | | | |
|--------------|---------------|--|--------------------------|------------------------------------|-----------------------------------|----------------------|---|-------------------------|----------|--|
| | | | | Passenger car | Truck, bus and commercial vehicle | Motorcycle / bicycle | Agricultural, forestry and construction | Industrial and Off-road | Aircraft | Mobile cranes and specialised machines |
| 3911 | 2021 | Wheels and rims for pneumatic tyres — Vocabulary, designation and marking | X | X | X | X | X | X | X | X |
| 4000 | 2024 | Passenger car tyres and rims | X | X | | | | | | |
| 4209 | 2001/ 2020 | Truck and bus tyres and rims (metric series) | | | X | | | | | |
| 4223 | 2017/ 2020 | Definitions of some terms used in the tyre industry — Part 1: Pneumatic tyres | X | X | X | X | X | X | X | X |
| 4249 | 1985/ 1990 | Motorcycle tyres and rims (Code-designated series) — Part 1: Tyres | | | | X | | | | |
| 4250 | 2023 | Earth-mover tyres and rims. Tyre designation and dimensions and Loads and inflation pressures | | | | | | X | | |
| 4251 | 2019 | Code designated diagonal tyres (ply rating marked series) for agricultural tractors, trailers and machines. Tyre designation and dimensions, and approved rim contours and Tyre load ratings | | | | | X | | | |
| 5751 | 2010 | Motorcycle tyres and rims (metric series) | | | | X | | | | |
| 5273 | 2025 | Passenger car tyres. Preparation method for an artificially worn state for wet grip testing | | X | | | | | | |
| 5775 | 2023/ 2021 | Bicycle tyres and rims — Part 1: Tyre designations and dimensions | | | | X | | | | |
| 6054-1 | 1994 | Motorcycle tyres and rims (Code-designated series) — Diameter codes 4 to 12 — Part 1: Tyres | | | | X | | | | |

| ISO Standard | Year | Title | General tyre definitions | Standards by vehicle / application | | | | | | |
|--------------|------|---|--------------------------|------------------------------------|-----------------------------------|----------------------|---|-------------------------|----------|--|
| | | | | Passenger car | Truck, bus and commercial vehicle | Motorcycle / bicycle | Agricultural, forestry and construction | Industrial and Off-road | Aircraft | Mobile cranes and specialised machines |
| 7867 | 2018 | Metric series for agricultural, forestry machines and construction tyres. Tyre designation, dimensions and marking, and tyre/rim coordination and Load ratings for agricultural tyres | | | | | X | | | |
| 8664 | 2018 | Tyres for agricultural tractors and machines. Code-designated and service-description marked radial drive-wheel tyres | | | | | X | | | |

1855 Source: Own compilation

1856 **Table 4-7** shows an overview of tyre-related ISO standards that concern performance, testing
 1857 and environmental aspects.

1858 **Table 4-7: Tyre-related ISO standards with regard to performance, testing and environmental**
 1859 **aspects.**

| ISO Standard | Year | Title | Performance/testing/ environment | | | | |
|-----------------|------|---|---|----------------|-----------------------|------------------------------|------------------------------|
| | | | Rolling resistance, wet grip, and snow/ice grip | Noise emission | Valves and components | Environmental and life cycle | Tyre and road wear particles |
| 10844 | 2021 | Acoustics — Specification of test tracks for measuring sound emitted by road vehicles and their tyres | | X | | | |
| 13325 | 2019 | Tyres — Coast-by methods for measurement of tyre-to-road sound emission | | X | | | |
| 14040/1 4044 | 2006 | Environmental management — Life cycle assessment — Principles and framework / Requirements and guidelines | | | | X | |

| ISO Standard | Year | Title | Performance/testing/ environment | | | | |
|--------------|-----------|--|----------------------------------|---|---|---|---|
| 14067 | 2018 | Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification | | | | X | |
| 14960 | 2023/2024 | Tubeless tyres. Valves and components. Clamp-in tubeless tyre valve. Test methods | | | X | | |
| 15222 | 2021 | Truck and bus tyres. Method for measuring relative wet grip performance. Loaded new tyres | X | | | | |
| 18106 | 2016 | Passenger car, commercial vehicle, truck and bus tyres — Methods for measuring snow grip performance — Loaded new tyres | X | | | | |
| 18164 | 2005 | Passenger car, truck, bus and motorcycle tyres — Methods of measuring rolling resistance | X | | | | |
| 19447 | 2021 | Passenger car tyres — Method for measuring ice grip performance — Loaded new tyres | X | | | | |
| 20908 | 2023 | Tyre sound emission test — Methods of drum | | X | | | |
| 22638 | 2024 | Rubber. Generation and collection of tyre and road wear particles (TRWP). Road simulator laboratory method | | | | | X |
| 23671 | 2021 | Passenger car tyres — Method for measuring relative wet grip performance — Loaded new tyres | X | | | | |
| 28580 | 2018 | Passenger car, truck and bus tyre rolling resistance measurement method — Single point test and correlation of measurement results | X | | | | |

1860 Source: Own compilation

1861 **4.4.1.1. General tyre definitions and vocabulary**

1862 **Table 4-8** presents the main ISO standards that provide definitions, vocabulary and equivalent
 1863 technical terms related to pneumatic tyres used in the tyre industry, regardless of application
 1864 type, including other components like valves and tubes.

1865 **Table 4-8: ISO Standards about general tyre definitions and vocabulary.**

| Standard | Title | Brief Description |
|----------------------|---|---|
| ISO 3877:1997 | Tyres, valves and tubes - List of equivalent terms | Provides a list of equivalent technical terms for tyres, valves, and tubes. |
| ISO 3911:2021 | Wheels and rims for pneumatic tyres — Vocabulary, designation and marking | Defines vocabulary and marking conventions for wheels and rims used with pneumatic tyres. |

| Standard | Title | Brief Description |
|--------------------|---|--|
| ISO 4223:2017/2020 | Definitions of some terms used in the tyre industry | Provides definitions for terms related to the tyre industry. Part 1 is about pneumatic tyres, and Part 2 is about solid tyres. |

1866 Source: Own compilation

1867 4.4.1.2. Tyre and rim standards by vehicle/application

1868 ISO standards comprehensively address tyres and rims by defining requirements and test
1869 methods according to vehicle and application type.

1870 Passenger cars

1871 For passenger cars, the standards specify tyre dimensions and rim compatibility (ISO 4000:2024),
1872 as well as laboratory test methods to verify safety (ISO 10191:2021), performance characteristics
1873 such as wet grip (ISO 23671:2021), ice grip (ISO 19447:2021), and procedures for preparing tyres
1874 in artificially worn states for testing purposes (ISO 5273:2025).

1875 Motorcycles and bicycles

1876 Motorcycles and bicycles are covered by dedicated standards that set out the dimensions,
1877 marking, and testing protocols relevant to these vehicles (ISO 10231:2025, ISO 4249:1985/1990,
1878 ISO 5751:2010 and ISO 6054-1:1994 for motorcycles and ISO 5775:2023/2021 for bicycles).

1879 Trucks, buses and commercial vehicles

1880 For trucks, buses, and commercial vehicles, ISO standards define metric series dimensions and
1881 rim compatibility (ISO 4209:2020), and include methods for performance testing, particularly for
1882 wet grip of new loaded truck and bus tyres (ISO 15222:2021).

1883 Aircraft

1884 Aircraft tyres and rims are subject to their own specifications and test methods (ISO 3324-
1885 1:2013, ISO 3324-2:2013), reflecting the unique operational and safety requirements of aviation.

1886 Other vehicles

1887 In the agricultural, forestry, and construction sectors, standards address both diagonal and radial
1888 tyre constructions, load ratings, rolling circumference, and compatibility for a wide range of
1889 machinery (ISO 4251:2019, ISO 7867:2018, ISO 11795:2018, ISO 8664:2018, ISO 18807:2019, ISO
1890 18808:2021), ensuring that tyres and rims are suitable for the demanding conditions of these
1891 applications. Earthmover, industrial, and off-road vehicles are also addressed through standards

1892 that provide for the designation, dimensioning, marking, load ratings, and inflation pressures of
1893 tyres and rims (ISO 4250:2023, ISO 3739-1:2022, ISO 3739-2:2021), including those for mobile
1894 cranes and specialised machinery (ISO 10571:2024).

1895 Collectively, these ISO standards ensure that tyres and rims are appropriately designed, tested,
1896 and marked for their intended vehicle applications, supporting safety, performance, and
1897 international compatibility across all types of road and off-road vehicles.

1898 **4.4.1.3. Performance, testing and environmental standards**

1899 Performance, testing, and environmental standards ensure that tyres meet safety, efficiency,
1900 and sustainability requirements throughout their life cycle. ISO standards set out harmonised
1901 methods for assessing rolling resistance, grip, noise, materials, and environmental impacts.

1902 **Rolling resistance, wet grip and snow/ice grip**

1903 Rolling resistance is a key parameter for tyre energy efficiency and is addressed by methods
1904 applicable to a wide range of tyres, including those for passenger cars, trucks, buses, and
1905 motorcycles (ISO 18164:2005), with further harmonisation and correlation of measurement
1906 results provided for passenger car, truck, and bus tyres (ISO 28580:2018). Wet grip and ice grip
1907 performance are critical for safety; ISO standards specify laboratory methods for measuring
1908 these properties in both passenger car (ISO 23671:2021 for wet grip, ISO 19447:2021 for ice grip)
1909 and truck and bus tyres (ISO 15222:2021 for wet grip).

1910 **Noise emission**

1911 Tyre noise emissions is another important aspect, with coast-by methods⁷ (ISO 13325:2019) and
1912 drum test methods (ISO 20908:2023) used to quantify the noise produced by tyres, while the
1913 characteristics of test tracks for such measurements are defined separately (ISO 10844:2021).
1914 There is no specific ISO standard concerning internal noise. However, ISO 5128:2023 concerning
1915 Acoustics-Measurement of interior vehicle noise has a section about tyre conditions.

1916 **Valves and components**

1917 The testing and specification of tyre components, such as valves for tubeless tyres, are covered
1918 by dedicated standards (ISO 14960-1:2023 and ISO 14960-2:2024).

⁷ Method for “measuring tyre-to-road sound emissions from tyres fitted on a motor vehicle under coast-by conditions, i.e. when the vehicle is in free-rolling, non-powered operation. This is typically achieved by putting the transmission in the neutral or equivalent position and switching off the engine as well as all auxiliary systems not necessary for safe driving” (ISO 13325, 2019).

1919 **Environmental and life cycle impacts**

1920 Finally, environmental and life cycle considerations (although not tyre-specific) are integrated
 1921 through standards for LCA principles and requirements (ISO 14040/14044) and for the
 1922 quantification of product carbon footprints (ISO 14067:2018). Furthermore, the growing focus
 1923 on non-exhaust emissions is reflected in standards for the generation and collection of tyre and
 1924 road wear particles using laboratory road simulators (ISO 22638:2024).

1925 **ISO/TS 22638 Rubber — Generation and collection of tyre and road wear** 1926 **particles (TRWP) — Road simulator laboratory method**

1927 Technical specification ISO/TS 22638 on “Rubber — Generation and collection of tyre and road
 1928 wear particles (TRWP) — Road simulator laboratory method” specifies guidelines for generating
 1929 TRWP based on a laboratory method. The method has been developed as taking samples of
 1930 wear particles generated on roads is subject to various interferences such as dust and liquids
 1931 found on roads like oil and grease which affect the composition of the sample. Other methods
 1932 for TRWP generation are also explained to be less representative of actual conditions and may
 1933 thus also introduce interferences that affect their composition. The technical specification
 1934 describes the methods and equipment to be used in the generation process.

1935 This technical specification is understood to be relevant to the testing being performed with the
 1936 aim of developing abrasion limits as part of addressing microplastic pollution from tyres under
 1937 UNECE Regulation 117 and subsequently under the EU EURO 7.

1938 **4.4.1.4. EN standards concerning materials obtained from End-of-Life Tyres**

1939 As mentioned above, most tyre-related European Norms are now harmonised with ISO.
 1940 Nevertheless, a series of EN standards concerning materials obtained from End-of-Life Tyres
 1941 (ELT) was published in 2024, which provides a framework for the characterisation, sampling, and
 1942 quality assessment of secondary raw materials derived from used tyres. These standards specify
 1943 methods for sampling granulates and powders (EN 17188:2024), determining moisture content
 1944 (EN 16916:2024), measuring true density (EN 17189:2024), and assessing the non-metallic
 1945 content of steel wire recovered from ELT (EN 17308:2024). These EN standards could support
 1946 the traceability, consistency, and safe reuse of ELT-derived materials in various industrial
 1947 applications, thereby contributing to resource efficiency and circularity within the tyre sector.
 1948 There is also a technical specification (CEN/TS 17045:2020) on selection criteria for ELT intended
 1949 for recovery or recycling operations.

1950 **EN 14243, Materials obtained from End-of-Life Tyres (ELT)**

1951 The series EN 14243 on “Materials obtained from End-of-Life Tyres (ELT)”, consists of three parts
 1952 dealing with methods (or terms) related to the determination of the properties of materials
 1953 derived from the processing of ELT. The three parts include (CEN/CENELEC, 2010):

- 1954 • Part 1: General definitions related to the methods for determining their dimension(s)
1955 and impurities
- 1956 • Part 2: Granulates and powders – Methods for determining the particle size distribution
1957 and impurities, including free steel and free textile content
- 1958 • Part 3: Shreds cuts and chips – Methods for determining their dimension(s) including
1959 protruding filaments dimensions

1960 **EN 17188:2024: Sampling Method for Materials Obtained from End-of-life Tyres**

1961 The EN 17188:2024 standard on “Sampling Method for Materials Obtained from End-of-Life
1962 Tyres” provides a sampling method for granulates and powders derived from ELTs. Included
1963 methods are designed to ensure the quality and consistency of materials derived for these
1964 products. The standard outlines the sampling procedures necessary to obtain representative
1965 samples of granulates and powders with the aim of ensuring that the materials meet the
1966 required specifications for further processing or use. “Sample increments at different levels
1967 within the bag are obtained, which represent the average particle size distribution within the
1968 bag. From these sample increments, a representative sample is derived. The methods specified
1969 in this document are applicable, for example, when the samples are to be tested for e.g. bulk
1970 density, durability, particle size distribution, moisture content, ash content, ash melting
1971 behaviour, calorific value, chemical composition, impurities” (EN 17188:2024 Materials
1972 Obtained from End-of-Life Tyres (ELT). Sampling Method for Granulates and Powders Stored in
1973 Big-Bags and Small-Bags, 2024).

1974 **EN 16916:2024 Materials obtained from End-of-Life Tyres. Determination of specific**
1975 **requirements for sampling and determination of moisture content using the oven-dry**
1976 **method**

1977 EN 16916:2024 on “Materials obtained from End-of-Life Tyres. Determination of specific
1978 requirements for sampling and determination of moisture content using the oven-dry method”
1979 details an oven based drying method for determining the moisture content of the following
1980 materials recovered from ELT: rubber powders, chips and granulates and textile. The standard
1981 details among others how to prepare a sampling plan and how to take and handle samples (EN
1982 16916 - 2024, 2024).

1983 **EN 17189:2024 Materials obtained from End-of-Life Tyres - Determination of the true density**
1984 **of granulates and powders - Method based on water pycnometry**

1985 Standard EN 17189:2024 on “Materials obtained from End-of-Life Tyres - Determination of the
1986 true density of granulates and powders - Method based on water pycnometry” specifies
1987 methods and protocols for determining the density of materials derived at various stages of
1988 processing of ELTs. As the density of such materials differs from that of similar materials derived
1989 from ethylene propylene diene monomer rubber (EPDM) products, it also provides a method
1990 that could be useful when determining the origin of various particle materials derived from such
1991 products (EN 17189 - 2024, 2024).

- 1992 Though the latter may not allow differentiating between primary and secondary rubber
 1993 materials, it could be useful in the case of a recycled content requirement for rubber which
 1994 differentiates between closed loop and open loop recycle.
- 1995 **EN 17308:2024 Materials produced from ELT - Steel wire - Determination of the non-metallic**
 1996 **content**
- 1997 Standard EN 17308:2024 on “Materials produced from end-of-life tyres - Steel wire -
 1998 Determination of the non-metallic content” details two different methods (pyrolysis and
 1999 hydrostatic) for estimating the level of non-metallic residues in steel cord recovered from ELT.
 2000 The standard details how to prepare a sampling plan and how to collect and handle samples as
 2001 well as their testing in the two different methods.
- 2002 **CEN/TS 17045:2020 Materials obtained from end-of-life tyres - Quality criteria for the**
 2003 **selection of whole tyres, for recovery and recycling processes**
- 2004 The technical specification CEN/TS 17045:2020 on “Materials obtained from end-of-life tyres -
 2005 Quality criteria for the selection of whole tyres, for recovery and recycling processes” is aimed
 2006 at facilitating the determination of an ELT as a tyre that can be subjected to recycling or recovery.
 2007 In other words, the specification aims at facilitating the determination of the “end-of-waste”
 2008 status, clarifying conditions and quality parameters for an ELT to be intended for recycling or
 2009 recovery operations. The document does not detail criteria for determining when an ELT can be
 2010 reused. It applies to mopeds and motorcycled, passenger cars, trucks and buses, industrial,
 2011 agricultural and industrial vehicles but not to bicycle or aircraft tyres nor to solid tyres in either
 2012 of the vehicle categories. Based on the definition that the specification gives for the “recycling
 2013 process”, the scope of treatment processes that are considered as recycling for tyres includes
 2014 physical, mechanical and chemical processes resulting in secondary raw materials or products.
 2015 Energy recovery and use of products as a fuel are excluded (CEN/TS 17045:2020, 2020).
- 2016 The technical specifications could be of interest should measures on the recyclability of tyres be
 2017 developed in future ESPR legislation.
- 2018 **4.4.2. Mandates issued by the European Commission to the**
 2019 **European Standardisation Organisations (ESOs)**
- 2020 The European Commission’s Mandate M/457 (21 Dec 2009) tasks CEN, CENELEC, and ETSI with
 2021 developing European standards for tyre pressure gauges (TPG) and their interoperability with
 2022 tyre pressure monitoring systems (TPMS). The goal was to ensure accurate, state-of-the-art,
 2023 safe metrological performance and interoperable communication between TPG and TPMS to
 2024 support road safety and energy efficiency objectives linked to Regulation (EC) No 661/2009,
 2025 which requires TPMS on new cars.
- 2026 No further mandates have been identified so far.

2027 **4.4.3. Test standards in individual Member States**

2028 In addition to ISO and EN standards, some EU member states have their own national tyre
 2029 standards. However, due to the harmonisation efforts in the European Union, several national
 2030 standards for tyres are now obsolete, withdrawn or superseded by EN or ISO standards.

2031 **Table 4-9** presents an overview of national tyre-related standards in EU member states that are
 2032 currently valid.

2033 **Table 4-9: National tyre-related standards in EU member states.**

| Country | Type of tyre | Standard | Title |
|---------|--|-------------------|--|
| Spain | Passenger car | UNE 69014:1991 | Tyres, rims and valves. Passenger car tyres. Dimensional characteristics |
| Spain | Passenger car | UNE 26255:1979 | Road vehicles. Passenger car wheels. Test method |
| Spain | not specified | UNE 69050:2017 | Tyres, rims and valves. Tyre use cycle. Maintenance, repair and regrooving of tyres manual |
| Spain | not specified beyond second-hand tyres | UNE 69051:2017 | Tyres, rims and valves. Tyre use cycle. Second-hand tyres |
| France | Lightweight vehicles | NF T47-749:2020 | Determination of control and quality criteria for the classification of reusable lightweight vehicle tyres |
| France | EoL tyre | XP T47-753:2007 | End of life tyres (ELT) - Determination of the format of products from primary shredding - Method based on the automated measurement of the largest projected length |
| France | EoL tyre | XP T47-759:2009 | End of life tyres (ELT) - Sampling of products from primary shredding - Scenario pile being moved |
| France | EoL tyre | XP T47-760:2010 | End of life tyres (ELT) - Characterisation of products from primary shredding - Guidance for a testing campaign |
| France | EoL tyre | XP T47-762-1:2011 | End of Life Tyres (ELT) - Sampling of steel from primary shredding or grinding process of End of Life Tyres - Part 1: conveyor scenario |
| France | EoL tyre | XP T47-763-1:2012 | End of life tyres (ELT) - Determination of density, porosity and void ratio of shredded tyres - Method(s) of measurement and test protocol(s) - Part 1: method based on water pycnometry (shredded tyres in the abounded state) |
| France | EoL tyre | XP T47-763-2:2012 | End of life tyres (ELT) - Determination of density, porosity and void ratio of shredded tyres - Method(s) of measurement and test protocol(s) - Part 2: method based on the measure of the compressibility (shredded tyres under stress) |
| France | EoL tyre | XP T47-765:2011 | End of Life Tyres (ELT) - Characterisation of granulates from granulation processes - Guidance for a testing campaign |

| Country | Type of tyre | Standard | Title |
|---------|---|-----------------|---|
| Germany | Passenger car | DIN 7803-5:1991 | Tyres for passenger cars; radial tyres; designation and marking |
| Germany | Bicycle | DIN 7800:1981 | Tyres for bicycles |
| Germany | Motorcycle | DIN 7801:1984 | Tyres for small cubic capacity motorcycles |
| Germany | Truck, bus, commercial vehicle | DIN 7805-3:1988 | Tyres for commercial vehicles and their trailers; radial construction tyres with a nominal aspect ratio exceeding > 95 % |
| Germany | Truck, bus, and commercial vehicle | DIN 7805-4:1988 | Tyres for commercial vehicles and their trailers; radial construction tyres; tubeless tyres mounted on 15° tapered rims |
| Germany | Truck, bus, and commercial vehicle | DIN 7811-1:1994 | Tyres for industrial and lift trucks; part 1: normal section sizes in diagonal construction |
| Germany | Truck, bus, and commercial vehicle | DIN 7811-2:1994 | Tyres for industrial and lift trucks; part 2: wide section sizes in diagonal construction |
| Germany | Truck, bus, and commercial vehicle | DIN 7805-5:1983 | Tyres for trucks, buses and their trailers; dual spacings and clearance for tyres on 15° tapered rims |
| Germany | Truck, bus, and commercial vehicle | DIN 7805-6:2020 | Tyres for commercial vehicles and their trailers - Part 6: Relationship between load-carrying capacity and speed |
| Germany | Agricultural, forestry and construction | DIN 7799-1:1981 | Tyres for road making machines, earth moving machines and road graders; regular sizes in diagonal construction |
| Germany | Agricultural, forestry and construction | DIN 7807:1995 | Agricultural drive wheel tractor tyres in radial construction - Service description (load index - speed symbol) marked tyres |
| Germany | Mobile cranes and specialised machines | DIN 7798-1:1988 | Tyres for earth moving machinery, dumpers and special vehicles in service on and off the road; diagonal ply tyres with a nominal aspect ratio exceeding 90% |
| Germany | Mobile cranes and specialised machines | DIN 7798-2:1988 | Tyres for earth moving machinery, dumpers and special vehicles in service on and off the road; wide base diagonal ply tyres |
| Germany | Mobile cranes and specialised machines | DIN 7798-3:1988 | Tyres for earth moving machinery, dumpers and special vehicles in service on and off the road; radial tyres with a nominal aspect ratio exceeding 90 % |
| Germany | Mobile cranes and specialised machines | DIN 7798-4:1988 | Tyres for earth moving machinery, dumpers and special vehicles in service on and off the road; wide base radial tyres |
| Germany | Mobile cranes and specialised machines | DIN 15076:1977 | Cranes; flanged crane rail wheels with tyre, with plain bearings, without gear wheel |
| Germany | Mobile cranes and specialised machines | DIN 15077 | Cranes; flanged crane rail wheels with tyre, with plain bearings, with gear wheel |

| Country | Type of tyre | Standard | Title |
|---------|--|-----------------|---|
| Germany | Mobile cranes and specialised machines | DIN 15080:1977 | Cranes; flanged crane rail wheels with tyre, with roller bearings, without gear wheel |
| Germany | Mobile cranes and specialised machines | DIN 15081:1977 | Cranes; flanged crane rail wheels with tyre, with roller bearings, with gear wheel |
| Germany | Mobile cranes and specialised machines | DIN 15083:1977 | Cranes; crane rail wheels, machined tyres |
| Germany | not specified | DIN 7845-1:1987 | Rubber solid tyres; dimensions and load capacities |
| Germany | not specified | DIN 7845-2:1977 | Rubber solid tyres; design guidelines for conical bases |
| Germany | not specified | DIN 7852:2022 | Rubber solid tyres for pneumatic tyre rims |

2034 Source: Own compilation

2035 As can be seen in the table, apart from its own passenger-car dimensional characteristics and
 2036 wheel tests, Spain’s UNE standards include maintenance, repair/regrooving, and second-hand
 2037 tyres. France has a set of experimental (XP) ELT norms defining criteria for reusable tyres and
 2038 standardised methods for classifying, sampling, and characterizing shredded tyres and derived
 2039 steel. Finally, Germany’s DIN portfolio is the broadest, with a heavy emphasis on commercial,
 2040 industrial, agricultural, and specialised machinery tyres, with numerous parts specifying
 2041 construction types (radial/diagonal), wide-base variants, dimensions, load/speed relationships,
 2042 industrial truck tyre sizes, rubber solid tyres and their bases, and even crane rail wheels with
 2043 tyres.

2044 4.4.4. Third country test standards

2045 Many countries outside of the EU apply their own testing requirements. This section provides
 2046 an overview of key third country test standards, with a focus on American (ASTM/SAE) standards
 2047 given their relevance and global recognition.

2048 4.4.4.1. ASTM Standards

2049 The American Society for Testing and Materials (ASTM), now known as ASTM International,
 2050 develops a wide range of voluntary consensus standards that are widely used across the tyre
 2051 industry. **Table 4-10** presents an overview of ASTM tyre-related standards.

2052 **Table 4-10: ASTM tyre-related standards.**

| Standard | Type of tyre | Title |
|--------------------------|---------------|---|
| ASTM D 1871:2025 | not specified | Standard Test Method for Adhesion Between Tire Bead Wire and Rubber |
| ASTM D 4776/D 4776M:2025 | not specified | Standard Test Method for Adhesion of Tire Cords and Other Reinforcing Cords to Rubber Compounds by H-Test Procedure |

| Standard | Type of tyre | Title |
|--------------------------|----------------------------|--|
| ASTM D 6270:2025 | EoL tyre | Standard Practice for Use of Scrap Tires in Civil Engineering Applications |
| ASTM D 7760:2018 | EoL tyre | Standard Test Method for Measurement of Hydraulic Conductivity of Materials Derived from Scrap Tires Using a Rigid Wall Permeameter |
| ASTM E 1136:2019 | not specified | Standard Specification for P195/75R14 Radial Standard Reference Test Tire |
| ASTM E 1337:2024 | not specified | Standard Test Method for Determining Longitudinal Peak Braking Coefficient (PBC) of Paved Surfaces Using Standard Reference Test Tire |
| ASTM E 1551:2016 | not specified | Standard Specification for a Size 4.00-8 Smooth Tread Friction Test Tire |
| ASTM E 1844:2008 | not specified | Standard Specification for a Size 10 × 4–5 Smooth-Tread Friction Test Tire |
| ASTM E 1859/E 1859M:2024 | not specified | Standard Test Method for Friction Coefficient Measurements Between Tire and Pavement Using a Variable Slip Technique |
| ASTM E 501:2008 | not specified | Standard Specification for Standard Rib Tire for Pavement Skid-Resistance Tests |
| ASTM E 524:2008 | not specified | Standard Specification for Standard Smooth Tire for Pavement Skid-Resistance Tests |
| ASTM F 1016:2007 | not specified | Standard Practice for Linear Tire Treadwear Data Analysis |
| ASTM F 1046:2021 | Passenger car, Light Truck | Standard Guide for Preparing Artificially Worn Passenger and Light Truck Tires for Testing |
| ASTM F 1112a:2006 | not specified | Standard Test Method for Static Testing of Tubeless Pneumatic Tires for Rate of Loss of Inflation Pressure |
| ASTM F 1426:2025 | Used tyres | Standard Practice for Identifying Tire Tread Surface Irregular Wear Patterns Resulting from Tire Use |
| ASTM F 1502:2023 | Passenger car, Light Truck | Standard Test Method for Static Measurements on Tires for Passenger Cars, Light Trucks, and Medium Duty Vehicles |
| ASTM F 1572:2021 | not specified | Standard Test Methods for Tire Performance Testing on Snow and Ice Surfaces |
| ASTM F 1649:2020 | Passenger car | Standard Test Methods for Evaluating Wet Braking Traction Performance of Passenger Car Tires on Vehicles Equipped with Anti-Lock Braking Systems |
| ASTM F 1650:2021 | not specified | Standard Practice for Evaluating Tire Traction Performance Data Under Varying Test Conditions |
| ASTM F 1805:2020 | not specified | Standard Test Method for Single Wheel Driving Traction in a Straight Line on Snow- and Ice-Covered Surfaces |
| ASTM F 1806:2021 | not specified | Standard Practice for Tire Testing Operations—Basic Concepts and Terminology for Reference Tire Use |
| ASTM F 1922:2021 | not specified | Standard Test Method for Tires, Pneumatic, Vehicular, Highway |
| ASTM F 1923:2021 | not specified | Standard Test Method for Tires, Pneumatic, Low Speed, Off Highway |
| ASTM F 1971:2012 | not specified | Standard Test Method for Electrical Resistance of Tires Under Load On the Test Bench |
| ASTM F 2493:2024 | not specified | Standard Specification for P225/60R16 97S Radial Standard Reference Test Tire |

| Standard | Type of tyre | Title |
|-------------------|-----------------------------------|--|
| ASTM F 2663a:2021 | Passenger car, Light Truck | Standard Test Method for Bead Unseating of Tubeless Passenger and Light Truck Tires |
| ASTM F 2779:2024 | Truck, bus and commercial vehicle | Standard Practice for Commercial Radial Truck-Bus Tires to Establish Equivalent Test Severity Between a 1.707-m (67.23-in.) Diameter Roadwheel and a Flat Surface |
| ASTM F 2803:2021 | not specified | Standard Test Method for Evaluating Rim Slip Performance of Tires and Wheels |
| ASTM F 2838:2025 | Passenger car, Light Truck | Standard Practice for Accelerated Laboratory Aging of Radial Passenger Car and Light Truck Tires through Load Range E for the Laboratory Generation of Belt Separation |
| ASTM F 2869:2024 | Light Truck | Standard Practice for Radial Light Truck Tires to Establish Equivalent Test Severity Between a 1.707-m (67.23-in.) Diameter Rotating Roadwheel and a Flat Surface |
| ASTM F 2870:2023 | Truck, bus and commercial vehicle | Standard Specification for 315/70R22.5 154/150L Radial Truck Standard Reference Test Tire |
| ASTM F 2871:2025 | Truck, bus and commercial vehicle | Standard Specification for 245/70R19.5 136/134M Radial Truck Standard Reference Test Tire |
| ASTM F 2872:2019 | Truck, bus and commercial vehicle | Standard Specification for 225/75R16C 116/114S M+S Radial Light Truck Standard Reference Test Tire |
| ASTM F 3015:2021 | Passenger car, Light Truck | Standard Test Method for Accelerated Laboratory Roadwheel Generation of Belt Separation in Radial Passenger Car and Light Truck Tires through Load Range E |
| ASTM F 3675:2024 | not specified | Standard Specification for 225/45R17 94H XL Radial Standard Reference Test Tire |
| ASTM F 3676:2024 | not specified | Standard Specification for 225/45R17 94V XL Radial Standard Reference Test Tire |
| ASTM F 3677:2023 | Truck, bus and commercial vehicle | Standard Specification for 315/70R22.5 154/150L Radial Truck Standard Reference Test Tire SW |
| ASTM F 3678:2025 | Truck, bus and commercial vehicle | Standard Specification for 245/70R19.5 136/134M Radial Truck Standard Reference Test Tire SW |

2053 Source: Own compilation

2054 ASTM standards include foundational terminology and operations (e.g. F538, F1806), as well as
 2055 tyre performance methods for traction, snow/ice, wet braking, rim slip, electrical resistance,
 2056 pressure loss, and sidewall cracking (e.g. F1572, F1649). Several standards also define friction
 2057 measurement between tyre and pavement and specify standardised test tyres used as
 2058 references for skid resistance and vehicle/road evaluations (e.g. E1859/E1859M, E501).

2059 Furthermore, ASTM covers data analysis and wear diagnostics (F1016, F1426), dimensional
 2060 measurements and footprint characterisation for passenger tyres (F421, F762/F762M, F870),
 2061 and bead unseating/static measurements applicable to passenger and light truck tyres (F2663a,
 2062 F1502).

2063 For commercial truck/bus tyres, ASTM standards provide specifications for multiple standard
 2064 reference test tyres and practices to align drum versus flat-surface severities (e.g. F3678, F2871).
 2065 Finally, EoL tyre utilisation and material characterisation in civil engineering are also addressed
 2066 (D6270, D7760).

2067 **4.4.4.2. SAE Standards**

2068 The Society of Automotive Engineers (SAE) establishes technical standards that evaluate tyre
 2069 performance within the broader context of vehicle design and operation. **Table 4-11** presents
 2070 an overview of SAE tyre-related standards

2071 **Table 4-11: SAE tyre-related standards.**

| Standard | Type of tyre | Title |
|--------------------------|---|--|
| SAE ARP 4955A:2018-09-02 | Aircraft | Recommended Practice for Measurement of Static and Dynamic Characteristic Properties of Aircraft Tires |
| SAE ARP 5257B:2020-09-18 | Aircraft | Tire Overspeed Landing Test |
| SAE ARP 5265C:2021-09-20 | Aircraft | Minimum Operational and Maintenance Responsibilities for Aircraft Tire Usage |
| SAE ARP 6265:2019-10-17 | Aircraft | Tire Burst Test Methodology |
| SAE AS 4833A:2019-10-17 | Aircraft | Aircraft New Tire Standard - Bias and Radial |
| SAE AS 50141C:2023-06-02 | Aircraft | Tube, Pneumatic Tire, Aircraft |
| SAE CRP-011:1996-12-01 | Truck, bus and commercial vehicle | Truck Tire Characterization |
| SAE J 1025:2012-08-31 | Truck, bus and commercial vehicle | Test Procedures for Measuring Truck Tire Revolutions per Kilometer/Mile |
| SAE J 1107:2012-08-31 | Passenger car | Laboratory Testing Machines and Procedures for Measuring the steady state Force and Moment Properties of Passenger Car Tires |
| SAE J 1232:2020-03-11 | Passenger car, Light Truck | Passenger and Light Truck Tire Traction Device Profile Determination and Classification |
| SAE J 1269:2020-12-22 | Passenger car, Truck, bus, commercial vehicle | Rolling Resistance Measurement Procedure for Passenger Car, Light Truck, and Highway Truck and Bus Tires |
| SAE J 1270:2017-10-12 | Passenger car, Truck | Measurement of Passenger Car, Light Truck, and Highway Truck and Bus Tire Rolling Resistance |
| SAE J 1315:2019-11-20 | Industrial and Off-road | Off-Road Tire and Rim Selection and Application |
| SAE J 1379:2020-11-12 | Truck, bus and commercial vehicle | Rolling Resistance Measurement Procedure for Highway Truck and Bus Tires |
| SAE J 1380:2020-11-09 | Truck, bus and commercial vehicle | The Measurement of Highway Truck and Bus Tire Rolling Resistance |

| Standard | Type of tyre | Title |
|-----------------------|---|---|
| SAE J 1440:1993-09-01 | Agricultural, forestry and construction | Off-Road Tire and Rim Classification Forestry Machines |
| SAE J 1561:2019-09-11 | Passenger car | Laboratory Speed Test Procedure for Passenger Car Tires |
| SAE J 1633:2019-09-11 | Truck, bus and commercial vehicle | Laboratory Speed Test Procedure for Light Truck Tires |
| SAE J 2047:2019-11-14 | not specified | Tire Performance Terminology |
| SAE J 2611:2017-02-13 | Industrial and Off-road | Off-Road Tire Replacement Guidelines |
| SAE J 2673:2021-03-01 | Truck, bus and commercial vehicle | Straight-Line Braking Test for Truck and Bus Tires |
| SAE J 2675:2024-05-09 | Truck, bus and commercial vehicle | Combined Cornering and Braking Test for Truck and Bus Tires |
| SAE J 2704:2018-11-20 | not specified | Tire Normal Force/Deflection and Gross Footprint Dimension Test |
| SAE J 2705:2018-11-20 | not specified | Tire Quasi-Static Envelopment of Triangular/Step Cleats Test |
| SAE J 2828:2016-11-18 | Industrial and Off-road | Off-Road Tire Fire Handling Guidelines |
| SAE J 345:2018-02-15 | Passenger car | Wet or Dry Pavement Passenger Car Tire Peak and Locked Wheel Braking Traction |
| SAE J 751:2025-02-25 | Industrial and Off-road | Off-Road Tire and Rim Classification - Off-Road Work Machines |
| SAE J 966:2019-11-14 | Passenger car | Test Procedure for Measuring Passenger Car Tire Revolutions Per Mile |

2072 Source: Own compilation

2073 The table consolidates key SAE standards that cover measurement methods, performance
2074 testing, specifications, and safety/maintenance practices across multiple tyre types. For aircraft,
2075 it covers property measurement, operational/maintenance responsibilities, new tyre standards,
2076 tubes, and critical safety tests like overspeed landing and burst methodology (e.g. ARP 5257B,
2077 ARP 6265). Besides rolling resistance and measurements, passenger and light truck entries
2078 address tyre force–moment characterisation, speed testing, uniformity machine requirements,
2079 traction device classification, braking traction, and revolutions per distance (e.g. J 1107, J 1561).
2080 Industrial/off-road and agricultural/forestry standards cover tyre/rim classification,
2081 selection/replacement guidelines, and fire-handling (e.g. J 1315, J 2611).

2082 General methods like tyre performance terminology and tests for normal force/deflection,
2083 footprint, and quasi-static cleat envelopment (e.g. J 2047, J 2704) are likewise addressed.
2084 Overall, the set maps the SAE landscape for tyre properties, safety-critical testing, reference
2085 equipment, and application-specific specifications across aviation, passenger/light truck,
2086 commercial, off-road, and agricultural domains.

2087 4.4.4.3. Others

2088 **Table 4-12** presents an overview of national tyre-related standards in other countries.2089 **Table 4-12: National tyre-related standards in third countries.**

| Country | Type of tyre | Standard | Title |
|-----------|--|-----------------------------|---|
| Australia | Industrial and off-road | AS 4457.2:2024 | Earth-moving machinery - Off-the-road wheels, rims and tyres - Maintenance and repair, Part 2: Tyres |
| Australia | Passenger car, truck, bus | AS 1973:1993 | Pneumatic tyres - Passenger car, light truck, and truck/bus - Retreading and repair processes |
| Brazil | Aircraft | ABNT NBR 7030:2015-04-10 | Aircraft - Storage of tyre and tube tyre |
| Brazil | Aircraft | ABNT NBR 8495:1996-02-28 | Aircraft - Tyre inspection |
| Brazil | Motorcycle | ABNT NBR 14180-9:2025-04-11 | Safety vehicular inspection - Motorcycles and the like it Part 9: Tyres and wheels |
| Brazil | Passenger cars and trailers | ABNT NBR NM 250:2001-04-30 | Tyres for passenger cars, station wagons and trailers - Requirements and test methods |
| Brazil | Truck, bus, commercial vehicle | ABNT NBR NM 251:2001-04-30 | Tyres for light trucks, micro-buses, trailers and trucks buses and trailers - Requirements and test methods |
| Brazil | not specified | ABNT NBR 14040-9:2023-06-13 | Safety vehicular inspection - Light and heavy vehicles Part 9: Tyres and wheels |
| Brazil | not specified | ABNT NBR NM 225:2000-10-30 | Standards for tyre selection for retreading and repair - Inspection and identification |
| Canada | Passenger car | CSA SPE-115:2021 | Minimum energy performance technical specification for passenger tyres |
| Japan | Passenger car, Truck, Bus | D4202:1994 | Automobile tyres - Designation and dimensions |
| UK | Agricultural , forestry and construction | BS AU 50-1.4.4b:1992-10-15 | Tyres and wheels. Tyres. Agricultural tractor and machine tyres. Specification for ply rating marked series tyres for log skidders and for logging and forestry service |
| UK | Industrial and Off-road | BS AU 50-1.5.3:1994-02-15 | Tyres and wheels. Tyres. Industrial vehicle tyres. Specification for pneumatic tyres (metric series) on 5° tapered or flat base rims: load ratings |
| UK | Industrial and Off-road | BS AU 50-1.5.4a:1994-02-15 | Tyres and wheels. Tyres. Industrial vehicle tyres. Specification for solid tyres (metric series) for pneumatic tyre rims: designation, dimensions and marking |
| UK | Industrial and Off-road | BS AU 50-1.5.5:1998-09-15 | Tyres and wheels. Tyres. Industrial vehicle tyres. Specification for solid tyres (metric series) for pneumatic tyre rims. Load ratings |

| Country | Type of tyre | Standard | Title |
|---------|--|----------------------------|---|
| UK | Industrial and Off-road | BS AU 50-1.5.6:1994-02-15 | Tyres and wheels. Tyres. Industrial vehicle tyres. Specification for cylindrical and conical base rubber solid tyres (metric series), designation, dimensions and marking |
| UK | Mobile cranes and specialised machines | BS 3037-1:1958-11-06 | Specification for tyres for crane rail wheels. Double-flanged parallel-tread tyres |
| UK | Mobile cranes and specialised machines | BS 3037-2:1975-03-27 | Specification for tyres for crane rail wheels. Forged or rolled steel double flanged rail wheels and tyres (metric units) |
| UK | Motorcycle | BS AU 50-1.6.3a:1995-12-15 | Tyres and wheels. Tyres. Motorcycle tyres. Specifications for designations, dimensions and load ratings for code designated series (diameter codes 4 to 12) tyres |
| UK | Motorcycle | BS AU 50-1.6.8:2000-06-15 | Tyres and wheels. Tyres. Motorcycle tyres. Method of measuring tyre rolling circumference for new tyres under loaded conditions. |
| UK | Passenger car | BS AU 50-1.1.2:2001-04-15 | Tyres and wheels. Tyres. Car tyres. Methods for measuring rolling circumference. Loaded new tyres |
| UK | Truck, bus, commercial vehicle | BS AU 50-1.2.1b:2001-09-21 | Tyres and wheels. Tyres. Commercial vehicle tyres. Tyres |
| UK | Truck, bus, commercial vehicle | BS AU 50-1.2.4:1994-01-15 | Tyres and wheels. Tyres. Commercial vehicle tyres. Method of test for verifying tyre capabilities |
| UK | Truck, bus, commercial vehicle | BS AU 50-2.7b:2017-08-30 | Tyres and wheels. Wheels and rims. Section 7b: Code of practice for the selection and care of tyres and wheels for commercial vehicles |
| UK | not specified | BS AU 50-1.0.1:1999-05-15 | Tyres and wheels. Tyres. General. Method of test for measuring tyre uniformity |
| UK | not specified | BS AU 50-1.0d:1998-04-15 | Tyres and wheels. Tyres. General |
| UK | not specified | BS AU 50-1.5.1:1994-07-15 | Tyres and wheels. Tyres. Industrial vehicle tyres. Specification for code-designated series tyres |
| UK | not specified | BS AU 50-1.8:1989-11-30 | Tyres and wheels. Tyres. Code of practice for the storage of tyres, inner tubes and flaps |

2090 Source: Own compilation

2091 The table compiles national tyre standards spanning definitions, measurements, performance,
2092 safety inspection, repair/retreading, and application-specific specifications, with Brazil and the
2093 UK being the countries found with the most numerous sets. Brazil's ABNT standards address
2094 aviation tyre storage and inspection (ABNT NBR 7030, 8495), passenger and light/commercial
2095 tyre requirements and tests (NM 250, NM 251), safety inspection of tyres and wheels for
2096 motorcycles and for light/heavy vehicles (NBR 14180-9:2025, NBR 14040-9:2023), and tyre
2097 selection for retreading (NM 225).

2098 The UK has a broad testing landscape, from general tyre uniformity testing and storage practices
2099 (BS AU 50-1.0.1, 50-1.0d, 50-1.8, 50-1.5.1), commercial vehicle tyre specifications, capability
2100 verification tests, and care/selection codes (BS AU 50-1.2, 50-2.7b), passenger car rolling
2101 circumference methods (BS AU 50-1.1.2), motorcycle tyre dimensions, load ratings, and rolling
2102 circumference measurement (BS AU 50-1.6), to industrial and off-road pneumatic and solid tyre
2103 specifications and load ratings (BS AU 50-1.5) and crane rail wheel tyres (BS 3037).

2104 4.4.5. Comparative analysis of overlapping test standards

2105 Though various standards exist regarding the performance of tyres (in relation to wet grip, ice
2106 grip, etc.), and on their emissions (e.g. noise, abrasion), such aspects are not in the focus of this
2107 study; they are already addressed under existing EU legislation or are expected to be in the short
2108 term and are thus not expected to be addressed under ESPR. As such, these standards have been
2109 mentioned but not reviewed in detail and a comparative analysis is viewed as superfluous. In
2110 contrast, standards on resources use, recycling of tyres and material aspects of tyres are not
2111 common.

2112 Though a number of EN standards concerning materials obtained from End-of-Life Tyres (ELT)
2113 (see **Section 4.4.1.4**) provide a framework for the characterisation, sampling, and quality
2114 assessment of secondary raw materials derived from used tyres, these appear to not to have
2115 overlaps, making a comparative analysis redundant. For tyres, there is currently no widely
2116 adopted, tyre-specific standard that provides a precise, uniform method to calculate and verify
2117 recycled content across all constituent materials (rubber compounds, carbon black/fillers, textile
2118 cords, steel) with full traceability. Industry practice is heterogeneous. “Renewable content”
2119 (e.g., natural rubber, biobased inputs) is often reported using supplier data and chain-of-custody
2120 or mass-balance approaches. Reporting formats and verification depth are not consistently
2121 standardised across the tyre sector. From exchange with stakeholders, the consultant
2122 understands that though tyre dimensions may be covered by certain legislation and standards,
2123 this does not influence the variety of tyre dimensions applied in practice to tyres placed on the
2124 market. Standard tyre dimensions are specified e.g. in UNECE Regulation No 108, however when
2125 measuring tyres for specification of dimensions, UNECE Regulation No 30 provides for tolerances
2126 of 4% or 6% for radial and bias ply tyre construction. This leads to large variance in the actual
2127 dimensions of tyres. The large variety of tyre dimensions, which is understood to be in
2128 continuous increase, is understood to be one of the aspects that hinder tyre retreading, in
2129 particular in the C1 and C2 classes. Should requirements be considered under ESPR aiming at
2130 increasing the number of tyres that can be retread, some form of standardisation may be
2131 needed which aims at increasing harmonisation of tyre dimensions.

2132 A further aspect that has been drawn to the attention of the consultants by stakeholders is the
2133 lack of standards for categorising tyres into the various market tiers. This prohibits comparisons
2134 of tiers of different manufacturers which are specified to be in the same tier.

2135

2136

2137
2138

Stakeholder question:
T1-17: Are you aware of any other gaps of relevance to ESPR?

2139 **4.5. Preliminary conclusions Task 1**

2140 **4.5.1. Definition of tyres**

2141 The scope of this study refers to tyres and their components and materials. Though tyres and
2142 their composition will influence the efficiency of a vehicle, the connection of the tyre to the
2143 vehicle as well as its hubcaps and the vehicle itself are beyond the scope of this study.

2144 Furthermore, as shall become more obvious throughout the chapters of this report, the amount
2145 of data and information available for each of the vehicle tyre groups differs. This may affect the
2146 ability to regulate certain types of products in the short term. However, at this stage all vehicle
2147 tyres are being considered until it can be clarified what ESPR provisions are to address tyres and
2148 how the inclusion of various tyre types in scope shall influence the impacts of such provisions.

2149 The functional unit to be used in further analysis is proposed to be a tyre throughout its life cycle
2150 stages. A standard tyre lifetime in the form of an expected mileage or rather kilometrage is to
2151 be defined based on the vehicle tyre to be analysed. Defining base cases for analysing life cycle
2152 impacts and life cycle costing in later tasks of this study, could be limited to tyres of vehicle
2153 categories for which sufficient data is available.

2154 Tyres are currently not defined as a product in legislation and thus the following definition is
2155 proposed:

2156 “A tyre consists of the casing fitted around the wheel rim of a vehicle. The tyre provides the
2157 interface between the vehicle and the surface (e.g. road or ground) on which the vehicle is
2158 situated. The tyre supports the load of the vehicle and the passengers or goods that it is carrying.
2159 It provides friction between the vehicle and the surface which enables the vehicle to stop,
2160 accelerate, stop and turn. The tyre absorbs irregularities in the surface, enabling the vehicle to
2161 drive through various terrain and weather conditions”.

2162

2163 Questions for stakeholders:
2164 T1-18: Do you agree with the proposed definition for “tyre”?
2165 T1-19: Does the term casing sufficiently reflect the tyre – please consider the
2166 definition to the term casing referred to in **Section 4.2.4.1** above, which suggests the
2167 casing is only the part left after tyre wear. Can you suggest an alternative?
2168 T1-20: Please explain which parts of the definition are suitable for defining a tyre as
2169 a product and propose changes where this is not the case in your opinion.
2170 T1-21: Please state which additional aspects should be addressed in the definition.

2171

2172 4.5.2. Other definitions of relevance to possible ESPR Tyre 2173 legislation

2174 Looking at the definitions of various terms related to tyres and in particular their waste
2175 management shows that for most terms multiple definitions exist. These are discussed under
2176 **Section 4.2.4** where larger differences are apparent and in some cases, questions have been
2177 developed for stakeholders. The overview below compiles the various questions raised. In
2178 particular a definition for tyres as a product is missing as are definitions for certain tyre types
2179 like self-sealing and noise reduction tyres.

2180 Compilation of questions for stakeholders on definitions:
2181
2182 T1-10: What limiting state is relevant in the case of tyres?
2183 T1-11: What criteria could be used to define the point of transition from the limiting
2184 state to EoL?
2185 T1-12: What criteria could be used to define the point of transition from the limiting
2186 state to the state at which a tyre should be sent to retreading?
2187 T1-13: Can the tyre tread abrasion rate be considered a relevant indicator for tyre
2188 service mileage and thus indirectly also to tyre durability?
2189 T1-15: In your opinion, is it necessary to include reference of the various retreading
2190 practices that are applied in practice to the definition of retreading?
2191 T1-16: If tyres are required to be retreadable in future ESPR legislation, do both need
2192 to be possible?
2193 T1-17: Are you aware of any other gaps of relevance to ESPR?

2194
2195 Proposed definition: “A tyre consists of the casing fitted around the wheel rim of a
2196 vehicle. The tyre provides the interface between the vehicle and the surface (e.g.
2197 road or ground) on which the vehicle is situated. The tyre supports the load of the
2198 vehicle and the passengers or goods that it is carrying. It provides friction between
2199 the vehicle and the surface which enables the vehicle to stop, accelerate, stop and
2200 turn. The tyre absorbs irregularities in the surface, enabling the vehicle to drive
2201 through various terrain and weather conditions”.
2202 T1-18: Do you agree with the proposed definition for “tyre”?

2203 T1-19: Does the term casing sufficiently reflect the tyre – please consider the
 2204 definition to the term casing referred to in Section 4.2.4.1 above, which suggests the
 2205 casing is only the part left after tyre wear. Can you suggest an alternative?
 2206 T1-20: Please explain which parts of the definition are suitable for defining a tyre as
 2207 a product and propose changes where this is not the case in your opinion.
 2208 T1-21: Please state which additional aspects should be addressed in the definition.

2209 **4.5.3. Preliminary focus of ESPR legislation and the scope of tyres**
 2210 **covered by this study**

2211 Drawing on the documents summarised in the above sections, it is observed that in many areas
 2212 where tyres and their use impact the environment, these are already covered by existing
 2213 legislation and standards or by ones being developed where they are to be addressed (e.g. rolling
 2214 resistance, noise, abrasion). Different technical parameters of tyres are already addressed in UN
 2215 and EU legislation. The regulation of these ensures that tyres are reliable and safe while also
 2216 fulfilling various performance requirements (some also relating to environmental performance).
 2217 Though these should not be the focus of the current study to avoid double regulation and related
 2218 uncertainties, it shall be of relevance to understand how such performance parameters may be
 2219 impacted by possible ESPR requirements to be considered for future legislation.

2220 In the first four tasks of the preliminary study, all types of tyres have been considered. In the
 2221 development of ESPR legislation, the determination of scope is usually motivated by targeting
 2222 product categories or sub-groups that are associated with environmental impacts, and which
 2223 have a significant market volume. This strategy is applied to increase the probability of new
 2224 provisions leading to significant improvement in terms of the environmental impacts of the
 2225 product group.

2226 For tyres, the following aspects have been identified that could be in the focus of potential future
 2227 ESPR legislation for tyres:

- 2228 • The use of renewable, sustainable and recycled materials in the production of tyres;
- 2229 • Materials and substances used in tyres that have a negative impact on the waste
 2230 management of tyres;
- 2231 • Retreadability of tyres;
- 2232 • Recyclability of tyres;
- 2233 • Provision of information on tyres to various stakeholders (e.g. consumers, authorities,
 2234 waste operators of tyres) in association with the above aspects.

2235 Energy efficiency is considered by the consultant to be covered through rolling resistance
 2236 stipulations under UNECE R117 (implemented by EU type approval) and supported by the Energy
 2237 Label (EU) 2020/740. Though microplastic emissions are not yet covered, standards have been
 2238 developed by UNECE to measure tyre abrasion as a means to regulate such emissions. These are
 2239 expected to lead over time to legislation at international and in any case at EU level (EURO 7).

2240 The ESPR further gives a mandate to develop regulation on product durability, resource
2241 efficiency, carbon and environmental footprints. As life cycle analysis shall be performed under
2242 task 5 of this study, it is assumed that the necessity to regulate tyres based on carbon or
2243 environmental footprints shall be considered at a later stage if relevant. Many of the aspects
2244 referred to above are material related and as such material efficiency is considered indirectly.
2245 Although tyre durability is of relevance in the comparison of tyres, the difficulty of defining
2246 durability in terms of reference to product lifetime is already addressed above. Nonetheless,
2247 tyre durability could be relevant for this study (see below, for example in relation to
2248 retreadability) and it thus remains to be seen how it could be defined. Materials and recyclability
2249 are expected to play a large role in potential ESPR legislation of tyres, which may enable a wider
2250 scope than the energy label as all tyres use similar materials. When looking at waste
2251 management, in particular pyrolysis (which is increasing in volume) processes all types of tyres.

2252 In other words, from a material perspective, as the inclusion of certain tyres in waste
2253 management may influence the composition of secondary materials, excluding certain vehicle
2254 tyre types shall only be considered at a later stage. It is thus suggested at this stage to consider
2255 an open scope. For practical reasons, analysis at the tyre level shall need to look at vehicle tyre
2256 types for which there is an abundance of data, such as C1, C2 and C3 tyres.

2257 In addition, as it is probable that retreadability shall be in focus, making it necessary to compare
2258 impacts between retreadable and non-retreadable tyres, it shall be necessary to consider a
2259 standard service life (i.e., number of km driven) for comparing e.g. how many new tyres
2260 (retreadable and non-retreadable) are needed to provide the standard service life. This shall
2261 need to be specified for each vehicle category tyre class analysed.

2262 Finally, to ensure that future ESPR requirements do not have negative effects on compliance
2263 with existing legislation, additional performance parameters shall need to be defined (e.g. rolling
2264 resistance, air and noise emission), as well as a standard level, to allow analysing whether
2265 changes to the tyre design may result in deviations from this level of performance.

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Questions for stakeholders:

T1-22: Do you agree to the strategy described above for scope?

T1-23: How do you see the relation between the various vehicle tyre types and the areas of focus identified so far for potential ESPR legislation?

T1-24: Which of the vehicle tyre types is relevant to each of the identified areas?

T1-25: In your opinion, which vehicle tyre types (or sub-categories) are not relevant and could be excluded from scope?

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2275 5. MEErP Task 2 – Markets

2276 5.1. Objectives of MEErP Task 2

2277 The main objective of MEErP Task 2 is to provide the necessary market information for the EU-
2278 wide environmental impact of the tyres product group. For this, task 2 provides data on the
2279 supply side of the market, insights into the latest market trends, and a practical data set of prices
2280 and rates to be used in a Life Cycle Cost (LCC) calculation. Under the task, recommendations
2281 shall be offered on a potentially refined product scope in MEErP Task 1. Furthermore, Task 2
2282 shall support MEErP Task 5 in developing base cases, e.g. by assessing the most relevant product
2283 categories from the economic/ commercial perspective.

2284 Concerning market trends, the task will indicate the channels to market, trends in product design
2285 and product features. It shall, furthermore, identify the major players, the number of
2286 employees, role of retreading and maintenance (service models) and observed innovations
2287 within the industry.

2288 5.2. Generic economic data

2289 This section presents official EU statistics (Eurostat) on production, trade and internal sale of
2290 tyres for all EU Member States, or at least half of them, referring to the last available year. The
2291 data refers to both physical volumes and values, i.e. monetary units expressed in manufacturer
2292 prices.

2293 The production data is extracted from PRODCOM - Statistics by product database (Eurostat,
2294 2025g), NACE code 22.11 (see **Table 4-3** in **Section 4.2.4.25** above., while trade data come from
2295 the COMEXT database (Eurostat, 2025a) in which reporting is based on the Harmonised System
2296 (HS) codes developed and maintained by World Custom Organisation, with the last HS
2297 nomenclature dating January 2022 (World Customs Organisation, 2022). Note that neither the
2298 NACE codes nor the HS codes correspond one-to-one to the tyres classification used by the
2299 UNECE R30, R54, R108, R109 or the EU 2020/740 (see also **Table 4-3** above). Therefore, due to
2300 this lack of correspondence, assumptions needed to be made in particular when classifying these
2301 codes into the C1, C2 and C3 classes, respectively. Specifically, class C2 is difficult to classify as it
2302 spreads over codes that are assimilated both with class C1 (HS code 4011.10) and class C2 (HS
2303 code 4011.20). The HS code for retreaded tyres is 4012. Class C1 can be mostly associated with
2304 HS code 401211, while class C3 can generally be associated to code 401212. Class C2 can spread
2305 across both of these codes.

2306 5.2.1. EU production

2307 5.2.1.1. New tyres

2308 Based on figures provided by ETRMA, the production of tyres is dominated by the replacement
2309 market with 76 % of the tyres produced. The remaining 24 % are original equipment, i.e. sold as
2310 part of new cars to the auto industry in a business-to-business setting.

2311 According to Eurostat data (see **Table 5-1**), in 2023 most of the production of tyres in the EU
2312 took place in Central and Eastern Europe of which Romania was the biggest producer among
2313 them, with over 38 million pieces. Among the western European countries, France, as well as
2314 two southern countries, Italy and Spain are notable in this regard. This is also confirmed by
2315 ETRMA data (ETRMA, 2024b) on the number of tyre plants production of their members, which
2316 shows 22 plants in Central and Eastern Europe, 31 in Western Europe⁸ and 16 in Southern Europe
2317 in 2025.

2318 More than half of the production of tyres for buses and lorries/trucks, with a load index above
2319 121 (tyre class C3) took place in Central and Eastern Europe, notably in Poland and Slovakia, with
2320 Spain producing around 3.5 million units (see **Table 5-1**).

2321 No production data is reported for the C2 class tyres and MS level, while motorcycles or bicycle
2322 tyres are produced in only three EU MSs, of which Germany being the largest producer of this
2323 type of tyre. Finally, tyres for agrarian mobile machines were produced mostly in Spain, Poland
2324 and Italy amounting to just over 2 million units.

2325 Detailed data on MS level for the 2023 production of these tyre categories is presented in **Table**
2326 **5-1**.

2327 **Table 5-1: Production of new tyres in the EU27 in 2023 (in units).**

| Country | New pneumatic rubber tyres for motor cars (including for racing cars) Class C1 | New pneumatic rubber tyres for buses or lorries with a load index <= 121 Class C2 | New pneumatic rubber tyres for buses or lorries with a load index > 121 Class C3 | New pneumatic tyres, of rubber, of a kind used on motorcycles or bicycles | Agrarian tyres; other new pneumatic tyres, of rubber |
|----------|--|---|--|---|--|
| France | 15,851,282 | : | 0 | 750,269 | : |
| Germany | : | : | : | 5,304,280 | : |
| Italy | 20,228,918 | 0 | : | : | 494,950 |
| Denmark | 0 | 0 | 0 | 0 | 607 |
| Portugal | 18,726,717 | 0 | 45,288 | 0 | 26 |

⁸ Of these, 15 are in France and 10 in Germany, despite production data for Germany not being reported in the PRODCOM database.

| Country | New pneumatic rubber tyres for motor cars (including for racing cars) Class C1 | New pneumatic rubber tyres for buses or lorries with a load index <= 121 Class C2 | New pneumatic rubber tyres for buses or lorries with a load index > 121 Class C3 | New pneumatic tyres, of rubber, of a kind used on motorcycles or bicycles | Agrarian tyres; other new pneumatic tyres, of rubber |
|--|--|---|--|---|--|
| Spain | 31,697,000 | 0 | 3,471,000 | : | 1,014,000 |
| Sweden | 40,100 | 0 | 0 | 0 | 0 |
| Lithuania | 2,679 | 0 | 0 | 0 | 0 |
| Poland | 28,229,000 | : | 2,279,000 | 0 | 609,393 |
| Czechia | 27,679,884 | : | : | 1,673,963 | : |
| Slovakia | 14,163,194 | 0 | 2,340,449 | 0 | 0 |
| Hungary | 28,324,118 | 0 | : | 0 | 0 |
| Romania | 39,104,347 | 0 | 729,814 | 0 | 127 |
| <i>Sum of all MSs for which data is public</i> | 224,047,239 | 0 | 8,865,551 | 7,728,512 | 2,119,103 |
| EU-27 total* | 270,000,000 | 9,000,000 | 12,000,000 | 10,000,000 | 3,420,000 |

2328 “:” stands for data not available.

2329 Countries for which all values were 0 or “:” values have been excluded.

- 2330 • *Figures provided by Eurostat, based on all the data received from MSs, including those for which
2331 the data is not public and rounded up to preserve confidentiality.

2332 Source: (Eurostat, 2025h), Downloaded April, 2025

2333 Important to note is that the Totals line in **Table 5-1** shows the totals based on the amounts
2334 reported by country in the table. For example, although for Germany there is missing data of C1-
2335 tyres production in 2023, the Prodcom database (Eurostat, 2025h) reports total production of
2336 **C1 tyres at EU-27 level of 270 million tyres**. Thus, although data for some individual countries
2337 are missing,⁹ they are included in the EU-27 overall figures. Similarly, note that while data is not
2338 available or reported as zero for the **C2 class** at MS level for all MSs, the same data source
2339 (Eurostat, 2025h) reports that **9 million units** of this tyre class and **12 million units of C3 class**
2340 were produced in the whole EU-27 in 2023. Production of aircraft tyres in EU-27 in 2023 was
2341 reported to be 40,000 units.

2342 The counterpart values in EUR of the production units presented in **Table 5-1** can be found in
2343 **Table 5-2**.

⁹ For instance, data for Germany is missing in the Eurostat database, but ETRMA (European Tyre and Rubber Industry, 2021) reports 17 tyre production plants of their members in the country as of December 2020, while this number dropped to 10 as of November 2024 (ETRMA, 2024b).

2344 **Table 5-2: Value of the production of new tyres in the EU27 in 2023 (in EUR, current prices).**

| Country | New pneumatic rubber tyres for motor cars (including for racing cars) Class C1 | New pneumatic rubber tyres for buses or lorries with a load index <= 121 Class C2 | New pneumatic rubber tyres for buses or lorries with a load index > 121 Class C3 | New pneumatic tyres, of rubber, of a kind used on motorcycles or bicycles | Agrarian tyres; other new pneumatic tyres, of rubber |
|--|--|---|--|---|--|
| France | 983,536,000 | : | 0 | 28,061,000 | : |
| Germany | : | : | : | 235,582,000 | : |
| Italy | 1,269,828,000 | 0 | : | : | 207,754,000 |
| Denmark | 0 | 0 | 0 | 0 | 13,555 |
| Portugal | 1,278,021,000 | 0 | 58,175,000 | 0 | 2,000 |
| Spain | 1,585,280,000 | 0 | 1,010,084,000 | : | 775,458,000 |
| Sweden | 10,796,512 | 0 | 0 | 0 | 0 |
| Lithuania | 3,000 | 0 | 0 | 0 | 0 |
| Poland | 1,298,547,776 | : | 569,784,676 | 0 | : |
| Czechia | 2,119,265,206 | : | : | 18,255,374 | : |
| Hungary | 1,553,645,892 | 0 | : | 0 | 0 |
| Romania | 2,181,540,623 | 0 | 229,234,641 | 0 | 118,463 |
| <i>Sum of all MSs for which data is public</i> | <i>12,280,464,009</i> | <i>0</i> | <i>1,867,278,317</i> | <i>281,898,374</i> | <i>983,346,018</i> |
| EU-27 total* | 16,000,000,000 | 800,000,000 | 4,000,000,000 | 490,000,000 | 2,000,000,000 |

2345 “:” stands for data not available.

2346 Countries for which all values were 0 or ‘:’ values have been excluded.

2347 *Figures provided by Eurostat, based on all the data received from MSs, including those for
2348 which the data is not public and rounded up to preserve confidentiality.

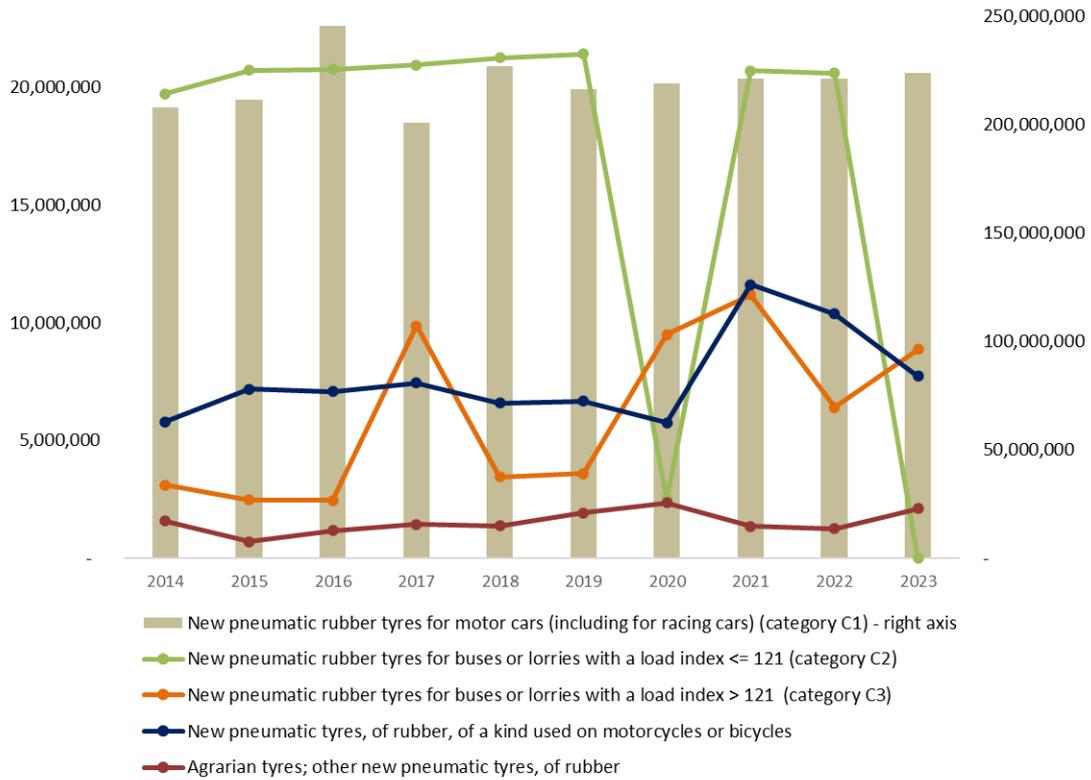
2349 Source: (Eurostat, 2025h), Downloaded April, 2025

2350 Here too, production value data is not available or reported as zero for the class C2 at MS level.
2351 However, the same data source (Eurostat, 2025h) reports overall production value for the whole
2352 EU-27 of EUR 800 million for this tyre class in 2023.

2353 **Table 5-2** shows that, in terms of value, the market for motor cars (C1 class) is the largest,
2354 followed by tyres for heavy duty vehicles (buses and lorries with a load index >121, i.e. C3 class),
2355 with agrarian tyres following closely and motorcycles and bicycle tyres coming in the fourth
2356 place, though they are more numerous in terms of production units than the agrarian tyres are
2357 (see **Table 5-1**).

2358 Regarding the evolution over time of the production of new tyres, as apparent from **Figure 5-1**
2359 below, this was relatively stable, with the exception of a sharp decline in 2023 in the production

2360 of tyres for buses or lorries with a load index below 121 (category C2). The latter may be due to
 2361 a lag in reporting by some MSs. So, this data must be regarded with caution.



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Figure 5-1: Total EU27 production of new tyres over 10 years (in units).

2364

Source: (Eurostat, 2025h), Downloaded April, 2025

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Note: category C1 (bar graph) is represented on the right axis; all the other tyre categories (the line graphs)
 2366 are represented on the left axis.

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5.2.1.2. Retreaded tyres

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A report by EY (EY, 2016) shows that a retreaded tyre can have the same performance as that of a new high-end tyre and that a premium tyre can be retreaded up to three times.¹⁰ Thus, the “lifespan of a tyre produced in Europe”, including its retreaded cycles, can be extended to around 660,000 km. The same report shows that in 2015, retreaded tyres for trucks (class C3) represented 30% of all truck tyres sold in the five EU countries in the scope of the study, namely France, Germany, Spain and United Kingdom. This represented a 20% decrease compared to the 2010 sales. In terms of value, this market amounted to EUR 1.2 billion in 2015 (excluding distribution value) in the EU 27, with important benefits for the domestic firms and tax revenues for the governments.

¹⁰ This may, however, not be true for the “average” tyre which also justifies the inclusion of specific labels for retreaded tyres.

2377 Retreading of tyres for passenger cars (C1 class) occurred mainly in Poland, Romania and Spain
 2378 with a total number of approximately 823,000 units. The largest number of retreaded tyres were
 2379 for buses and lorries¹¹ with about 2.28 million units. Most of the retreaded activity took place in
 2380 Western Europe with Spain, Germany and Italy leading, while France also had a significant
 2381 number of retreaded tyres for buses and lorries – see **Table 5-3**.

2382 **Table 5-3: Number of retreaded tyres in the EU Members States in 2023 (in units).**

| Country | Retreaded tyres of rubber of a kind used on motor cars Class C1 | Retreaded tyres of rubber of a kind used on buses and lorries Class C2 and C3 ¹² | Retreaded tyres of rubber (including of a kind used on aircraft; excluding of a kind used on motor cars; buses or lorries) |
|--|---|---|--|
| France | : | 338,091 | 76,867 |
| Germany | : | 459,861 | 8,462 |
| Italy | : | 422,467 | : |
| Denmark | 0 | 35,684 | 0 |
| Portugal | 72,492 | 89,176 | 27,844 |
| Spain | 149,000 | 460,000 | : |
| Finland | 0 | 63,807 | 1,954 |
| Estonia | 0 | 20,331 | 0 |
| Lithuania | 0 | 66,864 | 0 |
| Poland | 359,538 | 118,114 | 0 |
| Czechia | : | 51,476 | 0 |
| Romania | 239,447 | 68,574 | 0 |
| Bulgaria | 0 | 58,506 | 0 |
| Croatia | 2,253 | 24,136 | 0 |
| <i>Sum of all MSs for which data is public</i> | <i>822,730</i> | <i>2,277,087</i> | <i>115,127</i> |
| EU-27 total* | 1,256,486 | 2,500,261 | 180,000 |

2383 “:” stands for data not available.

2384 Countries for which all values were 0 or “:” values have been excluded.

2385 • *Figures provided by Eurostat, based on all the data received from MSs, including those for which
 2386 the data is not public and rounded up to preserve confidentiality.

2387 Source: (Eurostat, 2025h), Downloaded April, 2025

¹¹ Note that the Eurostat reporting does not differentiate this category of tyres by the load index; therefore C2 and C3 classes cannot be distinguished in this case.

¹² Note that in the PRODCOM database this data does not distinguish according to the load index as in the case of production of new tyres. Therefore, we assume that this includes both C2 and C3. According to stakeholders’ inputs, class C3 is the main retread market. Therefore, we assume that the majority of tyres in this category are of C3 class.

2388 Comparing the data on new tyres from **Table 5-1** with the production of retreaded tyres in **Table**
 2389 **5-3**, only an infinitesimal fraction of C1 tyres are retreaded (i.e. less than 0.4%), while the share
 2390 of C3 tyres retreaded in the total C3 tyres produced is considerably higher, i.e. around 26% in
 2391 2023.

2392 The counterpart value in EUR (manufacturer prices) of the retreaded tyres presented in **Table**
 2393 **5-3** can be found in **Table 5-4**.

2394 **Table 5-4: Value of the retreaded tyres in the EU27 in 2023 (in EUR, current prices).**

| Country | Retreaded tyres of rubber of a kind used on motor cars Class C1 | Retreaded tyres of rubber of a kind used on buses and lorries Class C2 and C3 ¹³ | Retreaded tyres of rubber (including of a kind used on aircraft; excluding of a kind used on motor cars; buses or lorries) |
|--|---|---|--|
| France | : | 81,079,000 | : |
| Germany | : | 115,729,000 | 6,432,000 |
| Italy | : | 92,960,000 | : |
| Denmark | 0 | 4,654,337 | 0 |
| Portugal | 4,317,000 | 16,826,000 | 4,498,000 |
| Spain | 6,698,000 | 122,629,000 | : |
| Finland | 0 | 14,052,000 | 963,000 |
| Estonia | 0 | 2,282,000 | 0 |
| Lithuania | 0 | 10,181,000 | 0 |
| Poland | 9,809,555 | 21,647,732 | 0 |
| Czechia | : | 9,684,969 | 0 |
| Romania | 4,008,733 | 4,680,292 | 0 |
| Croatia | 103,000 | 4,121,000 | 0 |
| <i>Sum of all MSs for which data is public</i> | <i>24,936,288</i> | <i>500,526,330</i> | <i>11,893,000</i> |
| EU-27 total* | 40,471,038 | 564,295,740 | 90,000,000 |

2395 “:” stands for data not available.

2396 Countries for which all values were 0 or ‘:’ values have been excluded.

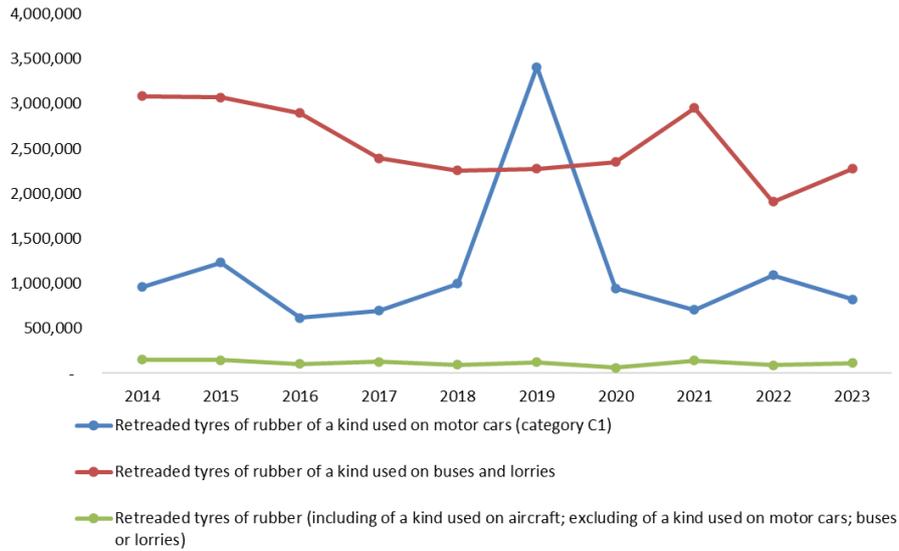
- 2397 • *Figures provided by Eurostat, based on all the data received from MSs, including those for which
 2398 the data is not public and rounded up to preserve confidentiality.

2399 Source: (Eurostat, 2025h), Downloaded April 2025

2400 In terms of evolution over time, as in the case of new tyres, a steady flat trend can be observed
 2401 with regard to the number of retreaded tyres, with the exception of a spike in 2019 of the
 2402 number of retreaded car tyres. This is due to a five-fold increase of this activity in Italy.¹⁴

¹³ ibid

¹⁴ This data should be regarded with caution as an error in the data is conceivable.



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Figure 5-2: Number of retreaded tyres in EU27 over 10 years (in units).

Source: (Eurostat, 2025h), Downloaded April 2025

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5.2.1.3. Extra data

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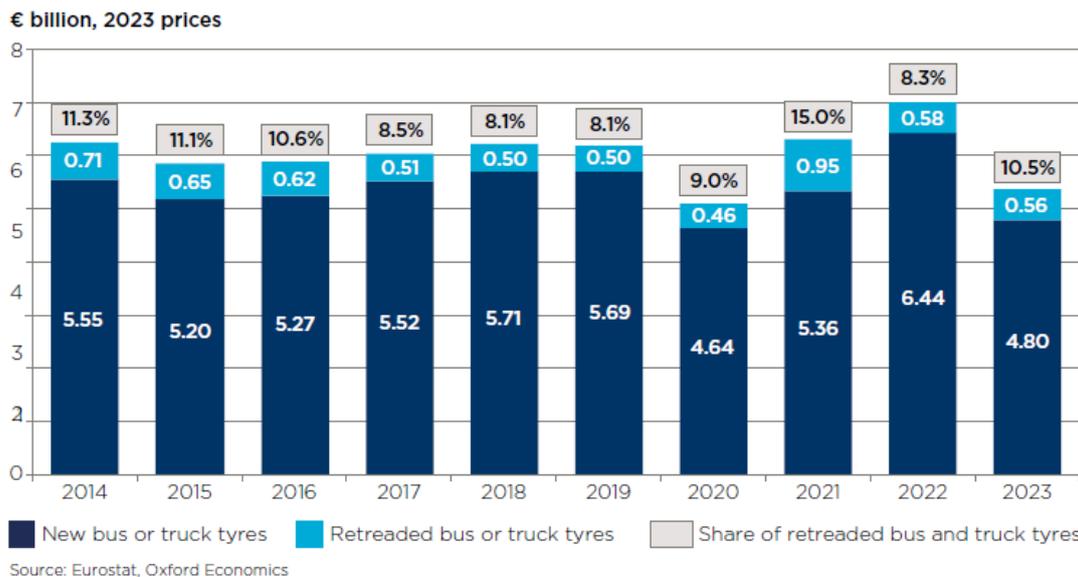
Figure 5-3 shows the value of the production of new bus and truck tyres along with that of retreaded tyres in the EU in constant 2023 prices in billion euro, based on a study commissioned by ETRMA (2024). Note that these figures are not directly comparable with the ones obtained from PRODCOM database (see **Table 5-5**) which reports the production value in current prices, i.e. nominal price at the time of reporting.

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Figure 5-3: Evolution of the production value of new tyres and retreaded tyres for buses and trucks (EUR billion, 2023 prices).

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Source: ETRMA (2024)

2417 To make them comparable, the values reported by PRODCOM have been adjusted for inflation
 2418 based on the inflation multipliers in column (4) of **Table 5-5**.¹⁵ The resulted constant 2023 prices
 2419 are presented in columns (5) and (6) of **Table 5-5**. Despite this adjustment, there are substantial
 2420 discrepancies between the PRODCOM data and those reported in the ETRMA report, with the
 2421 production of new tyres being understated by the ETRMA report, while the data for retreaded
 2422 tyres is overstated. These differences may come from different inflation rates used while the
 2423 ETRMA report may rely on more quality data on retreading collected in-house from their
 2424 members.

2425 **Table 5-5: Evolution of the production of new tyres and retreaded tyres for buses and trucks**
 2426 **(EUR billion).**

| Year (1) | New tyres for buses and lorries (nominal prices) (2) | Retreaded tyres for buses and lorries (nominal prices) (3) | Inflation multipliers based on annual HICP (4) | New tyres for buses and lorries (2023 prices) (5) | Retreaded tyres for buses and lorries (2023 prices) (6) |
|-------------|---|---|--|--|---|
| 2014 | 5.64 | 0.21 | 1.27 | 7.16 | 0.27 |
| 2015 | 5.76 | 0.21 | 1.27 | 7.31 | 0.27 |
| 2016 | 5.55 | 0.23 | 1.26 | 7.03 | 0.29 |
| 2017 | 5.79 | 0.25 | 1.24 | 7.21 | 0.31 |
| 2018 | 5.96 | 0.26 | 1.22 | 7.29 | 0.32 |
| 2019 | 5.97 | 0.26 | 1.20 | 7.19 | 0.31 |
| 2020 | 5.23 | 0.24 | 1.19 | 6.25 | 0.29 |
| 2021 | 6.26 | 0.29 | 1.16 | 7.27 | 0.33 |
| 2022 | 7.24 | 0.32 | 1.06 | 7.70 | 0.34 |
| 2023 | 7.49 | 0.39 | 1 | 7.49 | 0.39 |

2427 Source: (Eurostat, 2025h) and (Eurostat, 2025d). Downloaded April 2025

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Questions for stakeholders:
 T2-1: Do you find the ratio of retreaded tyres to new tyres presented in this report realistic and representative for the EU market?
 T2-2: The triangulation exercise above shows discrepancies in data. Where do you think these discrepancies come from?

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¹⁵ For this we used the EU-wide HICP data average index (Eurostat, 2025d).

2436 5.2.2. EU trade

2437 A report commissioned by ETRMA (ETRMA, 2024b), based on Oxford Economics data shows that
2438 the tyre export market of the EU amounted to a value of EUR 7.4 billion in 2023, while its imports
2439 valued EUR 6.9 billion. This includes new and retreaded tyres for cars, buses and trucks (i.e.
2440 classes C1, C2 and C3). These figures are similar to the ones provided by Eurostat International
2441 Trade database (COMEXT) which represents exports of the same tyre classes in 2023 valuing
2442 about EUR 7.9 billion and imports of about EUR 7 billion. While the direction of the trade balance
2443 is the same in both data sources, Eurostat shows a higher value for the net export.

2444 In fact, COMEXT data shows that since 2014, the EU has always had a positive trade balance in
2445 the classes of tyres named above, except for the years 2022 and 2024. While ETRMA (2024) does
2446 not present data for 2024, the report confirms the trade deficit observed in 2022. The
2447 explanation offered in the report is the temporary lifting by the European Commission of the
2448 anti-dumping duties on imports of bus and truck tyres from China in May 2022. Indeed, this led
2449 to a 26 % increase in the import from China of these tyres in 2022 compared to 2021.

2450 The same report by ETRMA shows that from 2014 to 2023, the main trade partners for the EU
2451 for import were China, the Association of Southeast Asian Nations (Brunei, Cambodia, Indonesia,
2452 Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam), Turkey, South Korea,
2453 Russia, Ukraine and Japan.

2454 The online stakeholder consultation conducted for this preparatory study has revealed a more
2455 detailed picture of the trading partners, as presented in **Table 5-6** and

2456 **Table 5-7.**

2457 **Table 5-6: Extra-EU export partners in 2024.**

| Rank/ Export partner and share | Class C1 | Class C2 | Class C3 | Motorcycles and moped |
|--------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| #1 | United States of America (29.23 %) | United States of America (40.60 %) | United States of America (36.13 %) | United States of America (23.28 %) |
| #2 | Turkey (17.31 %) | Turkey (32.5 %) | Turkey (19.95 %) | Turkey (6.84 %) |
| #3 | Canada (5.26 %) | Ukraine (4.56 %) | Morocco (5.87 %) | China (6.54 %) |
| #4 | Morocco (4.9 %) | Canada (4.56 %) | South Africa (3.96 %) | Colombia (6.33 %) |
| #5 | South Korea (4.55 %) | Mexico (4.43 %) | Ukraine (3.50 %) | Australia (6.26 %) |

2458 Source: Stakeholder (2025)

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2460 **Table 5-7: Extra-EU import partners in 2024.**

| Rank/Import partner and share | Class C1 | Class C2 | Class C3 | Motorcycles and moped |
|-------------------------------|-----------------------------|-----------------------------------|--------------------|-----------------------|
| #1 | China (65.21 %) | China (52.28 %) | Thailand (25.00 %) | China (25.79 %) |
| #2 | Republic of Korea (14.27 %) | Turkey (24.30 %) | Turkey (19.55 %) | Indonesia (18.43 %) |
| #3 | Turkey (6.50 %) | Thailand (8.11 %) | Vietnam (19.36 %) | Japan (17.41 %) |
| #4 | Japan (3.33 %) | United States of America (5.36 %) | China (16.32 %) | Thailand (15.10 %) |
| #5 | India (2.02 %) | Republic of Korea (2.74 %) | Egypt (4.81 %) | India (5.42 %) |

2461 Source: Stakeholder (2025)

2462 Adding to the stakeholder inputs, below we present data from Eurostat on the extra-EU (i.e. EU
 2463 importing from and exporting to third countries) and intra-EU (i.e. trade occurring among the
 2464 EU countries).

2465 **5.2.2.1. Extra-EU trade**2466 **New tyres**

2467 In 2024, according to COMEXT data (Eurostat, 2025a), the EU as a whole imported new tyres
 2468 from the rest of the world, i.e. from non-EU countries, in a value of around EUR 10 billion and
 2469 exported to the rest of the world around EUR 9 billion worth of tyres. Of these, the value of
 2470 imported passenger car tyres (class C1) was around EUR billion 5.7 with a comparable value for
 2471 the exports. Tyres for buses or lorries¹⁶ were imported in a value of over EUR 2.2 billion with
 2472 exports of EUR 1.6 billion.¹⁷

2473 **Figure 5-4** below shows the evolution of import and export values of the EU from/to the rest of
 2474 the world, for the different classes of tyres from 2014 to 2024, based on the latest available
 2475 Eurostat data.

2476 The HS codes of the categories presented in **Figure 5-4** are the following:

- 2477 • New pneumatic tyres, of rubber, of a kind used for motor cars, incl. station wagons and
 2478 racing cars: 401110

¹⁶ Note that the Eurostat (COMEXT) databased does not distinguish between heavy and light load of this tyres category, i.e. between C1 and C2 tyre classes.

¹⁷ Import and export data in units, i.e. number of tyres is not available in the Eurostat (COMEXT) database. Import and export quantities are available in kilograms.

- 2479 • New pneumatic tyres, of rubber, of a kind used for motorcycles or bicycles: 401140 and
- 2480 401150
- 2481 • New pneumatic tyres, of rubber, of a kind used for buses and lorries: 401120
- 2482 • Pneumatic tyres, new, of rubber, of a kind used on agricultural or forestry vehicles and
- 2483 machines: 401161, 401170 and 401192
- 2484 • Other NRMM new tyres: 401162, 401163, 401180 and 40119

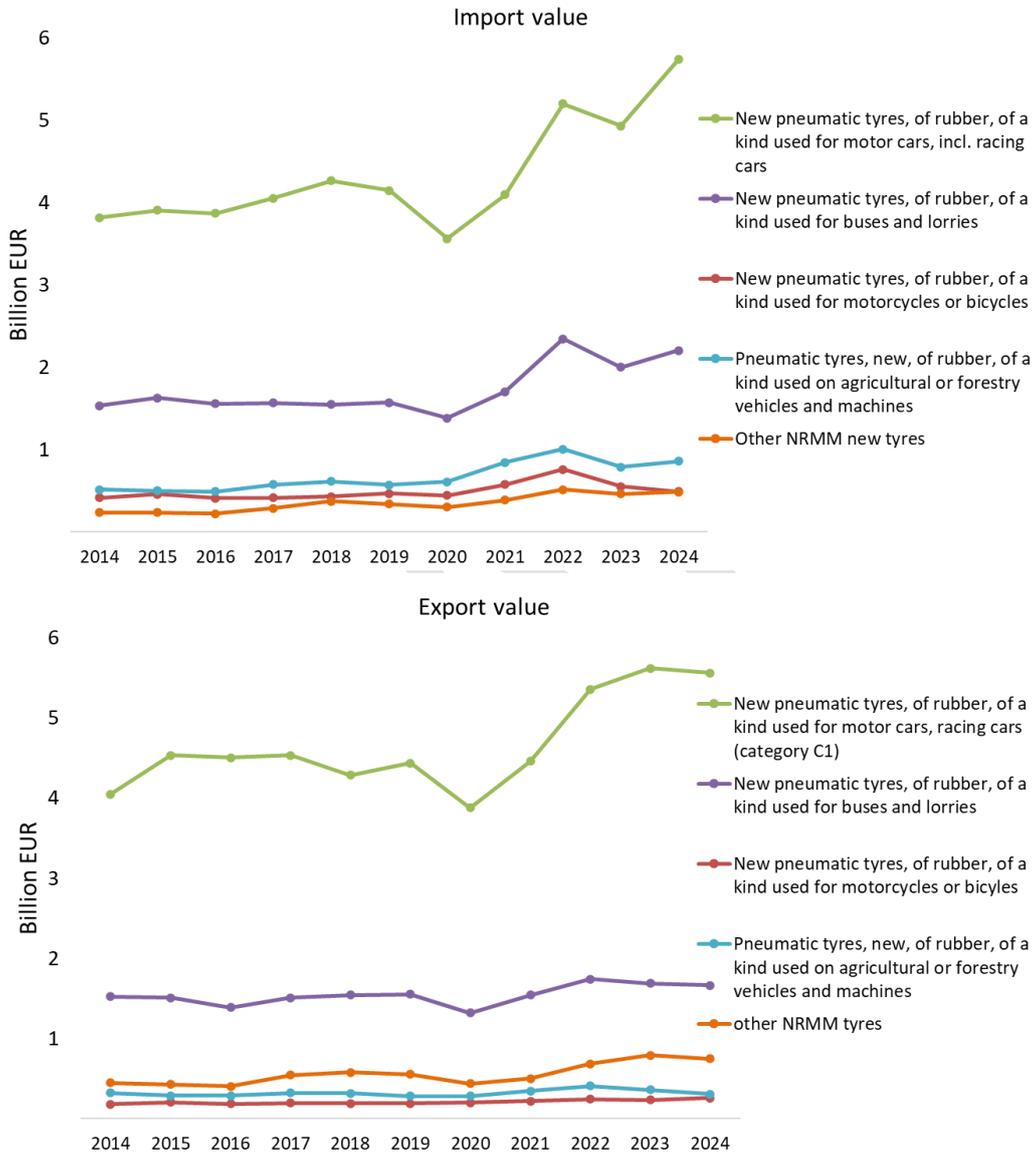


Figure 5-4: Trade values of new tyres over time in billion EUR, current prices.

Source: (Eurostat, 2025a). Downloaded April 2025.

2485

2486

2487

2488 *Retreaded tyres*

2489 According to the same COMEXT data, in 2024 the EU27 countries imported a total value of
 2490 retreaded tyres of almost EUR million 39.6 from outside the EU countries. Most of this value, i.e.

2491 over EUR million 28.5, is represented by tyres for buses and lorries.¹⁸ The value of the imported
2492 retreaded tyres for passenger cars (class C1) in 2024 amounted to around EUR 548,000 which is
2493 only about a third of that imported in 2023. This should be, however, regarded with caution, as
2494 the reported data may be incomplete at the time of the download.

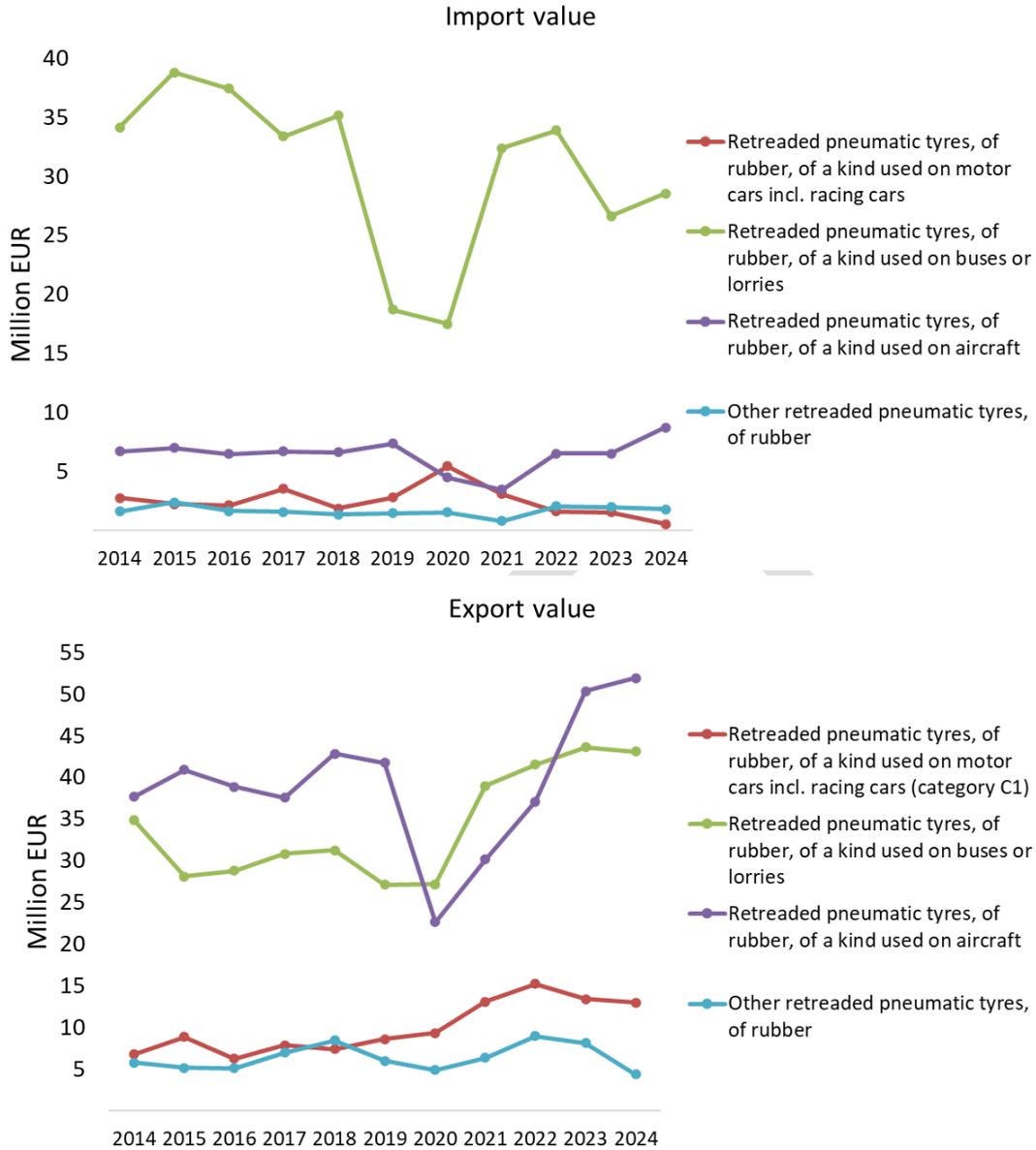
2495 EU27 has exported a higher value of retreaded tyres than it imported – in 2024 their value was
2496 EUR 112.4 million of which only EUR 13 million was represented by tyres for passenger cars
2497 (class C1) and EUR 43 million was the value of tyres for buses and lorries.

2498 **Figure 5-5** shows the value flow of imports and exports of the different categories of retreaded
2499 tyres over time. For most categories, the EU27 countries have exported more than they
2500 imported, and the trends were relatively flat over time, with the exception of the Corona
2501 pandemic year where both imports and exports dropped, recovering rather abruptly after 2021.
2502 Notably, the EU27 has exported a considerably higher worth of retreaded tyres for aircrafts than
2503 it imported and the export value of this category of tyres is on a constant ascending trend since
2504 the first post-pandemic year 2021, surpassing the export value of tyres for buses and lorries in
2505 2023.

2506 The HS codes of the categories presented in **Figure 5-5** are the following:

- 2507 • Retreaded pneumatic tyres, of rubber, of a kind used on motor cars incl. station wagons
2508 and racing cars: 401211
- 2509 • Retreaded pneumatic tyres, of rubber, of a kind used on buses or lorries: 401212
- 2510 • Retreaded pneumatic tyres, of rubber, of a kind used on aircraft: 401213
- 2511 • Other retreaded pneumatic tyres, of rubber: 401219
- 2512

¹⁸ Note that the Eurostat (COMEXT) database does not distinguish between heavy and light load of these tyre classes, i.e. between C1 and C2 tyre classes.



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Figure 5-5: Trade values of retreaded tyres over time in EUR, current prices.

Source: (Eurostat, 2025a). Downloaded April 2025.

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2521
2522

Questions for stakeholders:
T2-3: In the above trade figures of retreaded tyres, we notice a deep in both imports and exports of retreaded tyres for buses and lorries (the green lines). For both imports and exports this occurs in 2020 which could be explained by the slower economic activity during the pandemic. However, what could be the explanation for the drop in the export of this type of tyres that occurs already in 2019?

2523

2524 **5.2.2.2. Intra-EU Trade**

2525 **New tyres**

2526 The PRODCOM database shows that only a few EU countries produce tyres (see **Section 4.2.1**),
2527 but the COMEXT database shows that most of the EU 27 countries export intra-EU. A possible
2528 explanation for this apparent data anomaly is that some of the EU countries act as
2529 intermediaries for tyres imported from outside the EU.

2530 **Table 5-8: Export of new tyres of the EU countries to intra-EU market in 2024 (in EUR).**

| Country | New pneumatic tyres, of rubber, of a kind used for motor cars, incl. station wagons and racing cars Class C1 | New pneumatic tyres, of rubber, of a kind used for buses and lorries ¹⁹ | New pneumatic tyres, of rubber, of a kind used for aircraft | New pneumatic tyres, of rubber, of a kind used for motorcycles and bicycles | New pneumatic tyres, of rubber, of a kind used on agricultural or forestry vehicles and machines and other NRMM tyres |
|----------|--|--|---|---|---|
| Austria | 69,700,847 | 14,131,821 | 53,333 | 2,546,429 | 1,225,442 |
| Belgium | 559,084,702 | 324,332,369 | 14,701,239 | 81,905,009 | 91,536,670 |
| Bulgaria | 1,678,136 | 1,791,130 | | 256,220 | 715,613 |
| Czechia* | 1,340,508,554 | 388,345,235 | 178,126 | 27,446,655 | 192,523,111 |
| Germany* | 2,750,588,883 | 800,475,227 | 2,779,862 | 238,402,606 | 76,978,332 |
| Denmark* | 27,019,077 | 15,294,280 | | 4,676,126 | 6,553,692 |
| Estonia | 13,738,324 | 5,230,406 | | 125,104 | 1,441,515 |
| Spain* | 1,244,163,381 | 724,379,256 | 8,523,703 | 124,437,611 | 201,429,309 |
| Finland | 151,645,939 | 38,316,747 | | 3,068,001 | 47,756,300 |
| France* | 1,083,967,029 | 286,151,186 | 35,354,352 | 98,114,624 | 241,644,050 |

¹⁹ Note that the Eurostat (COMEXT) databased does not distinguish between heavy and light load of this tyres category, i.e. between C1 and C2 tyre classes.

| Country | New pneumatic tyres, of rubber, of a kind used for motor cars, incl. station wagons and racing cars Class C1 | New pneumatic tyres, of rubber, of a kind used for buses and lorries ¹⁹ | New pneumatic tyres, of rubber, of a kind used for aircraft | New pneumatic tyres, of rubber, of a kind used for motorcycles and bicycles | New pneumatic tyres, of rubber, of a kind used on agricultural or forestry vehicles and machines and other NRMM tyres |
|--------------|--|--|---|---|---|
| Greece | 6,651,189 | 2,833,001 | 94 | 633,946 | 380,916 |
| Croatia | 27,305,793 | 8,614,372 | | 58,510 | 1,803,337 |
| Hungary* | 1,413,881,995 | 195,365,913 | | 4,096,182 | 9,185,085 |
| Ireland | 2,729,990 | 9,144,463 | | 40,691 | 745,749 |
| Italy* | 1,007,236,755 | 269,454,932 | 137,489 | 45,925,940 | 174,311,731 |
| Lithuania* | 20,181,403 | 39,711,443 | 39,510 | 405,353 | 8,219,197 |
| Luxembourg | 101,930,346 | 442,706,378 | | 619,392 | 59,624,881 |
| Latvia | 52,152,398 | 16,683,474 | | 299,566 | 8,526,957 |
| Malta | 2,771 | | | 430 | |
| Netherlands | 1,529,488,378 | 233,143,833 | 20,207,842 | 67,889,799 | 92,837,099 |
| Poland* | 1,336,120,011 | 486,420,930 | 20,066 | 18,006,464 | 81,462,938 |
| Portugal* | 784,182,565 | 13,401,677 | 6,794 | 1,442,572 | 47,765,212 |
| Romania* | 1,292,354,268 | 419,524,344 | | 1,525,470 | 30,239,326 |
| Sweden* | 71,658,980 | 28,414,387 | 5,446 | 3,752,764 | 15,961,557 |
| Slovenia | 355,710,622 | 80,457,958 | 104,412 | 36,715,912 | 7,269,889 |
| Slovakia* | 830,790,796 | 1,087,741,284 | 2,422 | 3,648,304 | 23,744,985 |
| Total | 16,074,473,132 | 5,932,066,046 | 82,114,690 | 766,039,680 | 1,423,882,893 |

2531 * Denotes countries that have manufacturing of tyres. Countries without values have been deleted.
 2532 Source: (Eurostat, 2025a). Downloaded April 2025

2533 **Table 5-8** shows that the largest intra-EU exporter of passenger car tyres (class C1) in 2024 was
 2534 Germany, followed by the Netherlands and Hungary. Other significant exporters are Czechia,
 2535 Poland, Spain and Romania.

2536

Table 5-9: Import of new tyres by the EU countries from intra-EU market in 2024 (in EUR).

| Country | New pneumatic tyres, of rubber, of a kind used for motor cars, incl. station wagons and racing cars Class C1 | New pneumatic tyres, of rubber, of a kind used for buses and lorries ²⁰ | New pneumatic tyres, of rubber, of a kind used for aircraft | New pneumatic tyres, of rubber, of a kind used for motorcycles and bicycles | New pneumatic tyres, of rubber, of a kind used on agricultural or forestry vehicles and machines and other NRRMM tyres |
|--------------|--|--|---|---|--|
| Austria | 462,369,918 | 129,611,041 | 2,174,996 | 35,799,110 | 75,590,533 |
| Belgium | 709,254,876 | 493,897,771 | 468,639 | 15,231,276 | 57,694,463 |
| Bulgaria | 87,728,271 | 28,310,066 | | 2,545,996 | 16,015,068 |
| Cyprus | 23,884,502 | 2,822,732 | | 2,303,191 | 349,054 |
| Czechia* | 807,231,822 | 145,980,002 | 225,731 | 45,404,428 | 35,555,644 |
| Germany* | 3,585,993,987 | 1,131,181,386 | 17,410,627 | 94,753,653 | 371,751,728 |
| Denmark* | 217,466,025 | 58,532,505 | 283,813 | 13,428,403 | 21,779,153 |
| Estonia | 58,077,110 | 14,730,707 | 667,427 | 1,799,342 | 5,768,734 |
| Spain* | 929,974,102 | 347,980,276 | 20,506,741 | 69,269,074 | 54,743,955 |
| Finland | 107,797,673 | 61,653,119 | 9,502 | 10,282,389 | 40,101,519 |
| France* | 2,392,425,659 | 784,618,024 | 930,222 | 99,984,099 | 282,805,815 |
| Greece | 134,683,342 | 34,450,158 | 1,353,457 | 7,296,445 | 5,033,794 |
| Croatia | 157,942,311 | 47,427,695 | 74,135 | 5,851,481 | 8,051,860 |
| Hungary* | 418,395,590 | 121,954,941 | 726,147 | 10,177,885 | 13,065,474 |
| Ireland | 61,636,307 | 35,851,536 | 7,904 | 1,771,916 | 2,972,455 |
| Italy * | 1,227,581,747 | 417,453,649 | 11,082,912 | 83,966,265 | 75,927,782 |
| Lithuania* | 83,214,462 | 52,297,679 | 823,470 | 5,140,710 | 9,979,972 |
| Luxembourg | 75,590,774 | 214,933,055 | 867,667 | 4,191,040 | 6,579,513 |
| Latvia | 32,942,968 | 12,845,130 | | 1,135,114 | 8,526,896 |
| Malta | 1,550,939 | 224,391 | 16,594 | 116,863 | 27,546 |
| Netherlands | 1,168,571,230 | 434,875,529 | 77,292 | 49,923,550 | 68,927,203 |
| Poland* | 785,678,834 | 382,709,100 | 33,866 | 36,902,601 | 46,316,725 |
| Portugal* | 281,085,104 | 68,674,118 | 65,244 | 12,830,096 | 12,974,127 |
| Romania* | 415,944,457 | 104,035,049 | 200,553 | 5,585,320 | 12,219,989 |
| Sweden* | 315,832,244 | 182,748,931 | 1,900,119 | 15,924,439 | 141,220,810 |
| Slovenia | 162,849,503 | 31,674,467 | 60,965 | 10,531,334 | 6,980,163 |
| Slovakia* | 917,038,083 | 97,547,173 | 44,655 | 5,782,770 | 18,894,346 |
| Total | 15,622,741,840 | 5,439,020,230 | 60,012,678 | 647,928,790 | 1,399,854,321 |

2537

* Denotes countries that have manufacturing of tyres. Countries without values have been deleted.

²⁰ Note that the Eurostat (COMEXT) databased does not distinguish between heavy and light load of this tyres category, i.e. between C1 and C2 tyre classes.

2538 Source: (Eurostat, 2025a). Downloaded April 2025

2539 Interestingly, the manufacturers of tyres in the EU are also some of the largest importers,
 2540 especially for C1 class tyres. The largest importer across all tyres categories is Germany,
 2541 importing work of over EUR billion 3.6. Germany is followed by France in intra-EU imports. Given
 2542 that both countries are large auto manufacturers, it may be that a large part of these imports
 2543 are represented by original equipment, rather than replacement tyres.

2544

2545 Questions for stakeholders:
 2546 T2-4: How are the OEM tyres recorded when moving from one EU Member State to
 2547 another. For example, if an auto manufacturer in Member State X mounts tyres
 2548 produced in Member State Y on their cars, do these tyres appear as imported by
 2549 Member State X from Member State Y or are they recorded as inter-companies
 2550 transfers?

2551

2552 Retreaded tyres

2553 This section presents intra-EU trade data of retreaded tyres. **Table 5-10** shows the exporters of
 2554 retreaded tyres to the EU market in 2024. Interestingly, the largest exporter of retreaded C1
 2555 tyres is Slovakia, a MS that does not have retreading activity according to Eurostat data (see
 2556 **Table 5-3**). This suggests that Slovakia acts as an intermediary importing retreaded tyres,
 2557 possibly from thirds countries, and further exports them on the EU market.

2558 **Table 5-10: Export of retreaded tyres of the EU countries to intra-EU market in 2024 (in EUR).**

| Country | Retreaded pneumatic tyres, of rubber, of a kind used on motor cars "incl. station wagons and racing cars" | Retreaded pneumatic tyres, of rubber, of a kind used on buses or lorries | Retreaded pneumatic tyres, of rubber, of a kind used on aircraft | Retreaded pneumatic tyres, of rubber (excl. of a kind used on motor cars, station wagons, racing cars, buses, lorries and aircraft) |
|-----------|---|--|--|---|
| Austria | 9,621 | 636,048 | | 44,263 |
| Belgium | 92,149 | 10,863,358 | 16,841,536 | 1,075,357 |
| Bulgaria* | | 735,166 | | |
| Czechia* | 713,028 | 1,089,479 | | 1,927 |
| Germany* | 1,256,148 | 164,900,762 | 5,507 | 2,717,988 |
| Denmark* | | 23,185 | | |
| Estonia* | 109,491 | 308,782 | | |
| Spain* | 4,509,351 | 67,243,166 | 6,467 | 286,956 |
| Finland* | | 823,775 | | 7,738 |
| France* | 701,143 | 30,994,846 | 8,639,411 | 282,531 |
| Greece | 1,060 | 20,670 | 144,168 | 141,887 |

| Country | Retreaded pneumatic tyres, of rubber, of a kind used on motor cars "incl. station wagons and racing cars" | Retreaded pneumatic tyres, of rubber, of a kind used on buses or lorries | Retreaded pneumatic tyres, of rubber, of a kind used on aircraft | Retreaded pneumatic tyres, of rubber (excl. of a kind used on motor cars, station wagons, racing cars, buses, lorries and aircraft) |
|--------------|---|--|--|---|
| Croatia* | | 2,345 | | |
| Hungary | 970 | 17,037,166 | | |
| Italy* | 1,404,024 | 4,754,529 | 1,084,122 | 5,081,644 |
| Lithuania* | 36,054 | 1,049,750 | | 31,851 |
| Luxembourg | | 333,035 | | 2,970 |
| Latvia | 251,699 | 952,427 | | 23,029 |
| Netherlands | 3,688 | 3,143,329 | 9,476,767 | 2,395,687 |
| Poland* | 2,288,824 | 8,961,902 | | 518,259 |
| Portugal* | 2,252,402 | 2,115,025 | | 4,058,988 |
| Romania* | 2,107,352 | 64,601 | | 1,913 |
| Sweden | 584 | 3,948,809 | | 98,112 |
| Slovenia | | 89,831 | | 1,969 |
| Slovakia | 10,442,537 | 1,754,045 | | 39,963 |
| Total | 26,180,125 | 321,846,031 | 36,197,978 | 16,813,032 |

2559 * Denotes countries that have retreading activity. Countries without values have been deleted.

2560 Source: (Eurostat, 2025a). Downloaded April 2025

2561 The next table shows the imports of retreaded tyres from other EU MS. The largest importer of
 2562 "motor cars" retread tyres is the Netherlands, followed by Spain, Bulgaria, while France has
 2563 imported the highest value of buses or lorries retread tyres, followed by Hungary and Italy.

2564 **Table 5-11: Import of retreaded tyres by the EU countries from intra-EU market in 2024 (in**
 2565 **EUR).**

| Country | Retreaded pneumatic tyres, of rubber, of a kind used on motor cars "incl. station wagons and racing cars" | Retreaded pneumatic tyres, of rubber, of a kind used on buses or lorries | Retreaded pneumatic tyres, of rubber, of a kind used on aircraft | Retreaded pneumatic tyres, of rubber (excl. of a kind used on motor cars, station wagons, racing cars, buses, lorries and aircraft) |
|-----------|---|--|--|---|
| Austria | 4,889,065 | 7,179,672 | 13,925 | 189,708 |
| Belgium | 70,335 | 17,122,864 | 6,645 | 415,109 |
| Bulgaria* | 5,067,774 | 1,009,642 | | 1,980 |
| Cyprus | | | | 935 |
| Czechia* | 225,908 | 7,504,173 | 831,630 | 192,425 |
| Germany* | 412,008 | 16,291,327 | 137,510 | 488,664 |
| Denmark* | 68,802 | 4,549,101 | 232,952 | 201,964 |
| Estonia* | 77,393 | 489,790 | 629,552 | 82,209 |
| Spain* | 5,500,261 | 11,952,051 | 1,454,695 | 541,540 |

| Country | Retreaded pneumatic tyres, of rubber, of a kind used on motor cars "incl. station wagons and racing cars" | Retreaded pneumatic tyres, of rubber, of a kind used on buses or lorries | Retreaded pneumatic tyres, of rubber, of a kind used on aircraft | Retreaded pneumatic tyres, of rubber (excl. of a kind used on motor cars, station wagons, racing cars, buses, lorries and aircraft) |
|--------------|---|--|--|---|
| Finland* | 101,070 | 5,847,373 | | 310,095 |
| France* | 3,381,151 | 114,526,763 | 150,632 | 2,536,805 |
| Greece | 295,747 | 1,423,196 | 524,626 | 32,738 |
| Croatia* | 21,992 | 302,830 | | 60,132 |
| Hungary | 31,443 | 21,832,518 | 202,042 | 18,501 |
| Ireland | 3,328 | 162,318 | | 21,767 |
| Italy* | 70,666 | 20,727,159 | 929,807 | 14,055 |
| Lithuania* | 839,303 | 4,607,894 | - | 70,997 |
| Luxembourg | 64,508 | 18,972,036 | 133,093 | 47,970 |
| Latvia | 330,002 | 385,284 | 619,367 | 241,957 |
| Malta | | | | 32,612 |
| Netherlands | 6,280,163 | 12,115,190 | | 6,171,565 |
| Poland* | 26,361 | 19,207,159 | | 188,857 |
| Portugal* | 300,935 | 10,057,329 | | 23,775 |
| Romania* | 1,475,940 | 7,001,603 | 2,556 | 389,945 |
| Sweden | 106,675 | 10,982,966 | 1,135 | 2,400,262 |
| Slovenia | 2,501 | 2,109,496 | | 20,460 |
| Slovakia | 1,196,824 | 3,421,744 | | 103,729 |
| Total | 30,840,155 | 319,781,478 | 5,870,167 | 14,800,756 |

2566 * Denotes countries that have retreading activity. Countries without values have been deleted.
 2567 Source: (Eurostat, 2025a). Downloaded April 2025

2568 5.2.3. EU sales

2569 In the EU, around 25 % of tyres are fitted on new vehicles placed on the market, which are
 2570 indicated as original equipment supplied to vehicle manufacturers (OEMs). However, the
 2571 majority of tyres (roughly 75 %) are sold on the replacement market, meaning they are
 2572 purchased to replace worn tyres already fitted on vehicles in the EU fleet. These replacement
 2573 sales are directed to end-users such as car owners, fleet operators, and garages, rather than to
 2574 vehicle manufacturers. As PRODCOM does not provide this information, an estimate per country
 2575 has been derived by calculating apparent consumption (production – imports + exports). The
 2576 following sections first considers apparent consumption, then the available sales data on
 2577 replacement and OEM sales, and finally how the different sources compare.

2578 5.2.3.1. Apparent consumption per country

2579 Apparent consumption, based on PRODCOM data, is calculated by combining production and
 2580 import volumes and subtracting exports to generate the apparent consumption per country of
 2581 new tyres both in quantity (units) and value (€). PRODCOM does not specify whether the data
 2582 includes both replacement and OEM sales. This is shown below in **Table 5-12** and **Table 5-13**.

2583 As shown previously in **Figure 5-1**, the 2023 PRODCOM dataset appears to be incomplete, for
 2584 example, production data for the EU27 concerning C2 is missing (Eurostat, 2025h). This may lead
 2585 to inaccuracies and, in some cases, negative values, as illustrated in **Table 5-12**. Due to these
 2586 limitations, the 2022 data have been used instead to estimate apparent consumption in value
 2587 and quantity per country. For each country where production is indicated as ‘:’, it is assumed to
 2588 be zero. However, it has led to some issues, as certain values show negative results. This may be
 2589 due to some countries not reporting their production data.

2590 **Table 5-12: EU apparent consumption of new tyres in quantity per country in 2022.**

| | C1 tyres | C2 tyres | C3 tyres | Motorcycles or bicycles |
|-------------|-------------|------------|------------|-------------------------|
| France | 21,635,458 | -1,289,241 | 1,832,090 | 4,576,009 |
| Netherlands | 11,991,251 | 1,271,444 | 1,333,204 | 7,562,756 |
| Germany | 58,202,731 | 8,529,950 | 914,227 | 14,261,153 |
| Italy | 35,902,856 | 2,364,827 | 984,491 | 15,824,535 |
| Ireland | 3,558,760 | 151,099 | 198,274 | 161,036 |
| Denmark | 2,957,052 | 154,573 | 234,390 | 1,401,519 |
| Greece | 3,952,365 | 205,748 | 279,792 | 1,285,226 |
| Portugal | -11,877,099 | 17,814,081 | 406,116 | 4,959,437 |
| Spain | 29,888,249 | 1,533,196 | -2,829,378 | 3,602,142 |
| Belgium | 7,416,754 | 862,768 | 971,876 | 190,953 |
| Luxembourg | 805,480 | 44,225 | -1,370,216 | 96,837 |
| Sweden | 7,057,327 | 530,183 | 746,183 | 1,396,021 |
| Finland | 822,015 | -84,274 | 293,204 | 886,985 |
| Austria | 6,116,346 | 492,069 | 435,060 | 1,686,597 |
| Malta | 166,773 | 15,389 | 12,059 | 5,491 |
| Estonia | 865,748 | 42,189 | 58,271 | 118,050 |
| Latvia | 946,720 | -19,586 | 101,826 | 48,908 |
| Lithuania | 1,271,547 | 81,963 | 162,025 | 976,754 |
| Poland | 14,376,202 | 472,856 | 1,780,441 | 7,400,348 |
| Czechia | 19,695,755 | -2,648,657 | -391,462 | 3,106,535 |
| Slovakia | 11,862,983 | -5,185,790 | 954,739 | 1,063,417 |
| Hungary | 5,603,093 | -1,786,245 | 298,556 | 2,469,434 |
| Romania | 14,172,150 | -2,426,694 | 726,205 | 3,332,104 |

| | C1 tyres | C2 tyres | C3 tyres | Motorcycles or bicycles |
|-------------------|--------------------|-------------------|-------------------|-------------------------|
| Bulgaria | 2,600,247 | 201,090 | 251,848 | 3,398,807 |
| Slovenia | -5,476,857 | 46,968 | -565,055 | 441,447 |
| Croatia | 11,427,261 | 1,610,129 | 2,549,180 | 657,221 |
| Cyprus | 884,701 | 27,317 | 42,005 | 54,838 |
| Total EU27 | 256,825,868 | 23,011,577 | 10,409,951 | 80,081,666 |

2591

(1st Stakeholders consultation, 2025)

2592

Source: (Eurostat, 2025h), Downloaded April 2025

2593

2594

Table 5-13: EU apparent consumption of new tyres in value (€) per country in 2022.

| | C1 tyres | C2 tyres | C3 tyres | Motorcycles or bicycles tyres |
|-------------|---------------|---------------|--------------|-------------------------------|
| France | 1,074,500,952 | 13,535,484 | 390,404,615 | 40,104,440 |
| Netherlands | 434,988,499 | 67,620,660 | 325,412,331 | 63,828,092 |
| Germany | 2,106,257,552 | 500,094,321 | 158,040,480 | 140,306,954 |
| Italy | 1,695,004,372 | 116,972,870 | 163,610,021 | 130,464,942 |
| Ireland | 157,211,410 | 10,814,891 | 35,598,607 | 3,509,424 |
| Denmark | 180,655,950 | 12,533,710 | 60,220,737 | 16,451,457 |
| Greece | 169,625,289 | 11,237,646 | 58,508,557 | 15,555,398 |
| Portugal | -876,784,951 | 1,233,359,390 | 138,512,883 | 30,299,555 |
| Spain | 1,313,464,777 | 87,192,351 | -422,598,877 | 18,723,775 |
| Belgium | 342,259,119 | 89,022,720 | 206,556,788 | -39,109,948 |
| Luxembourg | 79,095,222 | 6,224,576 | -286,731,580 | 5,097,347 |
| Sweden | 399,228,062 | 39,879,836 | 183,659,693 | 15,772,448 |
| Finland | -39,078,128 | -10,677,711 | 61,252,707 | 13,664,741 |
| Austria | 385,372,162 | 23,837,709 | 109,398,972 | 33,948,407 |
| Malta | 6,704,170 | 420,309 | 2,510,466 | 179,600 |
| Estonia | 56,828,980 | 3,158,666 | 14,354,946 | 1,437,443 |
| Latvia | 38,930,122 | 116,202 | 21,979,476 | 1,083,659 |
| Lithuania | 68,548,953 | 4,810,519 | 37,268,225 | 6,351,134 |
| Poland | 473,748,401 | 10,218,601 | 396,037,032 | 39,256,358 |
| Czechia | 1,274,477,412 | -172,935,641 | -81,911,325 | 30,671,198 |
| Slovakia | -169,610,418 | -373,891,722 | -485,866,001 | 7,048,492 |
| Hungary | 443,109,489 | -146,764,746 | 47,042,450 | 17,438,996 |
| Romania | 725,699,322 | -135,296,170 | 174,809,327 | 14,000,218 |
| Bulgaria | 138,914,268 | 12,261,082 | 66,142,907 | 18,740,494 |
| Slovenia | -195,546,579 | 1,989,960 | -63,369,360 | -20,125,852 |
| Croatia | 97,321,750 | 7,542,831 | 34,882,083 | 4,687,488 |

| | C1 tyres | C2 tyres | C3 tyres | Motorcycles or bicycles tyres |
|-------------------|-----------------------|----------------------|----------------------|-------------------------------|
| Cyprus | 44,804,573 | 2,347,970 | 9,406,805 | 1,414,406 |
| Total EU27 | 10,425,730,730 | 1,415,626,314 | 1,355,132,965 | 610,800,666 |

2595 Source: (Eurostat, 2025h), Downloaded April 2025

2596 5.2.3.2. Sales data

2597 Two sources of sales data were identified: the European Tyre and Rubber Manufacturers' Association (ETRMA) during the stakeholder consultation, and the Ecodesign Impact Accounting (EIA) report (VHK, 2024b). The data provided by ETRMA covers only replacement sales, whereas
 2598
 2599 the EIA report includes and distinguishes between replacement and vehicle OEM's sales, which
 2600 are tyres fitted on new vehicles placed on the market. However, the methodology applied in the
 2601 EIA report is not clearly documented.
 2602

2603 Replacement sales refer to tyres sold to end-users, such as car owners, garages, or fleet
 2604 operators, to replace worn tyres on vehicles already in use. **Table 5-14** presents the replacement
 2605 sales in units for the total EU27 market across C1, C2, C3, motorcycle and moped tyres for the
 2606 years 2020 to 2024 as provided by ETRMA during the stakeholder consultation. It was specified
 2607 that C1 data includes cars and SUVs, while C2 data applies only to light trucks. Data from 2015
 2608 is also included as a reference point to illustrate sales growth over the past years. The data is
 2609 based on the total EU27 market, which is defined as the sum of ETRMA members' sales and net
 2610 imports (1st Stakeholders consultation, 2025). It is important to note that the data covers only
 2611 replacement sales and excludes OEM sales.

2612 **Table 5-14: Replacement sales in units of the total EU27 market.**

| Sales year | C1 Tyres | C2 Tyres | C3 Tyres | Motorcycles and moped tyres | Agricultural tyres* |
|------------|-------------|------------|------------|-----------------------------|---------------------|
| 2024 | 258,731,701 | 23,406,861 | 13,031,910 | 10,596,259 | 715,000 |
| 2023 | 234,145,368 | 20,138,188 | 12,302,088 | 10,210,195 | 681,000 |
| 2022 | 239,530,896 | 23,921,774 | 14,640,372 | 11,452,809 | 950,000 |
| 2021 | 236,650,857 | 22,946,744 | 13,790,818 | 11,300,360 | 1,220,00 |
| 2020 | 211,532,539 | 17,772,667 | 12,046,515 | 10,349,893 | |
| 2015 | 217,290,271 | 16,881,913 | 11,605,051 | 10,362,184 | |

2613 Source: (1st Stakeholders consultation, 2025). * Based on the quarterly reports of ETRMA (ETRMA, 2025c),
 2614 representing sales of ETRMA members.

2615 **Table 5-14** shows that the total annual sales of C1, C2 and C3 tyres together exhibited a slightly
 2616 increasing trend over the last five years since 2020, with a growth rate of around 20% between
 2617 2020 and 2024, but an annual average growth rate of around only 5 %. The big leap from 2020
 2618 to 2024 sales is clearly due to the pandemic year when the economy activity slowed down. The
 2619 sales are slowly returning to the 2019 level, though in 2024 they were still under the 2019 level
 2620 estimated at around 330 million units for the C1, C2 and C3 categories (European Tyre and
 2621 Rubber Industry, 2021). EU sales of C1, C2 and C3 tyres together are around 90-95 % of the total
 2622 tyres sales on the EU market. This is an estimate based on the available data (approximately 95

2623 %) and may be slightly lower (approximately 90 %), as information is not available for all tyre
2624 types.

2625 For agricultural tyres, data was retrieved from the quarterly reports published by ETRMA
2626 (ETRMA, 2025c). It is important to note that this only includes ETRMA members, who represent
2627 only a small share of the total EU market. No data is available for 2021–2024 on the total EU
2628 market. For 2015–2020, however, data is made available in a report published by ETRMA and it
2629 shows that in 2020, the share of ETRMA members' sales for agricultural tyres was approximately
2630 19 % of the total EU market (ETRMA, 2021a). It is nevertheless unclear whether the UK is still
2631 included in the total. The data indicates a modest peak in 2017, followed by a gradual decline in
2632 total EU sales for agricultural tyres up to 2020, which appears consistent with ETRMA member
2633 sales from 2021 to 2023, although a small increase occurred in 2024, as shown in **Table 5-14**.

2634 The EIA report has also provided estimates of the number of units sold (VHK, 2024b). **Table 5-15**
2635 presents data for 2015 and 2020, along with projections for 2025 and 2030. The estimates
2636 differentiate between replacement sales and OEM sales for C1, C2, and C3 tyres. This appears
2637 to be the only source differentiating between OEM and replacement sales. The share of OEM
2638 and replacement sales in total sales is also calculated. The results indicate that the share of
2639 replacement sales is slightly higher than previously reported, amounting to 78 % for C1, 84 % for
2640 C2, and 76 % for C3 in 2020.

2641 **Table 5-15: Total EU27 new tyre OEM and replacement sales in quantity (units) including 2025**
2642 **and 2030 forecasts.**

| Year | End use | C1 tyres (units) | % of total | C2 tyres (units) | % of total | C3 tyres (units) | % of total |
|------|-------------|------------------|------------|------------------|------------|------------------|------------|
| 2030 | Replacement | 289,000,000 | 77 % | 32,000,000 | 82 % | 15,000,000 | 79 % |
| | OEM | 87,000,000 | 23 % | 7,000,000 | 18 % | 4,000,000 | 21 % |
| 2025 | Replacement | 260,000,000 | 77 % | 29,000,000 | 83 % | 14,000,000 | 78 % |
| | OEM | 78,000,000 | 23 % | 6,000,000 | 17 % | 4,000,000 | 22 % |
| 2020 | Replacement | 234,000,000 | 78 % | 26,000,000 | 84 % | 13,000,000 | 76 % |
| | OEM | 67,000,000 | 22 % | 5,000,000 | 16 % | 4,000,000 | 24 % |
| 2015 | Replacement | 210,000,000 | 76 % | 23,000,000 | 82 % | 11,000,000 | 79 % |
| | OEM | 67,000,000 | 24 % | 5,000,000 | 18 % | 3,000,000 | 21 % |

2643 Source: (VHK, 2024b)

2644 5.2.3.3. Data comparison and gaps

2645 **Table 5-16** presents a comparison of sales data from ETRMA collected during the stakeholder
2646 consultation, the EIA report (VHK, 2024b), and apparent consumption calculated from
2647 PRODCOM data. Since EIA values are available only for 2020 and 2025, linear interpolation was
2648 used to estimate 2022 and 2023 values. As mentioned above, PRODCOM data for 2023 is
2649 incomplete, but it has still been included in the table to provide more recent data.

2650 Some differences exist between the data sources, likely due to discrepancies or gaps in the data.
2651 In 2022, for C1 tyres, the stakeholder consultation reported 239,530,896 replacement units,

2652 compared to an EIA report estimate of 244,400,000 units, representing only a 2 % difference.
 2653 For C2 tyres, the figures diverge more noticeably: 23,921,774 units (stakeholder consultation)
 2654 versus 27,200,000 units (EIA report), a difference of 12 %. For C3 tyres, the difference is also
 2655 significant, with 14,640,372 units (stakeholder consultation) compared to 13,400,000 units (EIA
 2656 report), a difference of 8 %. The divergence may result from the EIA data being a linear
 2657 interpolation between 2020 and 2025, with an unclear underlying methodology. While the
 2658 ETRMA data from the stakeholder consultation reflects real-world figures, potential gaps cannot
 2659 be ruled out.

2660 As mentioned before, it is unclear whether the PRODCOM figures include both replacement and
 2661 OEM sales (Eurostat, 2025h). Comparing them with ETRMA data from the stakeholder
 2662 consultation suggests they align more closely with replacement sales. Assuming the figures
 2663 include only replacement sales, the differences between PRODCOM and stakeholder data for
 2664 2022 would be 7 % for C1 tyres, 4 % for C2, and 29 % for C3. In 2023, C3 figures are much closer,
 2665 with only a 4 % difference, likely due to the inclusion of Spanish production data, which seem to
 2666 be missing in 2022. Estimated sales based on PRODCOM data calculations in 2022 were
 2667 2,829,378 due to the absence of production data, whereas in 2023, including production, they
 2668 amounted to 1,896,529. In general, PRODCOM data may not align with actual sales figures, as it
 2669 represents an estimated apparent consumption and may be incomplete due to reporting errors
 2670 or missing data. Potentially, additional discrepancies may arise due to differences in timing or
 2671 scope between the sources.

2672 Data on motorcycle tyres could not be compared as PRODCOM reports this data by including
 2673 them together with the bicycle tyres in the same figure, while the data from the stakeholder
 2674 consultation only reports motorcycle tyres.

2675 **Table 5-16: Total EU27 new tyre sales in value and quantity in 2022 and 2023.**

| Sales | End use | Year | C1 tyres | C2 tyres | C3 tyres | Sources |
|-------------------|-------------|------|-------------|------------|------------|--------------------------|
| Quantity (Units) | Replacement | 2022 | 239,530,896 | 23,921,774 | 14,640,372 | Stakeholder consultation |
| Quantity (Units) | Replacement | 2022 | 244,400,000 | 27,200,000 | 13,400,000 | EIA report |
| Quantity (Units) | OEM | 2022 | 71,400,000 | 5,400,000 | 4,000,000 | EIA report |
| Quantity (Units) | Unknown | 2022 | 256,825,868 | 23,011,577 | 10,409,951 | PRODCOM |
| Value (€ million) | Unknown | 2022 | 10,425 | 1,415 | 1,355 | PRODCOM |
| Quantity (Units) | Replacement | 2023 | 234,145,368 | 20,138,188 | 12,302,088 | Stakeholder consultation |
| Quantity (Units) | Replacement | 2023 | 249,600,000 | 27,800,000 | 13,600,000 | EIA report |
| Quantity (Units) | OEM | 2023 | 73,600,000 | 5,600,000 | 4,000,000 | EIA report |
| Quantity (Units) | Unknown | 2023 | 268,533,495 | 1,185,482* | 11,871,115 | PRODCOM |

| Sales | End use | Year | C1 tyres | C2 tyres | C3 tyres | Sources |
|-------------------|---------|------|----------|----------|----------|---------|
| Value (€ million) | Unknown | 2023 | 11,108 | -106* | 2,126 | PRODCOM |

2676 *Note: Production data is missing from PRODCOM

2677 Questions for stakeholders:
 2678 T2-5: Are there any discrepancies in the EIA data? If so, how can these figures be
 2679 assessed better?
 2680 T2-6: Particularly, are the OEM sales figures in the EIA report (Table 5-15) accurately
 2681 presented, or are they over- or underestimated?
 2682 T2-7: Are there any notable gaps in the ETRMA dataset? For example, do these
 2683 figures cover the full EU market, or are some manufacturers (e.g. non-members) or
 2684 importers excluded? If so, to what extent?
 2685 T2-8: Are there any notable gaps in the PRODCOM dataset? For example, does
 2686 PRODCOM cover only replacement sales, or both replacement and OEM sales?

2687 5.3. Market and stock data

2688 5.3.1. Average product life

2689 Determining the average lifespan of a tyre can be challenging, as it depends on a range of
 2690 variables. Key factors such as tyre quality, typical road conditions, annual mileage, and the age
 2691 of the tyre all play a role in influencing its longevity. Driving habits and the type of vehicle may
 2692 also have an impact. For this reason, there is no straightforward answer regarding the product
 2693 life of a tyre, but an estimation is possible based on information from stakeholder consultations,
 2694 manufacturer websites, and relevant literature. These estimates are presented in **Table 5-17**.

2695 **Table 5-17: Lifetime of new tyres in km and years.**

| Type | Life time new (km) | | Life time new (years) | |
|------|--------------------|------------------|-----------------------|-------|
| | Average | Range | Average | Range |
| C1 | 40000 | 30,000 – 70,000 | 5 | 3 - 7 |
| C2 | 40000 | 10,000 – 90,000 | 3 | 1 - 5 |
| C3 | 150000 | 40,000 – 350,000 | 3 | 1 - 6 |

2696 Source: Compilation based on different values specified in stakeholder consultation, manufacturers' websites,
 2697 literature.

2698 The EIA status report has estimated lifetimes of 4.96 years for C1, 3.89 years for C2, and 3.97
 2699 years for C3 tyres, which differ slightly from the estimates presented above (VHK, 2024b).

2700 Retreading can further extend the lifespan of a tyre, although this largely depends on the quality
 2701 of the original tyre and the number of possible retreading cycles. For C1 tyres, retreading
 2702 appears to be limited or uncommon, typically resulting in 0 to 1 retreading cycles. In contrast,
 2703 C2 and C3 tyres may undergo up to 3 retreading cycles. According to stakeholder consultation,
 2704 retreading can extend the average lifespan of a C2 tyre to approximately 75,000 km representing
 2705 all cycles (the corresponding duration in years cannot be determined due to a lack of available
 2706 data). For C3 tyres, the extended lifespan can range from a total amount of 200,000 km to as
 2707 much as 1,000,000 km representing all cycles, corresponding to a service life of roughly 2 to 10
 2708 years.

2709

2710 Questions for stakeholders:

2711 T2-9: Could you provide insights on the average lifetime in kms across the different
 2712 tyre categories (see **Table 5-17**)? Please indicate where you think the numbers are
 2713 under- or overestimated.

2714 T2-10: Could you provide insights on the average lifetime in years across the
 2715 different tyre categories (see **Table 5-17**)? Please indicate where you think the
 2716 numbers are under- or overestimated.

2717 T2-11: For clarification, when referring to three retread cycles, should this be
 2718 understood as a total of four cycles (original plus three retreads)? If so, do the
 2719 numbers in the text make sense to you?

2720 T2-12: Do you have any additional information on C2 tyres, specifically regarding
 2721 lifetime in kilometres and in years (both with and without retreading)? The
 2722 information currently available to us suggests a lifetime of around three years in
 2723 both cases, which appears inconsistent.
 2724

2725

2726 5.3.2. Installed base

2727 Tyres represent one of the largest product groups in terms of units in use. The installed tyre
 2728 base, or stock, can be calculated by summing the number of units sold over the expected lifetime
 2729 of a tyre. For example, in the previous section it was established that C1 tyres have an average
 2730 lifetime of five years. Therefore, the sales data from the past five years are aggregated to
 2731 approximate the installed base. During the stakeholder consultation, only replacement tyre
 2732 sales data were provided, so OEM sales are not included. Consequently, the results presented
 2733 in

2734 **Table 5-18** include only replacement unit sales, as obtained from the consultation, combined
 2735 with the average lifetime estimates from the previous section to determine the stock for each
 2736 tyre category. The sales numbers used in the stock calculation are highlighted in grey. total
 2737 replacement tyre stock amounts to 1,288,032,554 replacement units in stock in 2024.

2738 **Table 5-18: Estimated stock of replacement tyres in 2024.**

| Year | C1 Tyres (units) | C2 Tyres (units) | C3 Tyres (units) |
|-------------------------|----------------------|-------------------|-------------------|
| <i>Lifetime (years)</i> | 5 | 3 | 3 |
| Sales 2020 | 211,532,539 | 17,772,667 | 12,046,515 |
| Sales 2021 | 236,650,857 | 22,946,744 | 13,790,818 |
| Sales 2022 | 239,530,896 | 23,921,774 | 14,640,372 |
| Sales 2023 | 234,145,368 | 20,138,188 | 12,302,088 |
| Sales 2024 | 258,731,701 | 23,406,861 | 13,031,910 |
| Stock 2024 | 1,180,591,361 | 67,466,823 | 39,974,370 |

2739 Note: The sales numbers used in the stock calculation are highlighted in grey

2740 Source: (1st Stakeholders consultation, 2025)

2741 According to the EIA Status Report, there were 1.5 billion tyre units in operation in 2020,
 2742 consisting of 88 % C1, 8 % C2, and 4 % C3 tyres (VHK, 2024b). This figure includes both
 2743 replacement and OEM sales and is shown in Table 5-19. When considering only replacement
 2744 sales in the EIA report, the stock was 1,204,000,000 units in 2020 and is projected to reach
 2745 1,337,000,000 units by 2025. These figures align closely with our own estimates performed
 2746 based on ETRMA data received during the stakeholder consultation.

2747 By 2030, the number of units in stock is projected to rise by 23 % to reach 1.9 billion units. If we
 2748 assume a linear growth, this would mean approximately 1.66 billion units in 2024 in total
 2749 including both replacement and OEM tyres according to the EIA report (VHK, 2024a).

2750 **Table 5-19: Total EU27 tyre stock (distinguishing between OEM and replacement stock) in**
2751 **quantity (units) including 2025 and 2030 forecasts.**

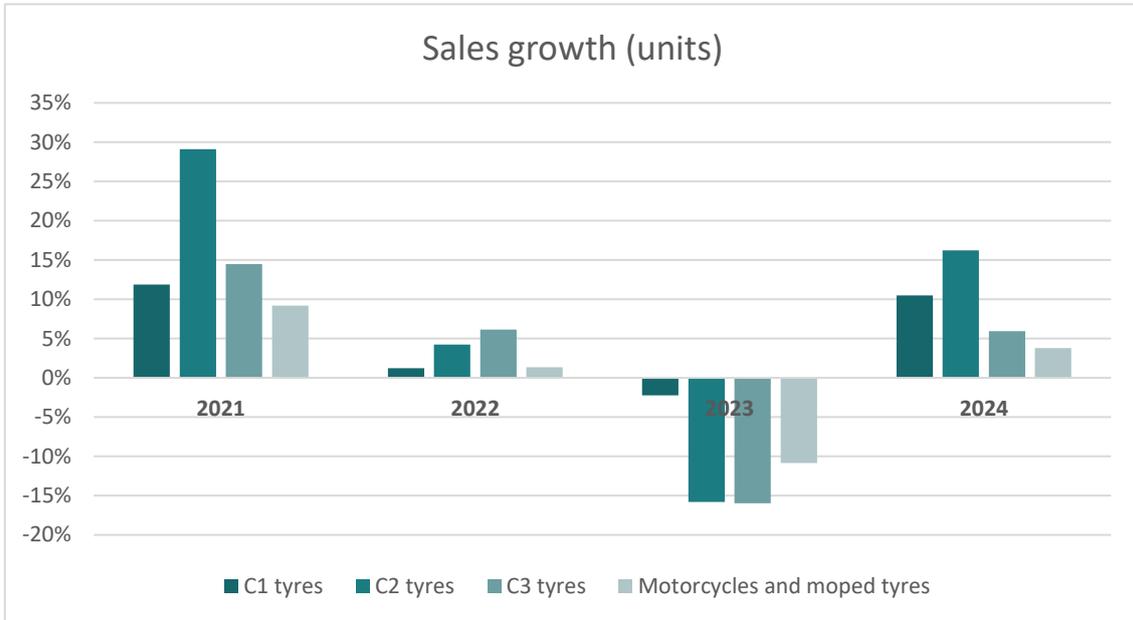
| Year | End use | C1 tyres | C2 tyres | C3 tyres |
|------|-------------|---------------|-------------|------------|
| 2030 | Replacement | 1,302,000,000 | 121,000,000 | 59,000,000 |
| | OEM | 392,000,000 | 26,000,000 | 17,000,000 |
| 2025 | Replacement | 1,174,000,000 | 109,000,000 | 54,000,000 |
| | OEM | 353,000,000 | 23,000,000 | 15,000,000 |
| 2020 | Replacement | 1,057,000,000 | 98,000,000 | 49,000,000 |
| | OEM | 324,000,000 | 21,000,000 | 14,000,000 |
| 2015 | Replacement | 966,000,000 | 88,000,000 | 39,000,000 |
| | OEM | 278,000,000 | 18,000,000 | 12,000,000 |

2752 Source: (VHK, 2024b)

2753 **5.3.3. Annual sales growth**

2754 As shown in **Figure 5-6**, all available tyre types experienced a significant increase in replacement
 2755 units sold from 2020 to 2021 according to the ETRMA data received during the stakeholder
 2756 consultation, followed by a modest growth from 2021 to 2022. In 2023, there was a notable
 2757 decline in sales, which was then followed by a renewed growth in 2024. The average annual

2758 replacement sales growth rate (CAGR) from 2020 to 2024 is 5.16 % for C1 tyres, 7.13 % for C2
 2759 tyres and 1.99 % for C3 tyres. The CAGR for the total (including C1, C2, C3 tyres) is approximately
 2760 5.16 %. The CAGR for motorcycle and moped tyres is 0.59 %. However, 2020 was the year of
 2761 COVID-19, during which there was a dip in sales. The CAGR of replacement sales from 2015 to
 2762 2024 is 1.96 % for C1 tyres, 3.7 % for C2 tyres, 1.3 % for C3 tyres, and 0.25 % for motorcycle and
 2763 moped tyres. The CAGR for the total (including C1, C2, C3 tyres) is approximately 2.06 %.



2764
 2765 **Figure 5-6: Sales growth in replacement units in 2021 – 2024 (Compared to the previous year).**

2766 Source: (1st Stakeholders consultation, 2025)

2767 As shown below in Table 5-20, between 2025 and 2030, the projected tyre sales shows modest
 2768 but uneven growth: replacement tyres expand steadily at around 1.4 – 2.1 % per year, while
 2769 OEM tyre sales is more volatile, with strong growth in C2 (~3.1 %) but stagnation in C3 (0 %). The
 2770 key uncertainty is whether this average ~2 % annual growth can realistically be expected to
 2771 continue beyond 2030.

2772 **Table 5-20: Projected CAGR (%) of tyre sales (distinguishing OEM and replacement sales)**
 2773 **(2025–2030).**

| End use | C1 tyres | C2 tyres | C3 tyres |
|-------------|----------|----------|----------|
| Replacement | 2.14 % | 1.99 % | 1.39 % |
| OEM | 2.21 % | 3.13 % | 0 % |

2774 Source: (VHK, 2024b)

2775

2776 Questions for stakeholders:
 2777 T2-13: Is it reasonable to assume an average annual growth rate of approximately
 2778 2 % over the next five years?

2779

2780 **5.3.4. OEM and replacement sales**

2781 As noted in the previous sections, ETRMA data as received during the stakeholder consultation,
 2782 only provides information on replacement sales. The total number of replacement sales for C1,
 2783 C2, and C3 tyres according to ETRMA in 2024 was approximately **295,170,472 units** (1st
 2784 Stakeholders consultation, 2025).

2785 The IEA report distinguishes between replacement and OEM sales. In 2020, replacement sales
 2786 totalled 273,000,000 units, with projections rising to 303,000,000 units by 2025, which aligns
 2787 with the figure mentioned above based on ETRMA data. OEM sales were 76,000,000 units in
 2788 2020 and are expected to reach 88,000,000 units in 2025 (VHK, 2024b). If linear growth is
 2789 assumed, that would mean that new sales in 2024 would be approximately **85,600,000 units**.
 2790 The breakdown by tyre type can be found in **Table 5-20**.

2791 **5.4. Market trends**

2792 Manufacturer brochures and websites as well as industry reports were analysed to identify
 2793 important product specific developments and trends in tyres.

2794 **5.4.1. General market trends**

2795 The following section outlines overall market trends, based on shifts in market share as well as
 2796 trends in technical tyre characteristics and vehicle developments.

2797 **5.4.1.1. Market shares by segment**

2798 Within the tyre market, distinctions can be made not only by vehicle class but also by seasonal
 2799 type and price segment. The stakeholder consultation indicates notable shifts over the past five
 2800 years:

- 2801 • Passenger cars and SUVs (C1 class): all-season tyres grew strongly (+84 %), while
 2802 summer tyres declined (-2 %) and winter tyres saw a slight increase (+1.6 %).
- 2803 • Light trucks (C2 class): winter tyres recorded the highest growth across all categories
 2804 (+87 %), whereas all-season tyres lost (-5 %) and summer tyres fell (-7 %).
- 2805 • Heavy trucks (C3 class): both summer and winter tyres declined (-6 % and -52 %
 2806 respectively), while all-season tyres remain uncommon in this segment.

2807 By price segment, budget tyres dominate sales across all classes, followed by premium tyres,
 2808 particularly in C1 and C3. The C3 market shows the most balanced distribution of market shares
 2809 across price tiers;

2810 **Table 5-21: Market share of price segments.**

| Category | Class C1 | Class C2 | Class C3 |
|----------|----------|----------|----------|
| Budget | 56,4 % | 70,7 % | 43,2 % |

| Category | Class C1 | Class C2 | Class C3 |
|--------------|----------|----------|----------|
| Medium-range | 19,3 % | 17,4 % | 26,4 % |
| Premium | 24,3 % | 11,9 % | 30,4 % |
| Total | 100 % | 100 % | 100 % |

2811 Source: (1st Stakeholders consultation, 2025)

2812 5.4.1.2. All-season/weather tyres

2813 The stakeholder consultation revealed that there has been a growth in all-season or all-weather
 2814 tyres over the past 5 years, which has been especially pronounced in the C1 class, where all-
 2815 season tyres expanded by more than 80 % between 2020 and 2024. In contrast, C2 class all-
 2816 season tyres declined slightly, reflecting different market dynamics, while C3 all-season tyres
 2817 remain rare (1st Stakeholders consultation, 2025).

2818 All-season tyres perform well in moderate conditions but are less effective in harsh winter
 2819 weather. All-weather tyres combine summer and winter features, providing reliable
 2820 performance year-round, including in snow and cold. Since 2013, all-weather tyres have
 2821 established themselves in Europe as a mature market segment. By 2023, they accounted for
 2822 19 % of total tyre sales, making them a key category in the European market (Hankook, n.d.).

2823 The rise of all-season or all-weather tyres can be closely tied to climate change, with milder
 2824 winters and unpredictable weather driving demand for year-round solutions. Designed to
 2825 handle rain, snow, and dry conditions, these tyres offer both convenience and safety. The
 2826 European all-season market is expected to grow even further over the next five years (Goodyear,
 2827 2024a) (Continental, n.d.-b).

2828 5.4.1.3. Rolling resistance and fuel consumption

2829 The rolling resistance coefficient (RRC) measures the resistance tyres generate as a vehicle
 2830 moves, expressed in kilograms of resistance per tonne of vehicle weight (kg/t) (see **Section 6.2.1**
 2831 for more information). Lower RRC values indicate more energy-efficient tyres, i.e., fuel savings
 2832 for the vehicle owner. While RRC has gradually improved since 1990, regulatory labelling has
 2833 significantly accelerated progress since it was introduced in 2012. Recent trends from 2005 to
 2834 2025 and projections towards 2030 are:

- 2835 • For C1 tyres, the average RRC was 12.2 kg/t in 2005. Currently the RRC is 9.7 kg/t and by
 2836 2030, it's projected to decrease to 9.4 kg/t without additional measures
- 2837 • C2 tyres followed a similar trend, dropping from 10.6 kg/t in 2005 with currently a RRC
 2838 of 8.7 kg/t and an expected 8.7 kg/t by 2030 without measures
- 2839 • C3 tyres started at 7.6 kg/t in 2005, with currently an RRC of 6.5 kg/t and with forecasts
 2840 of 6.4 kg/t in 2030 without measures.

2841 Further policy interventions could reduce RRC even more (VHK, 2024b).

2842 The rolling resistance of tyres accounts for 16-20 % of the fuel consumption of vehicles.
2843 Therefore, improving the rolling resistance can reduce fuel consumption and CO₂ emissions
2844 significantly. However, it is important that other properties of tyres, such as wet grip and
2845 durability, are not negatively affected when improving energy efficiency (VHK, 2024a).

2846 In 2005, annual fuel consumption due to tyre rolling resistance was approximately 650 TWh per
2847 year, prior to any efficiency measures. Without further action, this figure is projected to rise
2848 slightly to 660 TWh per year by 2030. However, the introduction of tyre labelling regulations,
2849 including the 2020 revision, is expected to reduce this to 603 TWh per year, achieving a savings
2850 of 57 TWh, or 9 %. These energy savings are estimated to result in a reduction of greenhouse
2851 gas emissions by 15 million tonnes of CO₂-equivalent annually by 2030 (VHK, 2024a).

2852 5.4.1.4. Adapting tyres to vehicle trends

2853 The number of electric vehicles (EVs) and SUVs is steadily increasing, driving higher demand for
2854 other types of tyres across all markets. SUV tyres are reinforced for higher loads and stronger
2855 engines. They are designed to hold more weight than standard car tyres and support the
2856 increased mass of an SUV without compromising grip or performance. Standard car tyres would
2857 not sufficiently support the weight of an SUV, making SUV tyres more efficient for this purpose
2858 (Michelin, n.d.-g) (Apollo tyres, n.d.-a).

2859 While electric vehicles and traditional internal combustion engine (ICE) vehicles may appear
2860 similar and can sometimes use the same tyres, the tyres specifically designed for EVs offer
2861 unique advantages. They are optimised for battery range, noise reduction in the cabin, and tyre
2862 longevity. EV tyres are built to handle the immediate power delivery during acceleration, which
2863 is more intense compared to the gradual acceleration in ICE vehicles. The immediate power
2864 deployment during acceleration leads to sharper and more intense weight transfers, which
2865 impacts tyre wear. EVs also require tyres that can support the increase in weight related to the
2866 traction battery. Additionally, as EVs are silent, the noise from tyres on the road surface becomes
2867 more noticeable, requiring quieter tyres to reduce interior noise. To enhance battery range, EV
2868 tyres are also designed to optimise rolling resistance, allowing for longer trips on a single charge
2869 (Apollo tyres, n.d.-b) (Michelin, n.d.-a) (Continental, n.d.-f).

2870 Furthermore, with the predicted rise of autonomous vehicles (AVs) in the next decade, special
2871 AV tyres or smart tyres may become crucial for safety and performance of such vehicles. They
2872 must provide consistent grip, precise handling, and reliable braking, while some even include
2873 sensors to monitor pressure, temperature, and wear for predictive maintenance (Continental,
2874 n.d.-e) (Goodyear, 2024b).

2875 5.4.2. Market channels and production structure

2876 5.4.2.1. Industry associations

2877 Multiple EU-wide associations, along with several local ones, focus on the tyre industry, as
 2878 outlined in a non-exhaustive list in **Table 5-22**. The ETRMA (European Tyre and Rubber
 2879 Manufacturers Association) is a key organisation focusing on the regulatory, environmental, and
 2880 technical aspects of the tyre and rubber industry. It represents manufacturers of tyres for cars,
 2881 trucks, and other vehicles, advocating for the industry's interests. Similarly, the ETRTO
 2882 (European Tyre and Rim Technical Organisation) represents European tyre manufacturers and
 2883 addresses a wide range of issues, including regulations, environmental impact, safety, and
 2884 innovation. The European Tyre Recycling Association (ETRA) plays a significant role in promoting
 2885 tyre recycling across Europe and addresses regulatory and market issues related to the
 2886 management of end-of-life tyres. EuRIC (the European Recycling Industries' Confederation), also
 2887 has a dedicated working group for tyres called the Mechanical Tyres Recycling (MTR) Branch,
 2888 which focuses on promoting tyre recycling and best practices across Europe. Finally, ITMA
 2889 (Imported Tyre Manufacturers' Association) represents the interests of non-European tyre
 2890 manufacturers operating within the European market, focusing on ensuring fair market access,
 2891 compliance with EU regulations, and promoting best practices among its members. For
 2892 retreaded tyres, BIPAVER (the European Retreading Association) represents the interests of the
 2893 retreading industry across Europe, promoting sustainable practices, advocating for supportive
 2894 legislation, and setting technical standards to ensure the quality and safety of retreaded tyres.

2895 **Table 5-22: Non-exhaustive list of EU associations in the tyre industry.**

| Association | Country |
|---|-------------|
| ETRTO (European Tyre and Rim Technical Organisation) | EU-wide |
| ETRMA (European Tyre and Rubber Manufacturers Association) | EU-wide |
| ETRA (European Tyre Recycling Association) | EU-wide |
| EuRIC (the European Recycling Industries' Confederation) | EU-wide |
| ITMA (Imported Tyre Manufacturers' Association) | EU and UK |
| BIPAVER (the European Retreading Association) | EU-wide |
| Bundesverband der Deutschen Reifenhändler und -hersteller (BRV) | Germany |
| Branchevereniging voor de banden- en wielenbranche (VACO) | Netherlands |
| ASSOGOMMA | Italy |
| Agrupación de Fabricantes de Neumáticos (AFANE) | Spain |

| Association | Country |
|---|----------------|
| Syndicat du Pneu | France |
| Polski Związek Przemysłu Oponiarskiego (PZPO) | Poland |
| Dækbranchen Danmark | Denmark |
| Asociace výrobců pneumatic | Czech Republic |
| Asociácia výrobcov pneumatík | Slovakia |
| Hungarian Tyre Association (HTA) | Hungary |

2896 Manufactures

2897 Table 5-23 below provides a non-exhaustive overview of all EU27-based headquarters and
 2898 manufacturing plants based on the members list of ETRMA. The focus is on tyre manufacturing
 2899 sites, and less so on retreading facilities. The list has been updated using figures provided by
 2900 ETRMA in a 2021 report (ETRMA, 2021a). In some cases, the location of manufacturers' facilities
 2901 was unclear, so discrepancies may exist. The only truly European-headquartered tyre companies
 2902 are Michelin, Pirelli, Continental, Nokian, and Prometeon, while most Asian and US tyre groups
 2903 (e.g. Bridgestone, Goodyear) have EU branches rather than EU headquarters. As of the end of
 2904 2022, among European manufacturers, Michelin (France) is Europe's largest tyre manufacturer,
 2905 followed by Continental (Germany).

2906 Based on the membership list of ITMA, there are also multiple EU importers without a
 2907 manufacturing plant, including Giti Tire, Aeolus Tyre Co. Ltd., Kenda Europe Technical Centre,
 2908 Kumho Tyres, Maxxis International, Prinx Chengshan Tire Europe, Sailun Co. Ltd., Shaanxi
 2909 Yanchang Petroleum, Shandong Linglong Tyre Co., Van den Ban Group (VDB Group), and Triangle
 2910 Tyre Europe (ITMA, n.d.).

2911

2912 **Table 5-23: Non-exhaustive overview of manufactures within the EU27 based on ETRMA**
 2913 **membership.**

| Company | EU Headquarters | Country (EU27-based facilities) |
|--------------|------------------|--|
| Apollo Tyres | - | Netherlands, Hungary |
| Bridgestone | Belgium (EU) | Spain, Poland, Italy, Hungary |
| Continental | Germany (Global) | Portugal, Slovakia, Germany, France, Czech Republic, Romania |
| Goodyear | Belgium (EU) | France, Germany, Luxembourg, Poland, Serbia, Slovenia |
| Hankook | Germany (EU) | Hungary |
| Linglong | - | Serbia |
| Michelin | France (Global) | France, Italy, Germany, Serbia, Poland, Spain |
| Nexen Tire | - | Czech Republic |
| Nokian Tyres | Finland (Global) | Finland, Romania |

| Company | EU Headquarters | Country (EU27-based facilities) |
|------------|-----------------|--|
| Pirelli | Italy (Global) | Italy, Romania, Poland |
| Prometeon | Italy (Global) | Italy |
| Toyo Tires | Germany (EU) | Serbia |
| Yokohama | Germany (EU) | Italy, Slovenia, Serbia, Czech Republic, Latvia, |

2914 Source: (ETRMA, n.d.-b) and company websites

2915 5.4.2.2. Employment

2916 In 2023, the economic contribution of the EU tyre manufacturing industry is estimated to have
 2917 supported nearly half a million jobs across the EU. This marks a 6 % decline compared to 2014.
 2918 Although tyre production increased over this period, the overall reduction in employment
 2919 reflects broader productivity gains within the EU economy and evolving market conditions,
 2920 including increasing global competition. Direct employment in tyre manufacturing amounted to
 2921 112,000 workers in 2023, representing roughly one in every 270 manufacturing jobs in the EU.
 2922 In addition, the sector supported 259,000 jobs through supply-chain activities and another
 2923 128,000 through wage-related spending by employees in the tyre manufacturing sector and its
 2924 supply chains (ETRMA, 2024b).

2925 The employment multiplier in this case was 4.5, meaning that for every 1,000 jobs within the
 2926 tyre manufacturing industry, an additional 3,500 jobs were supported elsewhere in the EU
 2927 economy. This employment multiplier is higher compared to the GDP multiplier (3.2x), which
 2928 underscores the sector's strong productivity levels. Productivity among tyre manufacturing
 2929 workers in 2023 was estimated to be approximately 60 % higher than the EU average (ETRMA,
 2930 2024b).

2931 In 2016, the European retreading sector supported approximately 32,000 jobs, primarily
 2932 concentrated in Germany (5,700 jobs), France (4,000), Italy (2,200), and Spain (1,600). At that
 2933 time, the United Kingdom (still part of the EU) accounted for 5,500 jobs. Most are direct jobs in
 2934 production and distribution (EY, 2016).

2935 5.4.3. Trends in product design/features

2936 Tyre manufacturers are advancing efforts to enhance product circularity and sustainability. In
 2937 the stakeholder consultation, several companies reported already integrating substantial
 2938 proportions of bio-based or recycled materials into production and industry roadmaps
 2939 commonly include targets of achieving more than 40 % recycled or renewable content by 2030,
 2940 with a long-term ambition of reaching 100 % by 2050 (Michelin, n.d.-d) (Continental, 2025c)
 2941 (Bridgestone, n.d.). The following tables present stakeholders' views on the importance and
 2942 emerging trends of specific product and technical features linked to improved circularity and
 2943 sustainability in C1, C2, and C3 tyres. Given the limited volume of feedback, the findings should
 2944 not be considered fully representative or exhaustive. Some stakeholders completed only parts
 2945 of the survey, resulting in varying response counts by feature and tyre category. Six stakeholders

2946 contributed to the table, though not all fields were completed by everyone. Cell values indicate
 2947 the number of respondents selecting each answer.

2948 **Table 5-24** presents the results for C1 tyres. According to stakeholders, most technical features
 2949 are considered to be of low importance to customers. In particular, features such as the use of
 2950 biodegradable components, lightweight construction, improved puncture resistance, modular
 2951 design elements, potential for reusability, and a high-speed index are perceived as less
 2952 important. Low rolling resistance/fuel consumption is viewed as somewhat important, while
 2953 high mileage/durability is rated as medium to high in importance. The trend in importance is
 2954 viewed as relatively stable for most features, with the exception of the use of recycled materials,
 2955 low microplastic pollution, and a low share of substances of concern, which are seen as clearly
 2956 increasing in importance. The use of recovered carbon black, high mileage/durability, and
 2957 responsible raw material sourcing are also considered to be somewhat rising in importance.

2958 **Table 5-24: Degree and trend of importance of sustainability or circularity features to**
 2959 **customers of C1 tyres (N = 5 - 6).**

| Technical features | Degree of importance | | | Trend in importance | | |
|--|----------------------|--------|------|---------------------|--------|--------|
| | Low | Medium | High | Declining | Stable | Rising |
| Use of bio-based materials | 2 | 3 | 0 | 1 | 3 | 1 |
| Use of recycled materials | 3 | 1 | 1 | 0 | 0 | 5 |
| Use of biodegradable components | 5 | 0 | 0 | 0 | 3 | 2 |
| Use of recovered carbon black | 3 | 2 | 0 | 0 | 2 | 3 |
| Use of silica (instead of carbon black) | 2 | 2 | 1 | 0 | 4 | 1 |
| Low rolling resistance/fuel consumption | 1 | 1 | 3 | 0 | 3 | 2 |
| Lightweight construction | 4 | 0 | 1 | 0 | 5 | 0 |
| Optimised tread patterns | 3 | 1 | 1 | 0 | 5 | 0 |
| Self-sealing layers | 3 | 1 | 1 | 1 | 2 | 2 |
| Improved puncture resistance | 4 | 1 | 0 | 1 | 3 | 1 |
| Modular design elements | 4 | 0 | 0 | 0 | 4 | 0 |
| Presence of a tyre pressure monitoring system (TPMS) | 2 | 3 | 0 | 0 | 4 | 1 |
| Embedded sensors | 4 | 1 | 0 | 0 | 5 | 0 |
| Self-healing materials | 4 | 1 | 0 | 1 | 3 | 1 |
| Reduction tyre weight | 3 | 2 | 0 | 0 | 5 | 0 |
| Potential for reusability (esp. retreading) | 4 | 1 | 1 | 2 | 3 | 1 |
| High speed Index | 5 | 0 | 0 | 1 | 4 | 0 |
| High mileage/ durability | 0 | 3 | 2 | 0 | 2 | 3 |
| Low manufacturing emissions | 3 | 1 | 1 | 0 | 3 | 2 |

| Technical features | Degree of importance | | | Trend in importance | | |
|-----------------------------------|----------------------|---|---|---------------------|---|---|
| Low microplastic pollution | 2 | 2 | 1 | 0 | 1 | 4 |
| Low share of substance of concern | 1 | 2 | 2 | 0 | 1 | 4 |
| Responsible raw material sourcing | 2 | 1 | 2 | 0 | 2 | 3 |

2960 Source: (1st Stakeholders consultation, 2025)

2961 For C2 tyres, the results are broadly similar. Most technical features are not considered
 2962 important to customers, particularly the use of biodegradable components, embedded sensors,
 2963 self-sealing materials, and a high-speed index. None of the features are rated as highly
 2964 important; however, low rolling resistance/fuel consumption and high mileage/durability are
 2965 seen as medium to high in importance, while the presence of a tyre pressure monitoring system
 2966 (TPMS) is viewed as moderately important. For most features, the trend in importance remains
 2967 stable, except for the use of recycled materials, low microplastic pollution, low share of
 2968 substances of concern, and responsible raw material sourcing, which all show a rising trend.

2969 **Table 5-25: Degree and trend of importance of sustainability or circularity features to**
 2970 **customers of C2 tyres (N = 4 - 5).**

| Technical features | Degree of importance | | | Trend in importance | | |
|---|----------------------|--------|------|---------------------|--------|--------|
| | Low | Medium | High | Declining | Stable | Rising |
| Use of bio-based materials | 2 | 2 | 0 | 1 | 2 | 1 |
| Use of recycled materials | 2 | 1 | 1 | 0 | 0 | 4 |
| Use of biodegradable components | 4 | 0 | 0 | 0 | 2 | 2 |
| Use of recovered carbon black | 3 | 1 | 0 | 0 | 2 | 2 |
| Use of silica (instead of carbon black) | 3 | 1 | 0 | 0 | 4 | 0 |
| Low rolling resistance/fuel consumption | 0 | 2 | 2 | 0 | 2 | 2 |
| Lightweight construction | 3 | 0 | 1 | 0 | 4 | 0 |
| Optimised tread patterns | 3 | 1 | 0 | 0 | 3 | 1 |
| Self-sealing layers | 3 | 0 | 1 | 1 | 2 | 1 |
| Improved puncture resistance | 3 | 0 | 1 | 1 | 3 | 0 |
| Modular design elements | 3 | 0 | 0 | 0 | 3 | 0 |
| Presence of a tyre Pressure Monitoring Systems (TPMS) | 0 | 4 | 0 | 0 | 3 | 1 |
| Embedded sensors | 4 | 0 | 0 | 0 | 4 | 0 |
| Self-healing materials | 4 | 0 | 0 | 1 | 3 | 0 |
| Reduction tyre weight | 3 | 0 | 1 | 0 | 4 | 0 |

| Technical features | Degree of importance | | | Trend in importance | | |
|---|----------------------|--------|------|---------------------|--------|--------|
| | Low | Medium | High | Declining | Stable | Rising |
| Potential for reusability (esp. retreading) | 2 | 2 | 1 | 1 | 3 | 1 |
| High speed Index | 4 | 0 | 0 | 0 | 4 | 0 |
| High mileage/ durability | 0 | 2 | 2 | 0 | 2 | 2 |
| Low manufacturing emissions | 3 | 0 | 1 | 0 | 3 | 1 |
| Low microplastic pollution | 2 | 1 | 1 | 0 | 1 | 3 |
| Low share of substance of concern | 1 | 2 | 1 | 0 | 1 | 3 |
| Responsible raw material sourcing | 2 | 1 | 1 | 0 | 1 | 3 |

2971 Source: (1st Stakeholders consultation, 2025)

2972 For C3 tyres, as shown in **Table 5-26**, the results are largely similar to C1 and C2 tyres with minor
 2973 discrepancies. Features such as the use of biodegradable components, self-sealing layers,
 2974 modular design elements, and a high-speed index are considered of low importance to
 2975 customers. Low rolling resistance/fuel consumption and high mileage/durability are again
 2976 viewed as highly important, consistent with the findings for C1 and C2 tyres. However, for C3
 2977 tyres, the potential for reusability is also regarded as important. The trend in importance is
 2978 generally stable, except for an increasing trend in the use of recycled materials, low share of
 2979 substances of concern, and responsible raw material sourcing.

2980 **Table 5-26: Degree and trend of importance of sustainability or circularity features to**
 2981 **customers of C3 tyres (N= 4 – 5).**

| | Degree of importance | | | Trend in importance | | |
|---|----------------------|--------|------|---------------------|--------|--------|
| | Low | Medium | High | Declining | Stable | Rising |
| Use of bio-based materials | 2 | 2 | 0 | 0 | 2 | 2 |
| Use of recycled materials | 2 | 2 | 0 | 0 | 0 | 4 |
| Use of biodegradable components | 4 | 0 | 0 | 0 | 3 | 1 |
| Use of recovered carbon black | 3 | 1 | 0 | 0 | 2 | 2 |
| Use of silica (instead of carbon black) | 3 | 1 | 0 | 0 | 4 | 0 |
| Low rolling resistance/fuel consumption | 0 | 0 | 4 | 0 | 2 | 2 |
| Lightweight construction | 2 | 2 | 0 | 0 | 4 | 0 |
| Optimised tread patterns | 1 | 2 | 1 | 0 | 3 | 1 |
| Self-sealing layers | 4 | 0 | 0 | 0 | 4 | 0 |
| Improved puncture resistance | 2 | 2 | 0 | 0 | 4 | 0 |
| Modular design elements | 3 | 0 | 0 | 0 | 3 | 0 |

| | Degree of importance | | | Trend in importance | | |
|---|----------------------|---|---|---------------------|---|---|
| | 0 | 3 | 1 | 0 | 2 | 2 |
| Presence of a tyre pressure monitoring systems (TPMS) | 0 | 3 | 1 | 0 | 2 | 2 |
| Embedded sensors | 3 | 1 | 0 | 0 | 3 | 1 |
| Self-healing materials | 4 | 0 | 0 | 0 | 4 | 0 |
| Reduction tyre weight | 2 | 2 | 0 | 0 | 4 | 0 |
| Potential for reusability (esp. retreading) | 0 | 0 | 5 | 1 | 3 | 1 |
| High speed Index | 4 | 0 | 0 | 0 | 4 | 0 |
| High mileage/ durability | 0 | 0 | 4 | 0 | 2 | 2 |
| Low manufacturing emissions | 3 | 0 | 1 | 0 | 3 | 1 |
| Low microplastic pollution | 3 | 0 | 1 | 0 | 2 | 2 |
| Low share of substance of concern | 1 | 2 | 1 | 0 | 1 | 3 |
| Responsible raw material sourcing | 2 | 1 | 1 | 0 | 1 | 3 |

2982 Source: (1st Stakeholders consultation, 2025)

2983 **5.4.4. Innovation**

2984 The study enabled the consultant team to identify some innovative concepts in the field of tyres.

2985 **Tyre-as-a-Service (TaaS) Models**

2986 Tyres-as-a-Service (TaaS) can take several forms. In some cases, it follows a subscription model,
 2987 similar to the approach described in the Preparatory Study for Ecodesign on Imaging Equipment
 2988 and its consumables, where cartridges are provided through subscriptions (JRC, 2024). For tyres,
 2989 Goodyear has introduced such a model for commercial and last-mile delivery fleets in the U.S.
 2990 and Europe. Through this service, fleets pay per distance travelled and benefit from access to
 2991 premium tyres, continuous monitoring, and regular servicing, while fully outsourcing tyre
 2992 management. The model is designed to increase vehicle uptime, reduce breakdowns, lower fuel
 2993 consumption, and ultimately improve total cost of ownership. A European pilot demonstrated
 2994 that Goodyear’s subscription helped a commercial fleet achieve nearly a 50 % reduction in
 2995 emergency breakdown events and up to a 4 % decrease in fuel consumption compared to the
 2996 previous year (Goodyear, 2024c).

2997 In a more advanced, data-driven model, TaaS leverages real-time vehicle data to optimise tyre
 2998 performance, safety, and sustainability. This includes monitoring tyre pressure, wear,
 2999 temperature, and damage using advanced algorithms and sensors. These systems can alert
 3000 drivers and fleet managers before issues arise, improving safety and reducing maintenance
 3001 costs. They also help optimise fuel consumption and reduce CO₂ emissions by ensuring tyres are
 3002 always in optimal condition. The model contributes to road safety by detecting potholes and

3003 mapping road hazards, which can inform infrastructure improvements. It can also support the
3004 transition to electric vehicles by helping manage energy consumption and extending battery
3005 range through low rolling resistance tyres. However, the success of data driven TaaS depends
3006 on fair access to in-vehicle data. Currently, vehicle manufacturers control this data, limiting
3007 third-party innovation (ETRMA, 2022b).

3008 [Biobased materials](#)

3009 A range of innovative bio-based materials are currently being investigated to enhance the
3010 sustainability of tyre manufacturing without compromising performance. Natural rubber from
3011 rubber trees remains the primary raw material, but alternative sources such as guayule and
3012 dandelion are under development to diversify supply and improve resilience in raw material
3013 sourcing (Bridgestone, n.d.) (Continental, n.d.-a). Plant-based oils, such as soybean oil, are being
3014 incorporated to improve elasticity and flexibility across a wide temperature range (Goodyear,
3015 n.d.). Agricultural residues are also being valorised: silica produced from rice husks functions as
3016 a reinforcing filler, contributing to improved grip (Continental, n.d.-d). In addition, lignin
3017 extracted from wood and other biomass offers a renewable substitute for carbon black,
3018 supporting reduced reliance on fossil-based inputs in tyre compounding (Nokian tyres, 2024).
3019 This is further examined in **Section 7.6.3**.

3020 [Use of artificial intelligence](#)

3021 Artificial intelligence (AI) is increasingly applied in the tyre industry to improve design,
3022 production, and performance monitoring. AI-driven simulations allow engineers to test new
3023 materials and tread patterns digitally, reducing the need for physical prototypes and shortening
3024 development cycles. In manufacturing, AI enhances quality control by detecting defects and
3025 optimizing production processes. On the road, smart tyres equipped with sensors may use AI to
3026 monitor pressure, temperature, and wear, enabling predictive maintenance and improving
3027 reliability. AI is also applied to sustainability efforts, supporting more efficient tyre recycling
3028 (Continental, 2024b) (Pirelli, n.d.-a) (Hankook, 2024).

3029 [Self-Healing Tyres](#)

3030 Self-sealing tyres are commercially available and contain a layer of sealant that plugs punctures
3031 immediately, maintaining air pressure and preventing flats. True self-healing tyres, on the other
3032 hand, are an emerging technology that repairs damage at a molecular level, potentially allowing
3033 the rubber itself to “heal” over time without a sealant. Using advanced materials, these tyres
3034 can automatically repair small punctures, reducing the need for replacements and cutting down
3035 on waste (Utrera-Barrios, Verdejo, Ángel López-Manchado, et al., 2023) (Pirelli, n.d.-b).

3036 **5.5. Consumer expenditure base data**3037 **5.5.1. Average EU price for private consumers**

3038 The price of tyres can vary widely depending on the category of tyres, the type of tyres (i.e.
 3039 summer, winter or all-seasons), size, market/country, the manufacturer or brand and the
 3040 retailer that puts them on the market. **Table 5-27** shows the retail prices for the different
 3041 categories and types of tyres in three selected countries, representing Eastern, Northern and
 3042 Western Europe, based on the catalogue of prices of a retailer that distributes in 17 EU countries.
 3043 Because these are catalogue prices, they include VAT.

3044 **Table 5-27: Observed retail prices.**

| Country | Tyre type | Observed Price range (incl. VAT) | Source |
|---------|------------------------------------|----------------------------------|---|
| Germany | Passenger cars (C1) – summer tyres | EUR 35 – 2,630 | https://tyresinternationalgroup.com/de |
| Germany | Passenger cars (C1) – winter tyres | EUR 32 – 1,112 | https://tyresinternationalgroup.com/de |
| Germany | Passenger cars (C1) – all year | EUR 26 - 624 | https://tyresinternationalgroup.com/de |
| Germany | Trucks (C3) - summer | EUR 12 – 1,287 | https://tyresinternationalgroup.com/de |
| Germany | Trucks (C3) - winter | EUR 12 - 683 | https://tyresinternationalgroup.com/de |
| Germany | Trucks (C3) – all year | EUR 25 – 1,297 | https://tyresinternationalgroup.com/de |
| Germany | Motorcycle - summer | EUR 12 – 1,183 | https://tyresinternationalgroup.com/de |
| Germany | Motorcycle – winter | EUR 38 - 158 | https://tyresinternationalgroup.com/de |
| Germany | Motorcycle – all year | EUR 65 - 937 | https://tyresinternationalgroup.com/de |
| Poland | Passenger cars (C1) – summer tyres | PLN 126 – 11,508 | https://tyresinternationalgroup.com/pl |
| Poland | Passenger cars (C1) – winter tyres | PLN 118 – 4,938 | https://tyresinternationalgroup.com/pl |
| Poland | Passenger cars (C1) – all year | PLN 130 – 4,044 | https://tyresinternationalgroup.com/pl |
| Poland | Trucks (C3) - summer | PLN 80 – 5,660 | https://tyresinternationalgroup.com/pl |
| Poland | Trucks (C3) - winter | PLN 100 – 2,251 | https://tyresinternationalgroup.com/pl |
| Poland | Trucks (C3) – all year | PLN 54 – 5,719 | https://tyresinternationalgroup.com/pl |
| Poland | Motorcycle - summer | PLN 139 – 9,558 | https://tyresinternationalgroup.com/pl |
| Poland | Motorcycle – winter | PLN 203 - 322 | https://tyresinternationalgroup.com/pl |
| Poland | Motorcycle – all year | PLN 260 – 5,119 | https://tyresinternationalgroup.com/pl |
| Denmark | Passenger cars (C1) – summer tyres | EUR 21 – 3,943 | https://tyresinternationalgroup.com/dk |

| Country | Tyre type | Observed Price range (incl. VAT) | Source |
|---------|------------------------------------|----------------------------------|---|
| Denmark | Passenger cars (C1) – winter tyres | EUR 36 – 5,326 | https://tyresinternationalgroup.com/dk |
| Denmark | Passenger cars (C1) – all year | EUR 36 – 3,776 | https://tyresinternationalgroup.com/dk |
| Denmark | Trucks (C3) - summer | EUR 12 – 7,832 | https://tyresinternationalgroup.com/dk |
| Denmark | Trucks (C3) - winter | EUR 20 – 8,597 | https://tyresinternationalgroup.com/dk |
| Denmark | Trucks (C3) – all year | EUR 16 – 23,951 | https://tyresinternationalgroup.com/dk |
| Denmark | Motorcycle - summer | EUR 12 – 1,519 | https://tyresinternationalgroup.com/dk |
| Denmark | Motorcycle – winter | EUR 55 – 87 | https://tyresinternationalgroup.com/dk |
| Denmark | Motorcycle – all year | EUR 61 – 1,200 | https://tyresinternationalgroup.com/dk |

3045 Note: Prices for Germany and Poland retrieved in May 2025. Prices for Denmark retrieved in September
 3046 2025. Exchange rate in May 2025: 1 EUR = 4.27 PLN based on [Exchange rate \(InforEuro\)](#).

3047 The stakeholder consultation also provided data on prices. Stakeholders input is presented in
 3048 **Table 5-28**. In general, the view is that the price depends on the size of the tyres and on the
 3049 intended use of the tyre.

3050 **Table 5-28: Sales price for new and retreaded tyres based on stakeholders’ input (in EUR, excl.**
 3051 **VAT).**

| Tyre category | New tyres | | Re-treaded tyres | |
|---|--------------------|---------------------|--------------------|---------------------|
| | Lowest price range | Highest price range | Lowest price range | Highest price range |
| Tyres primarily designed for passenger cars (C1) | 21 - 35 | 755 | 40 - 60 | 90 - 150 |
| Tyres primarily designed for light commercial vehicles (C2) | 38 | 194 | 60 | 90 |
| Tyres primarily designed for heavy commercial vehicles (C3) | 120 | 700 | 170 - 230 | 330 - 400 |
| Motorcycles and mopeds | 43 | 528 | n.a. | n.a. |
| Airplane tyres | 97 | 3,632 | 156 | 1,733 |

3052 Source: (1st Stakeholders consultation, 2025)

3053 **Table 5-29** below shows the Harmonised Index of Consumer Prices (HICP) for tyres from 2016
 3054 to 2024. This index shows the price change for tyres relative to the reference year 2015. For
 3055 instance, the index for Belgium in 2016 is 98.4 meaning that the price in 2016 decreased by 1.6%
 3056 compared to 2015. By contrast, the index was 102.2 in 2017, showing a price increase of 2.2%
 3057 relative to 2015.

3058 The highest increase in consumer price index for tyres in 2024 was recorded in Hungary, while
 3059 the lowest occurred in Estonia. The evolution of the HICP for these two countries along with that
 3060 of the EU as a whole is presented in **Figure 5-7** below.

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Table 5-29: Harmonised Index of Consumer Prices for tyres in the EU countries.

| Country | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| European Union | : | 100.39 | 101.00 | 101.40 | 102.80 | 105.28 | 114.53 | 124.89 | 128.55 |
| Belgium | 98.40 | 102.20 | 103.38 | 103.45 | 103.50 | 104.40 | 112.54 | 122.89 | 125.56 |
| Bulgaria | 94.99 | 94.14 | 92.73 | 91.81 | 90.80 | 92.68 | 100.61 | 109.16 | 108.66 |
| Czechia | 98.1 | 97.2 | 95.2 | 96.3 | 103.2 | 110.5 | 128.1 | 138.5 | 146.3 |
| Denmark | 101.0 | 101.4 | 101.1 | 102.5 | 104.8 | 104.0 | 106.6 | 111.0 | 115.6 |
| Germany | 99.0 | 98.7 | 98.7 | 99.0 | 99.8 | 102.9 | 112.3 | 123.7 | 126.8 |
| Estonia | 93.46 | 92.04 | 92.29 | 91.54 | 92.37 | 91.15 | 100.40 | 104.88 | 106.12 |
| Ireland | : | 100.3 | 105.6 | 105.7 | 107.7 | 113.4 | 125.3 | 133.6 | 136.0 |
| Greece | 99.41 | 99.72 | 99.20 | 98.93 | 99.36 | 100.46 | 108.96 | 122.52 | 125.98 |
| Spain | 96.96 | 96.55 | 96.91 | 96.49 | 97.87 | 99.99 | 109.85 | 120.22 | 123.02 |
| France | 98.13 | 96.91 | 96.63 | 96.37 | 97.58 | 98.56 | 108.67 | 115.89 | 118.41 |
| Croatia | 99.56 | 98.97 | 99.03 | 100.70 | 103.37 | 105.97 | 115.87 | 127.29 | 130.32 |
| Italy | 100.1 | 100.3 | 101.0 | 101.1 | 101.9 | 102.8 | 108.0 | 115.0 | 118.4 |
| Cyprus | 105.83 | 107.52 | 106.71 | 108.40 | 108.37 | 111.17 | 121.79 | 126.29 | 128.23 |
| Latvia | 96.04 | 94.22 | 92.46 | 92.70 | 91.91 | 93.88 | 103.16 | 107.07 | 106.52 |
| Lithuania | 98.00 | 97.41 | 97.76 | 96.41 | 98.45 | 101.81 | 112.38 | 122.07 | 124.64 |
| Luxembourg | 97.00 | 96.79 | 94.36 | 92.71 | 96.25 | 98.91 | 111.19 | 118.08 | 120.43 |
| Hungary | 100.97 | 102.89 | 105.79 | 109.01 | 113.11 | 122.00 | 145.74 | 167.82 | 175.08 |
| Malta | 102.38 | 104.49 | 106.55 | 107.48 | 111.42 | 118.66 | 135.36 | 139.42 | 138.17 |
| Netherlands | 96.40 | 95.78 | 101.17 | 102.82 | 103.26 | 105.86 | 122.94 | 136.79 | 146.51 |
| Austria | 97.87 | 100.20 | 101.81 | 102.25 | 104.80 | 106.51 | 118.85 | 133.62 | 137.36 |
| Poland | 100.3 | 102.0 | 101.9 | 102.1 | 105.2 | 113.4 | 132.7 | 144.7 | 145.3 |
| Portugal | 98.50 | 96.41 | 94.70 | 94.22 | 95.07 | 95.41 | 104.43 | 113.21 | 114.44 |
| Romania | : | 99.88 | 102.07 | 104.47 | 106.93 | 110.19 | 118.60 | 134.92 | 148.22 |
| Slovenia | 97.03 | 96.09 | 91.23 | 93.15 | 92.19 | 89.96 | 101.81 | 112.58 | 110.87 |
| Slovakia | 98.44 | 96.76 | 95.82 | 98.83 | 100.12 | 102.10 | 114.53 | 124.61 | 126.44 |
| Finland | : | 97.37 | 96.18 | 97.93 | 97.50 | 99.43 | 110.55 | 116.88 | 117.90 |
| Sweden | 101.04 | 100.84 | 101.66 | 102.22 | 107.21 | 108.21 | 119.20 | 129.39 | 132.43 |

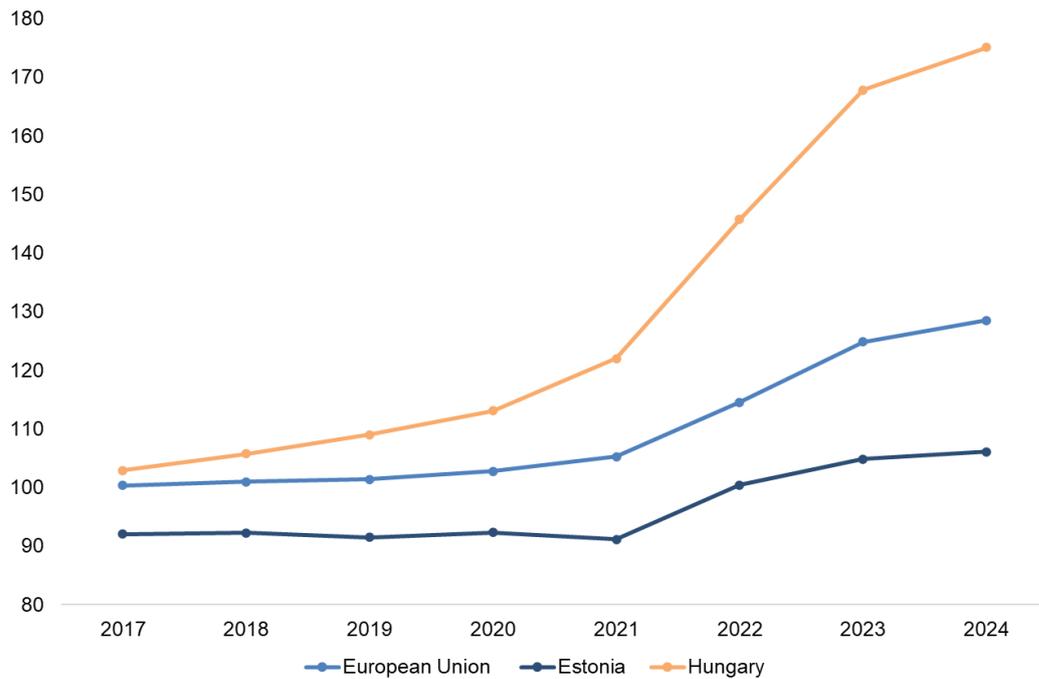
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“:” stands for data not available.

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Source: (Eurostat, 2025d). DOI: 10.2908/prc_hicp_aind - tyres. Downloaded: May 2025

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Figure 5-7: Evolution of HICP in the EU, Estonia and Hungary.

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Source: (Eurostat, 2025d), DOI: 10.2908/prc_hicp_aind - tyres. Downloaded: May 2025

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The HICP for tyres in Hungary reflects the overall high inflation rate in this country in the past 2-3 years. While starting from a level similar to that of the EU as a whole in 2017, the price for tyres almost doubled in 2024 compared to 2015. The index has shown a sharp increase in all countries and in the EU as a whole, following the Corona-virus pandemic in 2021, partly reflecting the distribution of the supply chain of raw materials.

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5.5.2. Average EU retreading costs

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The cost elements of retreading consist of labour and materials, starting with purchasing the casing, the grinding of the old tread, pouring of the new tread and finishing up with the curing of the newly treaded tyre. Cost data of this process are not available as they represent proprietary information. Therefore, we refer below at observed retail price of retreaded tyres, which do not necessarily reflect the true costs of the retreading process, as the business may not necessarily be profitable at its current scale.

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The retail price of retreading tyres varies based on tyre size, retreading method, and the condition of the original tyre casing. While specific pricing for retreading services is not widely advertised, purchasing retreaded tyres is a common and cost-effective alternative for fleets. For instance, the Estonian retailer Veguma²¹ sells retreaded tyres at prices ranging from EUR 160 to EUR 280. Sales prices for retreaded truck tyres range from EUR 150 and EUR 280 depending on tyre size, the tread applied and the original casing, among other features (STICHTING

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²¹ <https://veguma.ee/buy-retread-tires-for-trucks-in-europe/>

3086 KENNISCENTRUM LEIDEN, 2014). As these are 2014 prices, the inflation-adjusted values are EUR
3087 190 to EUR 355 in current prices.

3088 5.5.3. Maintenance and repair costs

3089 Care, repair and maintenance activities for vehicle tyres do not only provide for safety but are
3090 also essential for prolonging tyres' lifetime. Regular checks and maintenance activities range
3091 from visual inspection of their condition (e.g. damage, cracks, tread depth) to more substantial
3092 maintenance activities such as balancing, alignment and nitrogen inflation. Also, virtually all
3093 tyres can be repaired provided that they still have enough tread and the damage is deemed
3094 repairable.²²

3095 **Table 5-30** presents estimate costs for the most common maintenance and repair activities
3096 associated with tyres.

3097 **Table 5-30: Estimated costs of repair and maintenance activities.**

| Maintenance activity | Description | Costs (approx.) |
|-------------------------------|--|--|
| Regular tyre check/inspection | This can be done by the users themselves, at regular time intervals, e.g. weekly or bi-weekly. Damages and wear can be detected with the naked eye. | No monetary/negligible cost |
| Regular tyre rotation | This means swapping front and rear wheels to even the wear on the tyres. This is an operation that can be done by the users themselves. | No monetary/negligible cost |
| Tyres inflation | This means the tyre is neither too much nor too little inflated, but to the level recommended by the car manufacturer. Tyre inflation can be done at gas stations for free or for a small fee. This can be done with oxygen or nitrogen. | Free of charge or for EUR 1-2 per tyre ²³ |
| Check tyres age | This can be determined by looking at the Serial Tyre Identification Number. Tyres older than 10 years should be replaced as they can pose safety risks | No monetary/negligible cost |

²² In Germany there is a legal basis that regulates the assessment of tubeless tyre damage and reparability. This is given by the "Guideline for the Repair of Pneumatic Tires," which is an extension of paragraph 36 of the German Road Traffic Licensing Regulations (StVZO).

²³ In Romania the prices are: RON 5 = EUR 1 for oxygen and RON 10 = EUR 2 for nitrogen. Source: <https://autoserv.ro/continut/6-montare-si-echilibrare-anvelope>

| Maintenance activity | Description | Costs (approx.) |
|--|---|---|
| Professional wheel alignment | This should be done after every 10,000 km or every six months to ensure true steering. This operation is performed by technicians using dedicated technologies. | EUR 20 - 70 ²⁴ |
| Professional tyre balancing | It involves attaching small weights to the wheel to counterbalance the heaviest part of the tyre and wheel assembly using dedicated equipment. | Prices vary as a function of rim size, and the type of balancing performed. They range from EUR 20 – 40/set ²⁵ |
| Plug repair | This is a temporary fix that can be performed by the user with the help of a plug tyre kit which consists of rubber plugs, an insertion tool, and a reamer. | A plug kit costs approximately EUR 50 – 100. ²⁶ |
| Patching/puncture repair ²⁷ | This is performed through hot vulcanisation, where the puncture damage is filled with a special repair rubber and the carcass is strengthened with an appropriate repair patch. | EUR 30 – 50/tyre ²⁸ |

3098 Source: own elaboration based on <https://rema-tiptop.de/en/tire-repair-methods-limits-and-technical-requirements/> and <https://www.bridgestone.com.au/learn/maintenance>

3100 5.5.4. Installation costs

3101 Typically, vehicle tyres are changed twice a year at season change and whenever needed due to
 3102 wear and tear. Installation costs can vary significantly as a function of the service, the workshop
 3103 and the type of tyres to be changed.

3104 Tyre change can refer to one of the following operations:

- 3105 • wheel change – it involves replacing tyres that are already mounted on rims. This
 3106 operation occurs typically at the change of tyres between seasons.
- 3107 • tyre change with mounting – the tyre is removed from the rim, and a new one is
 3108 mounted. The wheel is then balanced. In addition, the programming of the tyre pressure

²⁴ <https://madeinvilnius.lt/en/news/circling-the-right-way/> and <https://tyreland.ie/wheel-alignment-dublin/>

²⁵ <https://www.huk-autoservice.de/ratgeber/reifen/reifen-wuchten> and <https://www.goodwheel.de/reifenratgeber/montage-pflege-und-wartung/autoreifen-auswuchten>

²⁶ <https://serencoshop.co.uk/products/complete-tyre-plug-kit-tools-50-plugs;>
<https://www.kaufland.de/product/532945678>

²⁷ If the puncture is in the sidewall, the tyre cannot be repaired.

²⁸ <https://www.nuoka.com/en/blogs/if-you-care-repair-alles-rund-um-eine-sichere-reifenreparatur/reifen-kaputt-warum-sie-reifenreparaturen-in-betracht-ziehen-sollten;>
<https://www.kwik-fit.com/tyres/information/tyre-repair>

3109 monitoring system may be required (if the vehicle is equipped with one), raising the
3110 total cost of the tyre installation.

3111 It is thus clear that a wheel change requires less time and effort than a tyre change and this is
3112 also reflected in the price of the operation.

3113 **Table 5-31: Tyre installation costs.**

| Service | Costs (approx.) |
|---|-----------------|
| Wheel change | EUR 20 – 50 |
| Tyre change with mounting and balancing | EUR 50 – 100 |
| Adjust tyre pressure monitoring system | EUR 5 – 20 |

3114 Source: <https://www.cashforcars.de/en/blog-tire-change-costs>

3115 The actual installation of a tyre includes mounding on the wheel and balancing. Therefore, we
3116 can assume that the installation of a tyre costs between EUR 50 and 100.

3117 5.5.5. Disposal tariffs

3118 In the European Union, the landfilling of used tyres is largely prohibited under the EU Landfill
3119 Directive 1999/31/EC (European Council, 1999). This directive bans the disposal of whole tyres
3120 in landfills since 2003 and shredded tyres since 2006, with certain exceptions such as bicycle
3121 tyres and tyres used as engineering material in landfills.

3122 Despite these bans, some member states may still impose landfill taxes or gate fees on waste,
3123 including tyres, under specific circumstances. These fees vary across countries. For instance, the
3124 (Confederation of European Waste-to-Energy Plants, 2021) shows that in France landfill taxes
3125 range from EUR 37 in “authorised” landfills with 75 % energy recovery to EUR 152 per tonne of
3126 waste in “non-authorised” landfills (reference year 2021). Since tyres are not suitable for biogas
3127 recovery, we can assume that the upper bound of this tax range apply in the case of tyres. The
3128 same sources shows that in Hungary, a landfill fee of HUF 6,000 per tonne (approximately EUR
3129 19.35) has been in place since 2013. In Luxembourg, a fee of EUR 8 per tonne is applied by the
3130 municipality who owns the only landfill in Luxembourg open for municipal waste. Finally, while
3131 in Malta there is no specific landfill tax, gate fees for mixed waste deposited at public facilities
3132 are set to increase from EUR 40 per tonne in 2023 to EUR 120 per tonne by 2027 (European
3133 Environment Agency, 2024).

3134 It's important to note that these fees are generally associated with the disposal of municipal
3135 waste and may not directly apply to tyres due to the aforementioned bans. Instead, tyres are
3136 often managed through alternative methods such as recycling, energy recovery, or repurposing
3137 in civil engineering projects.

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3140 Questions for stakeholders:
 3141 T2-14: How has the disposal of tyres in landfill evolved in the last five year (in your
 3142 MS)?
 3143 T2-15: Do you have knowledge of the gate fees for tyres (or general waste streams)
 3144 in your MS/region?

3145 **5.5.6. Other data**

3146 In terms of energy prices, the fourth quarter of 2024 ended with an average wholesale gas price
 3147 of 43 EUR/MWh, while the average retail price reached 106 EUR/MWh. However, within the EU
 3148 there was a wide variation in the retail price, ranging from 25 EUR/MWh in Hungary to 324
 3149 EUR/MWh in Sweden (European Commission, 2025c). Electricity wholesale prices in the fourth
 3150 quarter of 2024 averaged 92 EUR/MWh, which was 8 % above the same quarter of 2023, but 50
 3151 % below quarter four of 2022, the year of Russia’s invasion of Ukraine. The highest prices were
 3152 recorded in Eastern and Central European Member states and Ireland and Italy (European
 3153 Commission, 2025b).

3154 The yearly average prices for both gas and electricity, wholesale and retail, are presented in
 3155 **Table 5-32**.

3156 **Table 5-32: Average energy prices in 2024.**

| | Gas | Electricity |
|-----------|-------------|-------------|
| Wholesale | 35 EUR/MWh | 74 EUR/MWh |
| Retail | 104 EUR/MWh | 242 EUR/MWh |

3157 Source: European Commission, 2025b, 2025a

3158 Regarding fuel prices, in May 2025, the price (with taxes) of Euro-super 95 ranged from 1.184
 3159 EUR/litre in Bulgaria and 1.941 EUR/litre in Denmark. The minimum and maximum diesel prices
 3160 (with taxes) were recorded in the same Member States, namely 1.182 EUR/litre in Bulgaria and
 3161 1.685 EUR/litre in Denmark (European Commission, 2025g).

3162 According to the European Central Bank data (European Central Bank, 2025), in March 2025, the
 3163 monthly long-term interest rate in the EU Member States ranged from 2.6 % in Sweden to 7.04 %
 3164 in Hungary. **Figure 5-8** shows the monthly long-term interest rates for the EU countries for which
 3165 data is available. Figure 5-9 shows the same long-term interest rate for the EU combined,
 3166 denominated in all currencies for the past 10 years since 2014. A sharp increase took place in
 3167 2022 exceeding the historical high of 3 % recorded at the beginning of 2014.

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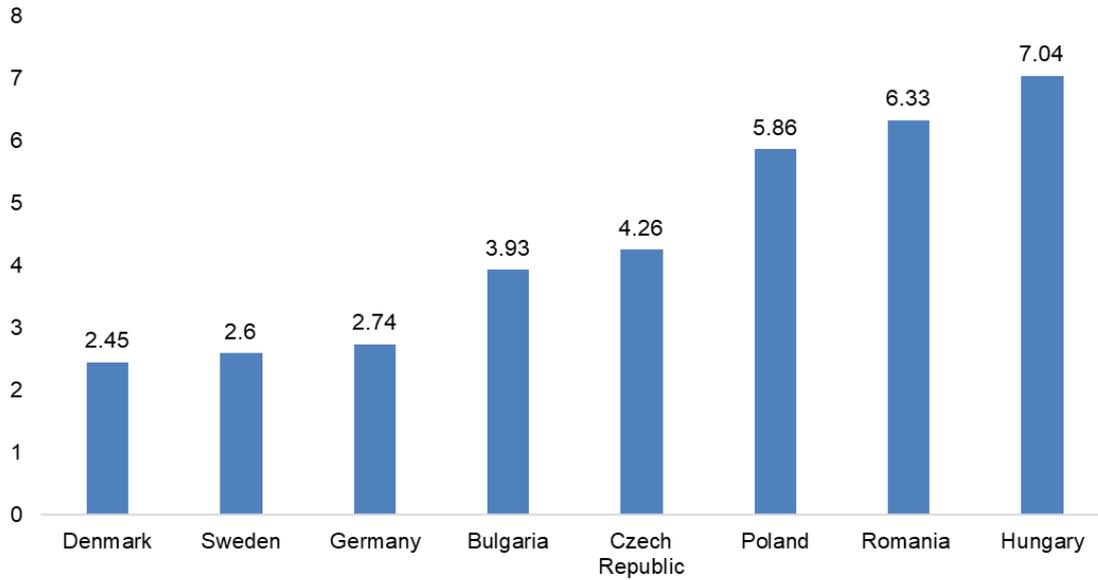
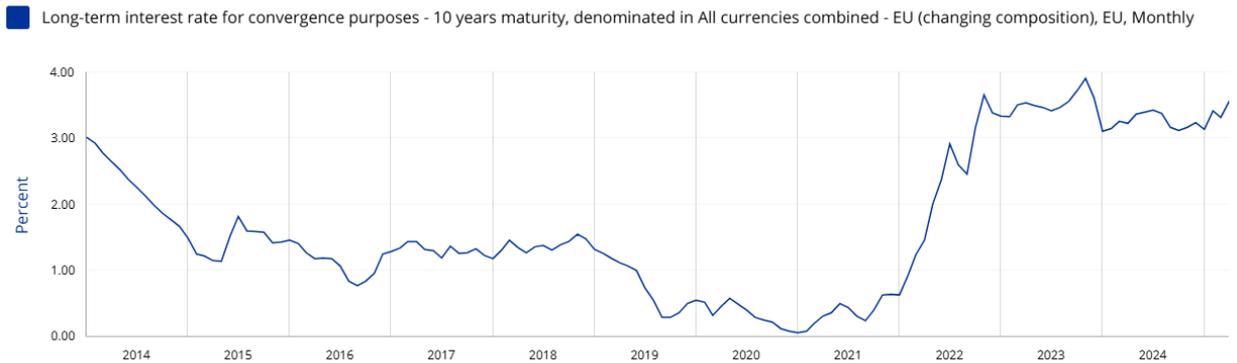


Figure 5-8: Monthly long-term interest rates in EU countries.

Source: (European Central Bank, 2025)

ECB Data Portal, 12 May 2025, 15:47 CET



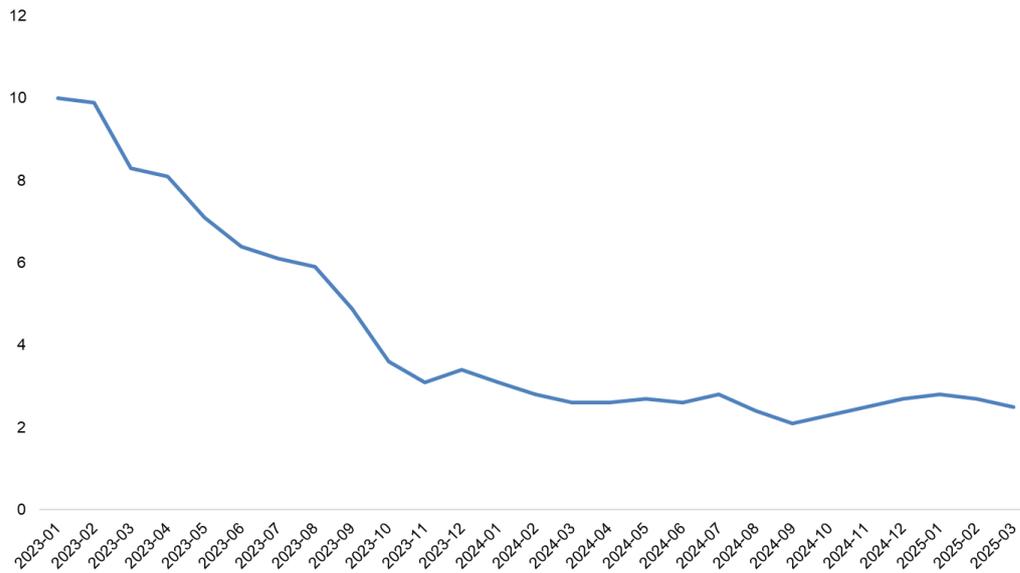
Source: ESCB

Figure 5-9: Monthly long-term interest rate EU, historical data.

Source: (European Central Bank, 2025)

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The month-on-month inflation rate based on all-items HICP in the European Union in March 2025 was 0.5 % (Eurostat, 2025e). **Figure 5-10** shows the monthly annual rate of change of the HICP in the EU between January 2023 and until March 2025, the last month for which data for this index is available. The index has a decreasing trend starting from 10 in January 2023 and stabilizing around the value of 2 towards the end of 2024.



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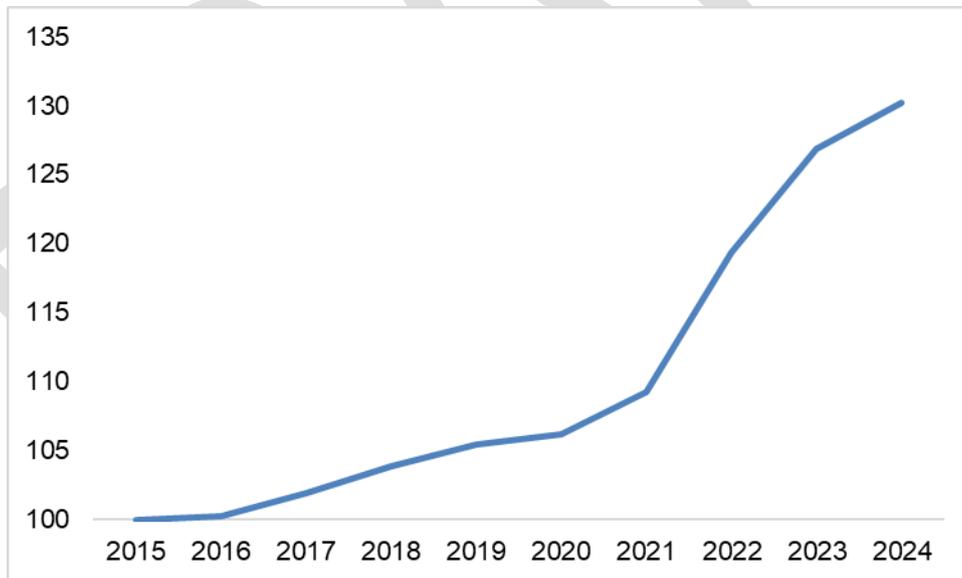
Figure 5-10: Evolution of HICP-monthly data (annual rate of change) in the EU.

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Source: (Eurostat, 2025e)

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3184 Inflation can also be calculated using a base year. (Eurostat, 2025d) reports the annual average
 3185 HICP with base year 2015. **Figure 5-11** shows the evolution of this index until 2024, the most
 3186 recent available data. The figure shows that prices have increased during the past 10 years
 3187 relative to the base year 2015.



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Figure 5-11: Annual average HICP.

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Source: (Eurostat, 2025d)

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3191 5.6. Recommendations

3192 5.6.1. Refined product scope

3193 Most available market data focus on C1, C2, and C3 tyres, with limited information for other
3194 categories. In the motorcycle and bicycle segment, data are inconsistently reported, sometimes
3195 combined and sometimes separately, making comparisons difficult. Moreover, the production
3196 of agricultural tyres in the EU is not significant, while the production of other non-road vehicle
3197 tyres is not reported by EUROSTAT. Only trade data of non-road vehicles are reported, but they
3198 are reported in the same figure together with agricultural and forestry vehicle tyres, precluding
3199 their separation.

3200 5.6.2. Barriers and opportunities for Ecodesign

3201 As this section has shown, the tyre market contains a wide variety of products that differ in
3202 numerous dimensions, such as class (vehicle type), seasonality (summer, winter, all-season),
3203 market segment (premium, medium, budget) etc. This variety alone can make setting Ecodesign
3204 requirements for tyres a challenge, since performance expectations, usage patterns, and
3205 technical specifications vary significantly across these categories. For instance, requirements
3206 that are appropriate for passenger car tyres may not be suitable for heavy-duty truck tyres, and
3207 the environmental impacts of winter tyres differ from those of summer or all-season tyres.
3208 Furthermore, national regulations, consumer preferences, and road conditions also introduce
3209 additional complexity, making it difficult to define harmonised criteria that are both effective
3210 and fair across all segments of the market. Moreover, throughout consultations with
3211 stakeholders, tyre safety and product complexity consistently emerged as central
3212 considerations. These factors introduce notable trade-offs between what can be achievable in
3213 terms of eco-friendly and sustainable design and the essential functional requirements of tyres
3214 themselves.

3215 Opportunities for Ecodesign extend beyond the adoption of bio-based or recycled materials—
3216 already a focus for some tyre manufacturers who are actively setting renewable content targets.
3217 Stakeholders also recognise the potential for reducing rolling resistance, thereby improving fuel
3218 efficiency and lowering emissions. The integration of digital tools and AI from design
3219 optimisation to predictive performance monitoring, offers avenues to refine tyre functionality
3220 and resource efficiency. Concepts such as modular tyre construction, self-healing materials, and
3221 the expansion of retreading technologies present further prospects, enabling both performance
3222 improvement and waste reduction.

3223 5.7. Preliminary conclusions Task 2

3224 The EU tyre market is highly diverse and largely dominated by replacement sales, which account
3225 for approximately 75–78 % of total tyre sales, with the remainder being original equipment fitted

3226 on new vehicles. Production is concentrated in a few Member States, yet intra-EU trade is
3227 extensive, reflecting a highly integrated market. The most important EU trading partners for
3228 tyres remain Asian countries, with China dominating the imports of tyres in classes C1 and C2,
3229 with over 50 % of total imports.

3230 Market trends show steady, though modest, annual growth of around 2 %, with notable shifts
3231 toward all-season tyres in the passenger car segment (C1) and a strong, albeit declining, tradition
3232 of retreading in the heavy-duty (C3) segment. Retreading rates are falling due to competition
3233 from low-cost new tyres, particularly in the truck and bus sector.

3234 Perceived importance of sustainability-related features is gaining some attention, though it
3235 remains limited. Key opportunities for new business models include the tyre-as-a-service model,
3236 while innovation could be further focused on bio-based materials, the use of artificial
3237 intelligence from design and production to performance monitoring and maintenance, and self-
3238 healing tyres.

3239 Price data show significant variation by country, tyre type, and segment, with a general trend of
3240 rising consumer prices in recent years, partly driven by inflation and supply chain disruptions.

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3243 Compilation of MEErP Task 2 questions for stakeholders:

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T2-1: Do you find the ratio of retreaded tyres to new tyres presented in this report realistic and representative for the EU market?

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T2-2: The triangulation exercise above shows discrepancies in data. Where do you think these discrepancies come from?

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T2-3: In the above trade figures of retreaded tyres, we notice a deep in both imports and exports of retreaded tyres for buses and lorries (the green lines). For both imports and exports this occurs in 2020 which could be explained by the slower economic activity during the pandemic. However, what could be the explanation for the drop in the export of this type of tyres that occurs already in 2019?

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T2-4: How are OEM tyres recorded when moving from one EU Member State to another? For example, if an car manufacturer in Member State X mounts tyres produced in Member State Y on their cars, are these tyres tracked as imported by Member State X from Member State Y or are they recorded as inter-companies transfers?

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T2-5: Are there any discrepancies in the EIA report data? If so, how could these figures be better assessed?

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T2-6: Particularly, do the OEM sales figures in the EIA report appear accurate, or are they over- or underestimated?

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T2-7: Are there any notable gaps in the ETRMA dataset? For example, do these figures cover the full EU27 market, or are some manufacturers (e.g. non-members) or importers excluded? If so, to what extent?

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T2-8: Are there any notable gaps in the PRODCOM dataset? For example, does PRODCOM cover only replacement sales, or both replacement and OEM sales?

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T2-9: Could you provide insights on the average lifetime in kms across the different tyre categories (see **Table 5-17** Error! Reference source not found.)? Please indicate where you think the numbers are under- or overestimated.

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T2-10: Could you provide insights on the average lifetime in years across the different tyre categories (see **Table 5-17**). Please indicate where you think the numbers are under- or overestimated.

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T2-11: For clarification, when referring to three retread cycles, should this be understood as a total of four cycles (original plus three retreads)? If so, do the numbers in the text make sense to you?

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T2-12: Do you have any additional information on C2 tyres, specifically regarding lifetime in kilometres and in years (both with and without retreading)? The information currently available to us suggests a lifetime of around 3 years in both cases, which appears inconsistent.

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T2-13: Is it reasonable to assume an average annual growth rate of approximately 2 % over the next five years?

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T2-14: How has the disposal of tyres in landfill evolved in the last five years (in your MS)?

3285

3286

T2-15: Do you have information about the gate fees for tyres (or general waste streams) in your MS/region?

3287 **6. MEErP Task 3 – Users**

3288 **6.1. Objectives of MEErP Task 3**

3289 The objective of MEErP Task 3 is to identify, retrieve, and analyse data on user behaviour—
 3290 including that of vehicle manufacturers (OEMs) and both private and professional vehicle
 3291 users—and the associated environmental impacts incurred during the use phase of tyres within
 3292 the study scope. Tasks 3.1 and 3.2²⁹ of the methodology focus on system aspects of tyre use that
 3293 have direct or indirect effects on energy consumption, examining how tyre performance
 3294 influences fuel consumption and emissions, and how factors such as driver behaviour, road
 3295 quality, material, weather, and other variables contribute to this impact.

3296 The MEErP Task 3 methodology focuses heavily on energy consumption aspects. Since tyres
 3297 performance in the use phase is the main driving variable from the users’ perspective, we have
 3298 added an additional chapter, providing background on the performance trade-offs for users
 3299 when choosing tyres for different applications.

3300 Additionally, the emission of microplastics during tyre use is analysed. The study further
 3301 investigates end-of-life behaviour (Task 3.3), local infrastructure (Task 3.4), and concludes with
 3302 recommendations on refining the scope, identifying barriers, and exploring opportunities for
 3303 Ecodesign (Task 3.5).

Energy related product (ErP) with indirect impact



3304 **Figure 6-1: Boundary for the analysis of tyres under MEErP Task 3.**

3305 Source: Own figure

3306 The report is structured as follows, based on MEErP Task 3:

3308 **MEErP Task 3.2 – Systemic aspects in the product use-phase:** identification and analysis of the
 3309 indirect environmental and resource impacts during the use phase of the product. Rolling

²⁹ The focus of this report will be on MEErP Task 3.2 due to the fact that tyres do not directly consume energy but have some impact on the overall energy consumption of their affected energy systems.

3310 resistance is used as a proxy for energy/fuel consumption. The topic of microplastic release due
3311 to abrasion during the use phase is also addressed.

3312 **MEErP Task 3.3 – End-of-life behaviour:** Identification and analysis of data on consumer
3313 behaviour (primarily focused on EU figures) on the end-of-life management of tyres. Topics such
3314 as extended mobility tyres and alternative product use models are also discussed.

3315 **MEErP Task 3.4 – Local infrastructure:** Identification and analysis of data relating to local
3316 infrastructure relating to the product group. Due to the nature of tyres, sub-topics such as water,
3317 telecommunication, and the physical environment (possibilities for the sharing of products for
3318 example) are not applicable and are hence not addressed.

3319 **MEErP Task 3.5 – Recommendations & Preliminary conclusions of Task 3:** This section presents
3320 a refined product scope for further analysis largely from a consumer behaviour perspective as
3321 local infrastructure is largely inapplicable to the product group. Barriers and opportunities to
3322 incorporate Ecodesign measures from a consumer behaviour perspective are also discussed.

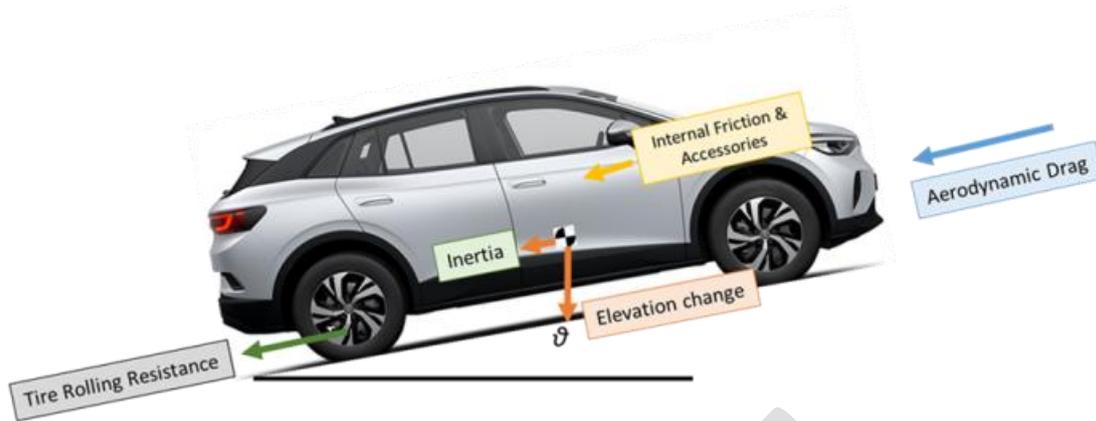
3323 6.2. Systemic aspects in the use-phase, for ErP with 3324 indirect energy consumption effect

3325 This section of the report analyses the indirect environmental and resource impacts associated
3326 with the use phase of tyres in relation to the broader energy system of vehicles. Emphasis is
3327 placed on factors influencing consumption and emissions resulting from manufacturing
3328 decisions such as material selection, performance characteristics, and information availability as
3329 well as on user behaviour. Additional consideration is the emission of microplastics, evaluated
3330 in terms of their relevance to the energy and environmental footprint of tyres with emphasis on
3331 aspects under the control of users and hence during the 'use phase' of the product.

3332 6.2.1. Description of the affected energy systems

3333 The interaction between tyres and vehicle energy consumption is primarily influenced by factors
3334 such as rolling resistance, tyre pressure, tread pattern, and size. As the sole contact point
3335 between a vehicle and the road, tyres not only support the vehicle's weight but also absorb
3336 surface irregularities, transmit forces related to acceleration and braking, and respond to
3337 steering inputs providing handling performance. Additionally, tyres are a notable contributor to
3338 vehicle noise generation.

3339 An overview of the various forces acting on a passenger vehicle, including those transmitted
3340 through the tyres, is presented in **Figure 6-2** below.



3341

3342

Figure 6-2: Resistive forces acting on a moving car.

3343

Source : [European Commission \(2025\)](#)

3344

Rolling resistance is the resistive force a tyre must overcome to keep rolling. It is dominated by hysteresis loss within the tyre, in which rubber and reinforcing materials compress and shear, then relax as they come into and out of contact with the road. Because rubber is viscoelastic, this deformation is not perfectly elastic: some of the mechanical energy is converted to heat each cycle. That hysteresis energy loss shows up as a constant drag force proportional to the tyre's vertical load. One review article finds that hysteresis accounts for 80-95 % of rolling resistance, with additional contributions from air drag 0-15 %, depending on the speed and 5 % from frictional micro-slip at the contact patch and the wheel rim (H. S. Aldhufairi & Olatunbosun, 2017).

3353

Calculation of rolling resistance coefficients (RRC) is specified by UNECE R117, as the rolling resistance force in kg, per ton of vehicle weight, t (kg/t) (also expressed as N/kN). UNECE R117 defines measurement methods according to ISO 28580 and sets limits for different tyre types. RRC is measured for a tyre under defined load, pressure, and speed conditions using a standardised drum test, with additional corrections to a reference temperature and drum diameter. There are a wide range of different rolling resistances for different tyre types, and rolling resistance can also be strongly impacted by operating conditions. Decreasing ambient and tyre temperature have been found to significantly increase rolling resistance in long haul vehicle truck tyres, for instance (Hyttinen, 2023b).

3362

The contribution of vehicle tyres to the overall energy system is illustrated by a study conducted by Holmberg et al. (2012), which found that the rolling resistance (defined³⁰ as the loss in energy or energy consumed per unit of distance travelled) generated by vehicle tyres accounts for approximately 11.5 % of the total energy consumption of passenger cars. For internal combustion engine (ICE) passenger cars, Holmberg et al. (2012) find that 28 % of the car's fuel

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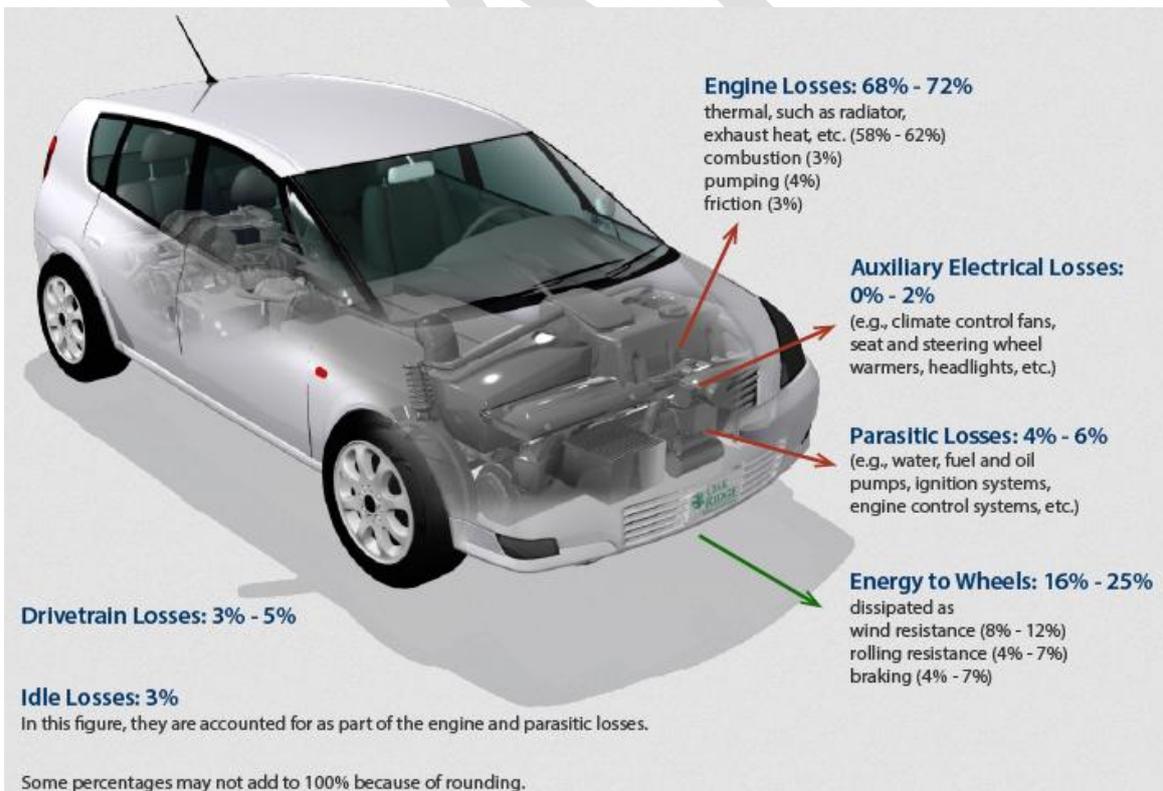
3366

³⁰ Definition elaborated under Regulation No 117 of the Economic Commission for Europe of the United Nations (UNECE) — Uniform provisions concerning the approval of tyres with regard to rolling sound emissions and/or to adhesion on wet surfaces and/or to rolling resistance [2016/1350]. It can also be thought of in simple terms as the mechanical energy losses of the tyre as heat because of tyre rolling for a given distance (H. S. Aldhufairi & Olatunbosun, 2017).

3367 consumption is lost to direct frictional losses through the tyres, transmission and engine. They
 3368 estimate that an EV has half the frictional losses of an ICE vehicle, making the impact of rolling
 3369 resistance proportionally higher in EVs.

3370 Rolling resistance depends on the size of and weight of the tyre and vehicle, as well as the
 3371 positioning of the tyre. It can be 22 % of fuel consumption for a 12t urban delivery truck, and 34
 3372 % for a 40t long haul vehicle, with strong variations between tyres (17 % at steering axle, and 50
 3373 % at rear trailer) (Frank Dünnebeil and Heiko Keller, n.d.). Fuel consumption is, however,
 3374 dependent on a wide range of factors. For this reason, rolling resistance coefficients are used to
 3375 determine impacts at the tyre level in the EU energy label, rather than fuel consumption. In long
 3376 haul vehicles, vehicle energy consumption calculation tool (VECTO) simulations are used, where
 3377 rolling resistance is modelled together with air resistance, gear box losses, auxiliaries and engine
 3378 maps etc. to simulate fuel consumption and determine CO₂ emissions over standard duty cycles
 3379 (Tansini et al., 2018).

3380 A reduction of around 10 % in rolling resistance may result in a ~0.5-1.5 % reduction in energy
 3381 consumption for light-weight vehicles and ~1.5-3 % for heavy-duty vehicles (1st Stakeholders
 3382 consultation, 2025; H. S. Aldhufairi & Olatunbosun, 2017). The Ecodesign Impact Accounting
 3383 Report 2024 refers to IDIADA data, which state a reference value of a 10 % change in RRC leads
 3384 to a 1.64 % (C1), 1.17% (C2) or 1.12 % (C3) change in vehicle fuel consumption (Van Holsteijn en
 3385 Kemna BV (VHK), 2024).



3386

3387

Figure 6-3: An overview of passenger car energy consumption (ICE vehicle).

3388

Source : US DOE / Thomas (2014)³¹

3389 In the context of rolling resistance forces, tyre design plays a critical role. Influential factors
 3390 include tyre size, rubber hysteresis³², rubber hardness, the construction of the belt and carcass,
 3391 tread pattern, and tread depth. Operational conditions further affecting rolling resistance
 3392 include tyre inflation pressure, ambient and pavement temperatures, pavement wetness, and
 3393 tyre load. An overview of operational and driving factors where tyres influence fuel consumption
 3394 is given below:

3395 **Table 6-1: Summary of factors affecting fuel consumption in tyres.**

| Factor | Potential impact on fuel consumption |
|--|---|
| Tyre type and rolling resistance class | Tyres are designed for different applications, higher rolling resistance class on the energy label will have lower fuel consumption. Winter/off-road tyres tend to have higher rolling resistance. 11 - 30 % improvement with low-rolling-resistance tyres is possible. |
| Tyre pressure / inflation | Underinflated tyres increase rolling resistance and increase tyre wear. ≈ 1 % fuel economy loss per 5 psi under-inflation (≈ 0.2 % per 1 psi) |
| Tyre size and construction | Wider (heavier tyres can have higher rolling resistance than narrower/lighter tyres, casing construction (e.g. radial-bias better than bias-ply) can impact as well. Each rol |
| Tread depth and wear state | Newer tyres tend to have higher rolling resistance than worn tyres. As tread decreases, rolling resistance improves. New light heavy vehicle tyres may cause 2-3 % higher fuel consumption than run-ins. |
| Tread pattern and compound | Winter treads typically have more grip and have higher rolling resistance. Rubber compounds aiming for more grip have higher rolling resistance than low friction compounds. |
| Ambient and road temperature | Lower temperatures lead to higher hysteresis in tyre, increasing rolling resistance. As tyre warms up this improves. |
| Load and vehicle mass | Higher loads and mass increase rolling resistance hysteresis, especially if underinflated. Inflating to correct pressure for the load can improve this. |

³¹ The figure provides an overview as would be typical in an ICE vehicle. In EVs, aspects such as exhaust losses are not present.

³² Rubber hysteresis refers to the energy loss that occurs when a tyre's rubber material undergoes repeated cycles of deformation and recovery as it rolls over a surface. An explanation of the phenomenon is available here: <https://www.nextgentest.com/blog/the-value-of-hysteresis-in-rubber-plastic-hardness-testing/>. According to (H. S. Aldhufairi & Olatunbosun, 2017), hysteresis accounts for about 80-90% of the total tyre's rolling resistance.

| Factor | Potential impact on fuel consumption |
|---------------------------------------|---|
| Speed and driving behaviour | At faster speeds air drag becomes more important resistance load, while low to moderate speeds are more affected by rolling resistance. Smoother driving styles (less aggressive) reduce heat build-up e.g. via harsh acceleration. |
| Road surface and wetness | Rough, coarse or wet surfaces can increase rolling resistance, as well as standing water. |
| Alignment of tyres and tyre condition | Poor alignment of axles can increase frictional losses. Tyres with uneven wear can increase micro-slip friction. If the wheels on HDV trailer are also misaligned, then fuel consumption can increase by up to 15 %. |
| Tyre temperature management | In heavy duty vehicles, driving for a long time or overloading under incorrect pressure may cause excessive heat build-up, increasing hysteresis/rolling resistance and tyre wear. |
| Retreads and casing quality | Good quality retreads with low rolling resistance tread have low rolling resistance, poor quality may have increased rolling resistance. |

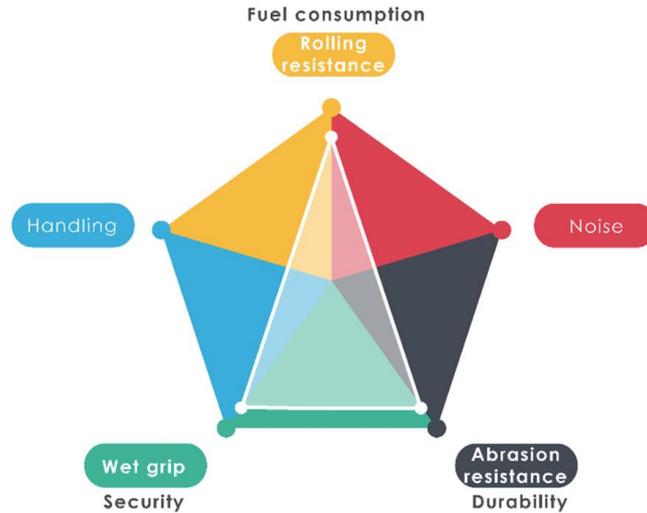
3396 Source: own table based on (H. S. Aldhufairi & Olatunbosun, 2017; Cleanfleet Report, 2020; Fueleconomy, 2025;
 3397 RBP Tires, 2023; Volvo, 2025)

3398 6.2.2. Performance characteristics of tyres

3399 Optimising rolling resistance on tyres can significantly reduce fuel consumption, however, it is
 3400 not straightforward, since optimising for one parameter affects the performance of the tyre in
 3401 other areas. The three parameters of rolling resistance, wet grip and tyre wear have physical
 3402 design trade-offs, known as the magic triangle in tyre design:

- 3403 • Rolling resistance (energy efficiency): lowering the rolling resistance can be achieved
 3404 through using a stiffer rubber compound with low hysteresis, however, this means that
 3405 it will also have lower grip with the road, affecting braking and steering performance.
 3406 Stiffer compounds generally also create more noise.
- 3407 • Wet grip (safety): ability to generate frictional forces for braking, steering, traction on
 3408 wet roads. Increasing the wet grip requires choosing softer compounds which interlock
 3409 with the road surface better and choosing treads which evacuate water. These treads
 3410 have higher rolling resistance and may cause more noise.
- 3411 • Wear (mileage/durability): tyre compounds designed to be resistant to tread abrasion
 3412 or mechanical degradation tend to have more casing support. Harder
 3413 compounds/reinforcing can sometimes increase rolling resistance, while grippy
 3414 compounds tend to abrade faster.

3415 These dynamics are captured in **Figure 6-4**.



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Figure 6-4: Illustration of the “magical triangle” of tyres.

3418

Source: (Araujo-Morera et al., 2021)

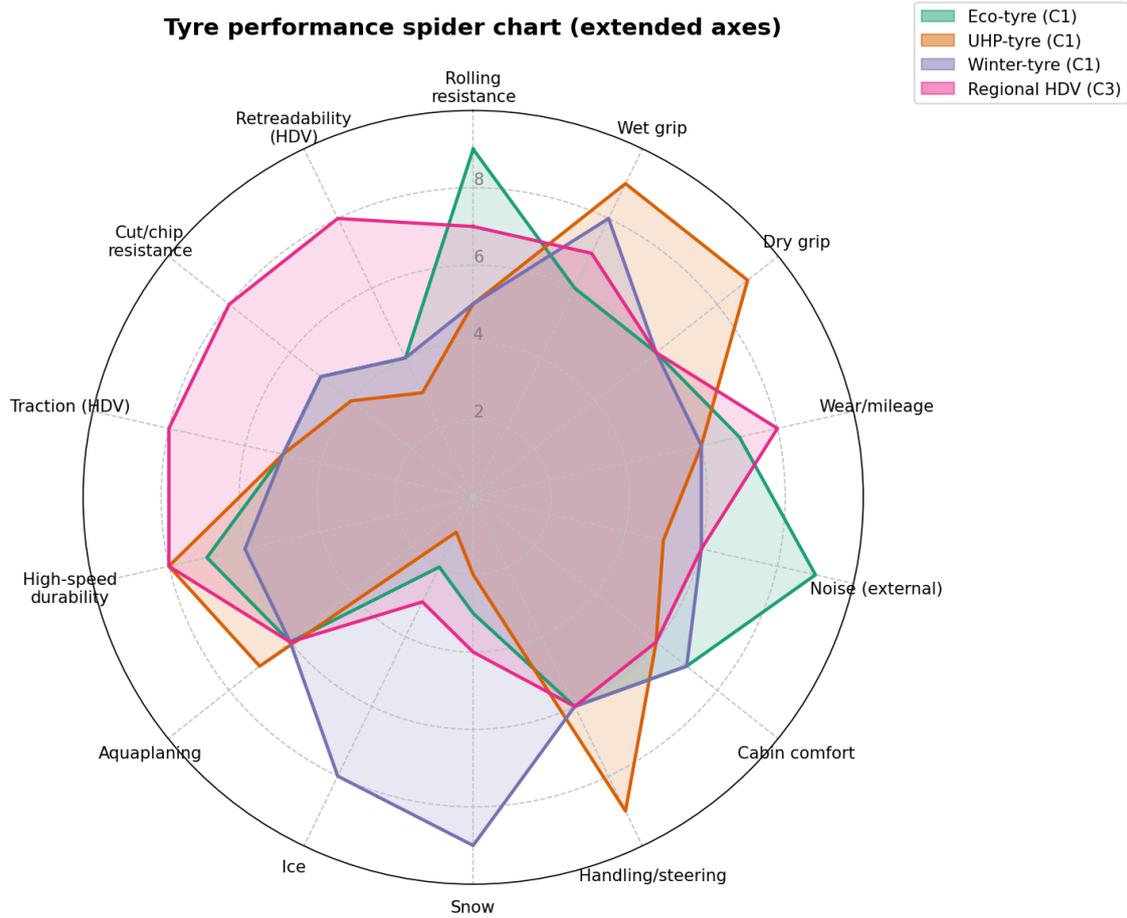
3419

This diagram shows the additional factors of external rolling noise, and handling. External rolling noise is caused by tread-blocks impacting the road, vibrations between the tyre and the road and air pumping effects in the tyre. It is possible to design treads which dampen this effect but these may in turn increase rolling resistance or reduce water evacuation. Handling is broader than wet grip, determining how a tyre transmits forces and feedback while driving, such as steering response, cornering, braking and turning, stability at high speed etc.

3425

From a consumer’s perspective, the five parameters shown in **Figure 6-4** provide enough information to make a decision. However, there are many more factors that play into the choice of tyre for a given application – all of them imply trade-offs, although the latest innovations in material composition are enabling some of these to be reduced. Tyres are optimised for various applications, and a large amount of R&D is necessary to achieve desired performance outcomes, whilst still meeting strong performance on label parameters of rolling resistance, wet grip and noise. Below the spider diagram shows illustrative examples of where different tyre types may perform functionally across different parameters.

3432



3433

3434 **Figure 6-5: Example of optimised tyre performance parameters across four fictional tyres.**

3435

Source (own diagram programmed with python/AI)

3436 The four example (fictitious) profiles reflect typical performance “shapes” that reflect tyre
3437 engineering trade-offs:

3438 (i) Eco-tyre: high rolling resistance performance (low RR), good noise and acceptable
3439 wear/comfort; modest wet/dry grip; weak snow/ice.

3440 (ii) Ultra-High Performance (UHP)-tyre: strong dry and wet grip and handling; middling
3441 wear/noise/comfort; weaker winter attributes.

3442 (iii) Winter-tyre: strong snow/ice and solid wet grip; moderate RR, wear and comfort.

3443 (iv) Regional heavy duty vehicle (HDV): good durability, traction, retreadability, cut/chip
3444 resistance; balanced RR and wet/dry performance.

3445 In addition to designing for optimum performance, manufacturers must meet minimum tyre
3446 safety requirements. Tyre safety underpins all other performance design considerations. A tyre
3447 must provide predictable and stable driving performance under different operating conditions,
3448 continue to provide this performance over conditions of wear throughout its lifetime, and resist
3449 damage or high loads at speed. Failure to do so can be fatal, so meeting safety requirements is

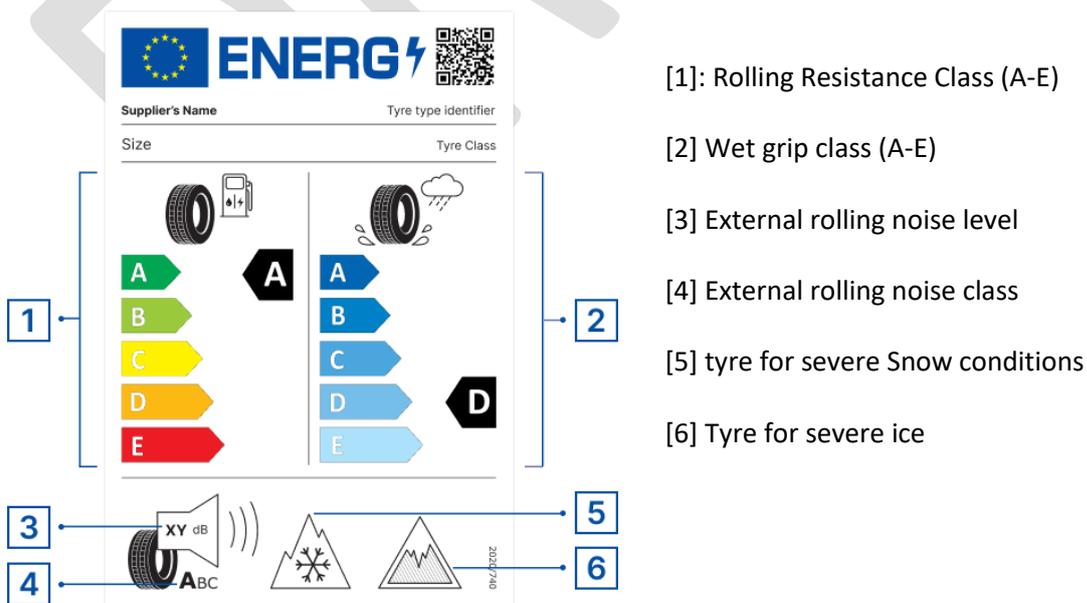
3450 essentially assumed by users and minimum standards are put in place by international legislation
 3451 and manufacturers.

3452 **6.2.3. Relevant standards and legislation with respect to the**
 3453 **affected energy system**

3454 **Section 4.3** gives an overview of relevant legislation that addresses performance and safety
 3455 aspects that are relevant for the use phase. Of key importance for the discussion on energy
 3456 consumption, are the EU tyres energy label and type approval based upon UNECE R117
 3457 requirements. Together these provide the framework under which energy consumption has so
 3458 far been directly regulated for tyres. The label is consumer oriented and uses the definitions and
 3459 categorisations of UNECE R117 on wet grip, noise and rolling resistance coefficients, adding
 3460 classes that perform above a minimum threshold. UNECE R117 on the other hand sets the floor
 3461 for minimum requirements of tyres in these categories. As such, UNECE R117 has acted as the
 3462 typical Ecodesign regulation so far, removing the lowest performing tyres across these
 3463 categories from the market. Further discussions on the energy consumption of tyres during the
 3464 use phase (using RRC as a proxy) are continued in **Section 6.2.6** of this chapter.

3465 **6.2.3.1. Regulation (EU) 2020/740 on the labelling of tyres**

3466 Regulation (EU) 2020/740 on the labelling of tyres (EU Regulation 2020/740, 2020) provides
 3467 requirements on the rolling resistance class, the wet grip index class (defined as stopping
 3468 distance on wet asphalt), the external rolling noise class, also clarifying under what conditions a
 3469 tyre can be labelled as having sufficient snow grip and ice grip performance. Provisions are in-
 3470 place for a future delegated act on retreaded tyres, however at present these are regulated
 3471 using UNECE R108 and UNECE R109 for passenger cars and truck tyres respectively.



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Figure 6-6: The EU Tyres Energy Label.

3474

Source: https://energy-efficient-products.ec.europa.eu/product-list/tyres_en

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In terms of energy consumption and impacts during the use phase, relevant parameters covered by this legislation are the RRC and information to users on tyre pressure. While the current label is under review by the Commission, the status quo as of now is presented in **Table 6-1** below.

3478

Table 6-1: Current tyre label for C1-C3 tyres in terms of RRC.

| Factor | C1 tyres | C2 tyres | C3 tyres |
|-----------------------|------------------|-----------------|-----------------|
| Fuel efficiency class | RRC in N/kN | RRC in N/kN | RRC in N/kN |
| A | RRC ≤ 6.5 | RRC ≤ 5.5 | RRC ≤ 4.0 |
| B | 6.6 ≤ RRC ≤ 7.7 | 5.6 ≤ RRC ≤ 6.7 | 4.1 ≤ RRC ≤ 5.0 |
| C | 7.8 ≤ RRC ≤ 9.0 | 6.8 ≤ RRC ≤ 8.0 | 5.1 ≤ RRC ≤ 6.0 |
| D | 9.1 ≤ RRC ≤ 10.5 | 8.1 ≤ RRC ≤ 9.0 | 6.1 ≤ RRC ≤ 7.0 |
| E | RRC ≥ 10.6 | RRC ≥ 9.1 | RRC ≥ 7.1 |

3479

Source: Own table based on (Giesen & Elsen, 2023)

3480

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In addition, the energy label requires registration of tyre product information in the EPREL database, with a product information sheet and label available to end users (including for distance/online sales).

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Currently, no recommended inflation pressures or loads are given on the label, as these are vehicle-specific and supplied by vehicle manufacturers, not specified per tyre model in (EU) 2020/740. Tyre load and speed indices are on the sidewall and in type-approval, but they're not part of the consumer energy label or EPREL disclosure fields for tyres.

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6.2.3.2. EU Legislation relevant to the use phase of tyres

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A range of legislation applies to ensure safety and performance across the use phase, while it also addresses energy consumption.

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3491

- Direct tyre regulations: set specific requirements that target performance and safety through UN Regulation No. 117 and the EU Tyre Labelling Regulation (EU) 2020/740, while UN R108/109 apply for retreaded tyres.

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- Indirect regulations apply to vehicles: these shape tyre specifications through mandating safety features on tyre pressure monitoring and safe use, non-exhaust emissions (Euro 7), vehicle dimensions and loads, pass-by noise, energy efficiency in public procurement and OEM fleet targets.

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- Rules on in-use compliance, waste phase, and national conditions: these set specifications on periodic or roadside inspections, checks on condition and tread depth, ensure proper collection, recycling/reuse of tyres, and apply national rules (e.g. different minimum tread depths for winter tyres).

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The main EU legislation relevant for the use phase is listed in **Table 6-2** below.

3503

Table 6-2: Overview of legislation relevant to the tyre use phase

| Legislation | Relevance to tyre use phase |
|--|--|
| UN Regulation No. 117 (via EU type-approval) | Sets minimum performance for rolling resistance (energy efficiency), wet grip (safety), and external rolling noise for tyres placed on the EU market, which directly influences in-use energy consumption and safety performance over the tyre's life. |
| UN Regulation No. 108 for C1 retreaded tyres and UN Regulation No. 109 for C2/C3 retreaded tyres | Ensure retreaded tyres meet safety/performance standards comparable to new tyres, supporting safe in-use operation. |
| EU Tyre Labelling Regulation (EU) 2020/740 | Guides consumer and fleet choices toward lower rolling resistance and better wet grip tyres, affecting in-use energy consumption, range (EVs), and safety. Enables market surveillance and informed replacement tyre selection. |
| Regulation (EU) 2019/2144 (General Safety Regulation) with UNECE references (e.g., UN R141 for TPMS) | Mandates Tyre Pressure Monitoring Systems (TPMS) and other safety systems on new vehicles; TPMS helps maintain correct inflation in use, reducing rolling resistance, improving safety, and extending tyre life. Uses UNECE technical prescriptions. |
| UN Regulation No. 142 (Tyre installation), applied via EU type-approval | Ensures correct tyre fitment and compatibility on vehicles, preventing unsafe in-use configurations that degrade safety and performance. |
| Regulation (EU) 2024/1257 (Euro 7) - vehicle emissions, including non-exhaust | Expands EU type-approval to non-exhaust emissions. Introduces brake particle limits/tests for light-duty vehicles and establishes a mechanism to adopt harmonised UNECE tyre abrasion test procedures and future limits into EU law once finalised. Affects in-use phase by targeting wear emissions and likely influencing tyre design alongside UN R117 minima and the EU label. |
| Regulation (EU) 2019/631 (CO2 standards for cars and vans) | Drives OEMs to optimise rolling resistance to meet fleet CO ₂ targets; indirectly shapes tyre specifications affecting real-world fuel/energy use during operation. |
| Weights and Dimensions Directive 96/53/EC (as amended by 2015/719 and 2024 updates) | Vehicle mass and axle loads affect tyre energy losses and wear in use; incentives for aerodynamic devices may interact with tyre energy shares. |
| Energy Efficiency considerations in Clean Vehicles Directive (EU) 2019/1161 (public procurement) | Public fleets required to consider energy/CO ₂ in procurement, green public procurement guidelines may impose tyre performance criteria (e.g. requiring low rolling resistance tyres) as a complementary measure |
| UN Regulation No. 51 (Vehicle pass-by noise) | Sets vehicle-level pass-by noise limits and test procedures. Tyre/road noise is a dominant component at low-to-medium speeds, so compliance influences tyre choice and tread design in use. Complements UN R117's tyre external rolling noise (component level) with the vehicle system view. |
| Roadworthiness Package: Directive 2014/45/EU (periodic inspection) and 2014/47/EU (roadside for commercial vehicles) | Ensures tyres in use meet safety condition requirements (tread depth, damage, inflation indirectly). Maintains in use performance and prevents unsafe/high-drag conditions due to severe wear or defects. |

| Legislation | Relevance to tyre use phase |
|---|---|
| End-of-Life Vehicles Directive 2000/53/EC and Waste Tyre rules (national) | While mainly end-of-life, EPR schemes sometimes promote maintenance and replacement practices (e.g., awareness on correct inflation); also affects selection of retreadable casings in heavy-duty fleets. |
| National traffic laws in Member States on minimum tread depth, winter tyre fitment, and recognition of snow/ice performance (3PMSF/alpine symbol per UN R117) | Directly affects in-use safety and performance; replacement timing and seasonal fitment influence energy/safety trade-offs. Minimum tread depth values and winter requirements vary by country. |

3504 Source: Own compilation.

3505 **6.2.3.3. An overview of relevant standards with respect to the affected**
 3506 **energy system**

3507 Relevant standards with a potential relation to technical parameters in the use phase such as
 3508 rolling resistance, and to topics such as retreading are listed in **Table 6-3** below:

3509 **Table 6-3: An overview of standards with influence on tyre performance and other technical**
 3510 **parameters.**

| Standard | Scope | Relevance |
|---------------------------------------|---|--|
| UN Regulation No. 117 (Annex methods) | Tyre component performance: rolling resistance, wet grip (C1/C2/C3), snow grip (C1/C2/C3), external rolling noise | Core EU reference for market access and labelling. Uses ISO 28580 for rolling resistance and ISO 10844/ISO 13325 for noise. Wet/snow grip procedures are defined in R117 annexes (and referenced by EU label). |
| ISO 28580:2018 | Rolling resistance measurement (single-point test, correlation) for C1–C3 | Principal RR method used under UN R117 and EU labelling; cornerstone for energy-use assessments. |
| SAE J1269 | Laboratory rolling resistance measurement (drum method) | Complementary to ISO 28580 |
| SAE J1270 | Vehicle coastdown method to infer rolling resistance | Useful on-vehicle method to correlate lab RR to road conditions; supports real-world validation. |
| ISO 10844:2021 | Specification of test tracks for measuring vehicle and tyre sound | Reference track for UN R117 (tyre external noise) and UN R51 (vehicle pass-by noise). |
| ISO 13325:2019 | Coast-by methods for tyre-to-road sound emissions | Component-level tyre external noise method used in UN R117 contexts. |
| UN Regulation No. 51 | Vehicle-level pass-by noise limits and test procedures | Complements tyre external noise (R117) with the vehicle system view; uses ISO 10844 tracks. |
| ISO 10191:2021 | Verifying capabilities of passenger car (C1) tyres (endurance, bead unseating, plunger energy, high-speed) | Capability/robustness tests; indirectly relevant to safe use but not energy/noise/wet grip metrics. |

| Standard | Scope | Relevance |
|---------------------------------|--|--|
| UN Regulation No. 141 | Tyre Pressure Monitoring Systems (TPMS) performance/verification | Supports in-use inflation control, preserving energy efficiency and safety; mandated via EU 2019/2144. |
| ISO 22638:2024 | Generation and collection of tyre and road wear particles (TRWP) in a lab road simulator | Emerging abrasion/particle method; relevant to Euro 7's pathway to regulate tyre wear emissions. |
| UN Regulation No. 54 | Commercial vehicle tyre approval requirements (capability tests) | Relevant for C2/C3 endurance/high-speed/strength; complements R109 for retreads. |
| UN Regulation No. 108 / No. 109 | Approval of retreaded tyres (C1 and C2/C3 respectively) | Ensures retreaded tyres meet safety/performance requirements comparable to new tyres; important for fleet use and circularity. |
| AFNOR T47-749 | Voluntary French standard on part-worn tyres. | Determination of control and quality criteria for the classification of reusable lightweight vehicle tyres |

3511 Source: Own compilation.

3512 **6.2.4. Economic and market analysis with respect to the affected**
 3513 **energy system**

3514 An in-depth economic and market analysis including technical parameters has been conducted
 3515 in Task 2 of this study (see **Sections 5.2** and **5.5** on general market trends and consumer
 3516 expenditure base data respectively).

3517 A study aimed at assessing consumer understanding of the tyre label and informing potential
 3518 revisions found that most respondents considered it very or extremely important for the label
 3519 to indicate fuel efficiency, wet grip, snow grip, and ice grip (Giesen & Elsen, 2023). Among these
 3520 features, wet grip (safety) was ranked as the most relevant, with fuel efficiency in second place.
 3521 External noise levels were seen as the least important. Many consumers also expressed a desire
 3522 for the label to include information on tyre durability (Giesen & Elsen, 2023).

3523 **Table 6-4: Perceived relevance of information on current tyre labels to consumers.**

| | % not at all important /not very important | % very important /extremely important | 5-point average |
|--|--|---------------------------------------|-----------------|
| How important would information about be to you when comparing tyres? | | | |
| Fuel efficiency | 12.8% | 64.0% | 3.7 |
| Wet grip | 7% | 75.6% | 4.0 |
| Snow grip | 15.0% | 63.7% | 3.7 |
| Ice grip | 16.3% | 60.0% | 3.7 |
| Noise level | 26.1% | 39.1% | 3.2 |
| How important would it be to you that this information is displayed on the tyre label? | | | |

| | % not at all important /not very important | % very important /extremely important | 5-point average |
|-----------------|--|---------------------------------------|-----------------|
| Fuel efficiency | 12.6% | 64.2% | 3.8 |
| Wet grip | 7.7% | 74.4% | 4.0 |
| Snow grip | 12.1% | 67.3% | 3.8 |
| Ice grip | 13.8% | 63.5% | 3.7 |
| Noise level | 23.2% | 45.7% | 3.3 |

3524 Source: Own table based on (Giesen & Elsen, 2023)

3525 While external noise is addressed by the tyre label, measures to reduce internal noise are
 3526 implemented by tyre manufacturers based on the requirements of vehicle manufacturers (1st
 3527 Stakeholders consultation, 2025). The technical description of internal noise reduction measures
 3528 and its impact on end-of-life management can be found in **Section 7.3.6.3**.

3529 It is unclear if end-users (private vehicle owners, fleet managers, etc. of ICE vehicles) purchase
 3530 or utilise these internal noise reduction tyres or not. Stakeholders indicated to the authors of
 3531 this study that end-users (replacement market) do not typically distinguish between internal and
 3532 external noise. However, a study by the tyre manufacturer Hankook, noted that internal noise
 3533 reduction was an important feature for electric vehicles due to the lower noise generated by the
 3534 vehicle's drive train which makes noise from tyres more noticeable hence the measures taken
 3535 by manufacturers to reduce this (Nolan, 2024). A comparison of the influence of noise reduction
 3536 tyres to the adoption of EVs in support of the electric transition would versus the challenges
 3537 posed in end-of-life management would yield further clarity and inform regulatory measures.

3538 Anecdotal information also indicates that most passenger vehicle owners rely on the advice of
 3539 service centres in the decision to replace their tyres. A press release from Apollo tyres in July
 3540 2025 appears to confirm this (Apollo Tyres, 2025): in a survey of 1000 European consumers when
 3541 choosing a replacement tyre brand, 30 % of consumers follow the tyre retailer / fitter's advice,
 3542 18 % follow online expert reviews, 17 % follow manufacturer advice or replace with the same
 3543 tyre as originally fitted, while 11 % follow customer reviews. The same situation may not exist
 3544 for C2 and C3 tyres as these are often part of fleets with professionals familiar with the impact
 3545 of vehicles tyres on fuel/energy consumption and hence its impact on the overall bottom line of
 3546 urban transport and freight organisations.

3547 Questions for stakeholders:

3548 T3-1: To what extent do consumers utilise internal noise reduction tyres after the
 3549 first purchase of vehicles equipped with such tyres? Differentiate answers between
 3550 ICE and EV if possible.

3551 T3-2: what typical share of tyre market sales are fleet operators and do a large share
 3552 follow green procurement criteria or apply certain total cost of ownership metrics?

3553 6.2.5. Relevance of material aspects for users

3554 From a user perspective, safety of tyres is non-negotiable. Changes to materials used in tyres
 3555 must therefore ensure this, and meet the user’s performance expectations. The responses from
 3556 stakeholders on different technical parameters in Task 2 indicate that rolling resistance and
 3557 durability/mileage are of medium to high importance across C1 and C2 tyres, and high
 3558 importance for C3 tyres. In addition, the retreadability for C3 tyres is stated of high importance.

3559 If changes to materials result in lower rolling resistance, then this can reduce the fuel
 3560 consumption costs for users. The results from the consumer survey in the last section show that
 3561 there will be less willingness to compromise on wet grip performance (safety), however.
 3562 Improving durability is relatively easy to do by taking a durable rubber compound (some of the
 3563 cheapest tyres have high durability ratings), but this does not necessarily mean the tyre will
 3564 continue to have good performance (see magic triangle trade-offs in **Section 6.2.2**).

3565 Robust consumer preference data on attitudes of consumers to alternative tyre materials are
 3566 scarce. The most relevant study proposes an acceptance model (not a survey) and concludes
 3567 that there is no specific market pull for alternative tyre materials yet; acceptance hinges on clear,
 3568 credible sustainability information and maintained safety and functionality, with labels or
 3569 certification likely to play a decisive role (Wurster & Schulze, 2020).

3570 In discussions with manufacturers during this study, one mentioned that there was no consumer
 3571 demand for different material compositions, while another mentioned that market demand
 3572 outstripped supply as soon as they brought a tyre to market with high performance and high
 3573 sustainable material content. This demand was driven by fleet owners and OEMs interested in
 3574 reducing the environmental impact of their operations.

3575 Instead of an energy label, the U.S. National Highway Traffic Safety Administration (NHTSA)
 3576 applies the Uniform Tire Quality Grading System, which informs consumers on safety (wet grip),
 3577 durability and temperature resistance of their tyres. Durability is measured through Treadwear,
 3578 where tyres are measured against a control tyre based on driving 7,200 miles in a convoy around
 3579 a 400 mile loop. It is a relative index, where “100” grade is the baseline; a tyre graded 300 should
 3580 last approximately 3 times longer under the same conditions. However, tyre lifetime is
 3581 extrapolated based on how worn the tyre is after the test circuit, so is not guaranteed.

3582 There is no EU-mandated durability metric on the label (e.g., standardised treadwear/mileage
 3583 rating). Any durability claims are voluntary and unstandardised. Taking the same approach for
 3584 the EU has not yet been done, as standardised mileage testing across Europe’s varied
 3585 climates/roads is difficult, has high test costs and variability. Once abrasion/durability tests are
 3586 standardised under the test standards of Euro 7, the EU could consider adding a treadwear or
 3587 particle-emission class to the EU Tyre Label in a future revision.

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Questions for stakeholders:
 T3-3: is there any evidence of users/OEMs/fleet operators willing to pay a premium or accept other trade-offs for sustainable materials included in tyres?
 T3-4: is there demand from consumers/fleet operators for durability or information on lifetime or abrasion on tyres in the EU?
 T3-5: is there evidence of consumer demand for sustainable materials (e.g. willingness to pay premiums) or preferences for certain ways to share this information (e.g. metrics, label)?

3598

3599 6.2.6. Analysis of the energy consumption in the use phase

3600 Building on **Section 6.2.1** which described the impact of tyres on a vehicle's total energy system,
 3601 this chapter analyses the direct energy consumption attributable to the tyre during the use
 3602 phase. Rolling resistance clearly influences fuel and energy consumption; however, quantifying
 3603 the resulting fuel/energy loss is complex because it depends on several additional factors
 3604 (vehicle mass, speed profile, road gradient and surface, ambient conditions, powertrain, and
 3605 driving behaviour). Nevertheless, studies such as as Fontaras et al. (2017a) and Blömer (2022)
 3606 provide useful indications of the dynamics at play.

3607 Fuel demand ($fuel_{RR}$) required to overcome rolling resistance can be determined by means of a
 3608 straightforward energy equation. The equation is dependent on the rolling resistance coefficient
 3609 (RRC), the vehicle weight ($m_{vehicle}$), the gravitational force (g) the vehicle speed (v) and the
 3610 efficiency of the drivetrain ($\eta_{drivetrain}=[0.2...0.4]$ for ICE and $[0.65...0.81]$ for electrical vehicles
 3611 (Blömer, 2022)³³). The equation below shows the correlation.

Equation 6-1: Increase in fuel consumption depending on rolling resistance and speed for a passenger car with ICE (1.500 kg).

$$fuel_{RR} = \frac{(RRC \cdot m_{vehicle} \cdot g \cdot v)}{\eta_{drivetrain}}$$

3612

Source: (Blömer, 2022; Fontaras et al., 2017a)

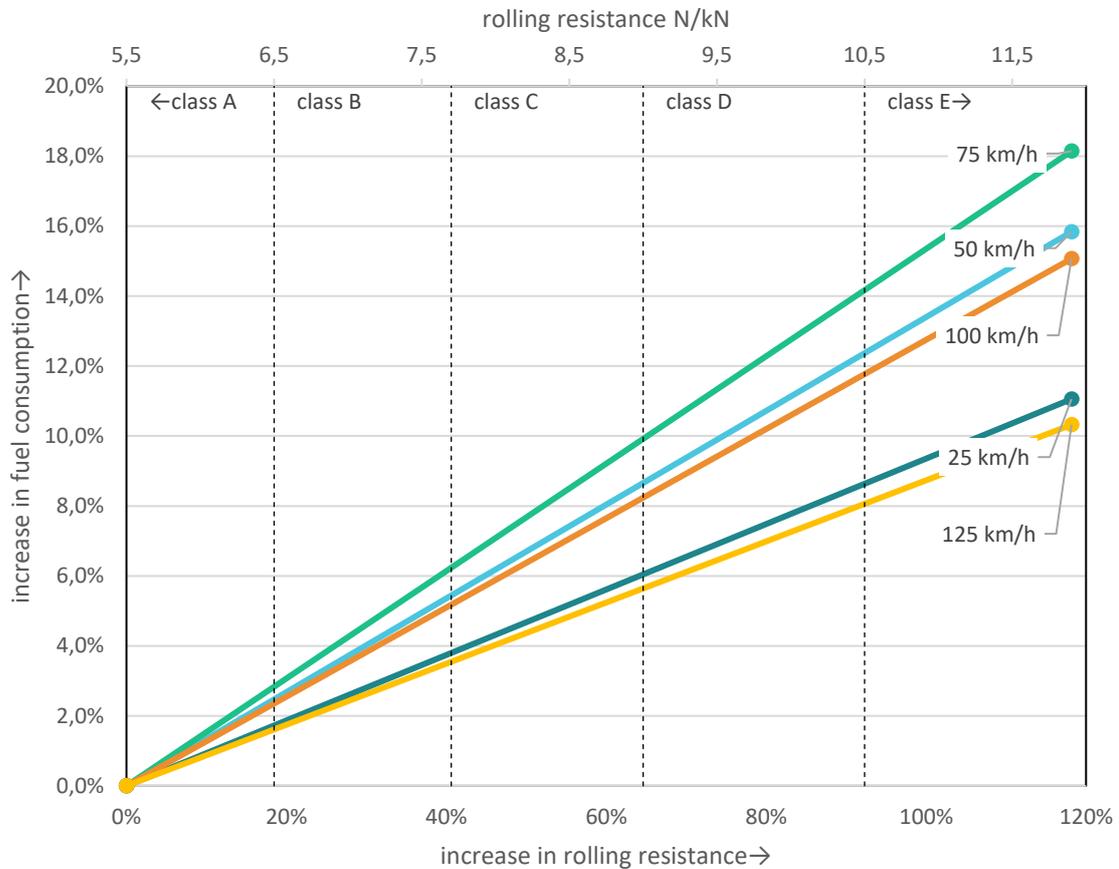
3613

3614 For passenger cars an increase in rolling resistance by 10 % would yield an additional fuel
 3615 demand of 0.8-2.2 %.³⁴ Doubling the rolling resistance (e.g. from 6 N/kN to 12 N/kN) could

³³ The product category rules for tyres (2022) specifies an efficiency of 0.81 for electric vehicles

³⁴ Assuming a passenger car weight of 1.5 tonnes and an increase in rolling resistance from 8N/kN to 8.8 N/kN. Fuel consumption of a passenger car was derived from literature (Fontaras et al., 2017a)

3616 increase the fuel demand by >15 %. **Figure 6-7** pictures the relationship between increase in
 3617 rolling resistance and fuel consumption for a passenger car.



3618

3619 **Figure 6-7: Impact of rolling resistance on fuel consumption.**

3620 Source: Own figure. A rolling resistance of 5.5 N/kN equals 0 % and a rolling resistance of 11 N/kN equals 100 %
 3621 (own calculations).

3622 Fontaras et al. (2017a) found that higher RRC tyres and impacts from pavements may increase
 3623 fuel consumption by about 12-18 %, while special “low rolling resistance” tyres designed for
 3624 electric vehicles may lead to a 20 % potential reduction in fuel consumption.

3625 EV powertrains are more efficient than ICE. That means a larger fraction of the battery energy
 3626 reaches the wheels, and the rolling resistance losses correspond to less upstream primary
 3627 energy than for ICE. However, the tyre level rolling resistance is the same for a given mass,
 3628 speed, and RRC. EVs are typically heavier due to batteries. Higher mass increases rolling
 3629 resistance force and thus energy per km attributable to tyres, all else equal. This can make
 3630 tyre-related energy a larger share of traction energy in EVs at lower speeds where aerodynamic
 3631 drag is smaller.

3632 **Section 5.4.1.3** gives an overview of the market trends relating to the energy label and rolling
 3633 resistance coefficient.

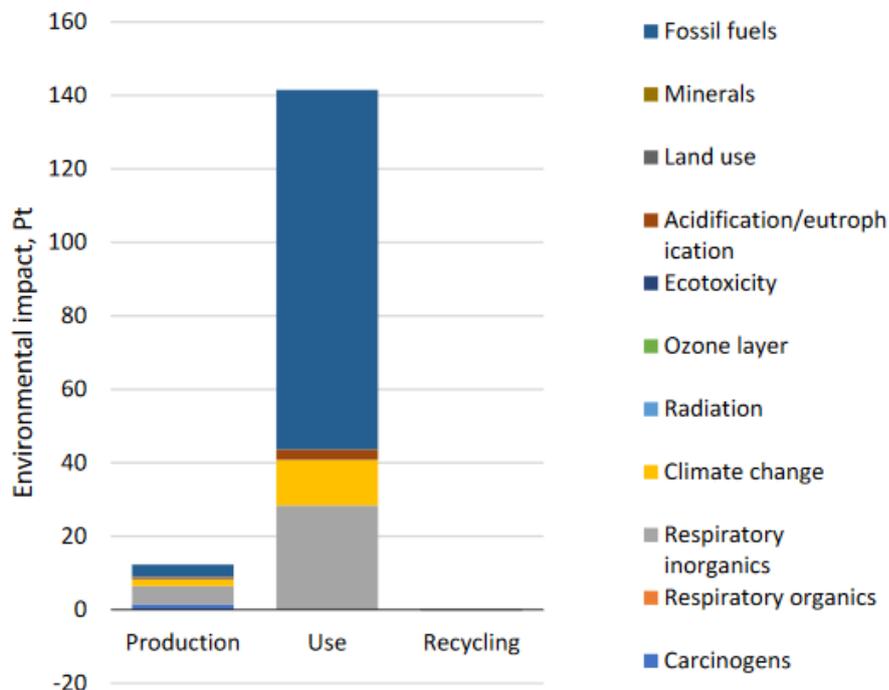
3634 **6.2.7. Interaction mechanisms between ErP and the affected energy**
 3635 **system**

3636 A description of the physical and chemical mechanisms establishing the relationship between
 3637 vehicle tyres and the overall vehicle have been addressed in subsequent sections of this chapter
 3638 (see **Sections 6.2.7** and **6.2.8**). Further information may be added after online consultations and
 3639 the first stakeholder consultation in Brussels.

3640 **6.2.8. Quantification of environmental impacts during the use phase**

3641 As part of the preparatory study, a mapping of available data in 86 studies available in the
 3642 literature was made to identify relevant studies by tyre type (C1, C2, C3, motorcycle, bicycle or
 3643 other). This has been undertaken to support developing a Product Environmental Footprint
 3644 approach to quantify environmental impacts in Task 5 and will be supplemented by additional
 3645 LCA information through the stakeholder consultation. This section therefore provides some
 3646 indicative information from single LCAs, but does not try to capture all relevant studies at this
 3647 stage.

3648 Research by Piotrowska et al., based on an LCA, found that the highest environmental impact of
 3649 car tyres occurs during their use phase and is directly related to the vehicle fuel consumption
 3650 (Piotrowska et al., 2019).



3651

3652 **Figure 6-8: Results of grouping and weighing of environmental impacts at lifecycle stages of**
 3653 **an ICE car.**

3654

Source: Piotrowska et al (2019)

3655 Their methodology included Eco-indicator 99, cumulative energy demand (CED), and
 3656 Intergovernmental Panel on Climate Change (IPCC) assessment methods. The impact categories
 3657 identified across the tyre's life cycle are presented in below.

3658 **Table 6-5: The share of impact categories in the car tyre life cycle (relevant impact categories).**

| Impact category ³⁵ | Contribution % | | | |
|-------------------------------|--------------------|------------|--------|-----------|
| | Life cycle (total) | Production | Use | Recycling |
| Carcinogens | 0.981 | 12.309 | 0.001 | 2.232 |
| Respiratory organics | 0.013 | 0.019 | 0.012 | 0.190 |
| Respiratory inorganics | 21.712 | 40.431 | 20.077 | 12.263 |
| Climate change | 9.247 | 14.754 | 8.766 | 6.353 |
| Radiation | 0.002 | 0.022 | 0.000 | 0.000 |
| Ozone layer | 0.000 | 0.003 | 0.000 | 0.006 |
| Ecotoxicity | 0.149 | 1.842 | 0.000 | 0.006 |
| Acidification/eutrophication | 2.089 | 3.024 | 2.008 | 1.917 |
| Land use | 0.126 | 1.573 | 0.000 | 0.000 |
| Minerals | 0.007 | 0.100 | 0.000 | 0.939 |
| Fossil fuels | 65.675 | 25.922 | 69.137 | 77.337 |

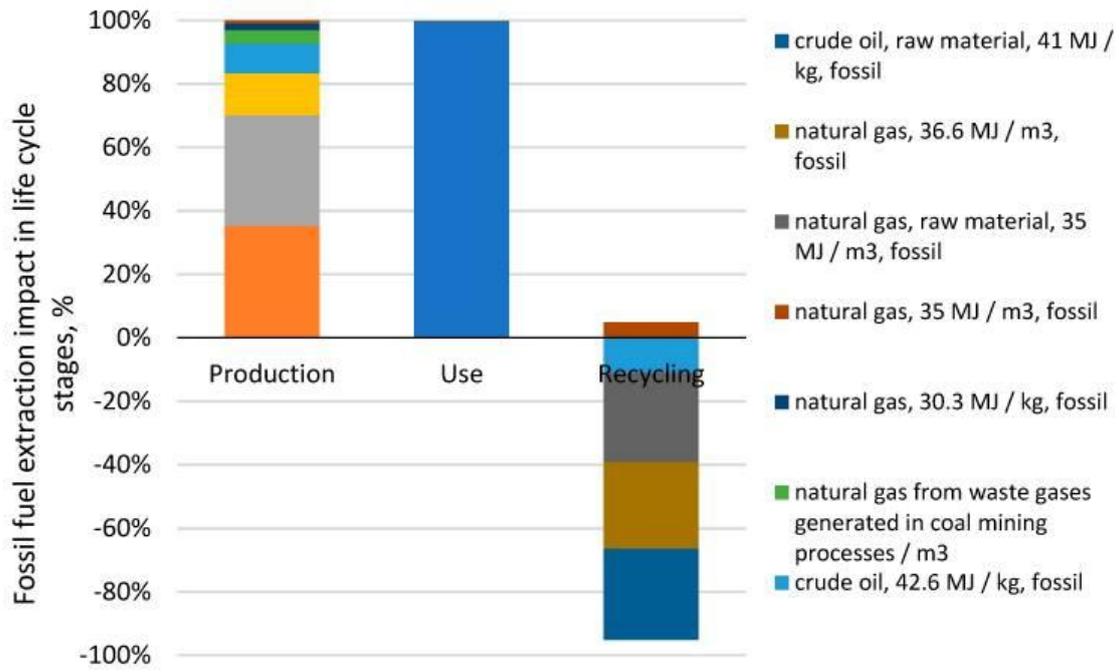
3659 Source: (Piotrowska et al., 2019), most relevant categories across entire lifecycle or lifecycle stage marked orange.

3660 As noted in **Section 6.2.1**, the environmental impact of vehicle tyres is predominantly
 3661 concentrated in the use phase of the product's life cycle, with comparatively minor contributions
 3662 from the manufacturing phase. This is primarily due to the fuel consumption required during
 3663 vehicle operation. The study further found that among all the processes analysed, natural gas
 3664 extraction had the most significant impact in this category, accounting for 100 percent of the
 3665 harmful impacts in the use phase and 96.85 % across the entire tyre life cycle. Additionally, the
 3666 extraction of natural gas (35.17 %) and oil (34.85 %) were identified as major contributors to
 3667 environmental degradation and can be considered key hotspots in the fossil fuel extraction
 3668 category during the use phase. Other notable contributors include hard coal extraction (13.28
 3669 %), crude oil at 42.6 MJ/kg, and general fossil fuel extraction (9.29 %) (Piotrowska et al., 2019).

3670 The referenced study identified natural gas and oil extraction as hotspots for fossil fuel impacts
 3671 in use for an ICE vehicle. For EVs, the electricity generation pathways determine how large the
 3672 share of fossil fuel related impacts are. A cleaner grid reduces these impacts; a coal or gas-
 3673 dominated grid sustains them. Managing charging (e.g., using renewable tariffs, on-site PV) can
 3674 therefore reduce the fuel-related use phase impacts.

3675

³⁵ Relevant impact categories for the use phase are in bold.



3676

3677 **Figure 6-9: Results of grouping and weighing of environmental impacts for the processes**
 3678 **connected with the extraction of fossil fuels involved in a car tire life cycle.**

3679 Source: (Piotrowska et al., 2019)

3680 A comprehensive literature review by the researchers Dong et al. (2021), supports these
 3681 findings. Impacts related to transportation are generally negligible and are therefore omitted
 3682 from most studies. In terms of environmental impact, the literature review indicates effects on
 3683 impact categories outlined in **Table 6-6** below based on the analysis of a single passenger car
 3684 tyre. Averages are provided as well as data ranges due to the different methodologies, and
 3685 allocations used in the LCAs. It should be noted that these values pertain to passenger ICE vehicle
 3686 tyres. An analysis of tyres designed for EVs would likely show different environmental impacts
 3687 due to differences in manufacturing and more especially in the use phase (based on the grid mix
 3688 of the electric energy source).

3689 **Table 6-6: Environmental impacts of a passenger car tyre.**

| Impact category | Production | Transportation | Use | End-of-life (recycling) | Total | Unit |
|-----------------|--------------|----------------|-----------|-------------------------|-----------|-----------------------|
| Climate change | 0.28 | 0 | 2.4 | -0.083 | 2.6 | Pt |
| | 13.17-44.8 | 1.5-2.5 | 532-800 | -4.2-0.5 | 564-843.5 | KgCO ₂ eq |
| Acidification | 0.17 | 0 | 2.1 | -0.063 | 2.2 | Pt |
| | -0.019-0.27 | 0.012-0.031 | 0.54-3.13 | -0.0039-0.037 | 2.1-3.4 | KgSO ₂ eq |
| Eutrophication | 0.17 | 0 | 2.1 | -0.063 | 2.2 | Pt |
| | 0.0047-0.031 | 0.0021 | 0.06-0.46 | -0.0084-0.0080 | 0.39-0.48 | Kg PO ₄ eq |
| | 0.001 | 0 | 0 | 0 | 0.001 | |

| Impact category | Production | Transportation | Use | End-of-life (recycling) | Total | Unit |
|-----------------|-------------------|-------------------|-------------------|-------------------------|-------------------|------------|
| Ozone depletion | 5.6E-06 – 6.9E-06 | 1.8E-07 – 1.9E-07 | 3.1E-04 – 3.3E-04 | 0 | 3.1E-04 – 3.3E-04 | KgCFC-11eq |

3690 Source: (Dong et al., 2021)

3691 6.2.8.1. Contribution of vehicle tyre wear to microplastic emissions

3692 Tyres are one of the largest sources of microplastic emissions (particles ranging from 1 to
3693 5,000 μm), accounting for at least 35% of all microplastic pollution in Europe, while some studies
3694 suggest that their contribution may be as high as 85 % (Giechaskiel, Grigoratos, Mathissen, et
3695 al., 2024a). It is estimated that between 0.36 and 0.54 million tonnes of microplastics are
3696 released from tyre wear annually across Europe (Boucard et al., 2025; Giechaskiel, Grigoratos,
3697 Mathissen, et al., 2024b). According to Kole et al. (2017) per capita tyre-derived microplastic
3698 emissions are estimated to range from 0.23 to 4.7 kg per year, with a global average of
3699 approximately 0.81 kg/year. These emissions are notably higher than those from other sources
3700 of microplastics, such as aircraft tyres (2 %), artificial turf (12–50 %), brake wear (8 %), and road
3701 markings (5 %) (Kole et al., 2017).

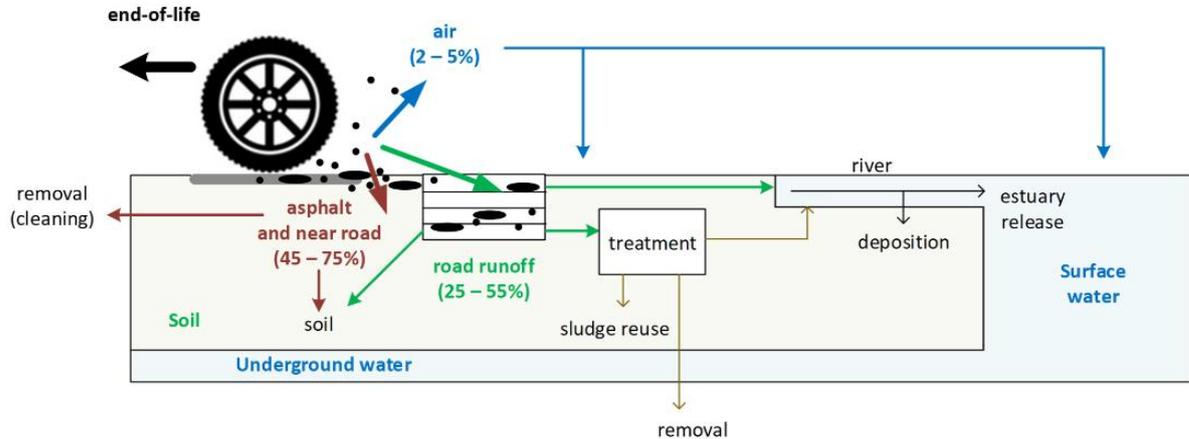
3702 Additionally, tyre wear contributes to particulate matter pollution. For PM_{10} (particles smaller
3703 than 10 μm), it is estimated that road transport accounts for 10–15% of total emissions, with
3704 tyre wear responsible for approximately 5–31 % of that share (Giechaskiel, Grigoratos,
3705 Mathissen, et al., 2024b). For PM_{10} there is a large uncertainty in the emission factor. Emission
3706 factors range between 0.3 % and 10.0 % of the total tyre mass (Charbouillot et al., 2023).

3707 The level of tyre wear emissions is influenced by numerous variables, including tyre composition,
3708 vehicle characteristics, road surface properties, environmental conditions, and driver behaviour.
3709 Recent review studies by Giechaskiel et al. (2024) based on approximately 300 measurements
3710 report a mean tyre wear rate of 110 mg/km per vehicle, or 68 mg/km per tonne for passenger
3711 cars. PM_{10} (particulate matter with a diameter of less than 10 μm) emissions were found to
3712 range from 1.4 to 2.2 mg/km per tyre. Furthermore, particle number emissions were observed
3713 to be on the order of 10^{10} particles per kilometre per tyre (Giechaskiel, Grigoratos, Mathissen,
3714 et al., 2024a).

3715 The study further examines the environmental fate of tyre-derived microplastics. Reported
3716 concentrations of tyre particles in soil near roads are typically around 10 mg of tyre per gram of
3717 soil ($\text{mg}_{\text{tyres}}/\text{g}_{\text{soil}}$), though levels can reach as high as 158 $\text{mg}_{\text{tyres}}/\text{g}_{\text{soil}}$. These concentrations are
3718 influenced by factors such as traffic intensity, road surface type, vehicle speed, and the presence
3719 of drainage and runoff systems. Additionally, accumulation at roadsides and in runoff is affected
3720 by the number of dry days prior to rainfall. A significant portion of tyre wear particles initially
3721 settles on the road surface and can be transported directly into surface waters through road
3722 runoff, with concentrations averaging around 50 mg of tyre per gram of runoff ($\text{mg}_{\text{tyres}}/\text{g}_{\text{runoff}}$),
3723 and ranging from 10 to 150 $\text{mg}_{\text{tyres}}/\text{g}_{\text{runoff}}$ (Giechaskiel, Grigoratos, Mathissen, et al., 2024a).

3724 Alternatively, tyre particles can enter surface waters indirectly if runoff is first directed to
3725 wastewater treatment plants. Only a small proportion of tyre wear becomes airborne, although

3726 some studies estimate this to be as high as 10 %. Of the airborne fraction, approximately 34%
 3727 has been found to eventually reach the oceans (Giechaskiel, Grigoratos, Mathissen, et al.,
 3728 2024a). **Figure 6-10** below illustrates the various pathways through which tyre particles are
 3729 released into the environment.



3730

3731 **Figure 6-10: Modelled source, release, and transportation of tyre particles in the**
 3732 **environment.**

3733 Source: (Giechaskiel, Grigoratos, Mathissen, et al., 2024a)

3734 As outlined in the impact assessment for the Euro 7 Regulation (EU Regulation 2024/1257,
 3735 2024), non-exhaust emissions, including microplastics, are expected to account for up to 90
 3736 percent of all particles emitted by road transport by 2050. This trend is primarily driven by the
 3737 anticipated reduction in exhaust emissions resulting from vehicle electrification. These non-
 3738 exhaust emissions are to be addressed through the work of two United Nations working groups
 3739 (the GRPE and the GRBP), which is developing tyre abrasion limits based on state-of-the-art
 3740 methodologies. In the event that uniform provisions on tyre abrasion limits have not been
 3741 adopted by UN WP.29 by 1 July 2026 for C1 tyres, 1 April 2028 for C2 tyres, or 1 April 2030 for
 3742 C3 tyres, the Commission shall adopt a delegated act to support the Union’s objective of
 3743 reducing microplastic emissions to the environment by 30 percent by 2030. The development
 3744 of this delegated act will also consider the specific characteristics of vehicles equipped with
 3745 traction batteries, including plug-in hybrid and battery electric vehicles. Further insights on tyre
 3746 abrasion can be found in **Section 7.3.3.6** of this study.

3747 **6.3. End-of-Life behaviour**

3748 **6.3.1. Product use & lifetime**

3749 Tyre lifetime is shaped by both technical specifications and how they are used and maintained.
 3750 A more detailed assessment of the technical lifetime of tyres in terms of mileage and in relation
 3751 to tread thresholds is given in **Section 0**.

3752 It is challenging to specify tyre usage data in terms of time, as this largely depends on how
3753 frequently vehicles are driven by their owners. Additional complexity arises from factors that
3754 are beyond the control of consumers, such as road conditions (potholes, curbs, and surface
3755 quality) and weather conditions such as ice, snow, and rain. Available data suggests that tyres
3756 on passenger vehicles are typically replaced after five to eight years, regardless of the distance
3757 travelled. It is important to note, however, that age-related degradation may begin to occur
3758 after four to six years, even if the tread depth remains within legal limits. This degradation can
3759 lead to consumer-initiated replacement based on safety concerns.

3760 Steering axle tyres, which support the front of the vehicle where the driver and passengers are
3761 seated, experience different stress patterns compared to rear axle tyres. Rear tyres typically
3762 bear variable loads depending on the weight and frequency of freight carried, which can
3763 significantly influence wear rates and replacement schedules. Lifetime is negatively affected by
3764 under-inflation, which increases carcass flex, heat build-up, and abrasion, shortening service life
3765 and undermining the efficiency gains users expect from low-rolling-resistance designs. Urban,
3766 stop-start cycles with frequent acceleration and braking increase mechanical abrasion relative
3767 to steady motorway use; heavy loads and high axle stresses do the same. Using 3PMSF winter
3768 tyres in appropriate conditions avoids excess wear, noise, and efficiency impacts when
3769 temperatures rise.

3770 Light commercial vehicles (classified as C2), which are commonly used on urban and regional
3771 routes, are exposed to similar operating conditions as passenger vehicles. However, their
3772 commercial nature often results in more frequent use. Wear rates of tyres of these vehicles are
3773 also increased due to frequent start/stop dynamics (1st Stakeholders consultation, 2025).

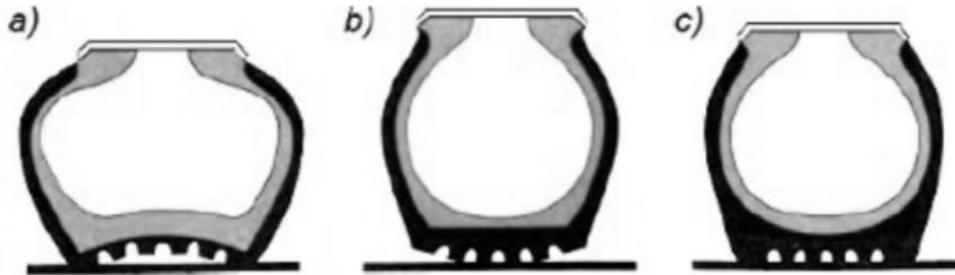
3774 In heavy-duty fleets, tyre lifetime is maximised by managing the casing as a long-lived asset:
3775 steer and drive axles experience different wear mechanisms, so rotation strategies and
3776 axle-specific selections matter, and retreading (under UN R109 requirements) can extend
3777 service across multiple lives when casings are well maintained.

3778 6.3.2. Repair and maintenance practices

3779 In most of the EU, tyre repair and maintenance are carried out by consumers in
3780 local/neighbourhood tyre repair and maintenance centres. While some end-users indeed
3781 undertake these repair and maintenance activities directly, there are anecdotal indications that
3782 this is on the decline and are more often undertaken during routine maintenance or in vehicle
3783 repair centres. Typical repair and maintenance actions are described below:

- 3784 • **Regular checks on tyre pressure:** This activity is recommended to be performed by end-
3785 users at least monthly and before long trips. In most jurisdictions, this forms part of
3786 driving license trainings. As mentioned in **Section 6.2.1** Error! Reference source not f
3787 ound., tyre pressure has an impact on fuel consumption. Over or under-inflated vehicle
3788 tyres distort the section of the tyre meant to have contact with the road and hence has
3789 a direct impact on frictional forces and rolling resistance. Over-inflation cause increased
3790 wear specifically to the centre tread of the tyre due to the abovementioned increased
3791 contact with the road surface. A decrease in tyre pressure increases rolling resistance

3792 and hence fuel consumption (Belayneh et al., 2021; Synák & Kalašová, 2020). The effect
 3793 of pressure on rolling resistance is reportedly not linear with deflations of 0.3 bar
 3794 causing increases to fuel consumption of 6%, while deflations of 1 bar causing increases
 3795 of 30% (Fontaras et al., 2017b).



3796

3797 **Figure 6-11: Tyre deformations in a) low pressure, b) high pressure, c) proper pressure.**

3798

Source: (Szcucka-Lasota et al., 2019)

3799

- 3800 • Tyre rotation: This is a scheduled maintenance activity intended to equalise tread wear
 3801 across all tyres, thereby helping to achieve the expected service life. Front tyres typically
 3802 exhibit accelerated wear due to steering inputs and the higher static and dynamic loads
 3803 they carry. Periodic rotation distributes wear more uniformly across the set, which can:
 - 3804 ○ Extend aggregate tyre life and allow coordinated replacement of all four tyres
 3805 rather than staggered, piecemeal replacement.
 - 3806 ○ Maintain lower rolling resistance by avoiding uneven wear, thereby reducing
 3807 fuel consumption and associated operating costs.
 - 3808 ○ Preserve predictable handling characteristics and contribute to overall vehicle
 3809 safety.

3810 Typical service practice recommends rotation at intervals of approximately 6 months or
 3811 8,000–13,000 km (Fixter, 2025). OEMs specify rotation intervals and patterns in vehicle
 3812 documentation; those specifications should take precedence for a given model and tyre
 3813 configuration. Proper tyre inflation and wheel balancing are necessary complementary
 3814 measures to realise the efficiency and safety benefits of rotation.

- 3815 • Tread depth and wear inspection: In most jurisdictions, the minimum tread depth of
 3816 vehicle tyres are regulated and checked. In Germany for example the legally minimum
 3817 tread depth for passenger vehicles is 1.6mm. Drivers inspect visually for uneven wear
 3818 patterns, bulges, cuts, and embedded objects in tyres (Fixter, 2025; Underwood, 2021)
 3819 The impact of rolling resistance on fuel consumption is discussed in **Section 6.2.1** and
 3820 **6.2.6** . Tread depth affects rolling resistance and by extension fuel consumption. This
 3821 relation is explained by the so-called ‘Michelin Formula’ and given as:
 3822 $CR = CR_0 * (1 - 0.0224 * (H - h))$, where CR is rolling resistance, CR_0 is rolling resistance with
 3823 full tread, H is tread depth at the start (new tyre), and h is the current tread depth
 3824 (Blömer, 2022).
- 3825 • Wheel alignment and balancing: While this is not performed directly on vehicle tyres, it
 3826 is mentioned due to its impact on the product. Wheel balancing and alignment is
 3827 performed on the steering and wheel assembly of vehicles during routine maintenance
 3828 or when misalignment between steering and driving direction is detected by the driver.

3829 Misalignment of wheels leads to uneven wear of tyres. Besides significant safety
3830 concerns, unevenly worn tyres may negatively affect fuel consumption.

3831 Other maintenance such as visual inspections, regular cleaning, etc. are rather basic and
3832 intuitive. They are not significant to fuel consumption and environmental protection and are
3833 therefore not mentioned here.

3834 6.3.3. Collection rates

3835 Tyres are covered by extended producer responsibility legislation in 22 member states,
3836 implemented via non-profit producer responsibility organisations (PROs) that levy management
3837 fees on new tyres placed on the market, calibrated to system cost.

3838 To give some country examples:

3839 • Belgium operates an EPR system for tyres via the national PRO (historically Recytyre).
3840 Academic and sector sources report that Belgium has achieved “collection rates above
3841 100 %” in several years, which can occur when the scheme covers tyres put on the
3842 market in previous years and/or flows from neighbouring countries, rather than
3843 indicating more-than-total performance in a single year (Winternitz et al., 2019). Recent
3844 PRO reporting states figures of 89 % collection in 2024 (RECYTYRE, 2024).

3845 • In Italy, the PRO Ecopneus has met or exceeded its annual collection targets in recent
3846 years. For 2024, Ecopneus reports achieving over 100% of its 150,000 t target; treatment
3847 shares are reported at approximately 52 % material recovery and 48 % energy recovery
3848 (Ecopneus, 2025).

3849 • In Estonia, residents may dispose of up to eight passenger car tyres at municipal waste
3850 stations; acceptance conditions and site coverage are facilitated for tyres covered by the
3851 Producer Responsibility Organisation MTÜ Rehviringlus. In practice, the free acceptance
3852 thresholds apply to household quantities, while larger commercial volumes use
3853 contracted collection channels (MTÜ Rehviringlus, 2025).

3854 • Germany follows a free-market model (no national tyre PRO/EPR), with ELTs managed
3855 by private collectors and recovery operators across material and energy routes.
3856 Household and small-volume ELT disposal is available via municipal recycling centres
3857 (e.g., BSR sites in Berlin), subject to local conditions and fees. The ZARE initiative brings
3858 together certified ELT disposal companies and promotes compliant, professional
3859 recovery across the country, with listed partners operating at multiple locations.

3860 In Europe, ELT collection and treatment rates are reported to be high. ETRMA reports a current
3861 treatment rate of about 97 % across Europe, with approximately 3.9 million tonnes of ELTs
3862 generated in 2024 (ETRMA, 2025b). In 2019, around 3,500 kilotons (kt) of end-of-life tyres (non-
3863 reusable, discarded tyres) were generated in the EU. Of this total, 55 % underwent material
3864 recovery, 40% were processed through energy recovery, and approximately 5 % were either
3865 stockpiled or categorised as ‘unknown’ (ETRMA, 2019).

3866 In July 2025, the ZARE initiative released a statement asserting that ELTs are increasingly being
3867 exported out of the EU to third countries with potentially unsustainable ELT management

3868 (Reifenpresse, 2025). The organisation asserts about 15-20 % of ELTs were lost to recycling in
3869 this way in 2023 – data for 2024 and 2025 are not yet available. According to a stakeholder
3870 interviewed for this study, a reason for this is that some end-users do not want to pay disposal
3871 fees and hence dispose of ELTs illegally (e.g. through illegal landfilling or burning) (1st
3872 Stakeholders consultation, 2025).

3873 In their 2025 EU Recyclers’ Manifesto, EuRIC calls on the EU Commission to ban the export of
3874 unprocessed and shredded tyres from the EU, pointing out that many of these are either being
3875 landfilled or entering dubious treatment operations (EuRIC, 2025a). They see the proper
3876 implementation of the revised WSR as essential to stop ELTs from being sent abroad for
3877 incineration in facilities that do not meet with EU environmental standards. In response to this
3878 call for a ban, ETRMA published a position requesting that the waste hierarchy be respected as
3879 far as possible to enable re-use and mechanical recycling, taking into account the fact that there
3880 is not sufficient treatment capacity in Europe and outlet markets are necessary for a functioning
3881 recycling market (or at least until outlet markets for recyclates can be established in the EU)
3882 (ETRMA, 2025b). Both ETRMA and EuRIC support the European Commission’s revision of the
3883 Waste Shipment Regulation relating to waste exports only being allowed for documented
3884 equivalent treatment facilities, however, it appears that better implementation is needed.

3885 According to Tyre and Rubber Recycling, 800,000 tons of tyres were imported from the UK and
3886 the EU to India between April and November in 2023 (Scott, 2024) (in 2019 AECOM reported
3887 427,640 tons of exports from the EU to India 2019 (Braithwaite et al., 2021). It is claimed that
3888 10-15 % of these are reused, while the rest enter “highly outdated batch pyrolysis” (Scott, 2024).
3889 Videos of this kind of informal pyrolysis process in India show heating of tyres in a rotating kiln
3890 using firewood to produce tyre pyrolysis oil and carbon black, in what appears to be an incredibly
3891 toxic and polluting process, with zero regard for health and safety³⁶. While the Indian authorities
3892 have now released standard operating procedures for pyrolysis facilities (Central Pollution
3893 Control Board, 2024), it cannot be expected to achieve compliance immediately, given that this
3894 targets formal facilities and some 757 plants were identified by the authorities in 2022
3895 (Upadhyay, 2022) (for comparison it is estimated that around 3 to 5 high-tech tyre pyrolysis
3896 plants are operating in the EU).

3897 Questions for stakeholders:
3898 T3-6: Are tyre collection rates for C1, C2, C3 the same? Are the collection
3899 rates/pathways for bicycle, motorcycle, agricultural, industrial and off-the-road tyres
3900 similar?

³⁶See example here <https://www.youtube.com/shorts/hi7jmN3uQu0>

3901 6.3.4. Estimated second-hand use, fraction of total and estimated
3902 second product life (in practice)

3903 6.3.4.1. Retreading

3904 Most tyres will be replaced at EoL with new tyres, this is particularly true in the passenger vehicle
3905 segment. However, in larger vehicles such as trucks and buses, an EoL tyre can also be replaced
3906 with a retreaded one. In retreading practice, a worn tyre tread of a used tyre is replaced with a
3907 new tread, thus extending the life of the tyre on the same carcass (see **Section 7.6.1.2** for
3908 technical details). According to ETRMA, truck tyres are designed to be retreaded up to three
3909 times. In the EU at present, only small amounts of van tyres have been stated as being retreaded.
3910 Generally, in the EU today, it is more economical to manufacture new tyres for this tyre class
3911 (C2) than to retread them³⁷. In the past, passenger car tyres were also retreaded, especially for
3912 winter tyres. Today, this practice is rare in Europe but is still seen in some low and middle income
3913 countries (Stakeholder SR7, personal communication, 2025 2024).

3914 In a comparison of the kilometrage of different tyres, (Mugnier et al., 2016) specifies the lifetime
3915 of a low budget truck tyre imported from Asia as 120,000 km as compared to 220,000 km for a
3916 premium truck tyre. The latter can be retreaded (depending on the source) either up to two or
3917 additional times, providing a comparable performance in each cycle and a total lifetime of about
3918 660,000 km.

3919 Information provided by stakeholders in interviews and submitted feedback indicates that while
3920 an active market for retreaded C3 tyres exists, C2 and C1 tyres especially do not have the same
3921 due to the presence of low-cost 'single-use' tyres on the European market. Consumers in the
3922 segment of C3 tyres have an economic incentive to undertake retreading given the high cost of
3923 C3 tyres compared to others (Truckersreport, 2013).

3924 According to (Rojas, n.d.), retreading represents approximately 26 % of the 18.3 million truck
3925 and bus replacement tyres (TBR) sold in Europe and can vary among countries/regions. Though
3926 tyre retreading is practiced for trucks in the EU, ETRMA statistics show that it is decreasing.
3927 Whereas in 2011³⁸ close to 5.5 million truck tyres were retreaded in the EU, in 2022 numbers
3928 were down to only around 4.29 million units. The market share of renewed truck tyres is steadily
3929 falling in Europe – from 34.2 % (2012) to 20.1 % (2022) (AZuR, 2023). Though a decrease in
3930 statistics is observed above for tyre sales between 2019 and 2020, in the case of retreading, the
3931 decrease is consistent throughout the 2011-2020 period and probably not tied with the COVID
3932 pandemic.

³⁷ This statement is valid especially for replacing the old tyre with less expensive budget tyres, often with a lower quality in comparison to retreaded ones. However, retreaded tyres are significantly less expensive than A brand tyres, as explained further in the section.

³⁸ In 2007 there were 5.81 million truck tyres retreaded.

3933 **Ownership:** Premium tyres with high-quality casings command higher purchase prices due to
 3934 their construction and multi-life potential. Manufacturers who retread tyres in their own plants
 3935 are also interested in purchasing or owning of retreadable tyres. In the vast majority of cases,
 3936 tyres are sold to dealers, and the end customer (an individual or a company) who purchases
 3937 them ultimately becomes the owner. For third party retreaders the truck user has an interest to
 3938 buy a premium tyre as they get a good price from the independent retreaders (Retreader
 3939 Interview, personal communication, 7 August 2025).

3940 While a customer typically owns their tyres, exceptions exist in specialised service models. In
 3941 fleet and long-term leasing, the leasing company often retains ownership of the tyres and is
 3942 responsible for their maintenance and disposal. Similarly, in the commercial transport and
 3943 aviation sectors, tyres are frequently leased from the manufacturer or a service provider. In such
 3944 models, the tyre owner maintains and handles all servicing, including retreading, which
 3945 increases the likelihood of tyres retreading. In case of tyre leasing when the manufacturer sells
 3946 kilometrage and not the trye, the manufacturer has an interest to make the tyre retreadable as
 3947 often as possible so that as little material as possible needs to be invested. The model is popular
 3948 with C3 tyre manufacturers that do their own retreading but also with leasing companies (part
 3949 of the fleet management) (*Stakeholder Interview SR8*, personal communication, 2025).

3950 **Estimated second product life**

3951 The estimation of second product life for retreaded tyres is based on stakeholder feedback
 3952 received from industry and will be further refined in further consultations. Information provided
 3953 is presented in an average format. It is also challenging to specifically state product life in years
 3954 as is normal in preparatory studies due to different driving habits and use cases of vehicles.

3955 **Table 6-7: Typical retread limits and mileage ranges of C1-C3 vehicle tyres (retreaded).**

| Tyre category | Nos. Of possible retread cycles | Second product life (km) | Second product life (years) |
|---|---------------------------------|--------------------------|-----------------------------|
| Tyres designed for passenger cars (C1 tyres) | 1 | 30,000; | - |
| Tyres designed for light commercial vehicles (C2 tyres) | 1 | 67,500 | 3 |
| Tyres designed for heavy commercial vehicles (C3 tyres) | 2 | 270,000 | 2 |

3956 Source: Own table based on stakeholder feedback.
 3957

3958 Questions for stakeholders:
 3959 T3-7: Stakeholders are asked to assess the information provided in Table 6-7 and
 3960 confirm their agreement or provide further information if necessary.

3961 **Barriers to retreading of passenger tyres (C1)**

3962 It is evident from the preceding sections that C3 tyres are more likely to be retreaded. This trend
 3963 is supported by clear economic incentives, established industry practices, and broad user
 3964 acceptance. In contrast, although the retreading of passenger tyres is both legally and
 3965 technically feasible, it does not appear to be commonly practiced. Further discussions on
 3966 challenges linked to retreadability of tyres including their design and other aspects influencing
 3967 development of tyres within the EU as well as description of the process itself, can be found in
 3968 **Section 7.6.1.2** of Task 4.

3969 **N. B. Retreading aspects will be extended/updated following the October stakeholder**
 3970 **meeting.**

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Questions for stakeholders:
 T3-8: are market conditions the key limiting factor to increasing retreading, or high rejection rates / non compatibility of tyres for retreading processes? Which factors lead to unusable tyres for retreads the most?
 T3-9: is there strong evidence that re-treads meet the same functional performance on rolling resistance, durability, wet grip and noise? What tolerance bands are usually applied?

3978 **6.3.4.2. Part-worn tyres on the consumer market and informal reuse of**
 3979 **ELTs.**

3980 The use of part-worn tyres (reused tyres without undergoing retreading) is legal in some EU
 3981 Member States albeit under stringent standards (vehicle and tyre legislation do not explicitly
 3982 ban the sale or transfer of tyres from one vehicle to the other). Effectively the tyre must conform
 3983 to all standards (safety, performance, tread depth, etc) as a ‘normal tyre’ and hence fulfil road
 3984 worthiness requirements. Some tyre manufacturers recommend the replacement of tyres at
 3985 tread depths higher than the legal limit of 1.6mm (usually 3mm and 4mm for summer and winter
 3986 tyres respectively, based on guaranteed best performance), which also generates potential
 3987 supply for these tyres. Other sources may be, for example, caused by national traffic laws that
 3988 request to replace by axle, even if only one tyre is bad.

3989 Second hand tyres for re-use are legally usable and hence attractive for resale, but this market
 3990 is not regulated or controlled making data hard to come by (1st Stakeholders consultation,
 3991 2025). The Tyre Industry Federation estimates around 5 million, or 10 % of all tyres purchased
 3992 in the UK are in the part-worn category (Lowe, 2022). In discussions with stakeholders on part-
 3993 worn tyres thus far, one manufacturer was able to provide rough information that
 3994 approximately 1 in 5 used tyres collected are viable for re-use coming from tyre replacement,
 3995 while 1 in 20 have 4mm of tread left. Collecting such re-usable tyres involves EPR schemes and
 3996 a lot of actors, making it challenging to acquire these tyres. The definition of and vocabulary for
 3997 EoL tyres also does not support this practice in Europe.

3998 The UK has the clearest rules currently, under The Motor Vehicle Tyres (Safety) Regulations
3999 1994. Part-worn tyres must be marked 'PART-WORN' (≥ 4 mm letters), carry an E-mark, have at
4000 least 2 mm tread across the full breadth and circumference at the point of sale, and be free of
4001 structural defects; an inflation test is also required. A French voluntary standard specifically
4002 addresses "pneus de réemploi" (second-hand tyres): AFNOR T47-749. It defines a multi-point
4003 inspection and traceability framework for the reuse of tyres, covering items such as visual
4004 integrity, bead/heel condition, carcass integrity, airtightness, regulatory markings, tread
4005 condition, and storage requirements.

4006 The ESPR could set harmonised minimum requirements to enable the safe placing on the market
4007 of second-hand tyres (part-worn and retread), rather than leaving this to uneven national
4008 practices. Today, tyres removed from the vehicle may generally be classified as waste; while
4009 safety is assessed at vehicle inspection, there is no EU-level conformity framework specific to
4010 re-use, and national controls on part-worn tyre resale vary. As a result, collectors and traders
4011 may reintroduce tyres to the market under heterogeneous criteria. The DPP could play a role
4012 here to record tyre identity and lifecycle events (placement on market, rotations, repairs,
4013 retreading, measured tread depth at removal), thereby discouraging premature removal and
4014 enabling verification that re-use meets safety thresholds.

4015 Informal reuse of ELT in other applications in the EU currently is on the small-scale level in
4016 domestic and rural settings. Common use cases include gardening, playground installations, and
4017 decorative functions. While there is no specific legislation against this practice, concerns of
4018 chemical leaching, breeding sites for insects, structural instability under cyclic loading, etc,
4019 potentially outweigh the environmental benefits as a result of extended product use in this way.
4020 Furthermore, EU legislation prioritises official 'end-of-life' management pathways, with
4021 investment in ELTs recycling and retreading this prioritisation is needed to ensure the supply of
4022 ELTs to these facilities to ensure that they have the critical volumes needed to maintain
4023 operations and achieve profitability.

4024 Stakeholder question:
4025 T3-10: would more harmonised rules on re-use of tyres across Europe be supported?
4026 Could the DPP support re-use markets to move into a more controlled/safer
4027 approach? Do you have any indications of the share of part-worn tyres in the EU
4028 (tyres reused without retreading)?

4029 6.3.5. Best practice in sustainable product use (end-user 4030 perspective)

4031 This subsection synthesises end-user practices that support safety, lower environmental impacts
4032 in use, and longer tyre lifetimes (see also **Sections 6.2.8, 6.3.2, 6.3.3, 6.3.4**).

- 4033 • Driving and operations: Maintain moderate speeds; avoid harsh acceleration/braking
4034 and sharp cornering; avoid kerb/pothole impacts; respect axle load limits.

4035 • Maintenance: Keep tyres at manufacturer-recommended pressures; perform periodic
 4036 rotation per OEM guidance; inspect tread and wear patterns; ensure alignment and
 4037 balancing.

4038 • Compliance with take-back: Use authorised collection channels defined under national
 4039 EPR schemes; avoid informal disposal routes; request documentation when ELTs are
 4040 collected.

4041 • Second-hand and retreads: Where part-worn tyres are permitted, ensure conformity
 4042 with national requirements (e.g., marking, residual tread at sale, structural integrity).
 4043 Retreads must comply with UNECE R108/R109 and can reduce cost per km in suitable
 4044 duty cycles; fleet policies should prioritise casing management.

4045 • Procurement levers (fleets): Specify casing quality and retreadability; evaluate total cost
 4046 of ownership across first and subsequent lives.

4047 Consumer behaviour strongly influences use-phase emissions. In an LCA covering a 50,000 km
 4048 tyre lifetime, variations in how people drive and choose tyres altered environmental impacts by
 4049 roughly a factor of 1.6–2.1 (Hennequin et al., 2023). Encouraging smaller vehicles and
 4050 fuel-efficient, long-lasting tyres can deliver substantial life-cycle benefits. Behavioural shifts
 4051 focused on tyres alone can reduce impacts by about 13 % for human toxicity and up to 26 % for
 4052 climate change.

4053 6.4. Local infrastructure

4054 6.4.1. Energy

4055 Local infrastructure in terms of energy refers to its reliability and availability to ensure the
 4056 functioning of the product under investigation. However, given this particular product group
 4057 does not require direct inputs of energy as envisioned by the MEErP methodology, this section
 4058 of the report is not applicable.

4059 6.4.2. Installation

4060 The installation of vehicle tyres involves a two-stage process: the installation of the ‘naked’ tyre
 4061 to a metallic rim and subsequently installing the ‘tyre & rim’ combination on the wheel hub
 4062 assembly. In its recommendations to customers, the manufacturer Continental tyres elaborates
 4063 on the dangers of mounting tyres on rims (Continental, 2025b). The firm recommends that
 4064 mounting should be done by qualified service professionals with appropriate tools due to
 4065 dangers such as accidental slips from the tyre & rim combination from pressurised air.

4066 In Europe, most end-users change their tyres and wheels at professional car workshops, tyre
 4067 service centres, or auto repair shops. Memberships to automobile clubs such as the Allgemeiner

4068 Deutscher Automobil-Club (ADAC)³⁹ enables calls to a qualified technician when members
4069 encounter a burst tyre while in transit. The use of such professional services also provides the
4070 opportunity for routine maintenance and repair activities on tyres. While some customers do
4071 undertake DIY repairs and replacement of tyres, the number is relatively low and decreasing due
4072 to the electronics involved Tyre Pressure Monitoring Systems (TPMS) and safety concerns.

4073 6.4.3. Physical environment

4074 This section is therefore not applicable to this product group.

4075 6.4.4. Telecom

4076 This section is likewise not applicable to this product group.

4077 6.4.5. Water

4078 This section is not applicable to this product group in the use phase.

4079 6.5. Recommendations & preliminary conclusions Task 3

4080 6.5.1. Refined product scope from the perspective of consumer 4081 behaviour and infrastructure

4082 Based on the findings detailed in this chapter of the study, the product scope from consumer
4083 behaviour and infrastructure is unchanged from the categories outlined in Task 1. The diverse
4084 use cases of C1, C2, and C3 tyres mandates that they be maintained as categories for further
4085 examination and analysis under Task 5 of this of this report and lead-up to the formation of base
4086 cases.

4087 In terms of retreading, C1 tyres appear to be the least product likely to be retreaded at the first
4088 product life, followed by C2 tyres. C3 tyres on the other hand have an established market and
4089 demand for retreading although the trend appears to be on the decline (see **Section 6.3.4.1**).

4090 Though it is not clear that retreading of C1 tyres would be economically feasible (opinions from
4091 stakeholders on this are diverse with some claiming retreading is possible albeit with several
4092 technical and operational challenges), the market for retreaded tyres in C2 and C3 vehicles could
4093 be encouraged by providing users with more information on tyre safety, for example through

³⁹ See information about the ADAC here: <https://www.adac.de/>

4094 labelling and/or a DPP. Green public procurement may also be helpful in this respect to support
4095 fleet managers make informed decisions about tyre replacements and support the decision of
4096 procurers in purchasing these tyres.

4097 **NB: this section will be updated after the first stakeholder consultation in September 2025.**

4098 **6.5.2. Barriers and opportunities for Ecodesign from the perspective**
4099 **of consumer behaviour and infrastructure**

4100 Consumer surveys on the tyre label parameters show that safety (wet grip) performance of tyres
4101 has highest priority, with fuel consumption also of high importance. Consumers assume that
4102 safety aspects are ensured according to the relevant legislation, which leaves them free to
4103 choose tyres based upon price or other performance characteristics. Due to the physical
4104 properties of rubber, optimising compounds for one performance parameter such as rolling
4105 resistance directly impacts other properties such as wet grip or durability. Innovations in
4106 material composition aim to reduce the level of these trade-offs, but generally result in different
4107 tyres being better suited for different applications. Any Ecodesign measure must take into
4108 account these trade-offs, with safety of the tyre being paramount for users.

4109 User driving behaviours and tyre choice have a large impact on the lifecycle of tyres. Choosing
4110 the right tyre for different conditions and outcomes impacts how well that tyre will perform,
4111 and whether or not it may or may not have a high-quality casing for retreading. Different driving
4112 and maintenance behaviours can directly influence the lifetime of the tyre, the rate of abrasion
4113 of the tyre, and whether or not the tyre will be re-usable again at EoL. For instance, rapid
4114 acceleration, under-inflation, uneven (over)loading, poor alignment and lack of tyre rotation can
4115 all lead to premature tyre wear.

4116 To date, legislation on tyres in the EU in the use phase mainly aims to ensure safety, reduce fuel
4117 consumption and noise. Legislation targeting tyres directly at the component level puts
4118 minimum requirements in place for both new and re-treaded tyres. At the vehicle level, road
4119 worthiness legislation aims to keep tyres in a safe condition and ensure monitoring of aspects
4120 such as tyre pressure to support users to avoid practices that put them at risk and contribute to
4121 fuel consumption, while fleet-level targets on CO₂ provide an incentive for vehicle OEMs to
4122 choose tyres with lower rolling resistance in OEM tyre sales. Green public procurement
4123 guidelines provide criteria for fleet operators to choose tyres that have lower impact on fuel
4124 consumption, and potential retreadability. National traffic laws still have some variation in how
4125 they apply rules relating to minimum tread depth (e.g. for winter tyres) and re-use of part-worn
4126 tyres.

4127 User attitudes to sustainable materials in tyres have not yet been widely researched; however,
4128 it can be assumed that consumers expect tyre safety and functional performance to remain
4129 within similar ranges, or exceed that of tyres they currently use, without major changes to
4130 pricing. It is conceivable that consumers respond to simple, trusted indicators (e.g., a verified
4131 recycled content badge and an abrasion class) integrated into the existing label. Fleet operators
4132 on the other hand are more interested in total cost of ownership (TCO), energy savings,
4133 durability, retreadability, and maintenance impacts. Here procurement criteria that support

4134 retreadability and abrasion performance without impacting rolling resistance or wet grip may
4135 be of interest. Some initial indications from manufacturers indicate that there could be an
4136 interest from fleet operators and OEMs for tyres with sustainable materials to meet their
4137 sustainability goals. Material claims are likely to benefit from having clear auditability and better
4138 comparison of metrics between manufacturers.

4139 While collection rates in tyre waste management systems are currently high, concerns have
4140 been raised by several stakeholders around exports of shredded and whole tyres for EoL
4141 processing in countries with dubious treatment infrastructure outside the EU. Increasing market
4142 demand for materials arising from tyre recycling and supporting increased re-use and retreading
4143 may be a complementary way to support the EU tyres treatment market. There are currently
4144 uneven rules around waste definitions and criteria for re-usable tyres across member states.

4145 Ecodesign measures that may support the use phase of tyres could include the following:

- 4146 • Minimum performance safeguards: Guarantees that any material targets
4147 (recycled/renewable content, abrasion) do not compromise wet grip and rolling
4148 resistance (anchored in UN R117 minima).
- 4149 • Criteria that support safe re-use of tyres across the EU.
- 4150 • Standardised metrics and scope that enable clear comparison of recycled content or
4151 other sustainable material use between manufacturers, with clear audit
4152 trails/verification.
- 4153 • Abrasion performance or durability class/information: a standardised, easy-to-read
4154 indicator once UNECE methods are ready could signal reduced tyre wear particles (and
4155 imply durability).
- 4156 • Inclusion of information requirements and/or more complete information in the EPREL
4157 database that allow better comparison between tyres and support user behaviour, such
4158 as material/abrasion indicators and maintenance guidance.
- 4159 • Support to public procurement measures that increase the market share of retreaded
4160 and higher-label tyres within the EU, thereby supporting sustainable business models
4161 and creating an economic incentive for the production of higher-label class tyres
4162 respectively.
- 4163 • Encouraging a shift in fleet management and car-sharing sectors towards practices that
4164 support the use of retreaded tyres and other circular economy solutions.
- 4165 • A DPP may support providing information on use phase/lifetime events that support re-
4166 use and retreadability options.

4167 **NB: this section will be updated after the first stakeholder consultation in October 2025.**

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Compilation of MEERP Task 3 questions for stakeholders:

T3-1: To what extent do consumers utilise internal noise reduction tyres after the first purchase of vehicles equipped with such tyres? Differentiate answers between ICE and EV if possible.

T3-2: what typical share of tyre market sales are fleet operators and do a large share follow green procurement criteria or apply certain total cost of ownership metrics?

T3-3: is there any evidence of users/OEMs/fleet operators willing to pay a premium or accept other trade-offs for sustainable materials included in tyres?

T3-4: is there demand from consumers/fleet operators for durability or information on lifetime or abrasion on tyres in the EU?

T3-5: is there evidence of consumer demand for sustainable materials (e.g. willingness to pay premiums) or preferences for certain ways to share this information (e.g. metrics, label)?

T3-6: Are tyre collection rates for C1, C2, C3 the same? Are the collection rates/pathways for bicycle, motorcycle, agricultural, industrial and off-the-road tyres similar?

T3-7: Stakeholders are asked to assess the information provided in Table 6-7 and confirm their agreement or provide further information if necessary.

T3-8: are market conditions the key limiting factor to increasing retreading, or high rejection rates / non compatibility of tyres for retreading processes? Which factors most often lead to tyres being unusable for retreading?

T3-9: is there strong evidence that re-treads meet the same functional performance on rolling resistance, durability, wet grip and noise? What tolerance bands are usually applied?

T3-10: would more harmonised rules on re-use of tyres across Europe be supported? Could the DPP support re-use markets to move into a more controlled/safer approach? Do you have any indications of the share of part-worn tyres in the EU (tyres reused without retreading)?

4199 7. MEErP Task 4 – Technologies

4200 7.1. Objectives of MEErP Task 4

4201 Alongside MEErP Tasks 1 through 3, Task 4 in particular lays substantial groundwork for:

- 4202 • MEErP Tasks 5 by developing a base case, which is supported by quantitative
4203 information on all life cycle stages and the provision of a bill of materials (BOM). Special
4204 focus is laid on waste management, both during production (post-industrial or “primary”
4205 waste) and in the EoL-phase (post-consumer or “secondary” waste).
- 4206 • MEErP Task 6 by outlining the potential to improve the base case, especially by
4207 incorporating a technical description of the BAT and BNAT.

4208 Following a short introduction on the components and materials used in tyres, Task 4 is
4209 structured into three main parts:

4210 1. Technical description of the “average tyre”

4211 The first part (**Sections 7.2 and 0**) analyses tyre properties with a particular focus on
4212 performance characteristics. Unlike the standard MEErP methodology, which focuses primarily
4213 on energy-related aspects (e.g. rolling resistance), this study also addresses safety aspects such
4214 as grip in wet, snowy, or icy conditions, noise levels, and performance at various speeds and
4215 loads. Based on existing products, standard improvement options are formulated, and an
4216 overview of BAT and BNAT is compiled.

4217 2. Production and distribution phases

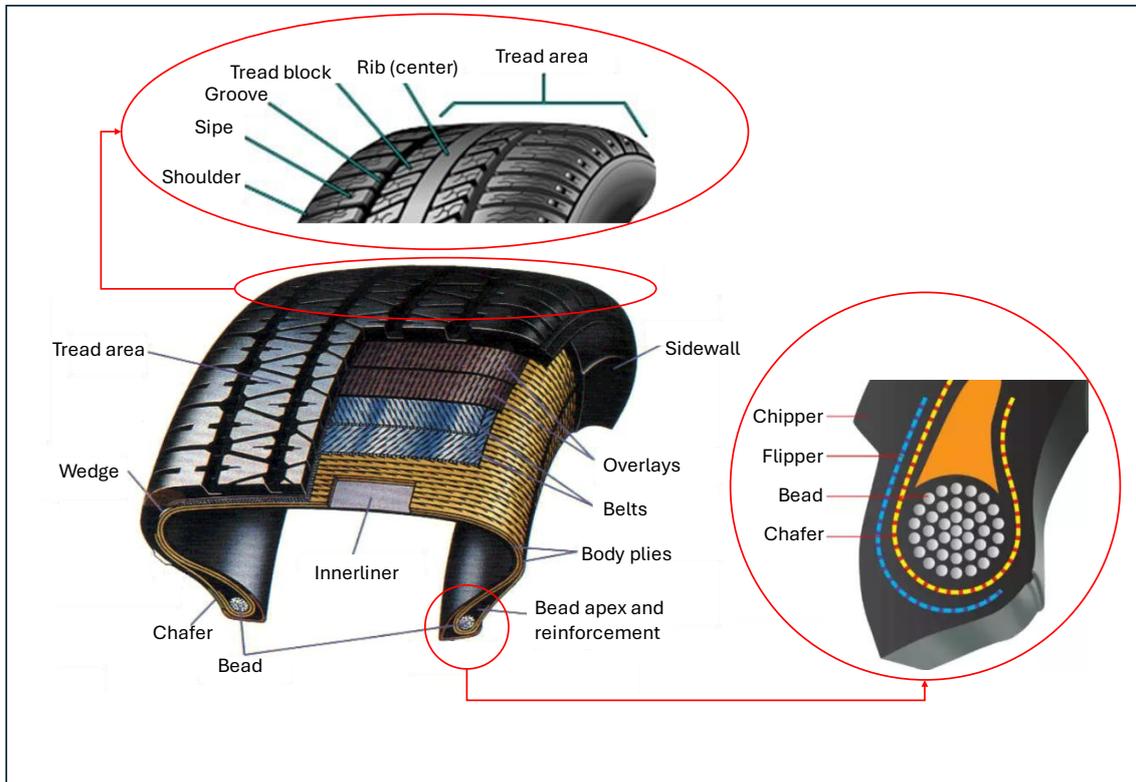
4218 The second part (**Section 7.4**) describes tyre weight and composition, which is substantial for
4219 the BOM and an LCA. In this regard, the production processes are detailed. The production
4220 process involves a qualitative assessment of potential primary waste flows and typical energy
4221 demands in manufacturing. It also examines distribution logistics, covering packaging materials,
4222 transport modes, and their environmental implications. The section concludes with an overview
4223 of the **technical product lifetime**, which for tyres is closely linked to expected mileage.

4224 3. Circularity and EoL considerations (*additional to MEErP methodology*)

4225 The third part (**Section 7.6**) goes beyond the conventional MEErP approach by addressing
4226 circularity aspects. It provides technical insights into EoL management and reuse, particularly
4227 retreading, as well as the integration of recycled and bio-based materials, the role of critical raw
4228 materials, and the management of substances of concern. This part concludes with
4229 considerations for implementing a DPP for tyres.

4230 7.2. Components and materials used in tyres

4231 To better understand technical aspects regarding tyre production, use, and EoL, an overview of
 4232 tyre components and materials is given first. Modern tyres contain a multitude of different
 4233 components. **Figure 7-1** shows the typical components found in C1, C2, and C3 tyres.



4234

4235 **Figure 7-1: Components of typical tyre. Own graphic based on (Ghoreishy, 2008; Sensor**
 4236 **Products In, n.d.).**

4237 Tyres can be divided into an interior part, known as the carcass or casing, and an exterior part,
 4238 which comprises the sidewall and tread. The tread is particularly important, as it is designed with
 4239 a specific tread pattern tailored to the tyre's intended application. The tread contains voids,
 4240 which are categorised as grooves and sipes. Grooves are wide, deep channels that facilitate
 4241 water, mud, and snow evacuation, while also contributing to heat dissipation. Sipes, in contrast,
 4242 are narrow slits within the tread blocks that enhance grip on slippery surfaces by increasing the
 4243 number of biting edges and allowing greater flexibility of the tread.

4244 **Table 7-1** lists the main components, as shown in **Figure 7-1**, the material(s) they are made of,
 4245 and their function in a tyre. Depending on the tyre model, some of the listed components may
 4246 not be present. Conversely, some components used in certain tyres may not be included in the
 4247 list.

4248

Table 7-1: Tyre components, materials used and their main function.

| Location | Tyre component | Material often used | Main function(s) |
|-------------------|--|---|--|
| Exterior | Tread area | Synthetic/natural rubber compound ^a . The rubber compound used in the sidewalls is typically softer and more flexible (high share of natural rubber) in comparison to the tread which relies on harder rubber compounds to increase durability (higher share of synthetic rubber). | Outer layer that has direct contact with the road surface and holds multiple functions such as traction, wear resistance or water dispersion |
| | Sidewall | | Protects casing from external damage and stabilises the tyre laterally |
| Interior (casing) | Overlays ⁴⁰ | Textiles (e.g. polyamide, aramid) embedded in a synthetic rubber compound ^a | Allows for high-speed stability and overall tyre durability and reduces tread and belt edge separation |
| | Wedge | Rubber compound ^a | Prevents damage to the steel belts and cap ply by smoothing the transition |
| | (Steel) belts (mostly braided at opposing angles, typical trucks have 4-5 belts) | Brass-plated/bronzed steel; motorcycles for instance may use textiles instead of steel | Enhancing tread stiffness, increasing puncture resistance, reduces rolling resistance |
| | Body plies (carcass/casing plies) | Mainly textiles (e.g. viscose (rayon), polyester, nylon) embedded in a rubber compound ^a in passenger car tyres. Steel is mainly used for reinforcement of truck tyres. | Maintains shape, controls the internal pressure of the tyre |
| | Bead | Brass-plated/bronzed steel | Allows for steering precision and secures the tyre to the rim |
| | Bead reinforcement (chipper, flipper) | Steel/textiles (chippers) Rubberised textiles (flippers) | |
| | Bead apex/ bead filler | Synthetic rubber | |
| | Chafer | Textiles (e.g. nylon, polyester) in rubber compounds, sometimes steel wires | Reinforcement of tyre sidewalls |
| | Inner liner | Synthetic rubber compound (e.g. halogenated polyisobutylene rubber) | Makes tyre impermeable, to prevent air loss, acts as inner tube in tubeless tyres |

4249

^a) Rubber compound is rubber combined with fillers (silica/carbon black) as well as plasticisers and antioxidants/antiozonants etc.

4250

⁴⁰ An overlay can be a cap ply (high-speed passenger car tyres), a spiral (run-flat tyres, aircraft tyres, etc.), or a partial overlay (only shoulder areas). Basic tyres may be missing an overlay.

4251 Sources: based on (Continental Reifen Deutschland GmbH, n.d.-h; Dunlop Tyres, n.d.; Michelin, n.d.-f; U.S. Tire
4252 Manufacturers Association, n.d.).

4253 “A typical tyre includes dozens of different components, using more than a hundred primary raw
4254 materials” according to a study prepared by AECOM (2021) for tyre and rubber manufacturers,
4255 as well as tyre recyclers. Tyre materials can be grouped into two main material groups: rubber
4256 compounds and reinforcement. An overview of these two groups is presented below, with in
4257 brackets some examples of common substances used in these materials (based on ETRMA
4258 (2009) and Secretariat of the Basel Convention (2024)), and in the last column their function in
4259 tyres (based on (U.S. Tire Manufacturers Association, n.d.)).

4260 **Table 7-2: Substance group, typical representatives and their function in tyres.**

| Material | Substance group | Function |
|---|--|---|
| Rubber compound | Natural rubber | Provides flexibility, elasticity, and tear resistance; ideal for sidewalls where impact resistance is critical. |
| | Synthetic rubber (e.g. styrene-butadiene, polybutadiene, butyl rubber) | Styrene-butadiene: wear and abrasion resistance, mainly in treads. Polybutadiene: improves low-temperature flexibility and resilience. |
| | Vulcanisation agents (e.g. sulphur, peroxides) | Create cross-links between polymer chains, enhancing elasticity, durability, and heat resistance. |
| | Vulcanisation accelerators (e.g. CBS ⁴¹ , DPG ⁴²) | Speed up the cross-linking process during vulcanisation. |
| | Vulcanisation activators (e.g. stearic acid, zinc oxide) | Facilitate the vulcanisation reaction. |
| | Fillers and pigments (e.g. carbon black, silica, TiO ₂ , CaCO ₃ , kaolin) | Improve mechanical strength, abrasion resistance, traction, and sometimes colour. |
| | Plasticisers and processing aids (e.g. petroleum-based oils, vegetable oils, resins) | Enhance processability, flexibility, and flow of the rubber matrix during manufacturing. |
| | Anti-degradants/stabilisers (e.g. 6PPD ⁴³ , wax) | Protect rubber from ozone and oxidative degradation. |
| | Tackifiers (e.g. hydrocarbon resin) | Improve adhesion between rubber compounds or layers. |
| | Mastication agents/peptisers (e.g. N,N'-dithiodi-o-phenylenedibenzamide) | Aid in breaking down rubber to improve processing. |
| Bonding agents (e.g. cobalt salts) | Promote adhesion between rubber and reinforcement materials. | |
| Emulsifiers (e.g. sulfates) | Assist in blending or dispersing materials during processing. | |

⁴¹ N-Cyclohexyl-2-benzothiazole sulfenamide

⁴² Diphenyl guanidine

⁴³ N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamin

| Material | Substance group | Function |
|----------------------|---|--|
| | Lubricants (e.g. fatty acids) | Reduce friction during mixing and processing. |
| | Solvents (e.g. naphtha, hexane) | Facilitate processing or cleaning of rubber compounds. |
| | Reinforcing agents (e.g. HMMM ⁴⁴) | Improve strength, stiffness, and durability of rubber. |
| | Release agents (e.g. silicones) | Prevent sticking to molds during manufacturing. |
| | Flame retardants (e.g., CTP ⁴⁵ , CP ⁴⁶) | Reduces flammability of rubber |
| Reinforcement | Steel cords (typically cold-drawn, high carbon [0.7-0.95 %], unalloyed, brass-plated/ bronzed, for adhesion) (Polyakova & Stolyarov, 2021) | Provide structural integrity, shape retention, and high-speed stability. |
| | Textile (e.g. nylon, aramid, PET ⁴⁷ , rayon), dipped in adhesion systems for bonding (e.g. RFL ⁴⁸) | Provides strength, shape retention, and flexibility. |

4261 Source: (ETRMA, 2009; U.S. Tire Manufacturers Association, n.d.).

4262 7.3. Technical product description in the use phase

4263 The technical regulations UNECE Regulation No. 30 and UNECE Regulation No. 54 standardise a
 4264 tyre marking format used for passenger tyres (C1 tyres) and commercial vehicles (C2 and C3
 4265 tyres) across Europe and UN countries. Amongst others, it defines dimensions and technical
 4266 properties of pneumatic tyres. Other tyre types are similarly regulated by UNECE Regulations
 4267 (motorcycle tyres are governed by UNECE Regulation No. 75, agricultural tyres and off-road tyres
 4268 by UNECE Regulation No. 106, while bicycle and airplane tyres are not in the UNECE scope).

4269 Regulation EU 2020/740 (repealing former regulation (EC) No 1222/2009) on the labelling of
 4270 tyres with respect to fuel efficiency and other parameters, thus amending Regulation EU
 4271 2017/1369 (Energy Labelling Framework Regulation) standardises the energy and performance
 4272 label of tyres for consumers. The EPREL database collects data on tyre marking and labelling
 4273 across models, according to the referenced UNECE Regulation and the EU Tyre Labelling
 4274 Regulation, providing an overview of models placed on the market that is used as a starting point
 4275 in this analysis. **Sections 7.3.1** and **7.3.2** explain the labelling system based on the UNECE
 4276 Regulations and the EU Tyre Labelling Regulation. The focus is on the technical properties of the
 4277 tyres rather than the labelling itself, using it as a foundation for defining the technical product
 4278 description in the use phase.

⁴⁴ Hexamethoxymethylmelamin

⁴⁵ N-(cyclohexylthio)phthalimide

⁴⁶ Chlorinated paraffin

⁴⁷ Polyethylene Terephthalate

⁴⁸ Resorcinol Formaldehyd Latex

4279 **7.3.1. Tyre marking according to UNECE Regulations**

4280 Tyre marking according to UNECE Regulations No. 30 and 54 is unambiguous and provides a
 4281 clear and comparable technical basis to describe C1, C2, and C3 tyres (the tyre marking for
 4282 agricultural and off-road tyres is excluded). The following format is found on tyres:

4283 [Width]/[Aspect ratio] [Construction type][Rim diameter] [Load rating][Speed rating].

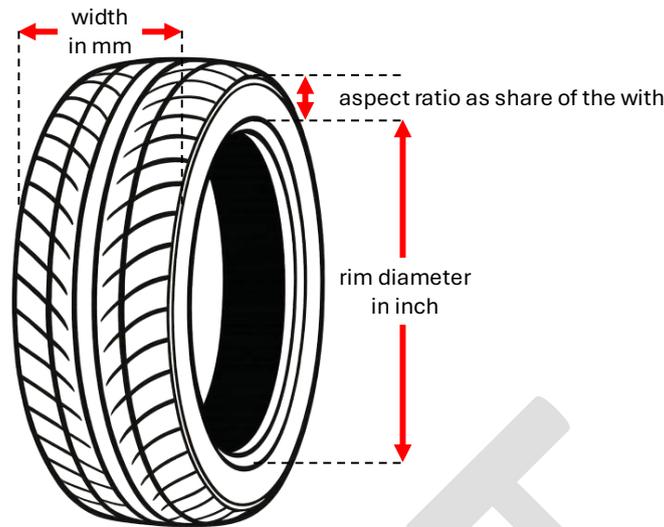
4284 An example of the marking in this format is 205/55 R16 91V.

4285 The **width** of the tyres is given in millimetres and is measured from sidewall to sidewall. This is
 4286 not identical with the tread width, which may be significantly narrower and shows a wide
 4287 variation between tyre models. The **aspect ratio** is the height of the tyre sidewall as percentage
 4288 of its width (e.g., 55 % of 205 mm equals ~113 mm sidewall height). A high aspect ratio therefore
 4289 indicates a higher side wall. The **construction type** uses one letter for marking and details on the
 4290 construction of the casing of the tyre. Most C1-C3 tyres today use a radial construction type
 4291 (letter R), while diagonal (letter D) or bias belt (letter B) is rarely used. **Table 7-3** gives more
 4292 details on the construction types.

4293 **Table 7-3: Construction types of tyres and their labelling.**

| Letter used in labelling | Meaning | Description | Application |
|--------------------------|-------------------|---|--|
| R | Radial | Plies run radially (90° to the direction of travel). | Majority of tyres, especially for C1, C2 and C3 tyres. |
| D | Diagonal/bias ply | Plies run diagonally across the tyre. Ply cords extend to the beads and are laid at alternate angles of substantially less than 90 ° to the centre line of the tread. | Mostly on motorcycles or old cars. |
| B | Bias belt | Bias ply with reinforcing belts. | Older vehicles and rarely for light trucks such as pickup trucks and SUVs. |

4294 The **rim diameter** is given in inches and is the nominal diameter of the bead seat (rim seat) on
 4295 which the tyre is mounted, but not the outer edge of the rim. **Figure 7-2** gives an overview of
 4296 the dimensions, width, aspect ratio and rim diameter.



4297

4298 **Figure 7-2: Characteristic dimensions of C1, C2 and C3 tyres. Own graphic. Tyre pictogram**
 4299 **created by Sora (OpenAI, 2025).**

4300 The **load rating** is the maximum load that each tyre can carry at its maximum speed (e.g. 91 =
 4301 615 kg per C1 tyre and 2460 kg in total, given the vehicle has 4 tyres). The number is based on a
 4302 non-linear incremental scale. It can be converted by means of standardised lookup tables found
 4303 in Annex IV of UNECE Regulation No. 30 and Annex IV of UNECE Regulation No. 54. This “Table
 4304 of Load Indices and Corresponding Maximum Loads” is sometimes referred to as “load index
 4305 chart”. For truck tyres it should be noted that often multiple load ratings are given, depending
 4306 on the vehicle and operating configuration (e.g., single vs. dual fitment).

4307 The **speed rating** is indicated by one letter and indicates the maximum speed the tyre can
 4308 handle. **Table 7-4** shows the respective lookup table. Tyres must be designed for at least the
 4309 maximum speed of the car, while higher speed ratings are always permitted. One exception are
 4310 winter and all-season tyres which may be slower than the car’s maximum speed (Netsch, 2023).
 4311 Similar to the load rating, the speed rating in trucks is dependent on the vehicle and operating
 4312 configuration.

4313 **Table 7-4: Letters used for speed rating and the corresponding maximum speed according to**
 4314 **UNECE Regulations No. 30 and 54.**

| Letter | Maximum speed (km/h) | Letter | Maximum speed (km/h) |
|--------|----------------------|----------------------------------|----------------------|
| L | 120 | T | 190 |
| M | 130 | U | 200 |
| N | 140 | H | 210 |
| P | 150 | V (only for passenger car tyres) | 240 |
| Q | 160 | W (only for passenger car tyres) | 270 |
| R | 170 | Y (only for passenger car tyres) | 300 |
| S | 180 | | |

4315 The application for approval as outlined in section 3 and 4 of UNECE Regulations No. 30 and No.
 4316 54 require further details, such as the trade name or mark and the category of use, i.e. ordinary

4317 (usually no symbol) or snow-tyre (three peak mountain snowflake symbol and/or the inscription
4318 M+S or M.S or M&S) or for temporary use (letter T).

4319 Additionally, if tyres possess specific performance characteristics these must be clearly stated.
4320 This includes whether the tyre is to be used **without an inner tube** (indicated by TUBELESS),
4321 whether the tyre is suitable for road use **following a puncture** (the letter 'F' is placed in front of
4322 the rim diameter marking) or whether the **tyre is reinforced** (indicated by RF or reinforced, XL –
4323 EXTRA LOAD^{49,50}). Reinforced tyres offer increased stiffness to better support the vehicle weight,
4324 making them especially suitable for heavier vehicles. Also, for electric vehicles, where the
4325 battery adds to the vehicle weight, reinforced tyres are commonly used. To achieve
4326 reinforcement, stronger sidewalls, higher ply ratings (i.e. more ply layers), and/or use of
4327 reinforcing materials in the carcass or belts are used.

4328 For C3 tyres, the marking may additionally hold a ply rating (e.g. 18PR suggests a tyre strength
4329 equivalent to 18 plies).

4330 7.3.2. The EU tyre labelling regulation and tyre performance 4331 characteristics

4332 Performance characteristics of tyres must be chosen based on the intended use. The
4333 performance of tyres is essentially based on two factors, (i) the tyre design, and (ii) the materials
4334 used (including their composition and how these materials were processed). Below are only a
4335 few examples of how both aspects can factor into the performance:

- 4336 • Tread design refers to the depth and width of the grooves and sipes on the tyre tread.
4337 The tread pattern can be symmetrical, asymmetrical, or directional, and it affects
4338 traction, grip, and handling.
- 4339 • Tyre geometry is determined by the width and aspect ratio. The tyre width affects grip
4340 and fuel consumption, while the aspect ratio affects handling and steering response, but
4341 also the shock absorption and durability. Additionally, the tyre geometry influences the
4342 load capacity and maximum allowable speed.
- 4343 • The rubber composition affects the grip, the resistance, and the stability of a tyre. A soft
4344 rubber composition enhances grip, while a hard composition increases mileage by
4345 reducing rolling resistance. Additionally, stability is affected, impacting the load capacity
4346 and maximum allowable speed.
- 4347 • Reinforcement elements (textiles and steel) provide safety, foster shape retention,
4348 enhance the strength of the tyre, provide more resistance against punctures, and finally
4349 increase the allowable load capacity.

4350 The performance characteristics of tyres are based on competing tyre properties. High tyre
4351 friction, for instance, causes an increased rolling resistance, thus negatively impacting fuel

⁴⁹ Only applicable according to UNECE R30 for C1 tyres.

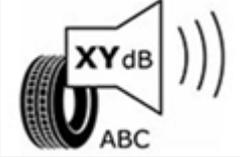
⁵⁰ In contrast to SL=standard load or LL=light load.

4352 efficiency, wear, and rolling noise. At the same time, high friction enhances grip required in
 4353 rainy, snowy, or icy conditions and may improve vehicle handling (European Commission,
 4354 2025f). A large number of different tyre types have emerged due to the wide range of
 4355 applications that tyres have to cover, making it challenging to define a base case.

4356 **7.3.2.1. Performance characteristics covered by the EU Tyre Labelling**
 4357 **Regulation**

4358 As detail in **Section 4.3.2.1**, Regulation EU 2020/740 categorises tyres’ fuel efficiency, external
 4359 rolling noise, and wet grip. It applies to C1, C2, and C3 tyres, while other tyres (e.g. off-road
 4360 tyres, motorcycle tyres, airplane tyres, etc.) are out of scope.⁵¹ In addition, a snow and an ice
 4361 grip pictogram is found on tyres if minimum index values laid down under UNECE Regulation No.
 4362 117 are satisfied. **Table 7-5** shortlists the tyre performance aspects targeted in EU 2020/740.

4363 **Table 7-5: Tyre labelling established under EU 2020/740.**

| Pictogram | Description |
|---|---|
|  <p>[fuel efficiency pictogram]</p> | <p>An incremental non-linear scale is applied to determine the fuel efficiency class. The scale is based on the rolling resistance coefficient (RRC) and is presented in Annex I, Part A of Regulation EU 2020/740. Five fuel efficiency classes are specified, i.e. ‘A’ (best performance) to ‘E’ (poorest performance).</p> |
|  <p>[wet grip pictogram]</p> | <p>An incremental linear scale is applied to determine the wet grip class. The scale is based on the wet grip index (G) and is presented in Annex I, Part B of Regulation EU 2020/740. The wet grip is measured according to a standardised braking test, where the braking distance is recorded. Five wet grip classes are specified, i.e. ‘A’ (best performance) to ‘E’ (poorest performance).</p> |
|  <p>[external rolling noise pictogram]</p> | <p>The external rolling noise is measured under standardised conditions in decibels and is to be specified as such (XY dB, where XY is the measured value in decibel). On the basis of limit values detailed in Part C of Annex II to Regulation (EC) No 661/2009, the external rolling noise is grouped into classes ‘A’ (best performance) to ‘C’ (poorest performance).</p> |
|  <p>[snow grip pictogram]</p> | <p>Snow tyres, contain this symbol (also known as three-peak mountain snowflake – 3PMSF symbol), if the snow grip performance satisfies a minimum snow grip index value. This applies to so called “winter tyres”. “All-season tyres” marked with the 3PMSF symbol also fall in the category of snow tyres.</p> |

⁵¹ It is noteworthy that, with Revision 6 of UNECE Regulation No. 117, a testing method for assessing the wet grip performance of worn tyres has been introduced. This marks a shift towards considering tyre performance at the EoL, which was previously assessed solely based on initial tread depth.

| Pictogram | Description |
|---|---|
|  <p>[ice grip pictogram]</p> | <p>This symbol represents an additional indication of grip on icy roads and is only available if the tyre holds this property. This is the case when the relevant minimum ice grip index value is satisfied.</p> |

4364 7.3.2.2. Performance characteristics not covered under the EU Tyre 4365 Labelling Regulation

4366 There are other aspects that define the performance of tyres which are not (yet) covered by the
4367 EU Tyre Labelling Regulation. Such aspects could include:

- 4368 • The durability of tyres (mileage) which is not yet covered, since a suitable criterion has
4369 not been agreed on yet (European Commission, n.d.).
- 4370 • The abrasion/wear of the tyre tread which is closely linked to the durability but also
4371 gives information on the emission of rubber particles.
- 4372 • The lateral acceleration which is related to safety aspects of tyres and describes the
4373 lateral force a tyre experiences when a vehicle is turning,
- 4374 • Internal noise which is caused by tyre and road interaction and becomes particularly
4375 relevant in electric vehicles, where overall cabin noise is no longer dominated by engine
4376 sounds.
- 4377 • Riding comfort which expands beyond internal noise and accounts for aspects of a
4378 smooth and stable driving experience due to impact absorption and vibration damping.
- 4379 • Further sustainability aspects, such as the country of manufacture of the tyre, the
4380 certification of the production according to various ISO standards, possible pollutants
4381 contained, and the potential of reuse in the context of retreading.
- 4382 • Other aspects are dry and wet handling, also with regard to ABS handling and
4383 aquaplaning.

4384 It should be noted that institutions that test tyres (e.g., TSC, ADAC) consider additional
4385 performance aspects when comparing tyres. They are based on testing methods, which are
4386 typically not standardised in international standards or regulations.

4387 7.3.3. Characteristics of existing products on the market

4388 The EPREL database (European Commission, 2025a) is the official EU database on energy-
4389 labelled products. For tyres it holds information on C1, C2, and C3 tyres sold in the EU. Data has
4390 been published since 2020 and contains tyres that were placed on the market as early as 1992.
4391 As of 2025 the database holds approximately 220,000 entries. Alone in 2024 around 25,000 tyre
4392 models were placed on the market, while in the past five years (2020-2024) approximately
4393 135,000 tyres were placed on the market according to the database. Of all tyre models

4394 published, ~80 % are C1 tyres, ~10 % are C2 tyres, and ~10 % are C3 tyres. Among others, for
4395 each tyre in the database, the following information can be retrieved:

- 4396 • Tyre class (i.e. C1, C2, C3),
- 4397 • Dimensions (width, aspect ratio, rim diameter),
- 4398 • Speed index, load capacity index, and indicator (e.g., SL, XL, RF),
- 4399 • Information related to the EU Tyre Labelling Regulation (fuel efficiency, external noise,
4400 wet grip) and indication of suitability for snow and ice.

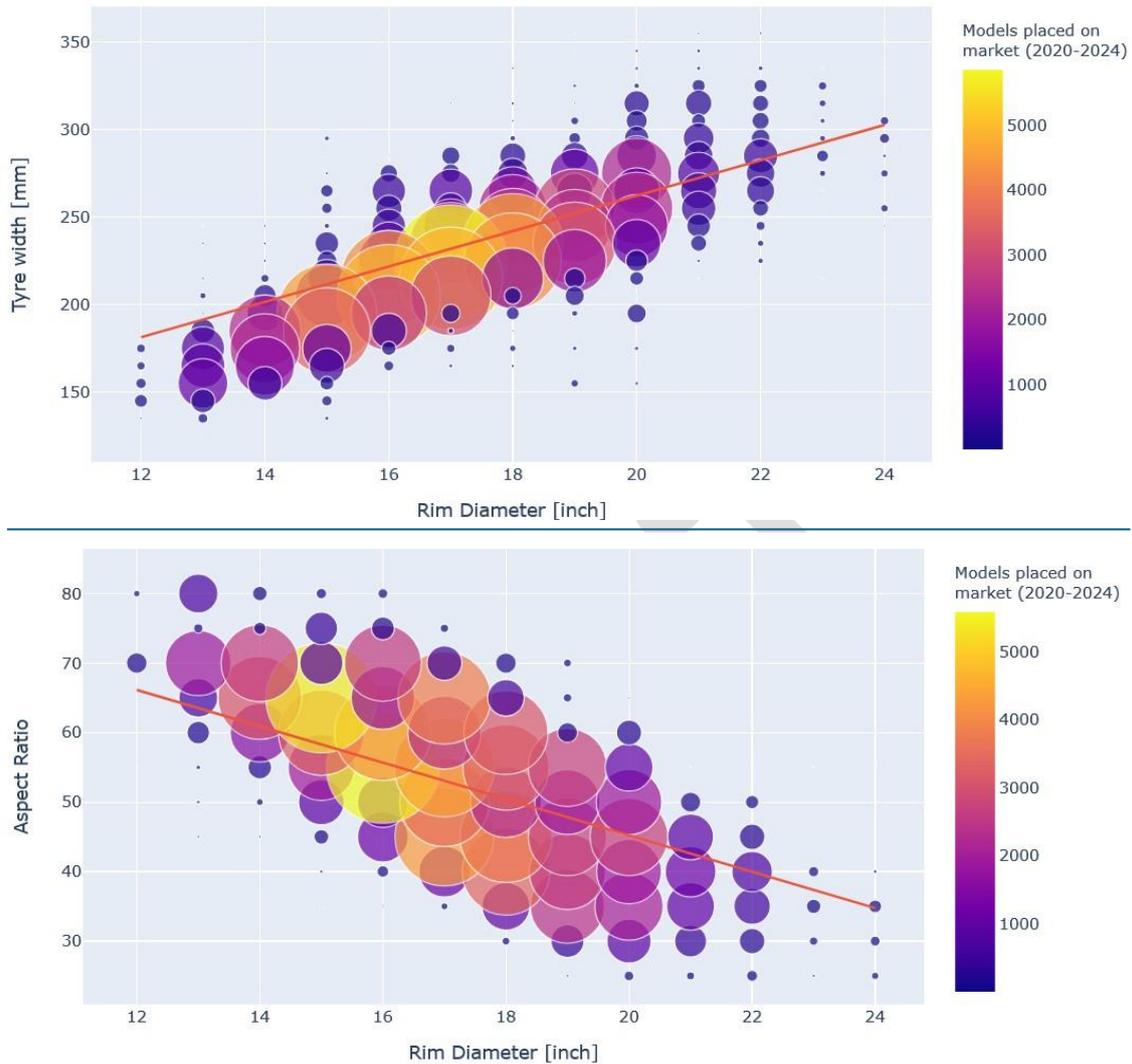
4401 To get an overview of existing C1, C2, and C3 products on the market, the EPREL database is
4402 used as a starting point. It is important to note that the EPREL database lists individual tyre
4403 models placed on the market but does not provide data on the number of units sold for each
4404 model. Nevertheless, it offers valuable insight into which tyre types—based on their geometry
4405 and performance characteristics—are relevant to the market, as the presence and variety of
4406 listed models can serve as a proxy for market trends and manufacturer focus. Tyres placed on
4407 the market in the past five years (2020-2024) are taken as basis for the assessment. This results
4408 in a dataset of 108,915 C1 tyres, 13,713 C2 tyres, and 13,579 C3 tyres.

4409 7.3.3.1. Dimensions

4410 The dimensions of tyres placed on the market between 2020-2024 were evaluated and are
4411 presented as a density scatter plot in **Figure 7-3** for C1 tyres, in **Figure 7-4** for C2 tyres, and in
4412 **Figure 7-5** for C3 tyres. The colour and the size of the bubble represents the number of models:
4413 e.g., a large yellow bubble indicates a high number of models, while a small blue bubble indicates
4414 a lower number of models. The rim diameter is plotted against the tyre width and the aspect
4415 ratio. Implausible tyre dimensions were excluded from the analysis—for example, entries with
4416 aspect ratios greater than 100, tyre widths below 100 mm, or cases where aspect ratios, rim
4417 diameters, and tyre widths appeared to be misclassified or mixed up.

4418 For C1 tyre models placed on the market between 2020 and 2024, more than 650 different tyre
4419 dimensions are recorded in the database. 214 of these tyre dimensions have more than 100
4420 models. Approximately 90 % of C1 tyres have a rim diameter between 14 and 20 inches⁵². In
4421 general, the rim diameter increases proportionally with the tyre width, while the aspect ratio
4422 tends to decrease as the rim diameter increases. The tyre width of 98 % of tyre models placed
4423 on the market range between 155 and 295 mm. The aspect ratio ranges between 30 to 80 %.

⁵² 1 inch=2.54 cm.



4424

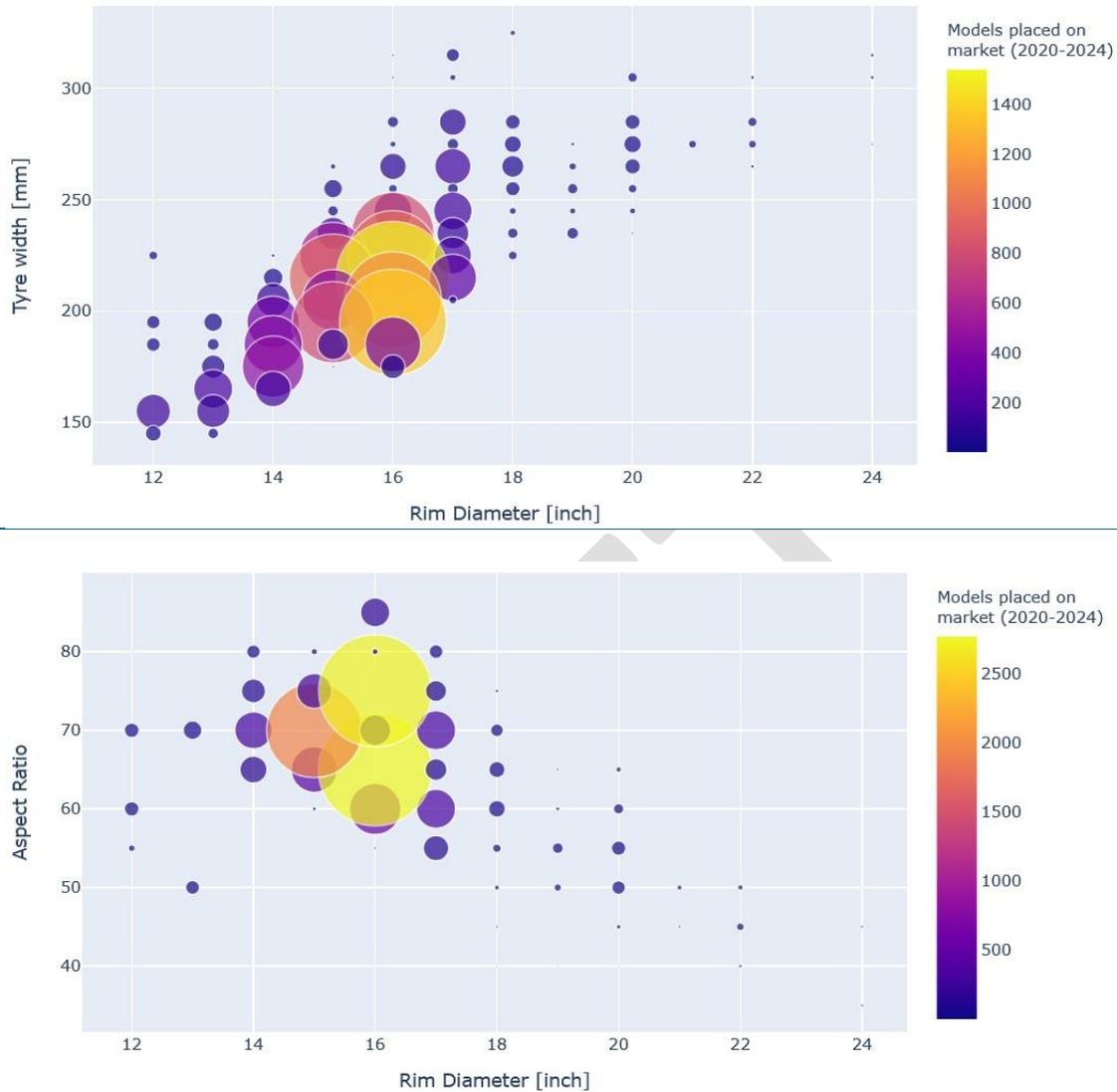
4425 **Figure 7-3: Tyre width (top) and aspect ratio (bottom) over rim diameter for C1 tyres placed**
 4426 **on the market between 2020 and 2024. Own evaluation based on data from the EPREL**
 4427 **database.**

4428

Source: (European Commission, 2025a).

4429 For C2 tyres over 200 dimensions were recorded in the database between 2020 and 2024.
 4430 However, only 32 dimensions feature more than 100 models each. Approximately 90 % of all C2
 4431 tyre models have rim diameters ranging from 14 to 17 inches, while 90 % also fall within a tyre
 4432 width range of 165 to 245 mm. Aspect ratios are predominantly between 60 and 75 %.

4433



4434

4435 **Figure 7-4: Tyre width (top) and aspect ratio (bottom) over rim diameter for C2 tyres placed**
 4436 **on the market between 2020 and 2024.**

4437

Source: own evaluation based on data from the EPREL database (European Commission, 2025a).

4438

4439

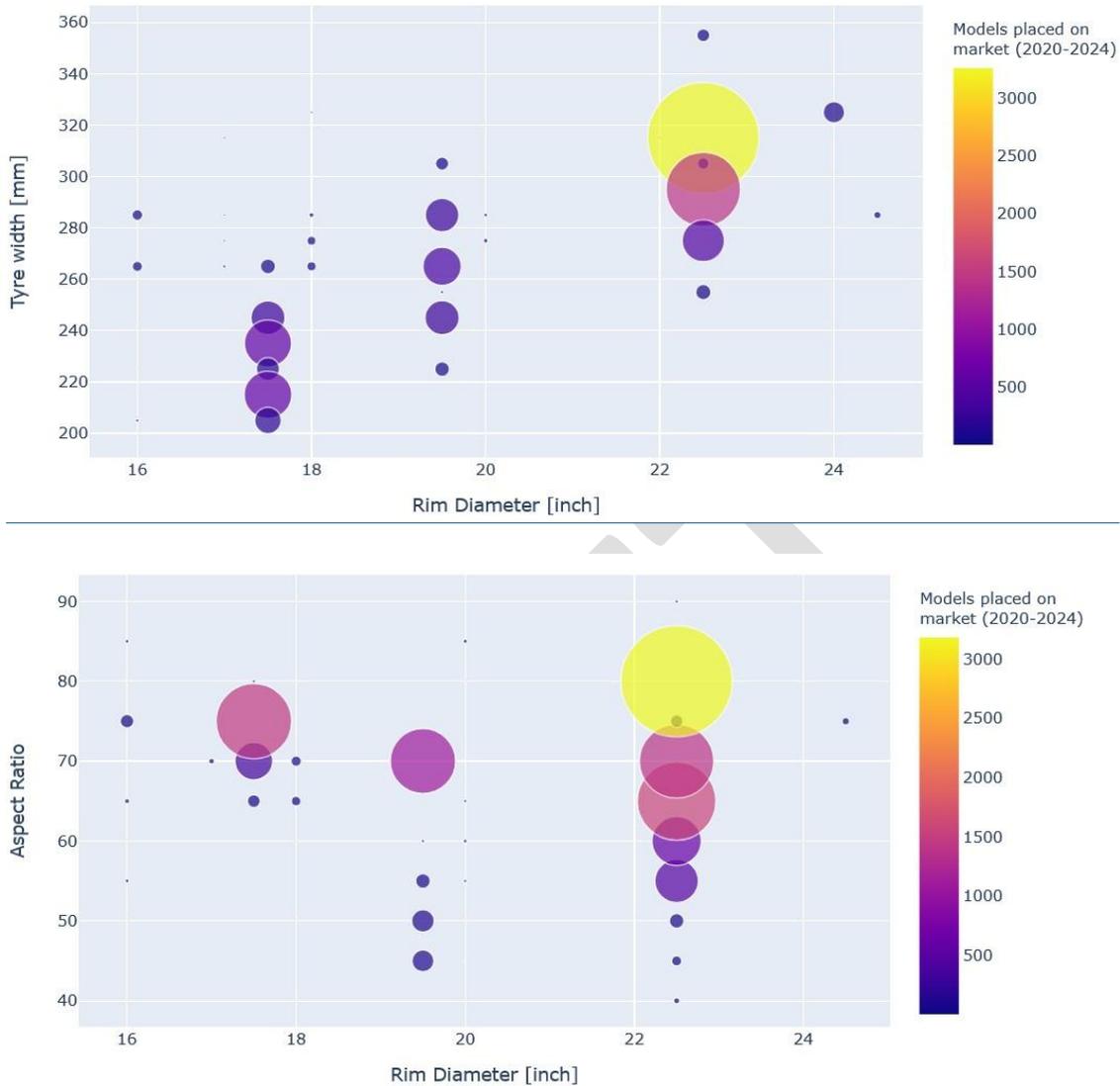
4440

4441

4442

4443

Between 2020 and 2024, C3 tyre models were predominantly registered in three rim diameters: 22.5 inches (68 % of all models), 17.5 inches (17 %), and 19.5 inches (13 %). Tyres with a 22.5-inch rim typically have widths ranging from 275 to 315 mm and aspect ratios between 55 and 80 %. As rim diameter decreases, tyre width also tends to decrease: 19.5-inch tyres are mainly between 265 and 305 mm wide, while 17.5-inch tyres generally range from 225 to 265 mm. For both 17.5- and 19.5-inch tyres, the aspect ratio is most commonly centred between 70 and 75 %.



4444

4445 **Figure 7-5: Tyre width (top) and aspect ratio (bottom) over rim diameter for C3 tyres placed**
 4446 **on the market between 2020 and 2024.**

4447

Source: own evaluation based on data from the EPREL database (European Commission, 2025a).

4448

7.3.3.2. Speed rating

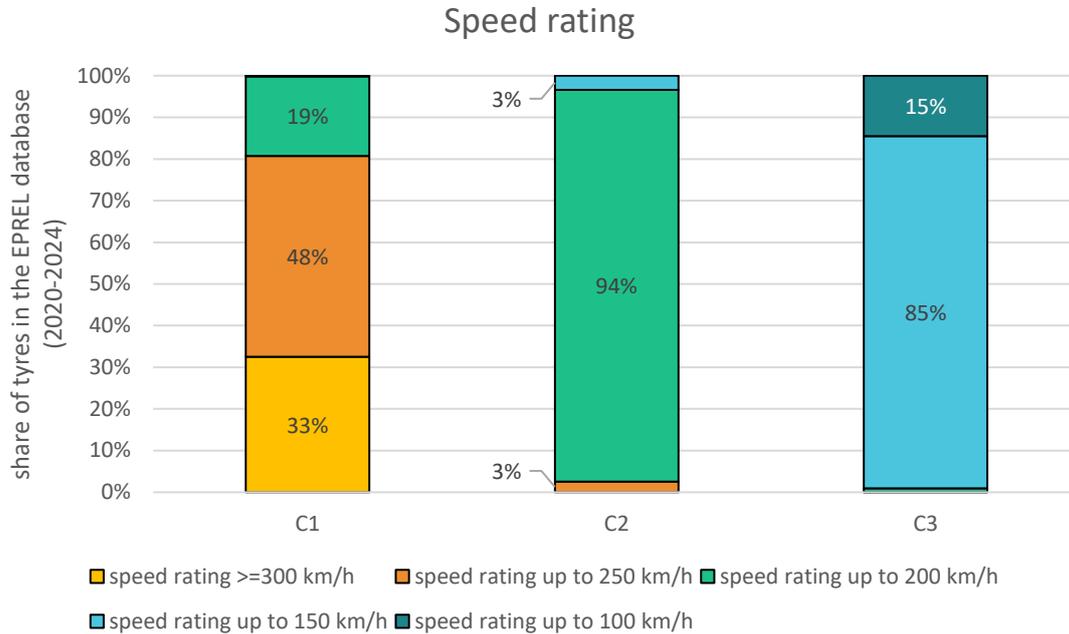
4449

The speed rating of tyres (i.e. maximum speed of tyres) recorded in the EPREL database is given
 4450 as a letter, which can be converted into the maximum speed (e.g., the letter M translates into a
 4451 maximum speed of 130 km/h). The speed rating of tyres was evaluated for tyre models placed
 4452 on the market between 2020 and 2024 and the results are presented in **Figure 7-6**.

4453

Among all recorded C1 tyre models, 33 % have a speed rating exceeding 300 km/h, while 48 %
 4454 are rated above 250 km/h. The remaining 19 % fall within a speed rating range of 150 to 200
 4455 km/h. Over the past decade, there has been a slight trend toward higher speed ratings: the
 4456 proportion of models rated above 300 km/h is gradually increasing, whereas the share of models
 4457 in the 150–200 km/h range is declining. The majority of all C2 tyre models (98 %) are found in

4458 the in the segment between 150 and 200 km/h. Some C3 tyre models (15 %) have a speed rating
 4459 up to 100 km/h, while most C3 tyres are listed for a maximum speed of up to 150 km/h.



4460

4461 **Figure 7-6: Speed rating (maximum speed) of C1, C2, and C3 tyre models placed on the**
 4462 **market in the EU between 2020 and 2024.**

4463 Source: own evaluation based on data from the EPREL database (European Commission, 2025a).

4464 **7.3.3.3. Load capacity and reinforcement**

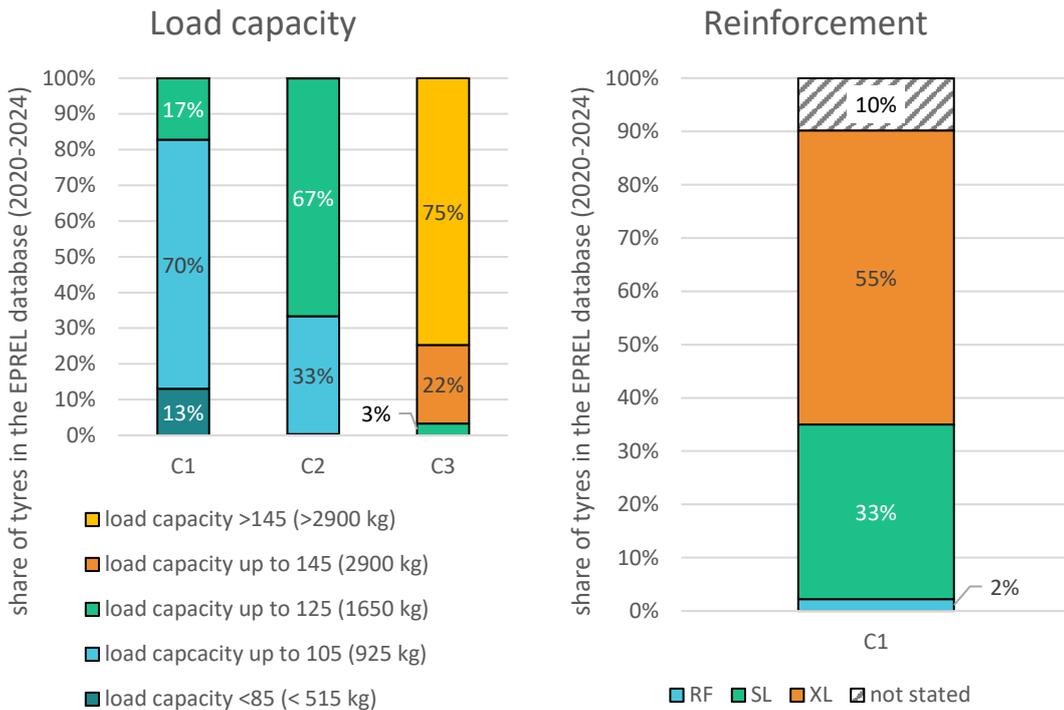
4465 Tyre models placed on the EU market between 2020 and 2024 show distinct patterns in load
 4466 capacity for C1, C2, and C3 tyres, reflecting their different applications. **Figure 7-7** shows the
 4467 distribution pattern. Most C1 tyres have lower load indices, with 83 % rated up to 105 (≤ 925 kg
 4468 per tyre), while C2 tyres are primarily in the mid-range (67 % between load index 105 and 125).
 4469 In contrast, 75 % of C3 tyres exceed a load index of 145, indicating capacities above 2900 kg per
 4470 tyre. For C1 tyres it can be observed that in the past decade the tyre models with load capacities
 4471 < 85 decreased by around 10 %, while those with load capacities between 105-125 increased,
 4472 reflecting also on the increasing weight of passenger cars. Similar trends can be seen for C2 tyres,
 4473 where tyres are also opted towards higher load capacities. For C3 tyres this is not the case.

4474 For 90 % of C1 tyre models placed on the EU market between 2020 and 2024 information is
 4475 given on their reinforcement in the database. Roughly two thirds of C1 tyre models are
 4476 reinforced (labelled as RF or XL⁵³), while only one third is not reinforced (labelled as SL). **Figure**

⁵³ The labels "XL" (extra load) and "RF" (reinforced) are both used to indicate tyres that need a higher inflated tyre pressure and carry greater loads in comparison to standard load (SL) tyres. "XL" is the term more commonly used. "RF" is an older designation that is still occasionally used. Both refer to tyres designed to operate at higher inflation.

4477 **7-7** shows the distribution. The trend over the last decade also indicates an increase in
 4478 reinforcement. While more than 50 % of all C1 tyre models listed were standard load tyres in
 4479 2015, only ~25 % of all tyre models placed on the market in 2024 are standard load tyres.

4480 For C2 and C3 tyres similar evaluations cannot be conducted. The designations XL and RF are
 4481 formally defined only for C1 tyres under UNECE Regulation No. 30, while for C2 and C3 tyres
 4482 (covered under UNECE Regulation No. 54), load capacity is specified through the load index and
 4483 pressure requirements, without official use of XL or RF labels.

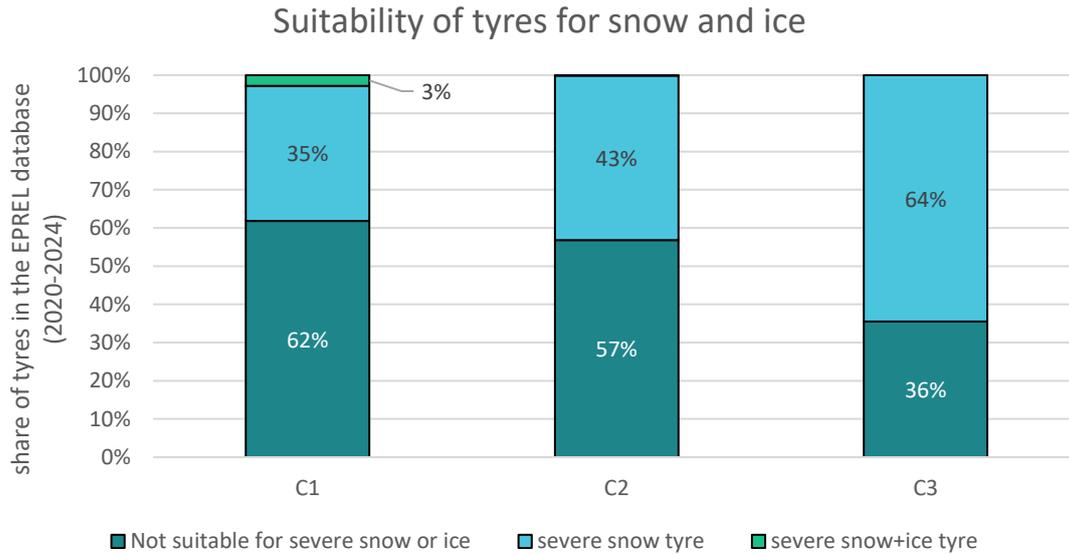


4484 **Figure 7-7: Load capacity and indication of reinforcement for C1, C2, and C3 tyres placed on**
 4485 **the market in the EU between 2020 and 2024.**

4486 Source: own evaluation based on data from the EPREL database (European Commission, 2025a).

4487 **7.3.3.4. Suitability for severe snow and ice**

4488 35 % of C1, 43 % of C2 tyres and 64 % of C3 tyres are snow tyres. Roughly 60 % of C1 and C2
 4489 tyres models placed on the EU market between 2020-2024 are not suitable for snow and do not
 4490 hold the 3PMSF. For C3 tyres the share in tyre models not suitable for snow is significantly lower
 4491 at 36 %. Most tyre models are not suitable for icy roads. Only 3 % of C1 tyre models fall in this
 4492 category, while hardly any C2 and C3 tyre models (close to 0 %) are suitable for icy roads.



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4494 **Figure 7-8: Suitability for snow and ice of C1, C2 and C3 tyres placed on the market in the EU**
 4495 **between 2020 and 2024.**

4496

Source: own evaluation based on data from the EPREL database (European Commission, 2025a).

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7.3.3.5. Fuel efficiency, wet grip and external rolling noise

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Figure 7-9 depicts the fuel efficiency, wet grip, and external rolling noise class of C1, C2, and C3 tyres as density scatter plots. The colour and size of the bubble represents the number of models: e.g., a large yellow bubble indicates a high number of models, while a small blue bubble indicates a lower number of models. All tyre models placed on the market in the EU between 2020-2024 according to the EPREL database are the basis for the evaluation.

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For all three tyre types, the majority of tyre models (approximately 50-65 %) fall into external rolling noise class B, fuel efficiency classes C and D, and wet grip classes B and C. Within the C1 tyre category, 459 tyre models (about 0.4 %) achieved the highest rating in all three categories (fuel efficiency, wet grip, and external rolling noise, so called triple A tyres). For C2 and C3 tyres, this share was lower, at around 0.01 %. On the contrary, one C1 tyre and three C3 tyre models got the lowest rating in all categories.

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Fuel efficiency: Approximately 55 % of all C3 tyre models fall into fuel efficiency classes D and E, indicating that C3 tyres generally achieve lower fuel efficiency ratings than C1 tyres. The share of C3 tyres in these lower classes is about 15 percentage points higher than for C1 tyres. For C2 tyre models, around 50 % fall into classes D and E, positioning their performance between that of C1 and C3 tyres. By contrast, about 10 % of all C1 and C3 tyre models achieve the highest fuel efficiency classes A and B, while for C2 tyres this share is notably lower, at just 4 %. Over the past five years, the share of tyre models in classes A and B has increased, while the share in classes D and E has declined.

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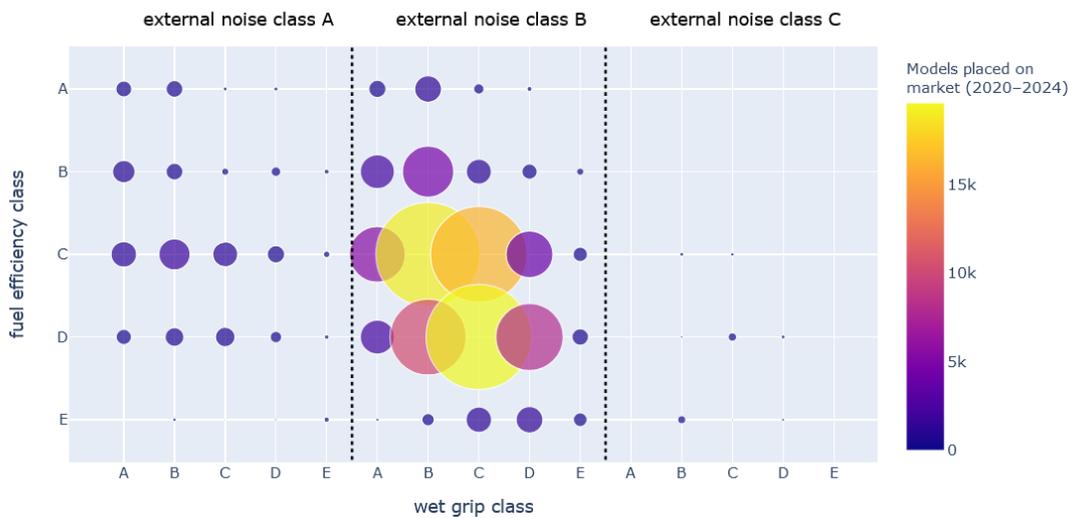
4518

Wet grip: For all tyre categories, the majority of tyre models are found in wet grip classes B and C — accounting for around 75 % of C1 and C2 tyres and about 90 % of C3 tyres. The highest wet

4519 grip class A is only achieved by 12.1 % of C1, 12.9 % of C2, and 6.6 % of C3 tyres. Very few tyres
 4520 fall into the lowest wet grip classes D and E, with shares for class E ranging from about 0.4 % to
 4521 1.5 %. An evaluation of the past five years shows that tyre models across all categories are now
 4522 more frequently found in classes A and B, while fewer models achieve class C. The share of tyres
 4523 in classes D and E has remained relatively stable.

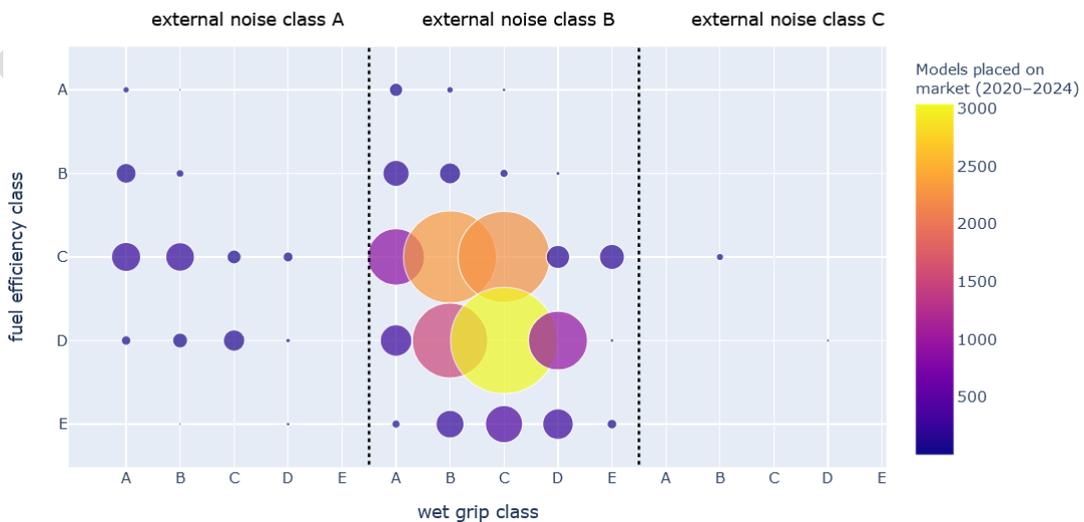
4524 **External rolling noise:** Very few tyres are classified in external rolling noise class C (0.4 % for C1
 4525 tyres, 0.1% for C2 tyres, and 1.5% for C3 tyres). By contrast, 6.6% of all C1 tyre models and 8.7%
 4526 of all C2 tyre models placed on the market achieved the highest rating, external rolling noise
 4527 class A. For C3 tyres, the share was even higher, at 27%. Over the past five years, there has been
 4528 a slight trend towards higher ratings for C1 and C2 tyres, while for C3 tyres no clear trend has
 4529 been observed.

C1 tyres

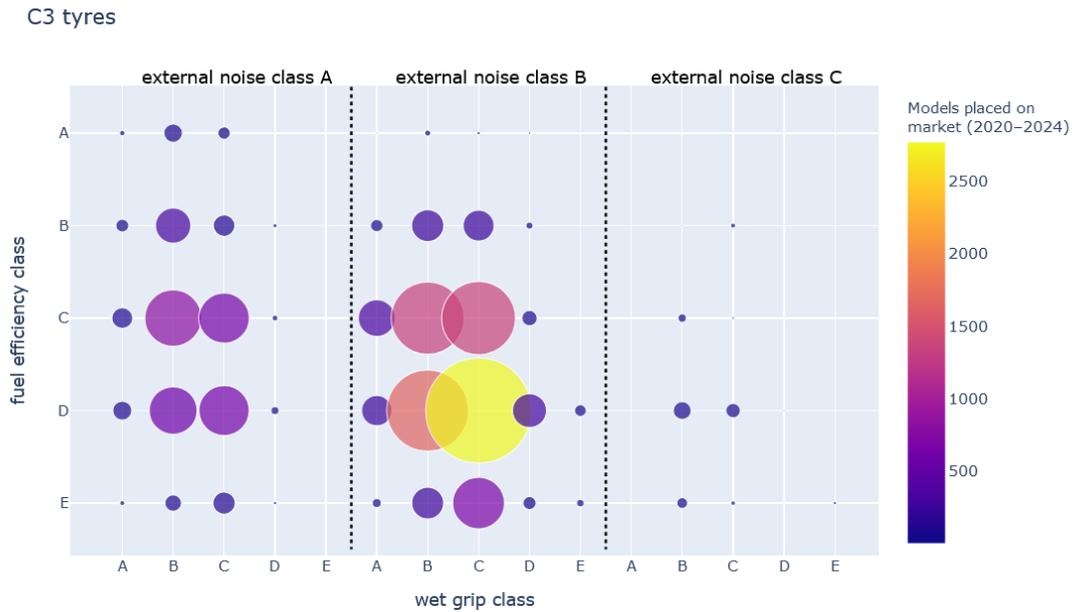


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C2 tyres



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4533 **Figure 7-9: Fuel efficiency, wet grip and external rolling noise class of C1, C2 and C3 tyres**
 4534 **placed on the market in the EU between 2020 and 2024.**

4535 Source: own evaluation based on data from the EPREL database (European Commission, 2025a).

4536 **7.3.3.6. Further aspects not covered in the EPREL database**

4537 Data fed into the EPREL database only cover some of the aspects relevant when describing
 4538 existing products. Further aspects relevant to the use phase include abrasion and emissions of
 4539 microplastics, additional aspects of safety, such as lateral acceleration as well as riding comfort,
 4540 including internal rolling noise.⁵⁴

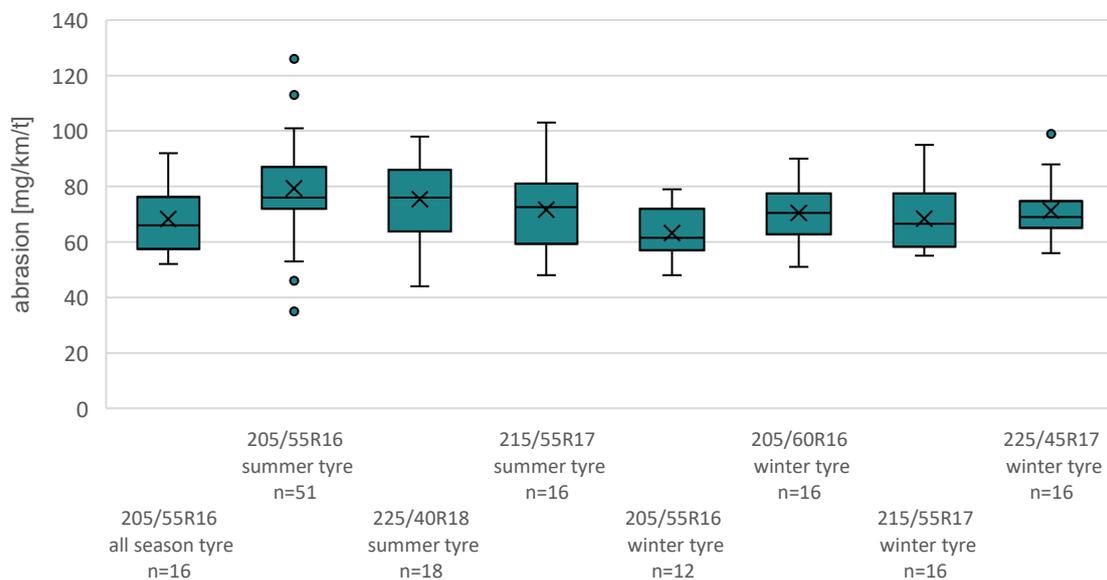
4541 **Tyre wear - abrasion and microplastics emissions**

4542 Tyre abrasion (i.e. the amount of tyre material released per km travelled) is dependent on the
 4543 vehicle type. Heavier vehicles, that partly also carry more tyres, have higher abrasion levels. Per
 4544 km, emission factors increase from C1 (car) to C2 (van) to C3 (truck) roughly in the ratios 1:2:8
 4545 (Giechaskiel, Grigoratos, Dilara, et al., 2024). One study suggests emissions of 62.5 mg per km
 4546 per t of weight for passenger cars, while it is 80 mg/km/t for light commercial vehicles and 29.1
 4547 mg/km/t for heavy vehicles⁵⁵(Boucard et al., 2025). Differences also exist between summer and
 4548 winter tyres, as well as electric cars. With regard to abrasion and particulate matter emissions,
 4549 an increase by factor 1.1 for winter tyres in comparison to summer tyres, and an increase of
 4550 factor 1.2 for electric vehicles in comparison to vehicles with an ICE is suggested (Giechaskiel,
 4551 Grigoratos, Dilara, et al., 2024).

⁵⁴ It should be noted that aspects of circularity - such as retreading, recyclability, or recycled content - are addressed separately in **Section 7.6**. Similarly, the aspect of durability is discussed in detail in **Section 0**.

⁵⁵ Assuming a passenger car weight of 1.65 t, 2.5 t per light commercial vehicle, and 27.5 t per heavy vehicle.

4552 In the ADAC wear test, tyres are evaluated over a total distance of 15,000 km under real-world
 4553 driving conditions on public roads. To assess each tyre model, a convoy of four vehicles covers
 4554 approximately 8,000 km, typically on one or more closed circuits that simulate a variety of
 4555 driving conditions (e.g., urban roads, motorways, and rural routes). After 7,500 km, tyre wear is
 4556 measured using high-precision laser technology. Since 2023, ADAC has included forecasted
 4557 mileage as part of the revised tyre testing methodology (ADAC, 2025b). The results of the test
 4558 are presented in **Figure 7-10**. Results are given for different tyre geometries and seasonal types
 4559 (i.e. summer, winter, and all-season tyres). The box plot illustrates the distribution of abrasion
 4560 levels. For each tyre, the box represents the so-called interquartile range (IQR)⁵⁶, with the
 4561 horizontal line inside the box indicating the median weight. Whiskers extend to 1.5 times the
 4562 IQR, and any outliers are shown as individual points. The 'X' symbol represents the mean
 4563 abrasion level.



4564

4565 **Figure 7-10: Abrasion level of C1 tyres tested by the ADAC.**

4566 Source: own evaluation based on data from ADAC (ADAC, 2025b).

4567 Tyre abrasion of tested C1 tyres was found to be between 60-80 mg/km/t on average, with larger
 4568 variations between tyre models of the same geometry. Abrasion varied between $\pm 10-30$
 4569 mg/km/t for the same tyre geometry and seasonal type. In contrast to suggestions by
 4570 Giechaskiel et al. (2024), no significant differences were found between summer and winter
 4571 tyres (Giechaskiel, Grigoratos, Dilara, et al., 2024).

4572 In 2024, the UNECE World Forum for Harmonization of Vehicle Regulations (WP.29) adopted a
 4573 proposal to add two standardised methods for measuring tyre abrasion of C1 tyres to UN
 4574 Regulation No. 117. The two methods comprise (i) laboratory tests, where tyres are mounted

⁵⁶ 50 % of the data points are within the IQR.

4575 on a rolling drum for 5,000 km, or (ii) on-road testing similar to the ADAC testing methodology⁵⁷.
 4576 The methodology shall be the reference methodology of the EURO 7 regulation (ETRMA, 2024c).

4577 **Noise, vibration and harshness (NVH)**

4578 Vibration, harshness and other comfort aspects are not measured in standardised test but are
 4579 sometimes subjectively determined in tyre tests⁵⁸. One aspect that can however be measured
 4580 and is of special focus is internal rolling noise. It arises from vibrations generated by the
 4581 interaction between the tyre tread and the road surface. Also, the vibration of air within the tyre
 4582 cavity—the air-filled hollow space inside a mounted tyre—adds to internal rolling noise. The tyre
 4583 cavity noise is caused by pressure variations inside a rolling tyre and can result in low-frequency
 4584 sounds that enter the vehicle cabin. OEMs often set internal noise requirements for tyres to
 4585 ensure good cabin acoustics. Especially for electric vehicles, tyre noise gains more attention
 4586 (given the missing noise from the ICE). Quantitative data on internal noise is scarce, as this aspect
 4587 is not yet under regulation. Therefore, a standardised testing method is missing. It should be
 4588 noted, however, that internal noise within the vehicle cabin is not solely determined by the
 4589 tyres. It is also strongly influenced by factors such as the type of asphalt or road surface, the
 4590 vehicle’s suspension system, and the overall car construction, including noise from ICEs,
 4591 insulation, body stiffness, and materials used.

4592 **Lateral acceleration**

4593 The tyre’s ability to withstand lateral acceleration is particularly important for cornering stability
 4594 and overall handling performance. In wet conditions, this characteristic is often assessed
 4595 through aquaplaning tests. For example, the ADAC uses the category “Aquaplaning in a curve:
 4596 lateral acceleration (m/s²)” to evaluate how well a tyre maintains grip before losing contact with
 4597 the road due to water buildup. In recent years, measured values for this test have ranged from
 4598 1.8 to 4.0 m/s², corresponding to approximately 0.18 to 0.41 g of lateral force (ADAC, 2025a).
 4599 These figures reflect the point at which the tyre begins to aquaplane and lose lateral stability in
 4600 wet corners.

4601 **7.3.3.7. Special tyre functions: puncture resistance and noise reduction**

4602 Run-flat tyres (RFT) and self-sealant tyres allow continued driving after a puncture⁵⁹, while silent
 4603 tyres typically incorporate foam inserts to minimise internal rolling noise. These three tyre
 4604 features are not very common. The market share of these tyre types within the European
 4605 context is not publicly available. However, in Germany, the proportion of ELT that are either self-
 4606 sealant (not including RFT) and/or silent reached approximately 4 % by 2025 (Zare, 2025).

⁵⁷ A convoy of four vehicles will drive for 8,000 km. Drivers will change every 500 km. A circuit on public roads with reproducible conditions is chosen.

⁵⁸ Tyre Reviews for example introduced a subjective comfort category, where comfort is rated on a scale from 1-10 (Tyre Reviews, 2025).

⁵⁹ While they allow for driving after a puncture, they will not increase longevity, since they are not reducing tread wear. Additionally, automotive safety experts warn that the perceived safety benefit is misleading, causing many drivers to neglect regular tyre inspections (Zare, 2025).

4607 Especially self-sealant and silent tyres are drawing increased attention from a recycling
4608 standpoint (see **Section 7.6**) due to the significant challenges they pose. Given this problematic
4609 issue, more information is gathered on these three tyre types.

4610 **Run-flat tyres:** RFT allow for driving after puncturing due to thicker sidewalls that allow for
4611 carrying the vehicle weight. The extra rubber and cords in the sidewall and bead add ~20-40 %
4612 in weight (Motor Werke, 2021). RFT historically have higher rolling resistance due to stiffer,
4613 heavier construction (tires easy, 2025). Many run-flats have one EU label grade lower for rolling
4614 resistance compared to equivalent standard tyres (e.g., a design that might be class B in standard
4615 form could be class C as a run-flat). Similarly their external rolling noise is higher (European
4616 Commission, 2025f).

4617 **Self-sealant tyres:** Self-sealant tyres (or sometimes simply seal tyres) contain a layer of viscous
4618 sealant inside that flows into and plugs small tread punctures (up to 5 mm) automatically when
4619 they occur and are predominantly applied to passenger cars (C1) (Continental Reifen
4620 Deutschland GmbH, 2022; *Self-Sealing Tire Market*, n.d.). The sealant is mostly rubber-based
4621 (e.g., natural or butyl rubber compounds mixed with plasticisers and tackifiers) but sometimes
4622 proprietary gels or silicone are used. They are applied to the inner liner in the crown area. This
4623 layer adds weight (~10 % of tyre mass, e.g., a few hundred grams for a car tyre) but is designed
4624 not to degrade performance (Roberts, 2025; D. Shaw, n.d.). Thereof, it would also not impact
4625 rolling resistance, as claimed by manufacturers (e.g., Michelin and Bridgestone (Just Auto, 2023;
4626 Michelin, n.d.-c; K. Shaw, 2022)). Following the logic of Continental self-sealant tyres means not
4627 having to carry a spare tyre. This reduces weight and even improves overall fuel efficiency
4628 (Continental Reifen Deutschland GmbH, n.d.-b).

4629 **Silent tyres:** Silent tyres are an emerging trend in passenger and EV segments, while their
4630 adoption in C2 or C3 tyres is negligible. Silent tyres feature polyurethane foam liners that cut
4631 interior noise by several decibel at certain frequencies (Baro et al., 2019; Gomez, 2024; Sams,
4632 2020). Noise-reduction tyres use lightweight open-cell polyurethane foam sheets glued to the
4633 inner liner. The foam is light (~500 g for passenger car tyres), and no significant impacts on rolling
4634 resistance are reported (McIntosh, 2017).

4635 **7.3.4. Least life cycle costs**

4636 The MEERP methodology applies an LLCC approach when assessing product groups. According
4637 to MEERP, the LLCC product is defined as “the product with lower resource use and emissions
4638 than the Base Case at the lowest life cycle costs”. For tyres, the parameters most directly linked
4639 to user costs are rolling resistance and durability. However, other aspects such as safety, noise,
4640 or abrasion are not factored in. As a result, the LLCC approach may favour a tyre with low rolling
4641 resistance and high mileage but otherwise poor performance in safety or environmental
4642 characteristics. This comparison is further complicated by the wide variety of tyre types and
4643 applications (e.g., summer vs. winter tyres). Moreover, there is little transparency on how much
4644 additional cost is required to improve specific performance aspects, such as moving from rolling
4645 resistance class B to class A, since performance characteristics are often in trade-off with each
4646 other. Finally, important circularity aspects—such as retreadability, recyclability, and the use of
4647 biobased or recycled materials—are not reflected in the product price.

4648 7.3.5. Products with standard improvement (design) options

4649 Regarding the use phase, the MEERP methodology primarily focuses on the energy consumption,
4650 with improvement efforts mainly targeting energy efficiency. In the case of tyres, energy
4651 efficiency is predominantly represented by a reduction in rolling resistance, which is addressed
4652 through the EU fuel efficiency labelling for C1, C2, and C3 tyres. Additionally, other Ecodesign
4653 aspects relevant to the use phase—such as external rolling noise—are already covered by the
4654 EU label, while abrasion is expected to be regulated soon under the EURO 7 standards.

4655 Compared to other energy-related products like electrical appliances, it is of paramount
4656 importance that tyres meet safety and performance requirements, which play a critical role in
4657 their design. For instance, wet grip, snow grip, and ice grip are important safety parameters
4658 incorporated into the EU tyre label, while UNECE regulations set the international standard. The
4659 fact that many performance and safety aspects of tyres are already regulated has driven
4660 innovation focused on enhancing these technical features.

4661 The following sections provide a brief overview of standard improvement options for C1, C2,
4662 and C3 tyres during the use phase, before going into specific examples of best available and best
4663 not yet available technologies (BAT and BNAT) in **Sections 7.3.6 and 0**. The **focus here is solely**
4664 **on performance characteristics relevant to the use phase**, excluding any considerations related
4665 to “sustainable” materials, reuse, and EoL treatment (e.g., retreading, recyclability, bio-based,
4666 or recycled content), and the product lifetime. Reuse and EoL aspects are covered in **Section 7.6**.
4667 Product lifetime is covered in **Section 0**. Materials used in the production process, especially,
4668 critical raw materials, substances of concern as well as recycled and bio-based materials are
4669 discussed separately and in detail in **Section 7.6** as they are more related to aspects of circularity.
4670 Digital tools in the field of a DPP are covered in **Section 7.6.7**.

4671 7.3.5.1. Reduction in rolling resistance

4672 Rolling resistance in tyres is mainly caused by hysteresis⁶⁰, which accounts for 80–90 % of the
4673 total resistance⁶¹. To effectively reduce hysteresis and achieve low rolling resistance, several key
4674 factors can be optimised: (i) tyre architecture, designed to minimise deformation and thus
4675 reduce energy loss through hysteresis; (ii) tyre weight, since heavier tyres generate more heat,
4676 increasing friction; and (iii) tyre composition, formulated to absorb energy in the most efficient
4677 way possible. Additionally, (iv) maintaining optimal tyre inflation pressure helps reduce
4678 hysteresis and consequently rolling resistance. While correct tyre inflation has traditionally been
4679 the user’s responsibility, advancing technologies are paving the way for automatic tyre pressure
4680 adjustment.

⁶⁰ Hysteresis is energy loss in the form of heat when the tyre’s rubber repeatedly deforms and recovers while rolling. Because tyre rubber is viscoelastic, not all the energy used for deformation is recovered.

⁶¹ Energy loss due to air drag and due to friction at contact patch are two other factors but only account for ~10 % of rolling resistance (Akutagawa, 2017; H. S. Aldhufairi & Olatunbosun, 2018)

4681 7.3.5.2. Decrease in abrasion

4682 Abrasion from tyres results from the friction between the tyre and the road surface. This
4683 abrasion is influenced by several factors, including the road surface texture and topography,
4684 vehicle operation and characteristics, and—most importantly—the tyre’s own properties. Key
4685 tyre characteristics affecting abrasion include size, tread depth, construction, composition, age,
4686 mileage, and tyre pressure. To reduce tyre particle emissions from abrasion, strategies in tyre
4687 technology focus on optimising material composition and incorporating innovative materials
4688 (Gehrke et al., 2023).

4689 7.3.5.3. Increase in tyre grip

4690 Wet, snow, and ice grip—as well as grip to counteract lateral acceleration—are primarily
4691 determined by the tread characteristics. These include the tread pattern design (e.g., density of
4692 sipes, groove geometry, and block stiffness), tread depth, the rubber compound composition,
4693 and the manufacturing process (e.g., mixing conditions, curing temperature, and the
4694 vulcanisation system) (Suchiva et al., 2019). For more information on the manufacturing process,
4695 please refer to **Section 7.4.2**.

4696 7.3.5.4. Noise reduction

4697 The tyre-road interaction causes noise. Especially **internal noise reduction** can be achieved by
4698 absorbing materials implemented within the tyres, while **external noise reduction** can be
4699 achieved by adjusting the tread pattern design as well as the rubber compounds used in the
4700 tyre.

4701 7.3.5.5. Further aspects

4702 One approach to increase the lifetime of tyres and to avoid repairing or replacement, are
4703 technologies that allow for usage of tyres after punctures.

4704 To maintain **optimal pressure** in the tyre adjustment of valves and materials can lead to reduced
4705 pressure loss over time, while technological solutions such as monitoring and self-adjusting
4706 systems can also help in maintaining optimal tyre pressure.

4707 7.3.6. Best Available Technology with regard to performance 4708 aspects in the use phase

4709 The concept of BAT, as defined in the MEErP methodology, traditionally emphasises
4710 technologies with the lowest energy consumption. However, this concept is not directly
4711 applicable to tyres. Tyre design involves trade-offs: optimising for one performance aspect (e.g.,
4712 rolling resistance) often compromises others (e.g., wet grip or durability).

4713 At the same time only few performance parameters are covered by the EU Tyre Labelling
4714 Regulation. ETRMA adds that current EU labelling focuses on tyres in the top two classes for
4715 rolling resistance and noise, while safety performances must not be compromised. However,
4716 this approach does not consider varying tyre applications. Different factors, such as winter
4717 versus summer tyres, load index, and speed index, mean that top-class tyres often do not exist
4718 for certain applications (1st Stakeholders consultation, 2025).

4719 Over time, several tyre models, components, manufacturing plants, and systems have been
4720 recognised for innovation through awards such as the “Tire Technology International Awards for
4721 Innovation and Excellence”. These awards offer valuable insights into technological
4722 advancements in the field and are a starting point for identifying the BAT in the field of tyres.

4723 Given the multitude of performance characteristics of tyres discussed in this chapter, a BAT is
4724 evaluated for each key performance indicator. Specific tyre models are not referenced, as doing
4725 so could imply that a particular tyre represents the overall BAT for tyre performance, rather than
4726 excelling in just one specific aspect.

4727 7.3.6.1. Reduction in rolling resistance

4728 Rolling resistance can be reduced by minimising the energy losses that occur during tyre
4729 deformation as it rolls over the road surface. This can be achieved through a combination of
4730 geometric, structural, and material-based strategies.

4731 One straightforward approach to lowering rolling resistance is to reduce the contact patch
4732 between the tyre and the road (Akutagawa, 2017). This can be achieved through higher inflation
4733 pressure, reduction of voids in the tread pattern⁶², or use of narrower tyres, which naturally
4734 reduces the contact area and the overall tyre weight, by lowering the mass that undergoes cyclic
4735 deformation.

4736 Reducing tread depth also decreases rolling resistance by minimising the amount of rubber that
4737 deforms (Luchini et al., 2001). However, this comes at the cost of reduced tyre lifespan and
4738 potentially lower safety performance, making it unsuitable as a BAT in most cases.

4739 Significant reductions in rolling resistance have historically come from innovations in tyre
4740 construction. Notably the introduction of radial-ply tyres in 1946 marked a major improvement
4741 over bias-ply designs, offering significantly lower rolling resistance (H. S. Aldhufairi &
4742 Olatunbosun, 2018). Cap plies, commonly used in high-performance and all-season tyres, help
4743 reduce rolling resistance at high speeds. However, their effect is reversed at lower speeds,
4744 where they may slightly increase rolling resistance (H. S. Aldhufairi & Olatunbosun, 2018).
4745 Reinforced tyres can also contribute to lower rolling resistance by limiting casing deformation,
4746 especially under heavy loads or high-speed conditions.

⁶² Reduction of voids in the tread pattern increases tread stiffness and reduces shear strain in individual tread blocks (Michelin, 2003).

4747 Today, the primary focus of rolling resistance research lies in the optimisation of material
4748 composition. This effort targets reducing hysteresis losses in rubber compounds and minimising
4749 overall tyre deformation through advanced material structures. Rolling resistance can be
4750 significantly reduced if the filler material is finely distributed within the polymer matrix. The use
4751 of nanomaterials enhances this effect due to their high surface area and better interaction with
4752 polymer chains. Silica leads to lower hysteresis losses compared to traditional carbon black,
4753 which is why it is commonly used in low rolling resistance tyres (see also **Sections 7.3.5.2 and**
4754 **7.3.6.2** on abrasion).

4755 Manufacturers fine-tune the polymer structure and coupling agents to reduce internal friction.
4756 This includes optimising the micro- and macrostructure of the polymer chains, as well as the use
4757 of advanced softeners to enhance elasticity and reduce energy loss during deformation (H. S.
4758 Aldhufairi & Olatunbosun, 2018). In this regard, “next-generation” synthetic rubbers
4759 (functionalised styrene–butadiene rubber (S-SBR) and neodymium-catalysed polybutadiene
4760 rubber (Nd-BR)) are noteworthy, as they allow for better bonding with fillers. They are mainly
4761 used in premium tyres and lead to a reduction in rolling resistance and wear, while increasing
4762 wet grip (Bisschop et al., 2021; Kloppenburg et al., 2018).

4763 Finally morphing tread patterns, where the part of the grooves and/or sipes in tyres open or
4764 close depending on the riding style was recently presented for a motorcycle tyre. Thus, either
4765 rolling resistance or grip is enhanced. The respective technology is a passive system that is
4766 readily available for motorcycle tyres (Autocar Professional Bureau, 2024; Pard, 2024).

4767 **7.3.6.2. Decrease in abrasion and increased longevity**

4768 A recent review paper has summarised technological approaches to reduce tyre wear (Gehrke
4769 et al., 2023).

4770 Using highly dispersible silica (HD silica) instead of carbon black as a filler material can reduce
4771 tyre abrasion. It is used in premium low-rolling-resistance and eco tyres. HD silica distributes
4772 more evenly throughout the rubber matrix, which strengthens the compound and makes it less
4773 prone to crack formation and propagation. This in turn reduces tyre wear. Additionally, silica
4774 reduces internal friction within the rubber compared to carbon black, resulting in lower heat
4775 build-up during driving. This helps prevent the tyre from softening excessively under high loads,
4776 which also reduces tyre wear. At the same time, it is noteworthy that silica does not compromise
4777 rolling resistance and wet grip properties of tyres. Prices for HD silica are higher compared to
4778 carbon black, given the higher processing efforts (HD silica production and mixing of silica into
4779 the rubber matrix) and the lower market maturity (economies of scale). Also, “green”
4780 alternatives to silica and carbon black are discussed, such as ashes from rice husk or other plants,
4781 but are still at a low technological maturity level.

4782

4783

4784 Another approach to reduce tyre wear is to slow down tyre aging. As tyres age, protective
4785 additives that guard against oxidation become depleted, making the rubber more susceptible to

4786 hardening and embrittlement. This degradation can lead to the formation of small cracks in the
 4787 tread, which in turn accelerates wear. Additionally, the tyre’s thermal stability declines with age,
 4788 increasing the risk of overheating during use. To counteract aging effects, manufacturers can
 4789 increase the rubber’s resistance to oxidation and ozone by incorporating (i) antiozonants (mostly
 4790 on tyre’s inner surface), (ii) antioxidants, and (iii) UV stabilisers (especially on sidewalls). The list
 4791 of substances used as anti-degradants is long. Among popular antiozonants and antioxidants are
 4792 amine-based chemicals (such as 6PPD, TMQ or IPPD⁶³), phenolic chemicals (such as BHT⁶⁴ or
 4793 styrenated phenols) and heterocyclic chemicals as well as waxes (physical antioxidant). To
 4794 mitigate UV-degradation, carbon black also HALS⁶⁵, UV-absorbers and surface protectants are
 4795 used.

4796 **7.3.6.3. Internal noise reduction**

4797 Some (premium) tyre models incorporate sound absorbing materials, such as polyurethane
 4798 foams, mostly glued inside the tyre lining, which damp the cavity resonance and can reduce
 4799 noise in the cabin by several dB⁶⁶ (Baro et al., 2019; Gomez, 2024; Sams, 2020). However, these
 4800 foams can constrain (mechanical) tyre recycling and are viewed as lack of Ecodesign (EuRIC
 4801 AISBL, 2022). In addition to foams, sidewall design and carcass damping are also targeted to
 4802 manage vibration transmission (T. Li, 2019).

4803 **7.3.6.4. External noise reduction**

4804 besides carbon black, HALS⁶⁷, UV-absorbers, and surface protectants are used.

4805

4806 External rolling noise is highly dependent on the road surface, especially if the road is wet or its
 4807 texture is coarse (UNECE R117). Especially at higher vehicle speeds the road’s characteristics
 4808 become more relevant. Nevertheless, the tyre-road interaction remains relevant and is affected
 4809 by the tread design, as well as to a certain extent by the tyre compound. Below are some
 4810 approaches used to reduce external rolling noise:

- 4811 • **Arrangement of the tread blocks:** If all tread blocks are designed in the same way they
 4812 would emit noise at the same frequency. By varying block size and shape, road contact
 4813 is randomised, and external rolling noise is reduced. This is referred to as pitch
 4814 sequencing (Tire Rack, n.d.).

⁶³ 6PPD=N-(1,3-dimethylbutyl)-N’-phenyl-p-phenylenediamine, TMQ=Polymerised 2,2,4-trimethyl-1,2-dihydroquinoline, IPPD=N-isopropyl-N’-phenyl-p-phenylenediamine

⁶⁴ BHT=2,6-Di-tert-butyl-4-methylphenol

⁶⁵ HALS=Hindered Amine Light Stabilisers (class of stabilisers – not a single compound)

⁶⁶ Examples of systems or tyre models include Continental ContiSilent, Pirelli Noise cancelling system technology, Michelin Acoustic Technology, Hankook Ventus, Falken Silent Core, Bridgestone B-Silent and Dunlop - Noise Shield Technology

⁶⁷ HALS=Hindered Amine Light Stabilisers (class of stabilisers – not a single compound).

- 4815 • **Groove design and angles:** Groove resonance adds to the external rolling noise. Air
4816 becomes trapped in the grooves and is then rapidly expelled from the grooves. This is
4817 referred to as air pumping. Optimising the design in grooves patterns and angles that
4818 disrupt uniform air pumping leads to noise reduction (Meng et al., 2025; Pinay et al.,
4819 2020).
- 4820 • **Reduction in hysteresis:** Technologies are already explained under rolling resistance and
4821 abrasion in **Section 7.3.6.1** and **Section 7.3.6.2**, respectively. It reduces energy loss and,
4822 therefore, also noise.
- 4823 • **Rubber compound:** Softer rubber compounds decrease external rolling noise by
4824 dampening vibrations (Tirecraft, 2024).
- 4825 • **Silent tyres:** are primarily designed to reduce internal noise, will also reduce external
4826 noise to a certain extent (see **Section 7.3.6.3** on internal noise reduction).

4827 7.3.6.5. Further aspects

4828 Self-sealing tyres are sometimes considered BAT in the tyre sector, as they enable continued
4829 driving after a puncture by sealing the damaged area with a viscous gel (1st Stakeholders
4830 consultation, 2025). This feature can extend the lifespan of the tyre by eliminating the
4831 immediate need for repair or replacement. However, these tyre types are often regarded as
4832 problematic in terms of EoL treatment and, like noise reduction tyres, are criticised for not
4833 aligning well with Ecodesign principles (1st Stakeholders consultation, 2025).

4834 Maintaining optimal pressure is directly connected to reduction in tyre wear, noise, and rolling
4835 resistance. Monitoring systems that use pressure sensors inside the tyre to directly measure
4836 pressure (direct tyre pressure monitoring system—direct TPMS) and those that estimate pressure
4837 by using wheel speed data (indirect TPMS) inform users about the current tyre inflation. Another
4838 approach are active components that regulate tyre pressure. Onboard inflation systems (in
4839 trucks and heavy-duty vehicles) and central tyre inflation systems (for off the road (OTR) tyres)
4840 do not require the user to inflate the tyres themselves anymore. Advanced systems even allow
4841 for an equalisation of pressure across all wheel positions. These automatic tyre inflation systems
4842 (ATIS) have some constraints: (i) they are currently not commercialised for passenger cars, (ii)
4843 they require a power source, and (iii) they can normally not deflate over-inflated tyres. A
4844 combination of both TPMS and ATIS allows for monitoring and auto-adjustment of tyre pressure
4845 (Bauer Built Tire &, 2021; Cullen, n.d.; Morgan, 2025).

4846 Furthermore, monitoring systems (“smart tyre sensors”) have been developed that not only
4847 monitor tyre pressure, but also:

- 4848 • **Tread depth:** to warn users as soon as the tyre’s tread depth is not safe for driving
4849 anymore.
- 4850 • **Tyre temperature:** tyre temperatures often increase rapidly prior to a tyre blow out.
- 4851 • **Small punctures** that often remain undetected (Continental Reifen Deutschland GmbH,
4852 n.d.-c).

4853

4854 **7.3.7. Best Not (yet) Available Technology with regard to**
 4855 **performance aspects in the use phase**

4856 The amount of innovation to enhance tyre performance is vast, and it is considered impossible
 4857 to cover all the BNAT in the tyre industry. However, Maan et al. (2025) have systematically
 4858 compiled a comprehensive overview of patents and new research in the tyre field. The following
 4859 subsections are based on that overview and constitute a non-exhaustive list of BNAT.

4860 **7.3.7.1. Advanced materials**

4861 Adjustment of tyre composition is under constant investigation. For instance, the utilisation of
 4862 hybrid filler systems, in binary or ternary system (e.g., carbon black, silica, and thermally
 4863 exfoliated graphite as described in Bijina et al., 2025) promises lower hysteresis thus lower
 4864 rolling resistance, while improving wet grip at the same time. Nanotechnology, especially the
 4865 utilisation of nanoprene and nanosilica, is often discussed as a measure to reduce tyre abrasion.
 4866 However, high costs as well as health, safety, and other risks are stated as significant barriers
 4867 (Gehrke et al., 2023). Finally, self-healing rubber, that repairs micro-abrasions to reduce particle
 4868 generation, is another approach to counteract abrasion⁶⁸. This approach is still in early research
 4869 and lab-scale development (Gehrke et al., 2023).

4870 **7.3.7.2. Tread adjustment**

4871 Another idea that has been followed over the years is a variable tyre profile, which is a concept
 4872 that aims to allow the tyre to change its aspect ratio dynamically during rolling. However, this
 4873 concept still needs to be extensively investigated with experimental research and field tests (H.
 4874 S. Aldhufairi & Olatunbosun, 2018). Three-tube or multi-chamber systems are one approach to
 4875 achieve adaptive tread adjustment (H. Aldhufairi et al., 2019).

4876 **7.3.7.3. Non-pneumatic tyres**

4877 Recently, an airless tyre employing shape-memory metal alloys has been developed and placed
 4878 on the market in the premium bicycle tyre segment. The metal alloy grid is integrated in a poly-
 4879 rubber material. The tyre supposedly adapts its profile to load or speed, is both elastic and
 4880 robust, and never goes flat (The SMART Tire Company, 2024). For other tyre types, especially for
 4881 OTR or light electric vehicles, the concept of shape-memory metal alloys or the broader concept
 4882 of non-pneumatic tyres has been under research for several years, but is little commercialised⁶⁹

⁶⁸ Self-healing rubbers are not “immune” to abrasion—the repaired area can be worn again. The benefit is that the material can close small cracks or cuts before they result in larger defects that accelerate particle release. In other words, the technology does not eliminate abrasion but slows down the progression of wear.

⁶⁹ Michelin’s Tweel tyres for instance are non-pneumatic tyres for the OTR tyre segment.

4883 (Hankin et al., 2025). A general disadvantage of non-pneumatic tyres remains the increased
 4884 mass and thus heat buildup, resulting in performance drawbacks. In addition, noise and
 4885 vibration increase, resulting in a harsher ride.

4886 7.3.7.4. Advanced monitoring and control systems

4887 Besides monitoring several aspects of the tyre conditions (e.g., pressure, temperature, tread
 4888 depth, vibration, etc.), next generation smart tyre sensors are connected to cloud-based
 4889 platforms for remote analysis of tyre health and targeted alerts or recommendations (ADAS
 4890 Depot, 2024). Sensor data from vehicles can be used by machine learning in connection with
 4891 artificial intelligence to spot patterns and predict how tyres will perform. Current research
 4892 explores methods to estimate the forces exerted on the tyre, taking into account the road quality
 4893 to predict wear and, among other things, calculate the time to failure (“health forecasting”)
 4894 (Maan et al., 2025). In the future, piezoelectric elements or triboelectric nanogenerators may
 4895 be used to power sensors. They are embedded in the tyre and harvest energy from deformation
 4896 and vibration (Meena et al., 2023; Zhao et al., 2023).

4897 Depending on the driving, weather, road, and other conditions, developments foresee that tyre
 4898 pressure is automatically adjusted to optimise either low rolling resistance (e.g., on dry
 4899 highways) or maximum grip (e.g., on wet urban roads). Self-inflation can, for instance, be
 4900 achieved through integrated pumps powered by the centrifugal forces acting on the rotating
 4901 tyres (Continental Reifen Deutschland GmbH, n.d.-d).

4902 The Vehicle-to-Everything (V2X) approach goes one step further. Data collected by vehicles will
 4903 be shared with nearby vehicles creating a swarm intelligence (Continental Reifen Deutschland
 4904 GmbH, n.d.-a; Vodafone, n.d.). With regard to tyres this approach could have interesting use
 4905 cases, for instance:

- 4906 • V2X could inform other vehicles on grip changes, aquaplaning, or icy patches.
- 4907 • V2X could inform (autonomous or semi-autonomous) driving systems about tyre state
 4908 (e.g., reduced grip), allowing them to adjust for instance braking distances or cornering
 4909 speeds.
- 4910 • V2X could integrate tyre health data with route planning—avoiding high-wear roads.

4911 7.3.7.5. Other

4912 Systems are being developed to capture particulate matter during driving to reduce the
 4913 environmental impact of tyre wear. A device is mounted in the wheel well and uses airflow
 4914 control and electrostatics to capture tyre particles that are 2.5 microns or less in diameter
 4915 (PM2.5) which carry a charge due to the carbon in rubber. These are collected and can be
 4916 disposed of by the user (E-Mobility Engineering, 2022).

4917 Tyres have a temperature range at which their performance excels. Tyre reseller Oponeo.pl S.A.
 4918 for instance states that the ideal temperature for car tyres is ~60 °C with regard to rolling
 4919 resistance (Oponeo.pl S.A., 2023). Phase change materials have recently been introduced in

4920 motorsport applications to maintain optimal tyre temperatures⁷⁰. In addition to design
4921 adaptations that improve tyre cooling, the future for standard tyres may include active heating
4922 or cooling systems (Lindberg, 2025; Sams, 2025).

4923 7.4. Production and distribution

4924 7.4.1. Product weight and Bills of Materials (BOMs)

4925 This section covers the composition and quantitative weight of tyres, focussing on C1, C2, and
4926 C3 tyres, with a brief discussion of other tyre types in respective subsections.

4927 7.4.1.1. Tyre composition of C1, C2, and C3 tyres

4928 To arrive at a **BOM** for tyres, reference compositions of tyres need to be determined first. A
4929 literature review was carried out and the results are presented in **Table 7-6**. The literature
4930 described the composition of tyres separately for passenger car tyres and truck tyres. In total,
4931 nine material compositions were found for passenger car tyres and seven material compositions
4932 for truck tyres. The evaluation shows that truck tyres contain a significantly higher steel content
4933 compared to passenger car tyres, while they have minimal textile content. In addition, the
4934 natural rubber share in truck tyres is almost twice as high compared to passenger car tyres.
4935 Accordingly, the synthetic rubber share is reduced in truck tyres. The proportions of fillers and
4936 other additives or processing agents show only minor differences across the three tyre
4937 categories.

4938 The reason for the increased reinforcing steel and natural rubber shares in truck tyres in
4939 comparison to passenger car tyres can be traced back to the heavier loads that have to be carried
4940 by trucks. Steel reinforcement can sustain the truck weight better and increased natural rubber
4941 shares increase (among others) elasticity, fatigue resistance, and tear strength, which becomes
4942 increasingly important at heavy loads.

⁷⁰ Phase change materials absorb or release heat as they change phase (mainly from solid to liquid and vice versa). Depending on the material, the change happens at a specific temperature (e.g. the phase change (from solid to liquid) in water happens at 0° C). Material is chosen to match the target temperature. In the motorsports sector (especially in Formula 1) phase changing materials are either used to store heat from warmed tyres or release heat to cold tyres. As a result, tyres are neither too cold nor do they overheat.

4943

Table 7-6: Composition of C1, C2, and C3 tyres found in literature.

| Material group | Subset | Passenger/ light truck tyre | Truck tyre | Passenger car tyre | Truck tyre | Passenger/ Light truck tyre | Truck tyre | Passenger car tyre | Truck tyre | Average vehicle tyre | Passenger car tyre | Truck tyre | Passenger car tyre | Passenger car tyre | Truck tyre | Passenger car tyre | Truck tyre | | | | | | | | |
|------------------------|------------------|--------------------------------|------------|--------------------|--------------------|--------------------------------|------------|--------------------|------------|----------------------|--------------------|--------------------|--------------------|--------------------|------------|--------------------|------------|--------------------|--------|-------|--------|------|------|--------------------|--------------------|
| Rubber | Natural Rubber | 44 % | 45 % | 43 % | 42 % | 17 % | 34 % | 47 % | 45 % | 18 % | 20.3 % | 36.1 % | 41 % | 21.2 % | 37.1 % | 19 % | 34 % | | | | | | | | |
| | Synthetic Rubber | | | | | 24 % | 12 % | | | 25 % | 23.6 % | 10.1 % | | 24.5 % | 10.0 % | 24 % | 11 % | | | | | | | | |
| Fillers | Carbon black | 26 % | 24 % | 28 % | 24 % | 29 % | 24 % | 21.50 % | 23 % | 28 % | 21.0 % | 21.4 % | 30 % | 18.9 % | 22.30 % | 26 % | 24 % | | | | | | | | |
| | Silica | | | | | | | | | | | | | 6.5 % | 3.8 % | | | 7.7 % | 1.30 % | | | | | | |
| other rubber compounds | Sulphur | 14 % | 10 % | 1 % | 1 % | 14 % | 9 % | 9 % | 7 % | 13 % | 0.9 % ^a | 0.6 % ^a | 2 % | 8.7 % | 7.20 % | 14 % | 10 % | | | | | | | | |
| | Zinc oxide | | | 2 % | 2 % | | | | | | | | | | | | | 1.4 % | 2.1 % | 6 % | | | | | |
| | Accelerators | | | 6 % | 0.9 % ^a | | | | | | | | | | | | | 0.6 % ^a | 2 % | 8.7 % | 7.20 % | 14 % | 10 % | | |
| | Anti-Detergents | | | | | | | | | | | | | | | | | | | | | | | 1.6 % ^b | 1.2 % ^b |
| | Stearic Acid | | | | | | | | | | | | | | | | | | | | | | | 0.7 % | 0.5 % |
| | Plasticiser | | | | | | | | | | | | | | | | | | | | | | | 5 % | 6.8 % |
| Steel | 12 % | 21 % | 13 % | 25 % | 12 % | 21 % | 17 % | 25 % | 11 % | 12.0 % | 21.0 % | 15 % | 10.8 % | 21.10 % | 12 % | 21 % | | | | | | | | | |
| Textiles | 4 % | 0 % | 5 % | 0 % | 4 % | 0 % | 5.50 % | 0 % | 5 % | 4.0 % | 0 % | | 3.7 % | 0.20 % | 4 % | 0 % | | | | | | | | | |
| Sum | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % | | | | | | | | |
| Source | | | (1) | | (2) | | (3) | | (4) | (5) | | (6) | (7) | | (8) | | (9) | | | | | | | | |

4944

^a) Specified as CBS. ^b) Specified as 6PPD.

4945

(1) (Utrera-Barrios, Verdejo, Lopez-Manchado, et al., 2023)

4946

(2) (Braithwaite et al., 2021)

4947

(3) (ETRMA, n.d.-c)

4948

(4) (Grammelis et al., 2021)

4949

(5) (Denny, 2024)

4950

(6) (Blömer, 2022)

4951

(7) (Continental Reifen Deutschland GmbH, n.d.-e)

4952

(8) (The Japan Automobile Tyre Manufacturers Association, Inc., 2012)

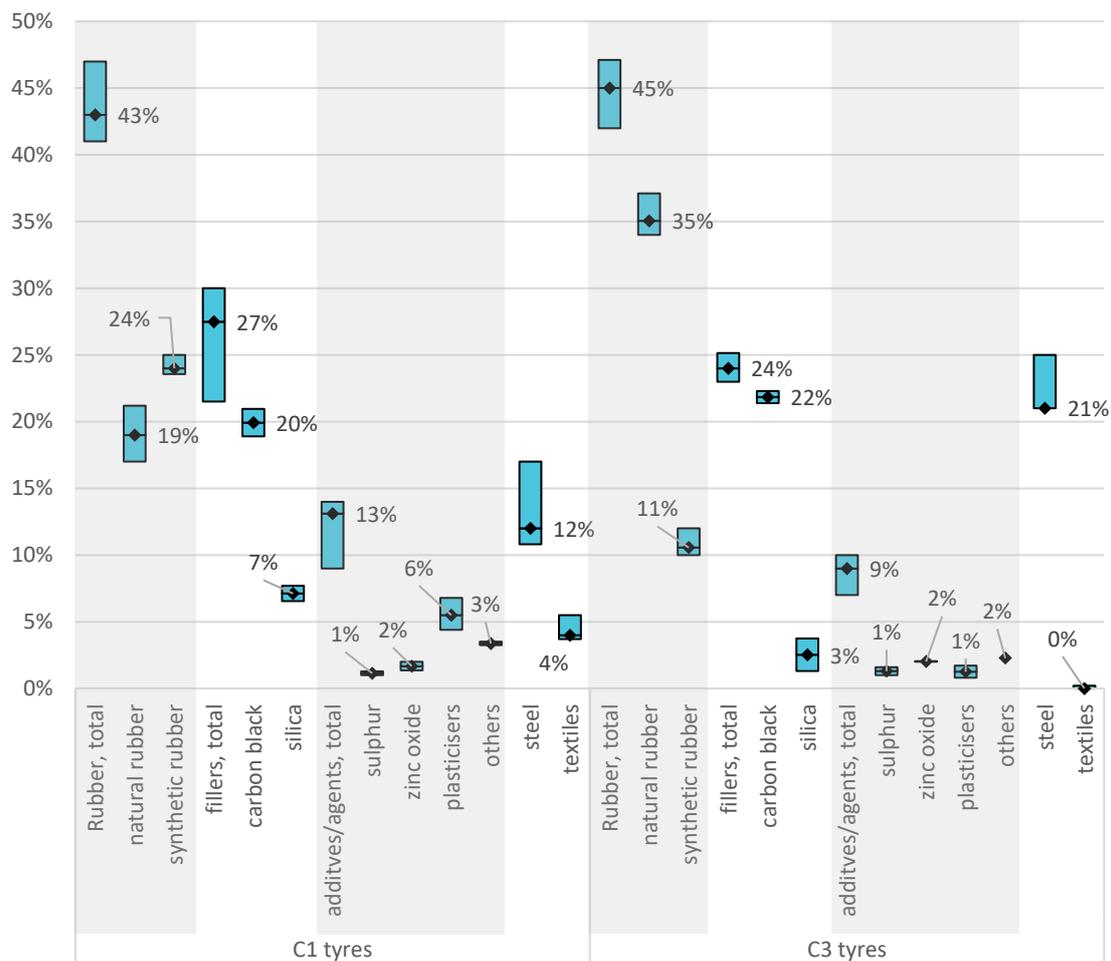
4953

(9) (U.S. Tire Manufacturers Association, n.d.)

4954 For most materials, there is little variation found in the literature. The compositions analysed in
 4955 the literature review shows a maximum deviation from the median of six percentage points
 4956 (absolute). However, there are larger uncertainties regarding the shares of fillers and steel used
 4957 in passenger car tyres.

4958 It should be noted that the choice between silica or carbon black technology for C1 tyres
 4959 determines the proportion of each material used. A tyre based on carbon black technology will
 4960 contain little to no silica, whereas a tyre using silica technology will have a relatively high silica
 4961 content, resulting in a reduced amount of carbon black (1st Stakeholders consultation, 2025).

Material breakdown of passenger car and truck tyres



4962

4963 **Figure 7-11: Variation in the composition of tyres found in the literature. The median value is**
 4964 **illustrated by a black diamond, and the blue bars show the range between the minimum and**
 4965 **maximum value.**

4966 The median values are taken from **Figure 7-11** to define a reference composition for C1 and C3
 4967 tyres. The reference compositions were normalised, since the sum of the medians does not add
 4968 to 100 %. Normalisation was performed by dividing each median value by the total sum of all
 4969 medians. By doing so, the relative proportions of the individual materials are maintained. No
 4970 distinct composition was found in the literature for C2 tyres. With the open public consultation
 4971 a composition for C2 tyres was provided (1st Stakeholders consultation, 2025).

4972 **Table 7-7: Normalised tyre composition used for the Bill of Materials.**

| Material | C1 tyres | C2 tyres | C3 tyres |
|------------------------|----------|----------|----------|
| natural rubber | 19.1 % | 20.2 % | 34.9 % |
| synthetic rubber | 24.1 % | 22.8 % | 10.5 % |
| carbon black | 20.3 % | 19.1 % | 21.7 % |
| silica | 7.3 % | 6.4 % | 2.5 % |
| sulphur | 1.3 % | 1.1 % | 1.7 % |
| zinc oxide | 1.9 % | 1.7 % | 2.7 % |
| plasticisers | 6.2 % | 4.4 % | 1.7 % |
| other additives/agents | 3.8 % | 5.7 % | 3.0 % |
| steel | 12.0 % | 12.5 % | 21.2 % |
| textiles | 4.0 % | 6.1 % | 0.0 % |
| Sum | 100.0 % | 100.0 % | 100.0 % |

4973 The elemental composition can be deduced from the tyre composition given in **Table 7-7**. In
 4974 **Table 7-8**, the specific elemental composition was approximated by multiplying the elemental
 4975 composition values of the individual shares of the stated materials⁷¹ (i.e. natural rubber,
 4976 synthetic rubber, etc.). To determine the share of fossil carbon, it was assumed that the carbon
 4977 source of all materials was based for 100 % on fossil carbon, except for natural rubber (100 %
 4978 biogenic carbon). Based on the elemental composition, the lower heating value (LHV)⁷² was
 4979 determined. Rodríguez *et al.* (2017) also presented an elemental composition for tyres, showing
 4980 an overall good match.

4981 **Table 7-8: Calculated elemental composition of tyres.**

| Parameter | C1 tyres | C2 tyres | C3 tyres |
|---|------------|------------|------------|
| Carbon | 67.5% | 67.7 % | 65.2 % |
| Share of fossil carbon (C_{fossil}/C_{total}) | 74.7 % | 73.3 % | 52.1 % |
| Hydrogen | 4.5 % | 4.6 % | 4.0 % |
| Nitrogen | 2.2 % | 2.4 % | 1.2 % |
| Oxygen | 2.6 % | 2.6 % | 0.9 % |
| Sulphur | 1.6 % | 1.6 % | 2.0 % |
| Chlorine | <0.1 % | <0.1 % | <0.1 % |
| Ash (including ZnO, steel, silica) | 21.6 % | 21.0 % | 26.7 % |
| Sum | 100.0 % | 100.0 % | 100.0 % |
| LHV | 27.9 MJ/kg | 28.1 MJ/kg | 26.8 MJ/kg |

⁷¹ Stoichiometric data was used where possible. Given the many different materials used, especially with regard to the “other additives/agents” the compositions can only be understood as an approximation.

⁷² The LHV is the amount of heat released during the complete combustion of a fuel excluding the energy recovered from condensing the water vapor in the combustion products.

4982 **7.4.1.2. Tyre composition of other tyres**

4983 Our literature scan revealed that the composition of other tyre types is addressed less
 4984 frequently, and we did not investigate these in the highest possible detail. The composition of
 4985 **motorcycle tyres** was found in the literature for one Continental tyre (Cycle News, 2018): 41 %
 4986 rubber (natural and synthetic rubber), 30 % additives (carbon black, silica, carbon, gypsum), 15 %
 4987 reinforcement (steel, polyester, rayon, nylon etc.), 6 % plasticisers (oils and resins), 6 %
 4988 chemicals for vulcanisation (sulphur, zinc oxide etc.), and 2 % anti-aging agents and other
 4989 chemicals. This is only one composition and cannot be considered representative of the market.

4990 For **bicycle tyres**, Schwalbe states that *“the rubber content is around 40-60 %. The filler amounts*
 4991 *to 15-30 % and the remaining components approx. 20-35 %”* (Schwalbe | Ralf Bohle GmbH,
 4992 2025). The composition varies greatly depending on the intended use or the type of bike the
 4993 tyre is designed for (e.g., mountain bike tyres vs. racing bike tyres). Information on the
 4994 composition of different tyre types was found on the website of the retailer Decathlon. To show
 4995 the variance in the material composition across different types of bike tyres, **Table 7-9** present
 4996 the composition of a representative tyre.

4997 **Table 7-9: Composition of different bike tyres based on the reseller Decathlon.**

| Tyre type | Road/racing tyre | Mountain tyre | Touring/trekking Tyre | Gravel tyre |
|---------------------------------|---|--------------------|-------------------------------|-----------------------|
| Tyre specification | Schwalbe Protect Light 700×28, folding) | MTB Dry1 27.5×2.00 | Riverside Road Protect 700×47 | Van Rysel 700×32 wire |
| Natural rubber (NR) | 30 % | 15 % | 11 % | 30 % |
| Synthetic rubber (SBR/BR, etc.) | 30 % | 39 % | 47 % | 30 % |
| Steel (bead/wire) | 0 % | 10 % | 0 % | 20 % |
| Nylon (polyamide) cords | 20 % | 21 % | 37 % | 20 % |
| Aramid fibres (Kevlar) | 20 % | 0 % | 5 % | 0 % |
| Carbon black (filler) | 0 % | 12 % | 0 % | 0 % |
| Oils & other plasticisers | 0 % | 3 % | 0 % | 0 % |

4998 Source: (Decathlon Deutschland SE & Co. KG, 2025).

4999 The composition of **OTR tyres** (mining and agricultural tyres) could only be found in one
 5000 literature source (Tyre Stewardship Australia, 2024) and is given in **Figure 7-12**. Given the variety
 5001 in OTR tyres, the presented composition serves only as an indication example, as actual material
 5002 compositions can vary significantly.

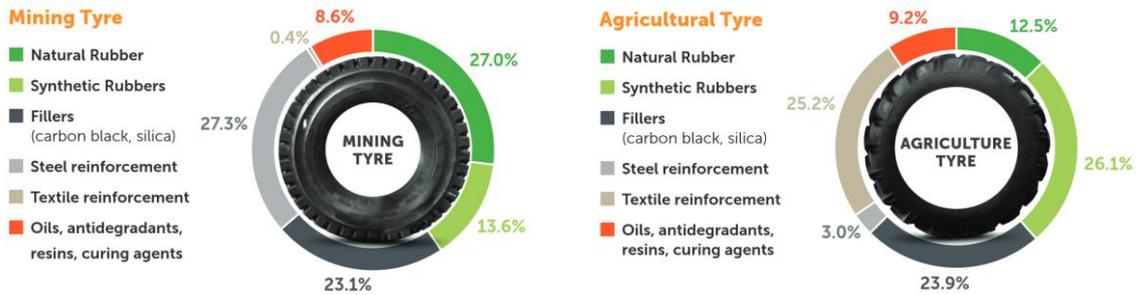


Figure 7-12: Composition of OTR tyres.

Source: (Tyre Stewardship Australia, 2024).

5003

5004

5005

5006 No compositions of **airplane tyres** were found in the literature.

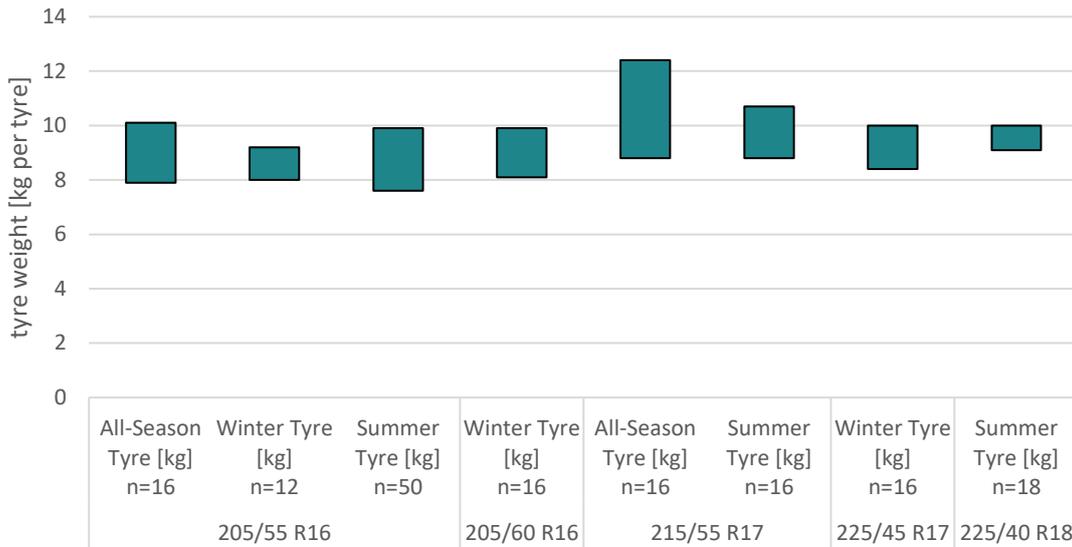
5007 7.4.1.3. Tyre weights of C1, C2, and C3 tyres

5008 Tyre weight depends on the specific tyre geometry, dimensions, and specific tyre design choices
 5009 made by the manufacturer. One stakeholder also noted that imported budget tyres are
 5010 sometimes narrower towards the tread to reduce rolling resistance, which in turn reduces the
 5011 overall tyre weight (Stakeholder Interview SR8, personal communication, 2025).

5012 **C1 tyres**

5013 Tyre models recently tested by ADAC (2025a) were assessed with regard to their weight,
 5014 categorised by seasonal tyre type: all-season, winter, and summer tyres. Tyre weights ranged
 5015 between 8-12 kg. The ranges of the tyre weights for each tyre type are presented in **Figure 7-13**.

5016 The graph shows that tyre weights of the same geometry can vary between one to four kg (i.e.
 5017 up to $\pm 20\%$). Additionally, the graph indicates that increasing tyre dimensions generally leads
 5018 to a corresponding rise in tyre weight. This trend is clearly observable when comparing tyre
 5019 models, such as 205/55 R16 and 215/55 R17, where both the rim diameter and tyre width
 5020 increase while the aspect ratio remains constant. The seasonal tyre type on the contrary is of
 5021 little relevance for the tyre weight.



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Figure 7-13: Tyre weights for C1 tyres tested by the ADAC. n indicates the number of models that were tested.

Source: own evaluation based on data from ADAC (2025a).

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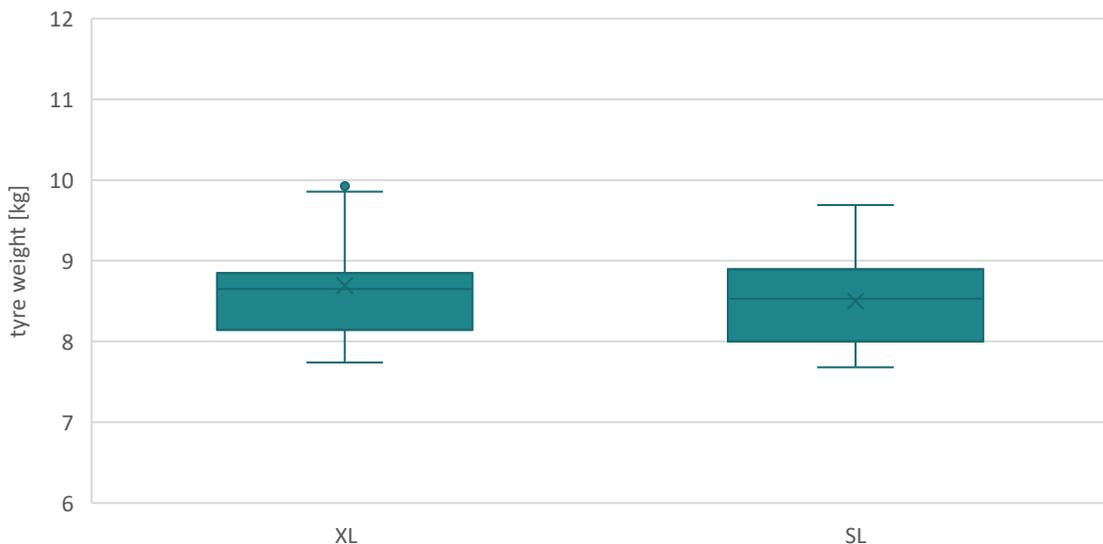
5030

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One aspect not covered in this initial assessment is the potential change in tyre weight due to reinforcement. Reinforced tyres contain more material in sidewalls, extra carcass plies, rubber, and potentially reinforced belts to maintain higher vehicle loads. A higher weight is therefore expected for reinforced tyres in comparison to standard load tyres. This aspect was evaluated for the tyre geometry 205/55 R16. However, based on tyre weights of 34 tyre models taken from Testsieger (Testsieger.de Vergleichsportal GmbH, 2025) no significant difference in the tyre weight was found between standard load (SL) and reinforced tyres (XL) as can be seen in **Figure 7-14**.



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Figure 7-14: Tyre weights of reinforced (XL, n=21) and standard load (SL, n=13) tyres of geometry 205/55 R16.

Source: own evaluation based on data from (Testsieger.de Vergleichsportal GmbH, 2025).

5038 The tyres tested by ADAC represent only a small segment of the entire market. Additionally, the
5039 tested tyres have similar geometries. To arrive at a representative weight for C1 tyres, tyre
5040 geometries placed on the market between 2020-2024 were assessed using data from the EPREL
5041 database. The assessment as presented in **Figure 7-3** in **Section 7.3.3** shows that the rim
5042 diameter dictates the tyre geometry of C1 tyres to some extent. Therefore, it is deemed
5043 worthwhile to link the tyre weight to the rim diameter. Tyre weights for C1 tyres are not readily
5044 available but can be partially sourced from the website Testsieger (*Testsieger.de*
5045 *Vergleichsportal GmbH*, 2025). However, not all tyres listed on that website include information
5046 on tyre weight, and those that do, can only be checked individually. Due to the high manual
5047 effort required to compile tyre weights, the evaluation was streamlined as follows:

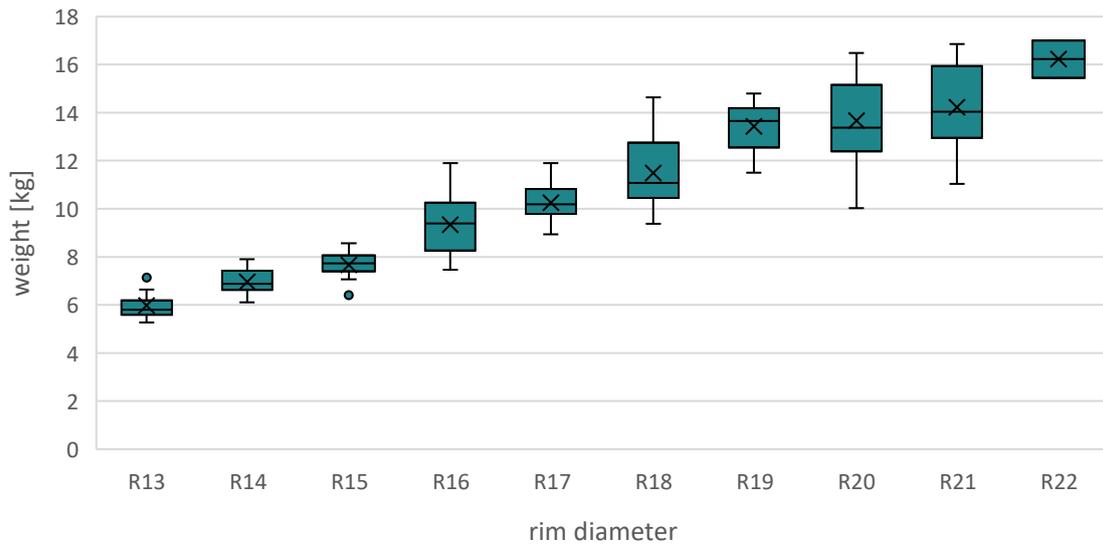
- 5048 • For each rim diameter from R13 to R22, the three tyre dimensions that held the most
5049 models in the EPREL database (European Commission, 2025a) were selected (e.g., for
5050 R13: 175/70 R13, 165/70 R13, 155/70 R13).
- 5051 • Exceptions were made for rim diameters R16, R17, and R18, for which five tyre
5052 dimensions were assessed due to their high market share. For R21 and R22, only few
5053 tyres were found overall and all of them were taken into consideration.
- 5054 • Only all-season tyres were considered⁷³.
- 5055 • For each tyre dimension, weights were collected from five different manufacturers to
5056 account for variation between brands. The five most popular models (based on the
5057 website Testsieger (*Testsieger.de Vergleichsportal GmbH*, 2025)) were taken.
- 5058 • No differentiation was made between standard load and reinforced tyres.

5059 The assessment is shown in **Figure 7-15**. The box plot illustrates the distribution of C1 tyre
5060 weights for rim diameters between R13 to R22. For each rim diameter, the box represents the
5061 so-called IQR⁷⁴, with the horizontal line inside the box indicating the median weight. Whiskers
5062 extend to 1.5 times the IQR, and any outliers are shown as individual points. The 'X' symbol
5063 represents the mean weight for each rim size. The graph shows that the variance of weights
5064 tends to increase for larger rim sizes.

5065 The data shows a clear linear trend between the tyre weight and the respective rim diameters
5066 ($R^2=98\%$). The tyre weight increases by ~ 1 kg per increase in rim diameter. The tyre weight can
5067 be approximated by the following formula: tyre-weight = 1.15 kg x (Rim diameter [inch]) - 9.32
5068 kg.

⁷³ The initial analysis of tyres tested by the ADAC (ADAC, 2025a) showed that tyre weight is little depended on seasonality. All-season tyres seem to be a fair compromise.

⁷⁴ 50 % of the data points are within the IQR.



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Figure 7-15: Distribution of C1 tyre weights by rim diameter.

5071

Source: own evaluation based on data from (Testsieger.de Vergleichsportal GmbH, 2025).

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C1 tyre weights range from approximately 5 to 17 kilograms. To determine an average weight representative of the market, tyre weights can be weighted according to the number of models placed on the market for each rim diameter, as recorded in the EPREL database. Based on this approach, **the weighted average weight of a C1 tyre is calculated to be 10.6 kilograms.** For comparison, the tyre geometry with the highest number of models placed on the market in the segment of C1 tyres - 205/55 R16 - has a median weight of 8.5 kg, with values ranging from 7.6 kg to 10.1 kg.⁷⁵

5079

Feedback from stakeholders (1st Stakeholders consultation, 2025) as compiled in **Table 7-10** suggest average weights and ranges and show an overall good alignment with our evaluation.

5081

Table 7-10: Average weight and ranges in the weight of C1 tyres as suggested by stakeholders.

| Stakeholder | Average weight [kg] | Minimum weight [kg] | Maximum weight [kg] |
|------------------------|---------------------|---------------------|---------------------|
| Stakeholder 1 | 9 | 7.5 | 16 |
| Stakeholder 2 | 10.7 | 4.9 | 19.3 |
| Stakeholder 3 | N/A | 6.5 | 10 |
| Stakeholder 4 | 10 | 7 | 15 |
| Stakeholder 5 | 10.5 | 4.5 | 29.4 |
| <i>This evaluation</i> | <i>10.6</i> | <i>5</i> | <i>17</i> |

5082

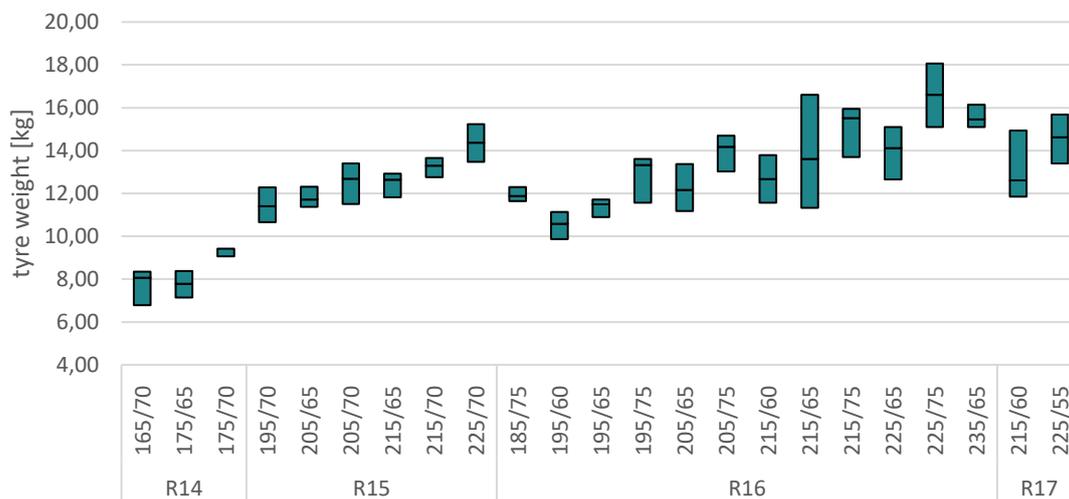
⁷⁵ Based on the evaluation of 78 models, as provided by ADAC (ADAC, 2025a)

5083 **C2 tyres**

5084 C2 tyres show less variability compared to C1 tyres. A total of 26 tyre geometries accounts for
 5085 70% of all C2 tyres placed on the market in years 2020-2024⁷⁶. The majority of these tyres are
 5086 found in rim diameters R15 and R16, with only a limited number of models available in the R14
 5087 and R17 segments. Other rim diameters are of minor relevance for C2 tyres.

5088 Tyre weights for these 26 geometries were determined using data from the Testsieger website
 5089 (Testsieger.de Vergleichsportal GmbH, 2025). The same methodology as for C1 tyres was
 5090 applied: only all-season tyres were considered, and five models were evaluated per tyre
 5091 geometry.

5092 The results are presented in **Figure 7-16**. The lower bound represents the minimum tyre weight,
 5093 the horizontal line in the box represents the median and the upper bound represent the
 5094 maximum tyre weight. The tyre weight ranges between ~7 to 18 kg.



5095

5096 **Figure 7-16: Tyre weights of relevant C2 tyre geometries.**

5096

5097

Source: own evaluation based on data from (Testsieger.de Vergleichsportal GmbH, 2025).

5098 To determine an average weight of C2 tyres, the median tyre weights presented in **Figure 7-16**
 5099 can be weighted according to the number of models placed on the market, as recorded in the
 5100 EPREL database. **Based on this approach, the weighted average weight of a C2 tyre is calculated**
 5101 **to be 13.1 kilograms.** For comparison, the tyre geometry with the highest number of models
 5102 placed on the market in the segment of C2 tyres - 235/65 R16 - has a median weight of 15.5 kg,
 5103 with values ranging from 15.1 kg to 16.1 kg.

5104 Feedback from stakeholders on the weight of C2 tyres, as presented in **Table 7-11**, shows an
 5105 overall good alignment with regard to the average and minimum weight. The maximum weight
 5106 is however considered to be higher. This is plausible, given that rim diameters above 17 inches
 5107 were not taken into account.

⁷⁶ For the remaining 30 % of tyre geometries less than 100 models are found in the EPREL database per geometry.

5108 **Table 7-11: Average weight and ranges in the weight of C2 tyres as suggested by stakeholders.**

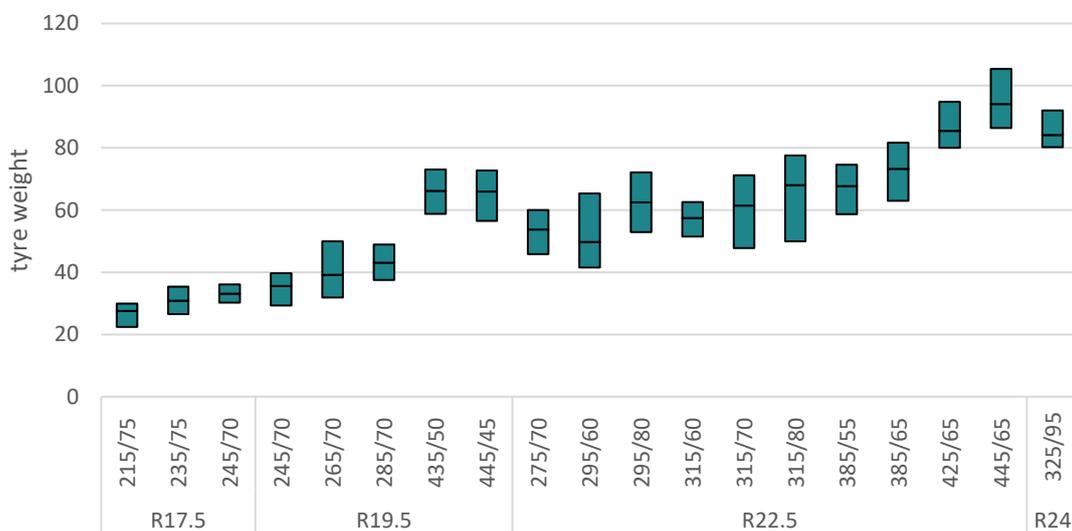
| Stakeholder | Average weight [kg] | Minimum weight [kg] | Maximum weight [kg] |
|------------------------|---------------------|---------------------|---------------------|
| Stakeholder 1 | 12.2 | 6.2 | 23.1 |
| Stakeholder 2 | N/A | 20 | 45 |
| Stakeholder 3 | 12 | 8 | 20 |
| Stakeholder 4 | 13.5 | 5.27 | 31.9 |
| <i>This evaluation</i> | <i>13.1</i> | <i>7</i> | <i>18</i> |

5109

5110 **C3 tyres**

5111 C3 tyres are primarily mounted on rims with diameters of 17.5, 19.5, and 22.5 inches. The tyre wholesaler and reseller Heuver Tyres (Heuver Tyrewholesale, 2025) provided the consultants
 5112 wholesaler and reseller Heuver Tyres (Heuver Tyrewholesale, 2025) provided the consultants
 5113 with a comprehensive list of tyre weights for all truck tyres available on their website. By
 5114 analysing 19 different tyre geometries, approximately 90 % of all truck tyres placed on the
 5115 market between 2020 and 2024—as recorded in the EPREL database—were covered.⁷⁷

5116 The results are presented in **Figure 7-17**. The lower bound represents the minimum tyre weight,
 5117 the horizontal line in the box represents the median and the upper bound represent the
 5118 maximum tyre weight. The tyre weight ranges between ~22 to 105 kg, while two thirds of tyre
 5119 geometries placed on the market hold a weight between 40-75 kg.



5120

5121 **Figure 7-17: Tyre weights of relevant C3 tyre geometries.**

5122 Source: own evaluation based on data from (Heuver Tyrewholesale, 2025).

5123 To determine an average weight of C3 tyres, the median tyre weights presented in **Figure 7-17**
 5124 can be weighted according to the number of models placed on the market, as recorded in the

⁷⁷ For the remaining tyre geometries less than 100 models are found in the EPREL database per geometry.

5125 EPREL database. Based on this approach, **the weighted average weight of a C3 tyre is calculated**
 5126 **to be 58.4 kilograms.** For comparison, the tyre geometry with the highest number of models
 5127 placed on the market in the segment of C3 tyres - 315/80 R22.5 - has a median weight of 67.8
 5128 kg, with values ranging from 57 kg to 78 kg.

5129 Stakeholders' responses on the weight of C3 tyres, as presented in **Table 7-12** can overall
 5130 confirm the average weight and the ranges determined in our evaluation.

5131 **Table 7-12: Average weight and ranges in the weight of C3 tyres as suggested by stakeholders.**

| Stakeholder | Average weight [kg] | Minimum weight [kg] | Maximum weight [kg] |
|------------------------|---------------------|---------------------|---------------------|
| Stakeholder 1 | 55.1 | 18.2 | 94.7 |
| Stakeholder 2 | N/A | 45 | 113 |
| Stakeholder 3 | 50 | 30 | 110 |
| Stakeholder 4 | 58 | 24 | 148 |
| <i>This evaluation</i> | <i>58.4</i> | <i>22</i> | <i>105</i> |

5132 7.4.1.4. Tyre weights of other tyres

5133 For other tyre types, the tyre weights can only be approximated. The tyre weight of **motorcycles**
 5134 **and mopeds** was estimated by one stakeholder to be between 4 to 9 kg (1st Stakeholders
 5135 consultation, 2025). **Bicycle tyres** can weigh less than half a kg (road bikes) but can weigh more
 5136 than 2 kg for fat bikes. **OTR tyres and agricultural tyres** may be used for many different purposes
 5137 and their range can lie anywhere between ~10 kg (e.g. for mowers) up to several hundred kg
 5138 (Heuver Tyrewholesale, 2025). The Secretariat of the Basel Convention (2024) gives a range of
 5139 136-454 kg for agricultural tyres and 1286-2784 kg for mining tyres. For **aircraft tyres** an average
 5140 weight can be approximated from tyres imported into the EU by taking into account two
 5141 different Eurostat databases⁷⁸ (Eurostat, 2025f, 2025b), giving an approximate weight of 37 kg
 5142 per tyre. The range is however expected to be very wide, e.g. low-weight tyres for small aircrafts,
 5143 e.g. a Cessna would lie in the range of 10-20 kg, while the weight for large military and cargo
 5144 aircrafts is in the range of several hundred kg.

5145 7.4.2. Assessment of the manufacturing process

5146 This section presents the manufacturing process of tyres and incorporates the sections on the
 5147 primary waste production in the realm of tyre production (qualitative) and the energy demand
 5148 in the manufacturing process (quantitative). The provided process is mainly apt for C1, C2, and
 5149 C3 tyres and may not be apt for other tyre types (especially airplane and bike tyres).

⁷⁸ One database gives all extra EU imports in kg, while the other uses items. For aircraft tyres there is a perfect match for both databases, while for other tyre types, this is not the case.

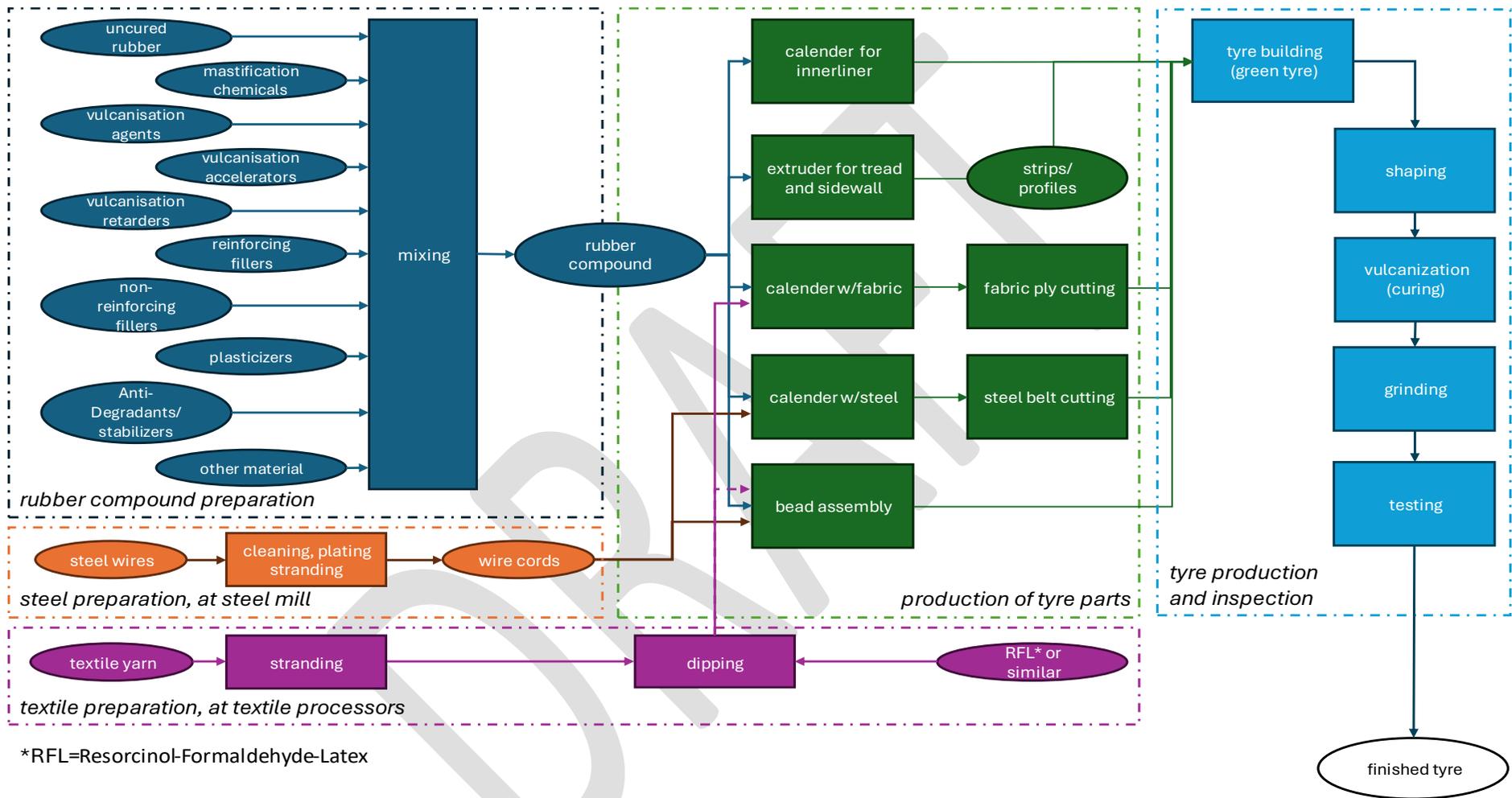
5150 7.4.2.1. Overview on the tyre production process

5151 Tyre production may be separated into:

- 5152 • Rubber, steel and textile preparation
- 5153 • The production of tyre parts such as the inner liner, the bead, the tread, the sidewalls,
5154 the carcass etc. and
- 5155 • the tyre production and inspection

5156 **Table 7-18** presents a simplified process scheme of the production of tyres, starting with the
5157 preparation of the materials used and ending with the finished tyre. Depending on the tyre type
5158 the process scheme may show deviations.

DRAFT



5159

5160

Figure 7-18: Simplified depiction of the tyre manufacturing process, highlighting most important process steps and flows (own illustration).

5161 7.4.2.2. Rubber compound preparation

5162 In the mixing room, raw uncured rubber—comprising both natural and synthetic types—is
5163 combined with various additives and chemicals. Mastication agents and plasticisers are
5164 introduced to reduce viscosity, improve flowability, and enhance overall mixing efficiency.
5165 Vulcanisation agents are added to enable the crosslinking of rubber macromolecules, while
5166 vulcanisation accelerators speed up the vulcanisation process. At the same time, retarders are
5167 incorporated to delay the onset of vulcanisation until the appropriate stage. Active, reinforcing
5168 fillers are used to improve the mechanical properties of the compound, whereas non-reinforcing
5169 fillers serve primarily as extenders. Finally, antioxidants and stabilisers are included to protect
5170 the material against embrittlement, wear, fatigue, and degradation over time (Engels et al.,
5171 2011). Depending on the final purpose and properties of the rubber compound further materials
5172 may be introduced but the referenced material groups may be considered as the most relevant
5173 ones.

5174 Mixing in tyre compound production is typically carried out in multiple stages, including several
5175 masterbatch cycles followed by a final mixing stage. Some materials are introduced in later
5176 stages (especially vulcanisation agents to prevent premature vulcanisation, but also anti-
5177 degradants, anti-ozonants)⁷⁹. Typically, internal mixers are used (ICONVEY, 2022)⁸⁰. Depending
5178 on the application and compound formulation, various internal mixer types are available. The
5179 most commonly used in tyre production are Banbury (tangential-rotor) mixers and intermeshing
5180 (e.g. twin-screw or Shaw-type) mixers (Limper, 2011)⁸¹. The mixer, which may be considered as
5181 the heart of the mixing room is attached to a periphery, which (simply put) comprises storage
5182 tanks, weighing systems, and feeding aggregates for the different raw materials used in rubber
5183 compound production (ICONVEY, 2022). Additionally filter systems are in place to mitigate dust
5184 and volatile organic compounds emissions to the environment.

5185 Material leaving the mixer through the discharge door is a hot (~100 °C), unshaped rubber
5186 compound mass—often referred to as a batch—which is immediately sent for further
5187 processing.

5188 Primary waste produced during rubber compound preparation may include (Öko-Institut e.V.,
5189 1995):

- 5190 • Start up and end-of-run waste, remaining in the mixers after completion of a batch or
5191 before reaching steady state,⁸² typically apt for energy recovery.

⁷⁹ While the first stages employ higher temperatures at around 160-170°C to allow for proper dispersion, the temperature is decreased to ~100 °C once vulcanisation agents and accelerators are introduced.

⁸⁰ For soft compounds and in small-scale settings roll mills may be an alternative. Also some mixing may be done in an extruder (Goodyear Rubber, 2023).

⁸¹ With the rise of silica technology, tandem mixer systems became more common. They combine two intermeshing mixers to improve dispersion and enable salinisation.

⁸² Raw, uncured rubber (sacrificial rubber) is sometimes used for cleaning the mixer (rubber purging), given its high adhesion. It physically picks up contaminants and residues stuck to rotors, walls, and drop doors. The contaminated cleaning batch is then discarded as waste.

- 5192 • Rubber compound batches that do not meet the quality control criteria, typically apt for
5193 energy recovery.
- 5194 • Cleaning agents (e.g., solvents and oils contaminated with rubber compounds), waste
5195 management depending on cleaning agent.
- 5196 • Waste from filter systems (dust from powdery material and wastewater and sludge, if a
5197 wet scrubber is installed), waste management depending on filtered material.
- 5198 • Sealing oils from dust sealing rings.
- 5199 • Spillage and packaging material of delivered raw materials.

5200 7.4.2.3. Steel preparation

5201 For tyre production, fine wires are drawn, cleaned, and coated (typically with brass, sometimes
5202 with bronze). The fine wires (<<1 mm) are then stranded according to the tyre design
5203 specifications (Tashiro & Tarui, 2003). Steel mills deliver the coated wire cords as coils to the
5204 tyre manufacturer (Continental Reifen Deutschland GmbH, n.d.-f). At the manufacturing plant
5205 steel cords are embedded in thin rubber layer called the “skim stock”. Cobalt salts are mixed
5206 into this skim stock to promote adhesion between rubber and steel (Umicore, n.d.).

5207 7.4.2.4. Textile preparation

5208 Textile yarn is stranded and is often dipped/impregnated (RFL⁸³ is widely used) to increase
5209 adhesion to rubber and to allow for flexibility and strength of the rubber-textile matrix.
5210 Impregnated textile fabric is sold as such to the tyre manufacturer (MAXXIS Sweden, n.d.;
5211 Pehlivan et al., 2025).

5212 7.4.2.5. Production of tyre parts

5213 Tyre production is described in the literature, by tyre producers or resellers (Fragassa & Ippoliti,
5214 2016; ICONVEY, 2022; MAXXIS Sweden, n.d.). The production of tyre parts requires defined
5215 profiles. The rubber compound batch leaving the mixer undergoes shaping (via rolling mills
5216 and/or extruders), grinding, cooling (e.g. in batch-off lines sometimes combined with wig-wag
5217 systems or by passing through a water tank) and sometimes aging. Depending on the tyre
5218 component, rubber is calendered (process of embedding steel cords or textile fabrics into rubber
5219 sheets) with steel or textile cords. Tyres typically consist of 15-30 components. Below describes
5220 the production of the main tyre parts:

- 5221 • Steel belts are produced by embedding steel cords into rubber using a calendering
5222 process. The cords are fed under tension through rollers where rubber is applied on all
5223 sides to create a composite sheet. The sheet is then cut into specific shapes and angles
5224 to fit the tyre structure.

⁸³ Resorcinol Formaldehyde Latex

- 5225 • Tread and sidewall components are created by extruding heated rubber compounds
 5226 through screw-type extruders. For tread, multiple rubber compounds are merged and
 5227 shaped through a die before being cooled and cut to length. Sidewalls are similarly
 5228 extruded but often require more complex machinery, especially when incorporating
 5229 whitewalls or lettering.
- 5230 • Ply production involves embedding textile or steel cords into rubber sheets through
 5231 calendering. Textile and steel cords are calendered under controlled tension. Cotton
 5232 yarns are often integrated to indicate fibre direction and absorb residual moisture. The
 5233 resulting ply sheets are cut to required specifications and serve as the structural
 5234 backbone of the tyre, providing strength and flexibility.
- 5235 • The inner liner is produced via calendering, where the rubber is formed into thin sheets
 5236 with precise thickness and surface quality. The sheets are pre-cut and stored.
- 5237 • Bead assembly production involves the coiling of steel wire into continuous loops
 5238 (without welding), which are then coated with rubber. These loops are assembled using
 5239 automated machines that position and shape the wire into consistent, circular forms. A
 5240 hard rubber compound is extruded and shaped into a wedge to form the bead filler,
 5241 which is combined with the wire loops during assembly.
- 5242 Primary waste during the production of tyre parts may comprise (Öko-Institut e.V., 1995):
- 5243 • Rubber waste, partly reinforced with steel and textiles from start-up, trimmings or
 5244 rejects (off-spec), typically apt for energy recovery.
- 5245 • Textile and steel cord waste from trimming or leftovers, apt for energy or material
 5246 recovery.
- 5247 • Rubber solutions from immersion and spray baths for bead rings, treads, side walls, etc.
- 5248 • Cooling water, to wastewater treatment plants.

5249 7.4.2.6. Tyre production and inspection

5250 Although tyre manufacturing has increasingly moved toward automated assembly to enhance
 5251 speed, precision, and reproducibility—and to accommodate the growing variety of tyres in
 5252 manufacturers’ portfolios—the fundamental steps of tyre building have not changed radically
 5253 over the years. The tyre components are prepared and assembled to a non-vulcanised structure,
 5254 referred to as green tyre. Drum-based machines are typically used for this purpose. Green tyre
 5255 assembly may be separated into two main stages, (i) the carcass construction, and (ii) the belt,
 5256 tread and sidewall application. During the first stage the inner liner⁸⁴ is first applied on the drum.
 5257 Subsequently, the textile or steel plies are wrapped around the drum. Afterward the bead
 5258 assembly is positioned at the edges of the plies. Finally, the plies are folded over the beads to
 5259 stabilise the structure. Depending on the tyre type additional rubber layers are added to
 5260 complete the carcass profile. Within the second stage the belt layers and the tread strip⁸⁵ (on
 5261 top of the belt layers) are applied to the carcass, which is inflated during this step. Finally, the

⁸⁴ In case of a tubeless tyre.

⁸⁵ At this point the tread strip does not show or only shows a very limited profile.

5262 side walls are attached to the outer side of the carcass. After all tyre components are in place
5263 the assembly is pressed together to ensure adhesion and to expel trapped air (Fragassa &
5264 Ippoliti, 2016).

5265 Finally, the tyre undergoes curing (vulcanisation)⁸⁶. A rubber bladder (bellow) is inserted into
5266 the green tyre and is then placed in a heated mould. The bladder is inflated, and the mould
5267 shapes the tyre to its final dimensions and imprints the tread pattern onto its surface. The
5268 process is a batch process and depending on the process parameters and the tyre size curing
5269 takes several minutes up to hours. During this process, high temperature (~150 °C) and pressure
5270 (20-30 bar) initiate cross-linking between rubber molecules, transforming the green tyre into a
5271 durable, elastic product (Maxxis Tyres Australia, n.d.; Michelin UK, 2020).

5272 Tyres are inspected prior to vulcanisation and after vulcanisation to ensure the quality of the
5273 tyres. X-Ray machines, uniformity and balance testing machines are among typical testing
5274 methods to identify faulty tyres. Visual or tactile inspections by humans is also part of the quality
5275 control test. In-depth testing is carried out for randomised samples (ICONVEY, 2022; Michelin
5276 UK, 2020).

5277 Primary waste during the tyre production and inspection may contain (Öko-Institut e.V., 1995):

- 5278 • Rejected tyres (off-spec).
- 5279 • Spent heating bellows (expandable components inside the curing press that help apply
5280 heat and pressure uniformly to the inner surface).
- 5281 • Spent tyre release/separating agents (spraying solutions).
- 5282 • Blast media residues can be generated during the cleaning of the heated press moulds.
- 5283 • Shavings from tyre vents (also known as “vent spews”, “sprue nubs”, “tyre nibs”) that
5284 are sometimes removed from the tyres before shipping.

5285 7.4.2.7. Assessment of the energy use, waste production and water 5286 discharge of manufacturing

5287 Data on the energy use during production of tyres is scarce. Stankevičiūtė (2000) analysed the
5288 energy flows during tyre manufacturing in Trelleborg, Sweden, and shows that preparation of
5289 rubber compound (i.e. mixing, milling, and extruding of rubber) accounts for ~20 % of the total
5290 energy demand (mainly electricity) and tyre pressing for 76 % of the total energy demand
5291 (mainly thermal energy). For the production of a radial tyre in China, (Sun et al., 2016) states an
5292 energy demand of 0.47 kWh electricity and 1.33 kWh natural gas per kg of tyre. An Indian tyre
5293 production plant used 1.01 kWh steam and 0.75 kWh (Shanbag & Manjare, 2020). In their ESG
5294 Report Hankook Tire, states 2.76 kWh/kg of finished tyre were required (Hankook Tire &
5295 Technology, 2025). Approximately 46 % of the total energy is electricity, 0.8 % renewable energy,
5296 while ~13 % are declared as purchased steam and ~40 % as “fuel”. Similarly, Bridgestone reports

⁸⁶ By definition, vulcanisation is a form of curing. Curing is the general term for cross-linking polymers, while vulcanisation is the specific sulphur-based curing process used for rubber. Sulphur vulcanisation is typically used for tyres.

5297 for 2024 an energy intensity of ~2.9 kWh per kg of input material (Bridgestone Corporation,
 5298 2025)⁸⁷. Continental states an energy consumption of 8,224 GWh for 2024 and a material and
 5299 product consumption of 3.7 million t, resulting in 2.2 kWh of energy per kg of input material
 5300 (Continental, 2024a). The latter values from Bridgestone and Continental however must be
 5301 carefully used, because they account for the entire companies' energy demand, not only those
 5302 associated with tyre production. However, a tyre manufacturer confirms an energy demand of
 5303 2-3 kWh per kg of finished tyre (*Stakeholder Interview SR8*, personal communication, 2025).

5304 ESG Reports from Hankook and Bridgestone also reveal data on waste treatment, water
 5305 withdrawal and discharge:

- 5306 • According to Hankook 44 kg of solid waste are produced per t of finished product
 5307 (Hankook Tire & Technology, 2025), with ~80 % being recycled. Bridgestone states that
 5308 77 kg of solid waste are produced per t of material input (Bridgestone Corporation,
 5309 2025), with 95 % being recycled.
- 5310 • According to Hankook 4.79 m³ of water are withdrawn per t of finished product
 5311 (Hankook Tire & Technology, 2025), while Bridgestone states that 16.8 m³ of water
 5312 withdrawal per t of material input, including seawater; excluding seawater the intensity
 5313 is 7.1 m³/t of product (Bridgestone Corporation, 2025).
- 5314 • Water discharge is measured at 1.57 m³/ t at Hankook (Hankook Tire & Technology,
 5315 2025), while similar data is not found in the Bridgestone report.

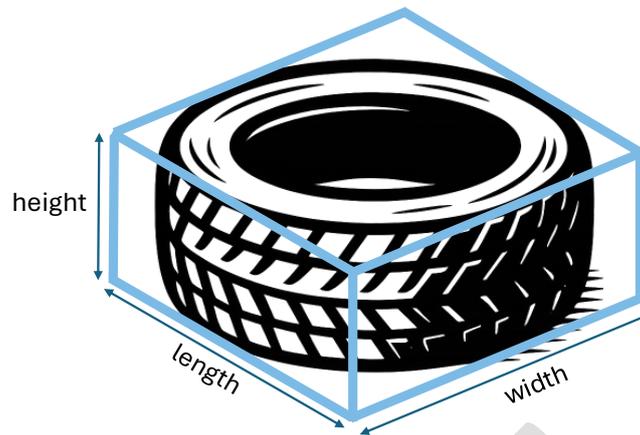
5316 7.4.3. Packaging materials

5317 Based on an exchange with ITMA (ITMA, personal communication, 18 June 2025), tyres generally
 5318 require minimal packaging. For C1, C2, and C3 tyres, no packaging material is typically used
 5319 except for shrink-wrapping (low-density polyethylene plastic film) to prevent them from falling
 5320 over. Pallets may be used, but only for air transport, which accounts for less than 1 % of
 5321 shipments. High-end bicycle tyres are packaged, though most manufacturers have transitioned
 5322 to materials such as cardboard. Individual tyre packaging is primarily used for shipments to the
 5323 Middle East. Smaller tyres, such as those for scooters and bicycles, may include some packaging,
 5324 and inner tubes are usually packed in boxes.

5325 7.4.4. Volume and weight of the packaged product

5326 Given that the packaging material has a negligible weight, the packaged weight is effectively
 5327 equal to the tyre weight. To estimate the packaged volume, it is initially approximated that the
 5328 tyre occupies the volume of a bounding box (cuboid), as shown in **Figure 7-19**.

⁸⁷ The amount of sold products is not available



5329

5330 **Figure 7-19: Approximation of the volume a tyre occupies (own illustration).**

5331

Source: tyre pictogram created by Sora (OpenAI, 2025).

5332 Based on the tyre marking format defined by UNECE standards — [width]/[aspect ratio] [rim
5333 diameter] — the tyre volume can be calculated using **Equation 7-1** and **Equation 7-2**⁸⁸. For
5334 example, for a tyre labelled 205/55 R16, the nominal width is 205 mm, and the sidewall height
5335 is calculated as 55 % of the width. The overall diameter of the tyre is approximately 631.9 mm.
5336 This results in a total volume of approximately 81.9 litres per tyre.

$$\mathit{height}_{\mathit{cuboid}}[\mathit{mm}] = \mathit{width}_{\mathit{tyre}}[\mathit{mm}] \quad \text{Equation 7-1}$$

$$\mathit{width}_{\mathit{cuboid}}[\mathit{mm}] = \mathit{lenght}_{\mathit{cuboid}}[\mathit{mm}] = \mathit{rim} - \mathit{diameter}[\mathit{inch}] \cdot 25.4 \frac{\mathit{mm}}{\mathit{inch}} + \mathit{aspect\ ratio} \cdot \mathit{width}[\mathit{mm}] \cdot 2 \quad \text{Equation 7-2}$$

5337 Shrink wrap foil, if used, has a negligible impact on the packaged product's volume and weight.
5338 Assuming a maximum thickness of 100 µm and a material density of approximately 1 g/cm³, fully
5339 wrapping a 205/55 R16 tyre (including tread, top and bottom) requires about 1 m² of foil. This
5340 corresponds to a volume of roughly 0.3 litres and a weight of approximately 100 grams. This may
5341 be considered as worst case, since the thickness is at the upper bound and because normally
5342 more tyres are wrapped together, rather than each tyre individually.

5343 A standard Euro pallet (EUR 1) has dimensions of 1.2 m x 0.8 m x 0.144 m (equals ~1.1 m³) and
5344 a typical weight of 20-25 kg. Depending on how many tyres are stacked on a pallet the overall
5345 weight and volume of the packaged product can be significantly affected.

5346 7.4.5. Actual means of transport employed in shipment of 5347 components, sub-assemblies and finished products

5348 Raw materials, especially those required for the rubber compound production and semi-finished
5349 products, most importantly steel and impregnated textile cords are transported to the tyre
5350 manufacturers. (Large) tyre manufacturers develop and mix their own rubber compounds in-

⁸⁸ Applicable for C1, C2, and C3 tyres.

5351 house, produce tyre components and assemble and cure tyres.⁸⁹ Tyre manufacturers distribute
5352 finished tyres to OEMs and the aftermarket (replacement tyres).

5353 This section covers the modes of transportation for shipping of the main raw materials within
5354 and into the EU (if the tyre is produced in the EU and raw materials are shipped from outside
5355 the EU). Rubber, steel and textiles are covered as well as the volumes of materials produced in
5356 the EU, imported and exported.

5357 For the finished product (i.e. the tyre) modes of transportation are considered for shipping into
5358 the EU, outside the EU and within the EU.

5359 7.4.5.1. Raw material stage

5360 Main raw materials (by mass) required for tyres are natural and synthetic rubber as well as
5361 carbon black.

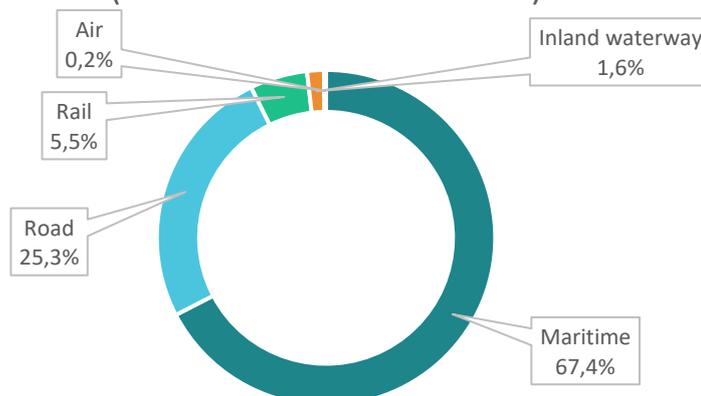
5362 **Natural rubber** is not produced in the EU. Instead, it is sourced in Southeast Asia, West Africa
5363 and South America, while 85 % of the total EU imports stem from Indonesia, Malaysia and Côte
5364 d'Ivoire. 85 % of natural rubber is collected by smallholder farmers, who sell latex to ~100,000
5365 local dealers and traders. Latex is then refined in ~500 processing facilities to rubber. 80 % of
5366 the rubber processed originates from within a 150–200 km radius of the processing plant⁹⁰,
5367 while about 15 % comes from distances between 200–500 km, and only 5 % from beyond
5368 500 km. Transport by trucks or similar may be assumed. From the processing plants pre-treated
5369 rubber is locally shipped directly or via traders (ETRMA, 2022a; JRC, 2020) .

5370 Statistical data collected by Eurostat as given in **Table 7-13** shows that natural rubber enters the
5371 EU primarily via maritime transport. The most relevant natural rubber stream is technically
5372 specified natural rubber (TSNR). Transport within the EU is not given per product group in
5373 statistical data. Aggregated data on the modal split within the EU (not specific to rubber or tyres
5374 in general), as shown in **Figure 7-20**, suggests that inland transport by road and to a smaller
5375 extent by rail within the EU is plausible.

⁸⁹ Smaller manufacturers may outsource rubber mixing or the production of components.

⁹⁰ Latex is coagulated, dried or smoked and then graded and packed.

Freight transport- Modal split in EU in 2023 (based on tonne-kilometres)



5376

5377 **Figure 7-20: Modal split for freight transport in the EU based on tonne-kilometres.**

5378

Source: (Eurostat, 2025c).

5379 The larger share of **synthetic rubber**, excl. latex and **carbon black** and other forms of carbon is
 5380 produced within the EU, while the remaining share is imported. **Table 7-13** shows the
 5381 distribution in production, imports and exports for carbon and synthetic rubber. In 2024, main
 5382 importers of carbon black⁹¹ to the EU were Russia (25 %), China (18 %), India (16 %) and Egypt
 5383 (13 %). For synthetic rubber⁹² main importers in 2024 the main importers to the EU where the
 5384 US (22 %), Japan, China and Russia (each 9 %), the UK (8 %), Saudia Arabia (6 %) and Taiwan (5
 5385 %). (Eurostat, 2025f) The modes of transportation employed for Extra-EU imports of synthetic
 5386 rubber, excl. latex and carbon black and other forms of carbon are detailed in **Table 7-13**. For
 5387 synthetic rubber and carbon black produced within the EU, modes of transportation can be
 5388 taken from **Figure 7-20**. For inland transport of imported goods, the same modal split excluding
 5389 maritime transport is proposed.

5390 7.4.5.2. Sub-assemblies and intermediate components

5391 It is assumed that within the Eurostat database, **steel cords** that are used for tyre production
 5392 are either reflected by “Wire of iron or non-alloy steel, in coils, plated or coated” or “Stranded
 5393 wire, ropes and cables, of iron or steel”. The latter is comprehensively covered across relevant
 5394 Eurostat databases. Relevant shares of stranded steel (~40 %) are imported into the EU as shown
 5395 in **Table 7-13**. Main imports of stranded steel outside the EU stem from Vietnam (42 %), China
 5396 (34 %), Turkey (14 %), and South Korea (6 %) (Eurostat, 2025f).

5397 **Textiles** used for tyres are reflected by “Tyre cord fabric” in the Eurostat Database. Tyre cord is
 5398 predominantly imported into the EU, as can be seen in **Table 7-13**. The majority of textile cords

⁹¹ Eurostat product: “Carbon "carbon blacks and other forms of carbon", n.e.s.”.

⁹² Eurostat product: “Synthetic rubber and factice derived from oils, in primary forms or in plates, sheets or strip; mixtures of natural rubber, balata, gutta-percha, guayule, chicle or similar types of natural rubber with synthetic rubber or factice, in primary forms or in plates, sheets or strip”.

5399 shipped into the EU stems from China (36 %), Turkey (14 %), Vietnam (12 %), Thailand (11 %),
5400 South Korea (9 %) and India (6 %) (Eurostat, 2025f).

5401 **Table 7-13** shows the modes of transportation for stranded wires and textile cords. For stranded
5402 steel and textile cords produced within the EU, modes of transportation within the EU can be
5403 taken from **Figure 7-20**. For inland transport of imported goods, the same modal split excluding
5404 maritime transport is proposed.

5405 **Table 7-13: Shares of production, import and export of carbon, synthetic rubber, tyre cord
5406 fabrics, and stranded wire in the EU in 2023; and modes of transportation employed for extra-
5407 EU imports of natural rubber, carbon black, and synthetic rubber in 2024; based on net mass.**

| Product/Raw material | Share of imports, own production and export in the EU | | | Modes of transportation for extra-EU import | | | | |
|---|---|-----------|---------|---|--------|--------|-------|-------|
| | Import | Own prod. | export | Sea | Rail | Road | air | other |
| Natural Rubber ^a | Not covered in the Eurostat database | | | 89.1 % | 7.9 % | 2.7 % | 0.3 % | 0.0 % |
| Carbon blacks and other forms of carbon | 29,1 % | 85,7 % | -14,8 % | 63.7 % | 6.9 % | 28.9 % | 0.5% | 0.5 % |
| Synthetic rubber and factice | 47,9 % | 85,0 % | -32,9 % | 78.8 % | 1.5 % | 19.0% | 0.7% | 0.7 % |
| Tyre cord fabric ^b | 63,2 % | 47,7 % | -10,9 % | 72,2 % | 11,4 % | 15,9 % | 0,4 % | 0,0 % |
| Wire of iron or non-alloy steel, in coils, plated or coated | Not covered in the Eurostat database | | | 71,0 % | 4,4 % | 24,3 % | 0,0 % | 0,0 % |
| Stranded wire, ropes and cables, of iron or steel | 38,5 % | 82,4 % | -20,9 % | 78,2 % | 4,0 % | 17,0 % | 0,3 % | 0,0 % |

5408 ^{a)} Includes smoked sheets of natural rubber; technically specified natural rubber "TSNR"; natural rubber
5409 in primary forms or in plates, sheets or strip; natural rubber latex, whether or not prevulcanised.

5410 ^{b)} Tyre cord fabric of high-tenacity yarn of nylon or other polyamides, polyesters or viscose rayon, whether
5411 or not dipped or impregnated with rubber or plastic.

5412 Sources: (Eurostat, 2025h) and (Eurostat, 2025b).

5413 7.4.5.3. Finished products

5414 **Finished tyres** may be distributed domestically and regionally (e.g. within Europe) or inside
5415 (imports to the EU from partner countries) and outside of Europe (exports from the EU to
5416 partner countries).

5417 In 2024, most new tyre imports to the EU (by mass) originated from China (41 %), followed by
5418 India (11 %), Turkey (9 %), and South Korea (8 %). EU tyre exports were primarily directed to the
5419 United States (22 %), the United Kingdom (19 %), Turkey (10 %), and Switzerland (7 %). The
5420 remaining 42 % of exports were distributed among various other countries, each accounting for

5421 less than 1 % of the total export volume (Eurostat, 2025f). Modes of transportation outside and
 5422 into the EU are given in **Table 7-14**. For tyre shipping within the EU, modes of transportation
 5423 within the EU can be taken from **Figure 7-20**.

5424 **Table 7-14: Modes of transportation for shipping of tyres outside and into the EU. Based on**
 5425 **net mass.**

| Mode of transport | tyres, new, total | for motor cars | for buses and lorries | for aircraft | for motorcycles | for bicycles | for agricultural/forestry vehicles | mining/industrial handling vehicles and machines | others |
|-------------------|-------------------|----------------|-----------------------|--------------|-----------------|--------------|------------------------------------|--|--------|
| Imports | | | | | | | | | |
| Sea | 84.0 % | 86.1 % | 77.2 % | 87.2 % | 76.8 % | 92.8 % | 85.6% | 92.5% | 90.1 % |
| Rail | 1.7% | 2.5% | 1.0% | 0.0% | 0.7% | 1.5% | 0.1% | 0.5% | 1.0% |
| Road | 13.5 % | 11.0 % | 21.5 % | 9.1% | 22.0 % | 3.4% | 10.4% | 5.8% | 7.5% |
| Air | 0.2% | 0.2% | 0.1% | 3.6% | 0.4% | 1.1% | 0.0% | 0.1% | 0.7% |
| Inland Waterway | 0.4% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 3.7% | 1.0% | 0.4% |
| Unknown | 0.2% | 0.3% | 0.2% | 0.0% | 0.1% | 1.3% | 0.2% | 0.1% | 0.3% |
| Exports | | | | | | | | | |
| Sea | 60.3 % | 56.7 % | 60.8 % | 32.5 % | 69.9 % | 40.9 % | 58.3% | 83.4% | 70.2 % |
| Rail | 2.7% | 3.3% | 2.9% | 0.2% | 0.4% | 1.0% | 0.3% | 0.2% | 1.5% |
| Road | 34.5 % | 36.6 % | 35.5 % | 44.6 % | 28.1 % | 52.1 % | 39.7% | 16.0% | 27.1 % |
| Air | 2.0% | 3.1% | 0.1% | 22.6 % | 1.0% | 5.9% | 0.2% | 0.2% | 1.2% |
| Inland Waterway | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Unknown | 0.4% | 0.2% | 0.7% | 0.0% | 0.6% | 0.1% | 1.5% | 0.2% | 0.1% |

5426 Source: (Eurostat, 2025b).

5427 7.4.6. Technical product life

5428 To support material efficiency requirements in Ecodesign product groups, a standard relating to
 5429 durability has been developed by CEN/CENELEC under EN 45552:2019, in which durability is
 5430 defined as the ability of a product to function as intended over a period of time. EN 45552:2019
 5431 is not specific to a product (horizontal standard), however, it was originally developed for
 5432 energy-related products. As such, certain aspects of its framework may not be fully suitable
 5433 when applied to tyres. One key example is the concept of "failure". In the context of EN
 5434 45552:2019, failure typically refers to sudden malfunctions—such as the breakdown of
 5435 electronic components or the obsolescence of software or hardware. Tyres, by contrast, are
 5436 consumable goods that gradually wear down through use. Maintaining structural integrity
 5437 throughout the tyre’s intended service life should be ensured and not compromised.

5438 Tyre service life is influenced by more than just active use or tread wear. Natural ageing
 5439 (especially oxidation causes a breakdown of the molecule structure), environmental factors

5440 (e.g., exposure to UV or heat) and driving conditions (e.g., punctures from sharp objects or
5441 sidewall damage caused by curb impacts) can also limit their lifespan. For example, a tyre on a
5442 rarely used vehicle may still appear to have sufficient tread but could degrade over time, making
5443 it unsuitable or unsafe for continued use despite low mileage. Tyre manufacturers often advise
5444 inspection of tyres after ~5 years and replacement after 10 years (e.g., Bridgestone Corporation,
5445 2021; Continental Reifen Deutschland GmbH, n.d.; Michelin, n.d.). Despite these considerations,
5446 the focus of this chapter will be on tread abrasion caused by driving, which may be considered
5447 the main cause and measurable contributor determining the EoL of tyres.

5448 According to Directive 89/459/EEC Tyres (for M1, N1, O1, and O2 vehicles) must not be used if
5449 their tread depths in the main grooves falls below 1.6 mm. According to this, the durability of
5450 tyres can be interpreted as the lifespan between the point of initial use (new tread depth⁹³) and
5451 the point at which the tread depth falls below the legal minimum of 1.6 mm⁹⁴. It is essential
5452 based on the usable tread height and the abrasion rate. Durability or wear testing is currently
5453 not standardised under the UNECE Regulation No 116. In the United States, the Uniform Tire
5454 Quality Grading (UTQG) system includes a treadwear rating, which is displayed on the tyre
5455 sidewall and serves as an indicator of the tyre's expected lifespan. In Europe, individual
5456 organisations, such as the ADAC (German automotive club) have developed standardised testing
5457 procedures to measure durability.

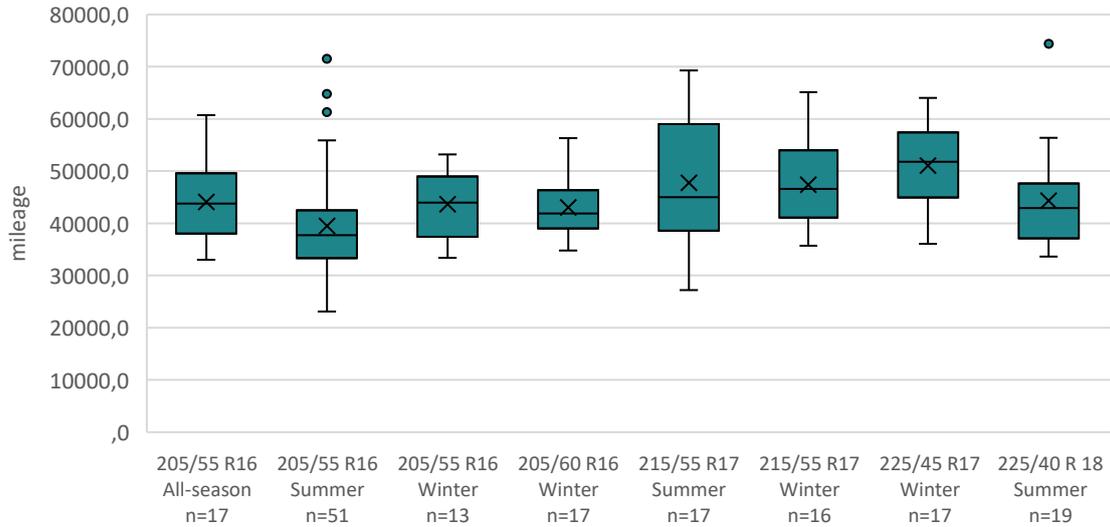
5458 7.4.6.1. C1 tyres

5459 As described in **Section 7.3.3** the ADAC conducts standardised tests on the abrasion levels for
5460 C1 passenger car tyres. On the basis of this test also mileage was determined. For five tyre
5461 geometries in the segment C1, the ADAC has provided the forecasted mileage up to the legal
5462 tread depth (ADAC, 2025a). Depending on the tyre, different seasonal types (i.e. summer,
5463 winter, all-season) were accounted for. In total 159 tyre models were tested. **Figure 7-21** shows
5464 the evaluation of the forecasted mileage in the form of boxplots. For each tyre geometry and
5465 seasonal type, the box represents the so-called IQR⁹⁵, with the horizontal line inside the box
5466 indicating the median mileage. Whiskers extend to 1.5 times the IQR, and any outliers are shown
5467 as individual points. The 'X' symbol represents the mean mileage.

⁹³ New C1 tyres usually have a tread depth of 7 to 9 millimetres, winter tyres can also have a tread depth of 10 millimetres when new. C3 tyres have typical tread depths between 14 and 25 mm, depending on whether they are steer or drive tyres.

⁹⁴ While some tyre manufacturers recommend replacing tyres before reaching the minimum tread depth, stakeholders found that the majority of ELTs are worn beyond the legal limit (*Stakeholder Interview SR8*, personal communication, 2025).

⁹⁵ 50 % of the data points are within the IQR.



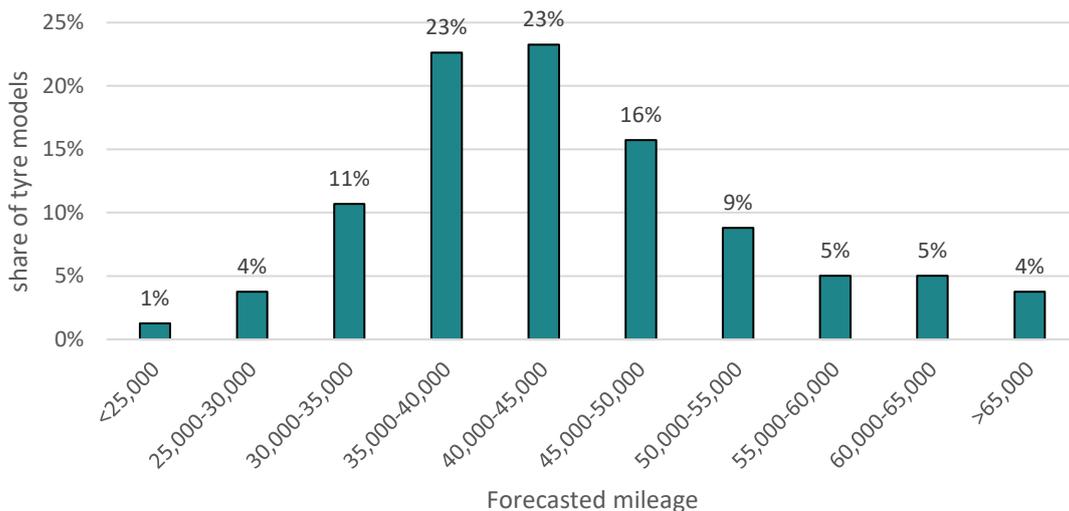
5468

5469 **Figure 7-21: Forecasted mileage of C1 tyres, separated by tyre geometry and seasons-type.**
 5470 **The number of models tested is indicated by “n”.**

5471 Source: own evaluation based on data from (ADAC, 2025a).

5472 More than 60 % of all tyres tested in the segment C1 show a forecasted mileage of 35,000-
 5473 50,000 km. Mileages beyond 60,000 km are achieved by less than 10 % of all tyres tested.
 5474 Notably 4 % of all tyres tested achieve mileages greater than 65,000 km. Top performers were
 5475 the summer tyre models “Doublecoin DC100” with a forecasted mileage of 74,400 km
 5476 (geometry: 225/40 R 18) and Michelin e.Primacy with a forecasted mileage of 71,500 km
 5477 (geometry: 205/55 R16). **Figure 7-22** shows the distribution in the forecasted mileage.

5478 It should be noted that the tyre life is dependent on the mounting position. Valentini & Pegoretti
 5479 (2022) state “[d]ata recorded from Michelin in the UK between 2006 and 2011 on passenger car
 5480 tyres (205/55 R16) showed that the average lifespan is around 36,554 ± 5851 km for tyres
 5481 mounted on the front axis and around 63,690 ± 8274 km for tyres mounted on the rear axis”.



5482

5483 **Figure 7-22: Distribution of the forecasted mileage based on testing of 159 C1 tyres.**

5484 Source: own evaluation based on data from (ADAC, 2025a).

5485

5486 Mileage of tyres is one of many properties a tyre needs to fulfil. This explains why tyres with a
5487 high forecasted mileage may though show a tendency towards higher costs but are not
5488 necessarily pricier. Also, budget tyres are found among tyres with a high forecasted mileage.
5489 Secondly mileage may compete with other tyre properties. Increased wet grip requires softer
5490 rubber compounds which are prone to wear out faster, similarly, silica improves wet grip but
5491 also reduces longevity. The introduction of the EU label has also driven tyre manufacturers to
5492 reduce rolling resistance. Reducing tread depth is one way to reduce rolling resistance, as deep
5493 tread blocks bend and deform more while rolling and thus absorbing energy. In turn this
5494 increases rolling resistance but also reduces mileage of tyres.

5495 7.4.6.2. C2 tyres

5496 No data on the mileage of C2 tyres through testing is presented in the literature and C2 tyres
5497 have not recently been tested by the ADAC. Given that C2 tyres are built with more robust
5498 rubber compounds and are often reinforced, it is plausible to assume higher lifetimes than for
5499 C1 tyres. Giechaskiel, Grigoratos, Mathissen, et al. (2024a) assume that the mileage of C2 tyres
5500 lies between those of C1 and C2 tyres and assume it to be 40,000-70,000 km.

5501 7.4.6.3. C3 tyres

5502 Mileage of truck tyres has not been assessed across different models and/or by standardised
5503 testing. The EEA for instance assumes a lifetime of 100,000 km for truck tyres (EEA, 2024).
5504 Giechaskiel, Grigoratos, Mathissen, et al. (2024a) on the other side assume mileages of 220,000
5505 km for truck tyres before needing replacement or retreading. Tyre resellers and experts judge
5506 that truck tyre lifespan varies widely based on position (steer, drive, trailer, all-position) and
5507 usage, with short-haul urban delivery trucks experiencing significantly more wear due to
5508 frequent braking, turning, and impacts from curbs and potholes—typically lasting between
5509 40,000 to 70,000 km. In contrast, long-haul trucks operating at steady speeds on highways can
5510 achieve much higher mileage, potentially up to 600,000 km when retreaded multiple times
5511 (around 150,000 km per use). Operating environment, driving behaviour, and maintenance are
5512 critical factors influencing tyre longevity (Autos Sp. z o.o., n.d.; Cottingham, 2018; Moine, 2025;
5513 RealTruck, n.d.).

5514 7.4.6.4. Other tyres

5515 Other tyres are not subject to standardised testing with regard to their mileage. Information
5516 from manufacturers, resellers, repair shops or experts can help in estimating the average
5517 mileage.

5518 The lifetime of **bicycle tyres** is subject to large variation. The following mileages are given by tyre
5519 producers and resellers:

- 5520 • 1,500 - 5,000 km (Škoda, 2024).

5521 • 2,000 – 5,000 km for standard tyres and 6,000 - 12,000 for premium tyres (Schwalbe |
5522 Ralf Bohle GmbH, n.d.).

5523 • 3,000-4,000 km (Vittoria S.p.A., 2023).

5524 • 1,000-5,000 km for road bike tyres (Performance Bicycle, n.d.).

5525 Depending on the motorcycle and its use, **motorcycle tyres** typically last between 5,000-25,000
5526 km (Neill, 2024).

5527 For **OTR tyres** the lifetime is not given in mileage but rather in hours. Bridgestone Europe NV/SA,
5528 (2021) anticipates the lifetime for **agricultural tyres** in the range of 2,000 hours and 3,500 hours
5529 for rear tyres and between 1,700 hours and 3,000 hours for front tyres. Celik, (2015) analysed
5530 the lifetime of tyres used on heavy duty vehicles and found that these tyres last for 6,000-8,000
5531 working hours. Naturally the lifetime of OTR tyres is heavily dependent on the use phase,
5532 especially on the surface being driven on.

5533 For **airplane tyres** the lifetime is referenced to the number of landings. Air Canada (commercial
5534 passenger flights) for instance states that tyres last between 300 and 450 landings and
5535 sometimes even up to 600 landings (Air Canada enRoute, 2021). This number is however only
5536 an indication, as many aspects factor in the lifetime of aircraft tyres, such as landing speed,
5537 breaking intensity, and particularly the aircraft weight (the heavier the airplane, the more stress
5538 is imposed on the tyres during landing).

5539 7.5. Overview on quantitative data of existing C1, C2 and 5540 C3 tyres

5541 To sum up results from **Sections 7.3** and **7.4** on quantitative (measurable) data, **Table 7-15** gives
5542 an overview.

5543

5544 **Table 7-15: Overview on quantitative data of C1, C2, and C3 tyres, regards their weight,**
 5545 **performance aspects, composition, manufacturing and distribution phase as well as the**
 5546 **product lifetime.**

| Parameter | | C1 | C2 | C3 |
|--|------------------------|--------------------------|-------------------------|-------------------------|
| Weight (min and max in brackets) [kg] | | 10 (5-29) | 13 (5-45) | 55 (22-148) |
| Average wet grip class (shares of tyre models reported in the EPREL database in reference years 2020-2024 in brackets) | | B (35.9 %) - C (37.2 %) | B (32.8 %) – C (42.8 %) | B (40.6 %) – C (49.1 %) |
| Average rolling resistance class (shares of tyre models reported in the EPREL database in reference years 2020-2024 in brackets) | | C (45.8 %) - D (39.1 %) | C (45.9 %)-D (43.7 %) | C (34.4 %)-D (47.5 %) |
| Average external noise class (shares of tyre models reported in the EPREL database in reference years 2020-2024 in brackets) | | B (90.9 %) | B (93.3 %) | B (93.3 %) |
| Share of tyres apt for severe snow | | 38 % | 43 % | 64 % |
| Share of reinforced tyres | | 63 % | - | - |
| Elemental composition [wt-%] | Natural rubber | 19.10 % | 20.20 % | 34.90 % |
| | Synthetic rubber | 24.10 % | 22.80 % | 10.50 % |
| | Carbon black | 20.30 % | 19.10 % | 21.70 % |
| | Silica | 7.30 % | 6.40 % | 2.50 % |
| | Sulphur | 1.30 % | 1.10 % | 1.70 % |
| | Zinc oxide | 1.90 % | 1.70 % | 2.70 % |
| | Plasticisers | 6.20 % | 4.40 % | 1.70 % |
| | Other additives/agents | 3.80 % | 5.70 % | 3.00 % |
| | Steel | 12.00 % | 12.50 % | 21.20 % |
| | Textiles | 4.00 % | 6.10 % | 0.00 % |
| Energy demand [kWh/kg tyre] | | 2-3 | | |
| Primary waste production (solid waste) [kg/t tyre] | | 40-80 | | |
| Water consumption [m ³ /t tyre] | | 5-7 (excluding seawater) | | |
| Packaging material | | Mainly negligible | | |
| Product lifetime (based on mileage) | | 40,000 (25,000-65,000) | 55,000 (40,000-70,000) | highly dependent on use |

5547

5548 7.6. Aspects of circularity

5549 Implementing circularity starts with ecodesigning durable, recyclable tyres and establishing
 5550 systems for maintenance, repair, and retreading to extend their life. This section focuses on
 5551 circularity aspects not covered earlier, including preparation for reuse and EoL treatment,
 5552 alternative tyre materials, and the management of substances of concern and critical raw
 5553 materials. These aspects primarily affect the manufacturing and EoL phases, rather than the use
 5554 phase, which is discussed in detail in **Section 7.3**. Circular tyre systems save raw materials,
 5555 reduce waste, lower costs for vehicle operators through fewer replacements and reduced
 5556 energy use, and contribute to environmental goals by cutting greenhouse gas emissions and tyre
 5557 wear pollutants.

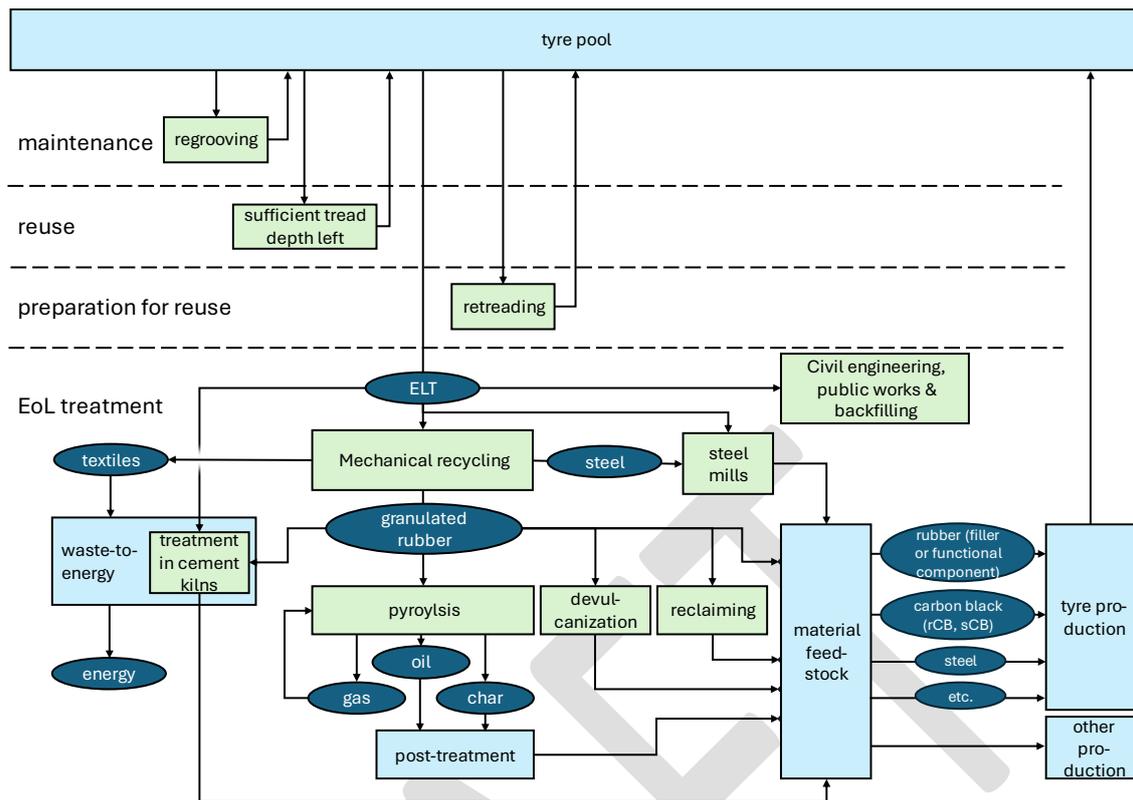
5558 7.6.1. Description of technologies used for preparation for reuse 5559 and End-of-Life treatment

5560 Over the years, several technologies were developed to prevent tyres becoming ELT, either by
 5561 maintenance or by preparation for reuse. One common technology for extending the lifetime in
 5562 the service life is regrooving the tread. The technology of regrooving is detailed in **Section**
 5563 **7.6.1.1**. A well-developed practice that **prepares tyres for reuse** is retreading, a specialised and
 5564 rigorous process in which the tread is replaced with a new one. Aspects of retreading are given
 5565 in **Section 7.6.1.2**.

5566 When tyres become waste, several **EoL treatments** are available. They may be clustered into
 5567 technologies for material and/or energy recovery. Technologies can be applied individually to
 5568 ELT or in a cascade. The EoL treatment options of most relevance are detailed in the following
 5569 chapters. They include:

- 5570 • **Mechanical Recycling**, where ELTs are mechanically processed to produce granulated
 5571 rubber, steel, and textile fractions, is detailed in **Section 7.6.1.3**.
- 5572 • **Devulcanisation**, where sulfur bonds in rubber are broken to restore plasticity and
 5573 enable remolding, is detailed in **Section 7.6.1.4**.
- 5574 • **Reclaiming**, where rubber scrap is treated with heat and chemicals to partially restore
 5575 workability, is detailed in **Section 7.6.1.5**.
- 5576 • **Pyrolysis**, a thermo-chemical process that decomposes ELTs in the absence of oxygen to
 5577 produce oil, gas, and char, is detailed in **Section 7.6.1.6**.
- 5578 • **Treatment in steel mills/foundries**, where the metal fraction of ELTs is recovered and
 5579 rubber waste is sometimes used as a carbon source and fuel, is detailed in **Section**
 5580 **7.6.1.7**.
- 5581 • **Treatment in cement kilns**, where the combustible fraction of tyres is used as fuel and
 5582 the non-combustible fraction is incorporated into the cement matrix, is detailed in
 5583 **Section 7.6.1.8**.

5584 **Figure 7-23** gives an overview over relevant (preparation for) reuse and EoL treatment
 5585 technologies, their main outputs and how these technologies may be used in cascade. Please
 5586 note that the figure covers not all potential routes but rather the most common ones.



5587

5588 **Figure 7-23: Overview on reuse and EoL treatment of tyres and relevant technologies applied**
 5589 **in the European scope. No waste hierarchy implied. Own graphic.**

5590 **7.6.1.1. regrooving**

5591 Tyre regrooving involves cutting new grooves into the rubber of a worn tyre to restore its tread
 5592 depth. Unlike retreading, which involves applying a whole new tread layer, regrooving simply
 5593 deepens the existing grooves. It is primarily used for commercial tyres and is an essential part of
 5594 fleet maintenance. Currently, regrooving is carried out on C3 tyres.

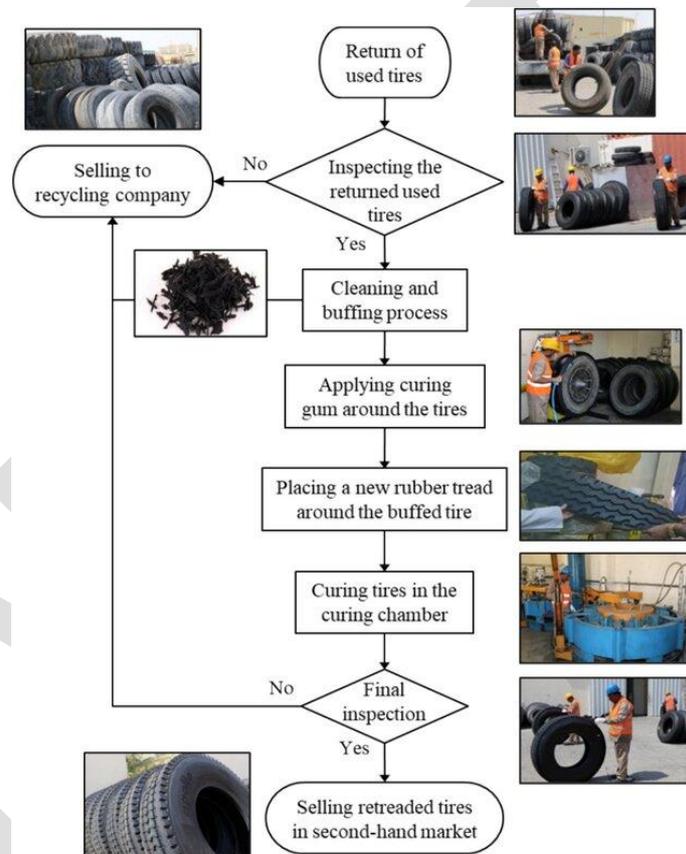
5595 Regrooving was once a common maintenance practice but has become less widespread today,
 5596 though specialised third parties still offer it. Unlike retreading, it is rarely tracked in official
 5597 statistics—organisations such as ETRMA or TNPf publish no data—since fleets or their service
 5598 partners often perform it internally. Tyres remain designed for regrooving, but the process
 5599 requires skilled, qualified labour (Stakeholder Interview SR8, personal communication, 2025).

5600 Tyres suitable for regrooving are marked “REGROOVABLE” on the sidewall, and the company
 5601 designs these tyres with extra rubber thickness—from the earliest design phase—to ensure the
 5602 process does not compromise tyre strength or robustness. Regrooving can extend the lifespan
 5603 of tyres by up to 25 %, while also improving fuel efficiency—reportedly saving up to 2 litres per
 5604 100 km. Restoring tread depth through regrooving also enhances grip—on wet surfaces,
 5605 transverse grip and traction can improve by approximately 10 % compared to worn-out tyres
 5606 that have not been regrooved (Michelin, n.d.-e).

5607 7.6.1.2. Retreading

5608 Tyre retreading⁹⁶ extends a tyre's service life by replacing its worn tread with new material. Tyre
 5609 retreading was originally a highly manual process, but advances in technology have gradually
 5610 introduced automation. Modern retreading plants increasingly rely on automated systems,
 5611 sometimes complemented with artificial intelligence-assisted robotics supporting employees
 5612 and enhancing efficiency and precision (Stakeholder Interview SR8, personal communication,
 5613 2025). The **retreading process is multi-stage**. **Figure 7-24** illustrates the overview process
 5614 flowchart for tyre retreading (process according to Aydin et al. (2024)). While the exact steps
 5615 may vary depending on the source, the existing retreading processes do not differ significantly.

5616



5617

5618

5619 **Figure 7-24: Process flowchart of tyre retreading process (following pre-cure retreading).**

5620

Source: (Aydin et al., 2024).

⁹⁶ Over the years, the retread tyre industry has used different names for its products: 'recap', 'retread', 'remould' and 'remanufactured tyre'. Some have distinct meanings. For example, a remanufactured or remoulded tyre has new rubber veneer applied to the sidewall (bead-to-bead retreading), adding a cosmetic enhancement. Recap is an outdated term for a retread and is seldom used (TRIB, 2025).

5621 The tyre's retreading process begins with both a visual **initial inspection** and an advanced
5622 electrical inspection using shearography to verify if a casing of each inspected tyre (inside and
5623 outside) is acceptable for retreading. Any damage identified on the casing needs to be
5624 determined whether repairable or not, so that the tyre can be either rejected or approved for
5625 further processing (Daystar et al., 2018; ETRMA, 2006). Following inspection, the tyre undergoes
5626 the buffing process to prepare the worn tread surface for retreading. This step involves
5627 mechanically abrading the remaining tread⁹⁷ and removing parts of the undertread along with
5628 the original tread pattern (Bauer Built Tire & Service, 2021; Qiang et al., 2020). Any minor
5629 damage is then repaired through skiving and patching⁹⁸, including defects revealed during
5630 buffing. In the next stage, new tread rubber is applied, either by the hot or cold retreading
5631 method.

5632 **Pre-mould retreading (cold cure retreading):** A pre-vulcanised tread with the new design is
5633 bonded to the buffed casing using a thin layer of cushion gum applied by an extruder. The
5634 uncured cushion compound must vulcanise while the pre-moulded tread is kept in position. The
5635 tyre is enclosed in an envelope, which applies pressure via a vacuum system, and then placed in
5636 a curing chamber (autoclave) where heat and pressure vulcanise the cushion gum at 100–120 °C,
5637 permanently adhering the new tread. Curing takes 90-120 minutes (Bauer Built Tire & Service,
5638 2021; Qiang et al., 2020). Unlike mould-cure retreading (see below), the cold cure process only
5639 applies new tread; the sidewalls remain unchanged, so the finished product may lack the “new
5640 tyre” appearance that hot cure can achieve by renewing sidewall markings. The cold cure
5641 process is predominantly used for C3 tyres, as appearance is less important than cost and service
5642 life (*Stakeholder Interview SR8*, personal communication, 2025).

5643 Cold cure retreading plants do not need extensive mould investments, since the pattern is
5644 formed in the pre-cured strip, lowering initial capital costs. However, pre-cured tread rubber is
5645 a finished product that has undergone multiple manufacturing steps (mixing, compounding,
5646 extruding, vulcanisation), leading to significant material costs. As a result, material costs for cold
5647 retreading are higher than for hot retreading.

5648 **Mould-Cure Retreading (hot cure retreading):** Uncured tread rubber is applied by an extruder
5649 to the buffed casing. The tyre with this uncured compound, still soft, pliable, and tacky, is placed
5650 in a rigid, heated mould containing the tread design (similar to new tyre manufacturing). A
5651 dedicated mould is required for each tyre size and tread design. Heat (about 160 °C) and
5652 pressure vulcanise the new rubber, forming the tread pattern and bonding it to the casing
5653 (Isayev, 2013; Qiang et al., 2020; Radburg tyres, 2021; *Stakeholder Interview SR8*, personal
5654 communication, 2025).

5655 Regardless of the retreading process a final quality check completes the procedure and involves
5656 a thorough inspection of the crown, sidewall, bead, and interior of the tyre. After passing final
5657 inspection, the retreaded tyre may be trimmed and painted.

⁹⁷ The abraded tyre material can be recycled/reprocessed.

⁹⁸ During **skiving** damaged or weakened rubber from the tyre surface is cut away (using a special knife or rotary tool) to expose solid material underneath. This ensures that no cracks, cuts, or embedded objects remain before repair. During **patching**, the cleaned and prepared area is reinforced with a repair patch or filling material.

5658 **Application of retreading:** Whether retreading can be applied to tyres depends primarily on the
5659 casing's structural integrity, making retreading feasible only when there is a steady supply of
5660 durable, high-quality casings. Many tyres, however, are unsuitable due to design limitations, in-
5661 use damage, or poor casing quality after a single life cycle. The latter aspect is noted by
5662 retreaders particularly with low-budget imports from Asia⁹⁹. Currently commercial truck and bus
5663 tyres (C3), aircraft, off-the-road, and speciality tyres (e.g. mining, construction, and agricultural
5664 vehicles) are the most retreadable. At the same time, efforts to lower rolling resistance have led
5665 to lighter casings, which complicates retreading, whereas reinforcing casings to improve
5666 retreadability would increase rolling resistance and affect LCA results (1st Stakeholders
5667 consultation, 2025; Borchers, 2023a; *Stakeholder Interview SR8*, personal communication, 2025;
5668 Stevens, 2023).

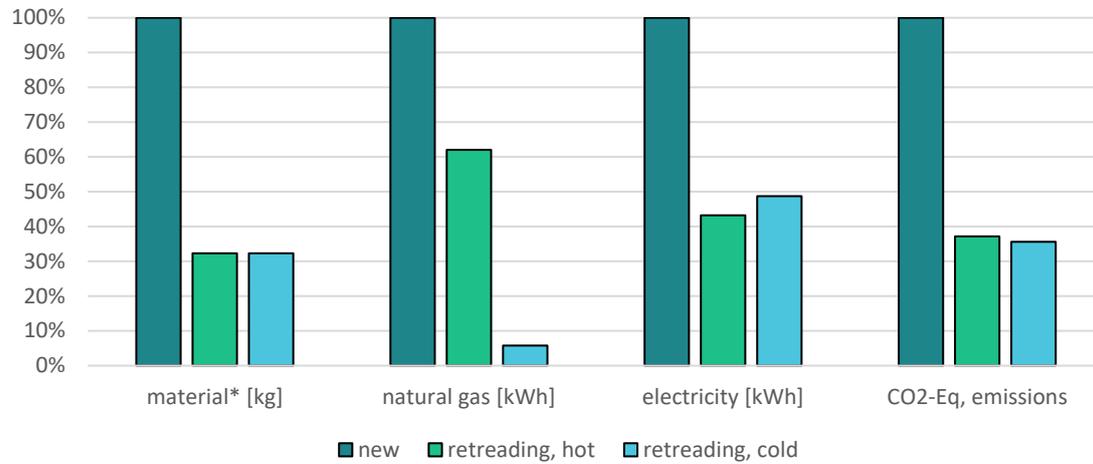
5669 In the open stakeholder consultation (Stakeholder, 2025), it was further highlighted that criteria
5670 for retreadable tyres cannot be defined before the use phase, since casing suitability can only
5671 be assessed after actual use. There will always be a rejection rate due to conditions during this
5672 phase, with driving behaviour and tyre pressure identified as major factors. Moreover, no design
5673 or test standard currently exists to assess casing suitability in advance.

5674 Passenger car tyres (C1 and C2) were retreaded more commonly in the past, but today this
5675 occurs mainly in niche markets. Stakeholders mention that a key challenge is the wide variety of
5676 models and casing geometries, which makes adapting retreading plants technologically,
5677 economically, and logistically difficult. Automated stages, such as hot cure retreading where the
5678 casing is placed in a rigid mould, may not accommodate irregular tyre sizes, causing uneven
5679 pressure, weak bonding, or internal damage. One stakeholder suggested introducing
5680 standardised tyre dimensions to facilitate retreading.

5681 Energy and material demands for retreading were assessed holistically in a study by Fraunhofer
5682 Umsicht (Blömer, 2022). The study concludes significant reductions in energy demands in
5683 comparison to the production of new tyres, as shown in **Figure 7-25**. The demand for natural
5684 gas and electricity of retreading in comparison to new tyre production is reduced by 40-70 %
5685 (refers to the on-site energy demand), while also 70 % less material is required. The latter value
5686 is consistent with Continental's statement "that around 70 percent of the material from the
5687 original tyre can be reused"(Continental AG, 2023). This results in kg CO₂-Eq reductions in the
5688 production phase of ~70 %. This applies equally to hot and cold retreading.

⁹⁹ Narrower low-budget tyres can also mismatch retreading moulds, causing excess material on the shoulders. This results in heat build-up while driving and thus poor performance.

Material and energy demands for retreading in comparison to the production of new tyres



5689

5690 * Refers to the mass of the new tread.

5691 **Figure 7-25: Material and energy demands of retreading in comparison the production of**
 5692 **new tyres.**

5693

Based on (Blömer, 2022).

5694 7.6.1.3. Mechanical recycling

5695 This chapter on mechanical recycling covers the processing of ELTs from their reception through
 5696 to the production of three main outputs: (i) a ground fraction of vulcanised rubber, (ii) a steel
 5697 fraction, and (iii) a textile fraction. Further treatment of the rubber fraction (e.g. devulcanisation
 5698 or pyrolysis) and the steel and textile fraction is not covered in this section.

5699 EURIC (EURIC & Genan, personal communication, 3 December 2024) explained that their
 5700 members treat C1, C2 and C3 tyres but do not recycle other types of tyres at their facilities. It is
 5701 thus not completely clear what happens with other tyres. EURIC further explained that for the
 5702 C1, C2, and C3 tyres, though compositions are different, there are only small variances, and the
 5703 treatment is more or less the same. As to other vehicles – motorcycles, buses, and airplanes –
 5704 the composition is different. From a recycling perspective, the first three categories can be
 5705 treated and mixed together. According to stakeholders (1st Stakeholders consultation, 2025)
 5706 problematic are however:

- 5707 • Self-sealing tyres (viscous gel can infiltrate/damage aggregates and even cause fires),
- 5708 • Silent tyres (foam inlets lead to increased shares of “fluff”),
- 5709 • Lithium batteries from TPMS (can cause fires if damaged),
- 5710 • High shares in reinforcing material (can damage blades or cannot be shredded)¹⁰⁰.

¹⁰⁰ Tyres with high reinforcing material shares are often rejected or require particular pre-treatment (e.g., bead removal), aramid fibres cannot be shredded by bladed.

5711 Mechanical recycling primarily aims to separate the textile and steel components from the
5712 rubber fraction, while simultaneously reducing the rubber fraction in size through grinding.
5713 Depending on the rubber size the products may be classified as:

- 5714 • Powder (0-1 mm),
- 5715 • Granulate (1-10 mm),
- 5716 • Chips (10-50 mm),
- 5717 • Small Shreds (40-75 mm),
- 5718 • Large Shreds (75-300 mm),
- 5719 • Cut (300 mm- ½ tyre).

5720 For grinding ELT, two main approaches exist, grinding at ambient temperature and cryogenic
5721 grinding (EuRIC AISBL, 2022). Other less common approaches are wet grinding (sometimes
5722 referred to as micro milling), hydro jet size reduction (Lo Presti, 2013) or ozone cracking (Xiao et
5723 al., 2022), which are not covered in detail here.

5724 **Ambient grinding** of tyres is the most widely used method for producing crumb rubber. The
5725 process is carried out at room temperature and involves a series of mechanical size-reduction
5726 steps. First the bead wire is extracted. Secondly the tyres are roughly shredded, where tyres are
5727 cut into chips of about 50 mm. These chips are further granulated to below 10 mm before steel
5728 is removed magnetically and textile fibres are separated using vibration and air classifiers.
5729 Successive grinding stages that typically involve granulators, cracker mills, and pulverisers,
5730 reduce the material to crumb rubber between 0.5–5 mm. The process is relatively simple and
5731 can be applied to different tyre types. However, the process generates significant heat (up to
5732 130 °C) that has the potential to oxidise and degrade the rubber. Producing very fine powders
5733 via ambient grinding is energy-intensive and costly, but is required for some applications,
5734 including application micronised rubber in tyres (Eco Green Equipment, 2020; EuRIC AISBL, 2022;
5735 Haq et al., 2025a; Kumar et al., 2024; Lo Presti, 2013; Xiao et al., 2022).

5736 The Secretariat of the Basel Convention (2024) suggests an energy demand of 120-125 kWh/t
5737 for the ambient grinding process from the reception of tyres to the production of rubber crumbs.

5738 For **cryogenic grinding** tyres are first roughly ground and freed from textiles and steel (similar
5739 to the ambient grinding). The cryogenic process itself, which is focused solely on rubber size
5740 reduction, is carried out at very low temperatures (around -100 °C). Therefore, the rubber
5741 chunks are immersed in liquid nitrogen. As a consequence, the rubber becomes brittle and is
5742 prone to fracturing under impact. The frozen material is crushed in hammer mills and particle
5743 sizes ranging from 250-425 µm can be achieved. The fine rubber crumbs have a relatively smooth
5744 surface and a wide particle size distribution. Advantages of cryogenic grinding include a clean
5745 rubber fraction that is not subject to oxidation, it allows for higher throughput rates and requires
5746 less aggregates to arrive at a fine particle size. Disadvantages of the process are caused by the
5747 smoother surface of the rubber crumbs, resulting in weaker binding, if the material is used in
5748 composite materials. Instead the material is, in comparison to material received from ambient
5749 grinding, more suitable for devulcanisation where it can be blended with virgin rubber to
5750 produce higher-value products (Eco Green Equipment, 2020; EuRIC AISBL, 2022; Haq et al.,
5751 2025a; Kumar et al., 2024; Xiao et al., 2022).

5752 It is stated that the grinding process requires less energy - not considering the energy demand
 5753 for providing liquid nitrogen (Xiao et al., 2022). However, specific energy demands were not
 5754 found in the literature. Based on the Secretariat of the Basel Convention (2024) 0.5-1 kg N are
 5755 needed for cryogenic grinding.

5756 **Outlet markets for ground tyre rubber** comprise sports and leisure surfacing, artificial turf
 5757 systems, rubber modified asphalt and industrial rubber and plastics compounding, each
 5758 requiring specific input¹⁰¹. Additionally, rubber may be sent for post-treatment in pyrolysis
 5759 plants or devulcanisation/reclaiming facilities. PAH contents¹⁰² and microplastic emissions limit
 5760 their application. Since 2022, according to Annex XVII of Regulation (EC) No. 1907/2006, PAH
 5761 contents below 20 mg PAH/kg must be adhered to. The regulation applies to mulches (flakes 4-
 5762 130 mm) and granules (1-4 mm). Commission Regulation (EU) 2023/2055 restricts intentionally
 5763 added microplastic. As a consequence, granular infill for use on synthetic sports surfaces will be
 5764 prohibited. The ban takes effect on 17 October 2031. **Table 7-16** gives a non-exhaustive list of
 5765 outlet market for ground rubber.

5766 **Table 7-16: Typical outlet markets for ground rubber.**

| Outlet market | Examples | Preferable grinding method | Restrictions |
|--|--|---|--|
| Sports and leisure surfacing (bound systems) | Poured in place safety surfacing, playground tiles, running tracks base layers | Ambient grinding preferable, as the rubber crumbs produced allow for better adhesion and mechanical interlock (Eco Green Equipment, 2020) | Rubber in loose form on playgrounds or in sport applications must contain <20 mg PAH/kg rubber Regulation (EC) No. 1907/2006 |

¹⁰¹ According to (Orveillon et al., 2022) 50 % are recycled into playgrounds, 30 % into moulded objects, 20 % into bitumen. Rubberised asphalt (a specific application of bitumen that is covered on the umbrella term rubber-modified asphalt) remains a potential market outlet capable of substantial volume. this application is successful in other countries around the world such as the USA, but penetration in the European market remains very low (less than 2% of the granulation market) (1st Stakeholders consultation, 2025). For 2021, AECOM states that 30 % are used for synthetic turf including infill, 20 % for sport and children playgrounds, 26 % for moulded objects, 2% for asphalt and road paving, 12 % for other uses and 10 % are undetermined (export, traders)(Braithwaite et al., 2021).

¹⁰² PAH are not added intentionally to the tyre's rubber compound but are formed in the production of carbon black through pyrolysis.

| Outlet market | Examples | Preferable grinding method | Restrictions |
|--|---|--|---|
| Artificial turf systems | Performance infill (e.g. to improve ball roll, drainage) or elastic layers (to absorb impact/reduce risk of injury) in football fields and multi-sport facilities | Cryogenic ground rubber is preferable (Eco Green Equipment, 2020) | Rubber must contain <20 mg PAH/kg rubber. Regulation (EC) No. 1907/2006 Commission Regulation (EU) 2023/2055 restriction causes phase out intentionally added microplastics including polymeric infill, after a transition period, currently covers ~1/3 of the outlet market. (1st Stakeholders consultation, 2025) |
| Rubber modified asphalt | Dry and wet process, where rubber serves as aggregate or modifier ¹⁰³ | Typically rubber crumbs from ambient grinding is preferable (Eco Green Equipment, 2020; Lo Presti, 2013) | Out of scope of Regulation (EC) No. 1907/2006 and Commission Regulation (EU) 2023/2055 |
| Industrial rubber and plastics compounding | Tyres ¹⁰⁴ , rubber mats, automotive parts, hoses, belts | Depends on application | - |
| Further post-treatment | Pyrolysis, devulcanisation or potentially cement kilns | Pyrolysis: both possible, depends on pyrolysis process Devulcanisation: cryogenic grinding preferable (Xiao et al., 2022) | - |

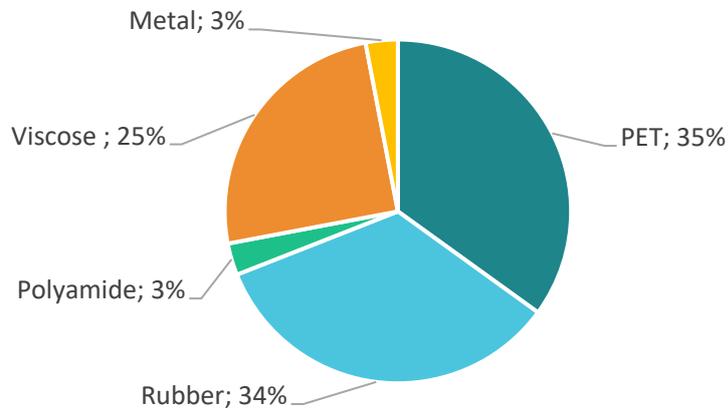
5767

5768 Recovered **steel** is recycled in steel mills (see **Section 7.6.1.7** for more information). The **textile**
5769 **fraction** is a mix of different textiles used in the tyre production (e.g., PET, viscose, or polyamide)
5770 and show higher shares of rubber content. **Figure 7-26** shows a typical composition of the textile
5771 fraction. As of today, there is no commercially available technology that would allow for
5772 industrial-scaled material recovery of textiles separated from tyres. Instead they are used for
5773 energy recovery, e.g. in cement kilns, or used for thermal insulation in the construction sector
5774 (EuRIC AISBL, 2022; Wagner et al., 2022).

¹⁰³ “The dry process involves mixing the [ground rubber] with heated aggregates before the introduction of asphalt binder to the mixture. The wet process modifies the asphalt binder directly by pre-blending with [ground rubber] at elevated temperatures [...] [Ground rubber] as a replacement for aggregates in the dry process, while in the wet process, it serves as a modifier.” (Xiao et al., 2022).

¹⁰⁴ Rubber used as filler rather than as functional component.

Composition of textile fraction from the regranulation of passenger car tyres



5775

5776 **Figure 7-26: Composition of the textile fraction that is received in the course of mechanical**
5777 **recycling**

5778

Source: (Wagner et al., 2022).

5779 7.6.1.4. Devulcanisation

5780 Devulcanisation is the process of selectively breaking sulphur cross-links in vulcanised rubber,
5781 effectively reversing aspects of vulcanisation, which originally enhances strength, elasticity, and
5782 durability. By cleaving monosulfidic, disulfidic, and polysulfidic bonds (C–S and S–S), the rubber
5783 becomes more pliable and can be reprocessed without significant degradation of the main
5784 polymer chains (Innes et al., 2024). The process requires ground rubber (e.g. from mechanical
5785 recycling) and can handle feedstock up to 10 mm in size. Clean feedstock is essential, as
5786 contamination from textiles, metals, or additives reduces efficiency and end-product quality
5787 (Markl & Lackner, 2020). According to stakeholder consultation, rubber from truck tyres is most
5788 suitable for devulcanisation (1st Stakeholders consultation, 2025). Despite these technical
5789 opportunities, the use of devulcanised rubber in tyres is not yet a priority for manufacturers and
5790 the presence of hazardous substances in rubber furthermore prevents its use in several markets
5791 (1st Stakeholders consultation, 2025).

5792 Devulcanisation methods are often classified by the type of energy applied: thermal,
5793 mechanical, chemical, microwave/ultrasonic, or biological (Kumar et al., 2024; Saputra et al.,
5794 2021):

- 5795 • **Thermal:** Heat (160–250 °C) in an inert atmosphere, sometimes aided by solvents or
5796 plasticisers.
- 5797 • **Mechanical:** Grinding, milling, or shearing forces to disrupt bonds; often used in
5798 combination with other methods.
- 5799 • **Chemical:** Agents such as ozone or caustic soda selectively break sulphur bonds but can
5800 introduce toxicity and handling challenges.
- 5801 • **Microwave/Ultrasonic:** Advanced techniques using selective heating or vibrations to
5802 disrupt cross-links.

- 5803 • **Biological:** Microbial desulphurisation is being explored but is not yet viable due to slow
5804 reaction rates.

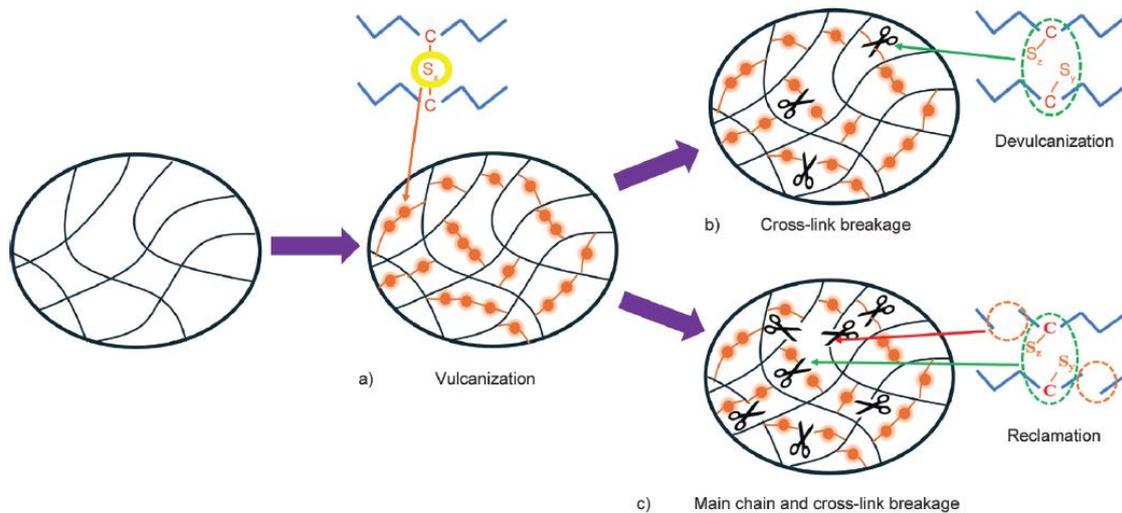
5805 In practice, hybrid approaches (thermo-chemical, thermo-mechanical, mechano-chemical) are
5806 most common (Haq et al., 2025b). For thermo-mechanical (extrusion) devulcanisation, the
5807 energy consumption is assumed to be in the range of 350-400 kWh/t (Umar, 2022; USEON, n.d.).

5808 Devulcanisation is inherently difficult: the bond energies of sulphur linkages (227–273 kJ/mol)
5809 are close to those of C–C bonds (348 kJ/mol), risking unwanted polymer chain scission (Seghar
5810 et al., 2019). Synthetic rubbers are generally harder to process than natural rubber due to
5811 structural differences (Dorigato et al., 2023). Even with controlled methods, some mechanical
5812 strength, elasticity, and durability are lost. Other challenges include the high energy intensity of
5813 many methods, the use of toxic or sulphur-based chemicals, and the presence of contaminants
5814 such as oils, fillers, and additives in ground tyre rubber (GTR) (Haq et al., 2025b). Finally,
5815 stakeholders note that butyl rubber (used in inner liners), reduce the quality of devulcanised
5816 outputs. Therefore ELT dismantling would be necessary, which is however currently not state-
5817 of-the-art (1st Stakeholders consultation, 2025).

5818 Despite named challenges, studies suggest that devulcanised rubber can replace significant
5819 amounts of virgin rubber without major property losses, reporting up to 40 % in natural rubber
5820 (Sabzekar et al., 2015), 65 % in virgin NR (Seghar et al., 2019), 30 % in styrene-butadiene rubber
5821 (Ghosh et al., 2020), and 30 % substitution in new tyres (Görbe et al., 2024). Also, commercial
5822 applications already exist. Tyromer converts crumb rubber into Tyre-Derived Polymer (TDP) for
5823 use in tyres, retreading, conveyor belts, and moulded goods without added chemicals (Tyromer,
5824 2021). LEVGUM produces devulcanised rubber compounds (DRC) blended at 10–20 % in tyres
5825 and up to 90 % in other products (LEVGUM Ltd., n.d.). Companies such as Rubber Conversion,
5826 Hexpol, Elastocinca, Rubberlink, and Schwalbe invest in scaling technologies. The latter already
5827 incorporates 20 % recycled butyl rubber in new inner tubes (Schwalbe Tubes, 2025).

5828 7.6.1.5. Reclaiming

5829 Reclaiming is the process of converting vulcanised rubber into a plasticised state that can be
5830 mixed, processed, and revulcanised using conventional methods. Unlike devulcanisation, which
5831 aims to selectively break sulphur cross-links, reclaiming typically involves both crosslink scission
5832 and main polymer chain scission (Weibold, 2020). This broader breakdown reduces molecular
5833 weight and significantly affects the properties of the recycled material (Innes et al., 2024; Seghar
5834 et al., 2019). **Figure 7-27** shows the difference between devulcanisation and reclaiming.



5835

5836 **Figure 7-27: Schematic representation of devulcanisation and reclamation. a) Vulcanisation**
 5837 **(sulphur cross-linking), b) devulcanisation and c) reclamation.**

5838

Source: (Haq et al., 2025b).

5839 According to ASTM D1566, *reclaimed rubber* is defined as vulcanised rubber that has been
 5840 plasticised for use as a diluent, extender, or processing aid in rubber compounding (Wiśniewska
 5841 et al., 2022). Reclaiming methods are typically thermo-mechanical or thermo-chemical, and
 5842 often involve the use of reclaiming oils or softeners to aid processing. More advanced
 5843 approaches, such as microwave and ultrasonic treatments, have been investigated but are not
 5844 yet widely adopted (Bockstal et al., 2019a). A general issue with reclaiming is that in addition to
 5845 sulphur crosslinks, carbon–carbon bonds of the main polymer chain are broken, making it
 5846 impossible to recover the original macromolecules and thereby decreasing quality (Seghar et al.,
 5847 2019).

5848 In comparison to devulcanisation, which produces a material closer to virgin rubber, reclaiming
 5849 yields a lower-quality material with reduced elasticity, tensile strength, and durability. Despite
 5850 these drawbacks, reclaiming remains widespread due to its relatively simple technology and low
 5851 production costs. Reclaimed rubber is commonly used in footwear, flooring, mats, hoses, belts,
 5852 and as a processing aid in rubber compounding (Wiśniewska et al., 2022). In Europe, however,
 5853 production is limited, as cheap imports from Asia dominate the market. Stakeholders note that
 5854 this price competition undermines the business case for domestic reclaiming or devulcanisation
 5855 initiatives (1st Stakeholders consultation, 2025).

5856 7.6.1.6. Pyrolysis

5857 Pyrolysis is a thermochemical conversion process in which organic materials chemically
 5858 decompose under heat in the absence or near-absence of oxygen (Reddy & Nair, 2021).
 5859 Alongside gasification, it is one of the most widely used methods for converting scrap tyres into
 5860 fuel (Zerin et al., 2023). While a completely oxygen-free environment is nearly impossible to
 5861 maintain, pyrolytic systems minimise oxygen to reduce unwanted oxidation. An inert
 5862 atmosphere, typically nitrogen gas, is introduced before and after the process to limit
 5863 combustion (Nkosi et al., 2021; Parthasarathy et al., 2016).

5864 Prior to pyrolysis, waste tyres are often shredded and separated from steel and textile fractions,
5865 similar to mechanical recycling (**Section 7.6.1.3**) (Verma et al., 2018). Some stakeholders
5866 therefore see the future role of mechanical recycling as a pretreatment step for pyrolysis (1st
5867 Stakeholders consultation, 2025). The pyrolysis of whole tyres is also possible¹⁰⁵. A uniform
5868 feedstock composition is necessary to ensure process stability and consistent products. In
5869 principle, all tyre types can be used; however, a homogeneous, steady feedstock is considered
5870 essential, and “silent” and self-seal tyres are generally considered problematic (1st Stakeholders
5871 consultation, 2025). High chlorine content in rubber compounds (e.g., deriving from halobutyl
5872 rubber) is unfavourable, as it can cause high temperature corrosion in the pyrolysis process.
5873 Consequently, pyrolysis operators must source appropriate ELT mixes to meet consistency
5874 requirements for recycled outputs (1st Stakeholders consultation, 2025).

5875 Pyrolysis reactions can be grouped as follows (Li et al., 2004): primary pyrolysis (250-520 °C),
5876 secondary post-cleavage of volatile components (600-800 °C), and gasification of pyrolytic
5877 carbon black with CO₂, H₂O, or O₂ (750-1000 °C). Waste tyres begin to decompose at 350 °C.
5878 Above 400°C, reactions such as dehydration, cracking, isomerisation, dehydrogenation,
5879 aromatisation, and condensation occur (Martínez et al., 2013). Waste tyres pyrolysis test have
5880 generally been carried out in the range of 450-700 °C (Reddy & Nair, 2021; Williams, 2013).

5881 Pyrolysis in general results in liquid, solid, and gaseous outputs and pyrolysis of waste tyres in
5882 particular generates three principal product outputs (Reddy & Nair, 2021): **tyre-oil** as the liquid
5883 product, **char** as the solid product that can be further processed to recovered carbon black (rCB)
5884 and **syngas** as the gaseous product.

5885 The distribution of char, oil and gas depends heavily on temperature and residence time and
5886 furthermore on key process parameters such as heating rate, particle size, catalyst use, and
5887 reactor configuration (Parthasarathy et al., 2016). Following the meta study of Zerin et al. (2023),
5888 that considered various reactor types, pyrolysis temperatures and retention times, the following
5889 yields can be viewed as typical for the pyrolysis of ELT:

- 5890 • Solid phase: 25-55 wt.-%¹⁰⁶,
- 5891 • Liquid phase: 25-65 wt.-%,
- 5892 • Gaseous phase: 0-30 wt.-%.

5893 Ramani et al. (2025) stated that temperature is the most critical factor affecting the quality and
5894 yield of pyrolysis outputs due to the endothermic nature of the process. At lower temperatures,
5895 typically between 300–450 °C, the process yields more carbon black. Mid-range temperatures
5896 between 450–550 °C generally produce the highest volume of tyre oil, while temperatures
5897 above 600 °C tend to favour gas production due to secondary cracking of the oil vapours
5898 (Parthasarathy et al., 2016). Increasing residence time generally leads to higher gas yields and
5899 lower char yields, as the feedstock undergoes more complete decomposition. Longer retention
5900 times would also favour the conversion from char to oil, but at the same time more oil is

¹⁰⁵ Although possible, pyrolysis of whole tyres would generally lead to uneven heat transfer and decomposition, lower or inconsistent product quality and allow for less flexibility in the reactor design.

¹⁰⁶ wt.-%=percentage by weight.

5901 decomposed to gas. Heating rate is another critical factor, as slow heating supports more char
5902 formation, while higher heating rates, lead to significantly higher oil yields¹⁰⁷ (Williams, 2013).

5903 In the process of pyrolysis, the natural rubber (NR) and synthetic rubber (SR) in the scrap tyre
5904 convert into volatile materials, resulting in the production of oils and gases (Zerin et al., 2023).
5905 The amount of fixed carbon or carbon material produced should match with the carbon black
5906 used in the primary production (Martínez et al., 2013). Inorganic substances in scrap tyres
5907 influence the amount of ash produced. The higher the proportion of inorganic substances, the
5908 more ash is produced (Zerin et al., 2023). It should be noted that PAH are inevitably formed
5909 during waste tyre pyrolysis given both the complex composition of tyres and their thermal
5910 decomposition into aromatic structures. High temperatures, slow heating rates, and sufficient
5911 residence times in the pyrolysis process enhance PAH formation, with PAHs primarily
5912 accumulating in the pyrolysis oil product (Kwon et al., 2015; Ye et al., 2022)

5913 Each of the pyrolysis products has potential applications.

5914 **Pyrolysis char** is a solid residue composed primarily of fixed carbon and ash. Carbon black has a
5915 calorific value close to low-grade coal (around 29-30 MJ/kg) and can be used as a fuel.
5916 Alternatively, pyrolysis char has potential for reuse as carbon black (rCB) or activated carbon.
5917 However, several aspects of pyrolysis char are unfavourable for their reuse in tyres. Most
5918 problematic are high ash and sulphur contents as well as particle size distribution, shape and
5919 surface area. **Table 7-17** lists non-exhaustive treatment steps needed to enhance the quality of
5920 rCB and to allow for closed-loop recycling (i.e. reuse of rCB in tyres).

5921 Pyrolysis char can contain up to 20 % mineral ash derived from tyre additives—primarily silicate
5922 compounds and zinc components (Eitner & Fleck, 2021). An increase in the ash content to 30 to
5923 35 % is expected in the foreseeable future, given the increased incorporation of silica instead of
5924 carbon black (RCB, 2023). The pyrolysis of high silica tyres (usually C1, C2) produces a low-quality
5925 recovered carbon black (1st Stakeholders consultation, 2025).

5926 **Table 7-17: Unsuitable properties of pyrolysis char for use as rCB and activated carbon and**
5927 **process steps required to upgrade pyrolysis char.**

| Unsuitable property of pyrolysis char | Options to improve the quality of char |
|---|--|
| Contains moisture | Drying (Maga et al., 2023) |
| Steel residues | Magnetic separation (Gao et al., 2022) |
| High ash content | E.g. acid and alkali solvent treatment (Gao et al., 2022; Kong et al., 2024), microwave demineralisation (Kononov, 2021) or flotation (T. Li et al., 2023) |
| High sulphur content | Desulphurisation (T. Li et al., 2023), e.g. through chemical leaching, thermal treatment or catalytic hydrodesulfurisation |
| Aggregated particles with wide particle size distribution and irregular shape | Milling/classification (Gao et al., 2022) |

¹⁰⁷ Volatiles are driven off before they can crack into gas or recondense on char.

| Unsuitable property of pyrolysis char | Options to improve the quality of char |
|---|--|
| Surface area/chemistry, pore structure, removal of trace oils/odour | For use as rCB: post-pyrolysis (Kononov, 2021) For use as activated carbon: Activation with steam or CO ₂ (Gao et al., 2022) |

5928 rCB quality grades range from N100 (highest) to N900 (lowest). Beyond post-treatment, quality
 5929 depends on feedstock of the pyrolysis char. for example, truck tyres tend to yield higher-quality
 5930 rCB than passenger car tyres. If char is insufficiently upgraded, it may be limited to low-grade
 5931 applications (e.g., in rubber or plastic products where performance is less critical, such as
 5932 construction materials) or used as filler in rubber goods. This underscores the need for a
 5933 homogeneous, clean feedstock, as consistency of rCB quality is as important as the quality grade
 5934 itself.

5935 **Pyrolysis oil**, also known as Tyre Pyrolysis Oil (TPO) or Tyre Derived Oil (TDO) , is a dark, aromatic-
 5936 rich liquid that also contains valuable compounds such as aromatics and limonene
 5937 (Parthasarathy et al., 2016). TPO can be used as a heating fuel in industrial boilers or engines.
 5938 The high sulphur content would lead to high SO_x-emissions, that require either refining of the
 5939 TPO (Bowles & Fowler, 2022), more resources in the flue gas treatment or blending of TPO with
 5940 fuels of lower sulphur content (Frigo et al., 2014) to meet limit values set for combustion
 5941 plants.¹⁰⁸ Alternatively, TPO can be used as chemical feedstock. TPO is often described as similar
 5942 to diesel (similar density and calorific value) and is rich in aromatics and aliphatic hydrocarbons
 5943 (Frigo et al., 2014). Conventional petrochemical units (hydrotreating, catalytic cracking) can
 5944 remove impurities such as nitrogen, oxygen, aromatics, metals, and other carbon-based
 5945 substances of concern to produce dry gas, LPG, naphtha, and light cycle oil (Martínez et al.,
 5946 2023). TPO also contains highly valuable compounds—benzene, toluene, ethylbenzene, xylene,
 5947 rubber monomers, and limonene—that can be selectively recovered by vacuum distillation
 5948 (Bowles & Fowler, 2022; Martínez et al., 2023); (Martínez et al., 2023; Parthasarathy et al.,
 5949 2016). Finally, TPO can also be processed to so called “sustainable carbon black” (sCB) or
 5950 sometimes referred to as circular carbon black. It is typically produced by using it as a feedstock
 5951 in a furnace carbon black reactor instead of conventional fossil-based oil. The process mirrors
 5952 standard furnace black production. In comparison to rCB the pathway for production of sCB is
 5953 not challenged by high ash contents. TPO’s high aromatic content promotes efficient carbon
 5954 black formation, whereas its sulphur content has no impact on yield or properties but is
 5955 important for environmental considerations (e.g. abatement of SO_x emissions) (Weibold, 2020).

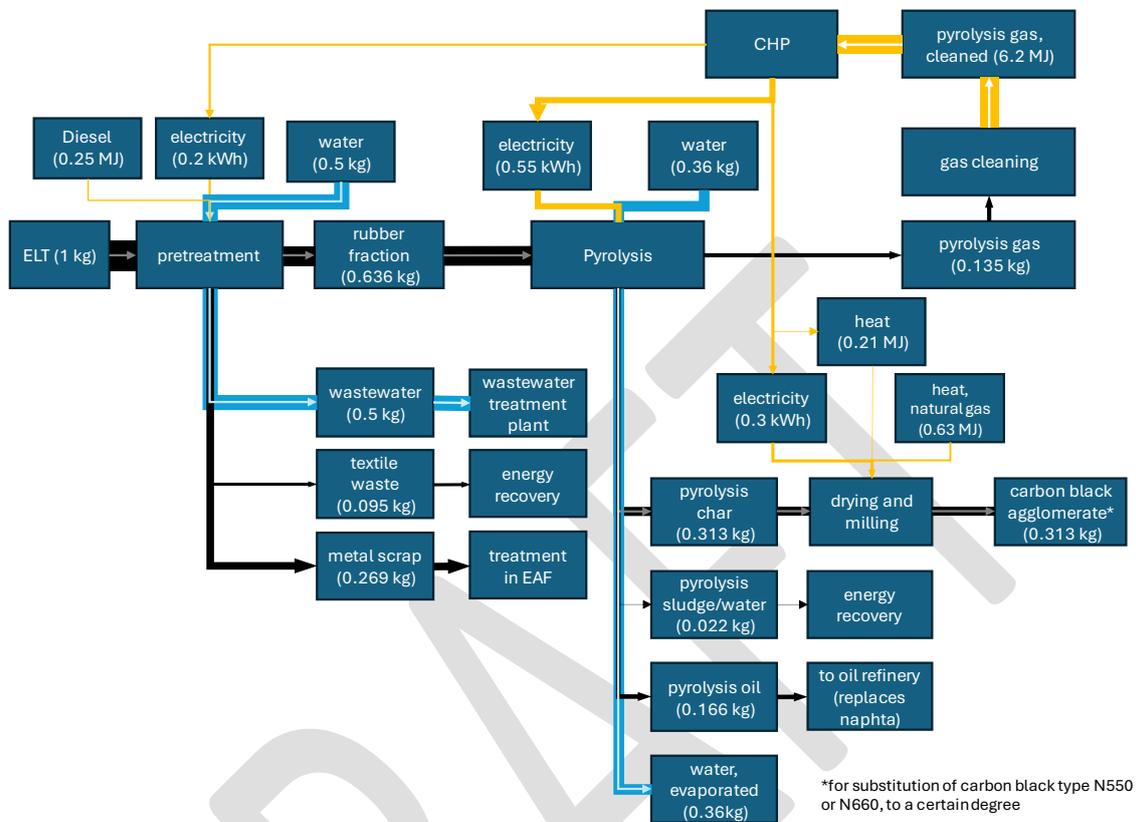
5956 **Syngas** is composed of combustible gases such as CO, H₂, CH₄, and light hydrocarbons. It contains
 5957 a high energy value (around 30–40 MJ/m³) and is typically incinerated within the system, e.g. in
 5958 a combined heat and power plant¹⁰⁹, to sustain the pyrolysis process and to reduce the demand
 5959 in external heating (Nkosi et al., 2021; Parthasarathy et al., 2016; Williams, 2013).

5960 To get a better understanding of the pyrolysis process, **Figure 7-28** shows the process steps
 5961 required for the preparation of the feedstock and the subsequent pyrolysis process. On the basis

¹⁰⁸ E.g., Directive 2010/75/EU or Directive (EU) 2015/2193.

¹⁰⁹ Cleaning of the syngas prior to incineration in a CHP-plant is typically required, especially given the high sulphur contents.

5962 of an LCA study conducted by Maga et al. (2023) the main mass and energy flows are presented.
 5963 As previously detailed, the pyrolysis process is subject to high variance with regard to both
 5964 process design and yields of products. The flowchart is therefore not representative for all ELT
 5965 pyrolysis systems.



5966

Figure 7-28: Energy and material flows for tyre pyrolysis.

5967

5968

Source: Own graphic based on LCI data from Maga et al. (2023).

5969 Pyrolysis is debated: some stakeholders view it as the most promising future tyre recycling
 5970 technology to meet sustainability goals, while others point to environmental concerns,
 5971 economic challenges, and limitations in technology and output quality. Poor quality of raw char
 5972 and oil—especially high PAHs in TPO—and the complexity and cost of post-treatment are
 5973 common criticisms. Conversely, significant R&D and investment are driving chemical recycling
 5974 routes such as pyrolysis (1st Stakeholders consultation, 2025).

5975 In tyre pyrolysis, the **allocation of recovered products** in new applications is a topic of ongoing
 5976 discussion. Recovered materials (especially rCB and TPO), can potentially be reincorporated into
 5977 the production of new tyres or other industrial products. A central question is whether these
 5978 recycled materials must be used exclusively in the same product category from which they
 5979 originated (i.e., tyres) or whether they can be allocated across a broader range of products. The
 5980 latter approach, known as the mass balance approach, allows recycled materials to be tracked
 5981 and distributed proportionally across multiple product streams rather than being restricted to a

5982 single product group¹¹⁰. Currently, this allocation debate is particularly relevant in the context
5983 of green claims and sustainability reporting, where manufacturers highlight the use of recycled
5984 content in their products. At present, there are no binding recycled content quotas for tyres,
5985 which means that the mass balance approach offers a flexible method to demonstrate circularity
5986 and support sustainability objectives. Stakeholders utilising pyrolysis products as chemical
5987 feedstock view the mass balance approach as essential for achieving efficient material reuse (1st
5988 Stakeholders consultation, 2025).

5989 7.6.1.7. Treatment in steel mills/foundries

5990 In steel mills, tyre components can substitute two main resources: (i) steel from bead and cord
5991 wires substitute iron ore, and (ii) rubber substitutes coke or similar materials as a reducing agent.
5992 While processing steel parts from tyres in steel mills is typically a downstream option following
5993 mechanical recycling/pretreatment, the treatment of whole tyres in steel mills and foundries is
5994 not widespread in Europe (ETRMA, 2021b).

5995 However, a few European steel mills (e.g., ArcelorMittal in Belval, LU (AIST, 2012), LME in Trith-
5996 Saint-Léger, FR and Industeel Belgium (Ayed et al., 2007)) use or have used **rubber as a reducing**
5997 **agent** in electric arc furnaces (EAF). To reduce oxidation of scrap in EAF, a carbon source (here:
5998 rubber and to a minor extent also textiles and other carbon base compounds) is introduced in
5999 the furnace to bind the surrounding oxygen (AIST, 2012). This reaction is exothermic and
6000 provides additional heat to the system. The reaction of oxygen with carbon causes a release of
6001 carbon monoxide ($\text{FeO} + \text{C} \rightarrow \text{Fe} + \text{CO} \uparrow$), leading to slag foaming (Zaharia et al., 2012), i.e. a
6002 viscous, stable foam layer over the molten metal bath to shield the electric arc. Other elements
6003 from tyres are either incorporated into the slag phase or released as gaseous emissions during
6004 EAF operation. For example, zinc, present mainly as zinc oxide (ZnO) in tyres, volatilises at high
6005 temperatures, later oxidising and forming fine ZnO particles that are captured by baghouse
6006 filters or scrubbers as part of the EAF dust. Sulphur is typically released as gas, either as sulphur
6007 dioxide (SO₂) under oxidising conditions or as) in reducing environments. Certain inorganic
6008 fillers, such as silicon may be transferred to the slag (Zaharia et al., 2012),

6009 The **treatment of scrap steel** in steel mills from tyres is state of the art. Ideally the separated
6010 scrap steel stream contains few non-metallic components. A clean stream enhances the
6011 valorisation and makes steel recycling more profitable, as recycling operators receive higher
6012 remuneration from steel mills. To arrive at a steel stream with few impurities, ELTs are
6013 mechanically shredded. This step loosens steel cords and belts from the rubber and textile
6014 compounds. The stream containing steel is then separated from the other tyre parts by means
6015 of magnetic separators. At this point the steel stream may still contain significant amounts of
6016 rubber and textiles. Thereof further mechanical cleaning is required consisting of multiple
6017 stages. The Italian company “TIREs Soluzioni per l'Ambiente” for instances claims that their
6018 “Clean Steel wire system” module enhances the metal share to “*more than 97 % compared to*
6019 *the standard approximately 85 % coming out of the Granulation stage*” (TIREs Soluzioni per

¹¹⁰ The lower heating value is for instance used in regards of the TPO.

6020 l'Ambiente, 2024). Other plant constructors such as the Danish company Eldan Recycling A/S
6021 claim to reach purities of up to 99 % (Eldan Recycling, n.d.).

6022 Scrap steel recovered from end-of-life tyres is typically processed in EAF. This is primarily due to
6023 two reasons: first, overall less scrap steel is sent to the BOF route in Europe¹¹¹ (Rostek et al.,
6024 2022), and second, BOFs require highly controlled and homogeneous scrap inputs, typically for
6025 temperature control rather than as a main raw material. Given the variable composition (and
6026 the high share of copper and carbon) of tyre-derived steel, it is generally unsuitable for use in
6027 BOFs.

6028 As detailed in **Section 7.2** and **Section 7.4.1**, steel wires from tyres are typically plated with brass
6029 (copper-zinc alloy) or sometimes with bronze (copper-tin alloy) to enhance adhesion with
6030 rubber. **Copper** may be a problematic contaminant in steel recycling, as it can lead to hot
6031 shortness, causing the steel to become brittle during processing (Dworak et al., 2023). Constant
6032 agglomeration of copper from steel scrap makes copper a problematic impurity (“red problem”)
6033 that must either be diluted with copper-free scrap from production or otherwise inferior-quality
6034 products are produced (Gramlich & Krupp, 2022).

6035 To determine the copper share in tyre steel cord, the following assumptions are used:

- 6036 • Thickness of brass plating: 0.2-0.3 µm (Chanel & Pébère, 2001; Fulton, 2005),
- 6037 • Copper content in brass: 55-75% (Coppens et al., 1991; Dong-min, 2016),
- 6038 • Diameter of steel cord: 0.15-0.38 mm (Hangzhou Suntech Machinery Co, Ltd, n.d.;
6039 Henan Hengxing Science & Technology Co., Ltd., n.d.).

6040 This would yield a copper share of ~0.05-0.35 wt.-%. A data sheet on tyre wire from ELT confirms
6041 that the copper content is typically < 0.3 wt.-%. In EAF steelmaking reinforcing bars (rebar) can
6042 tolerate up to 0.4 wt.-% Cu, while many flat steel products require significantly lower levels,
6043 often less than 0.1 wt.-% (Daehn et al., 2019).

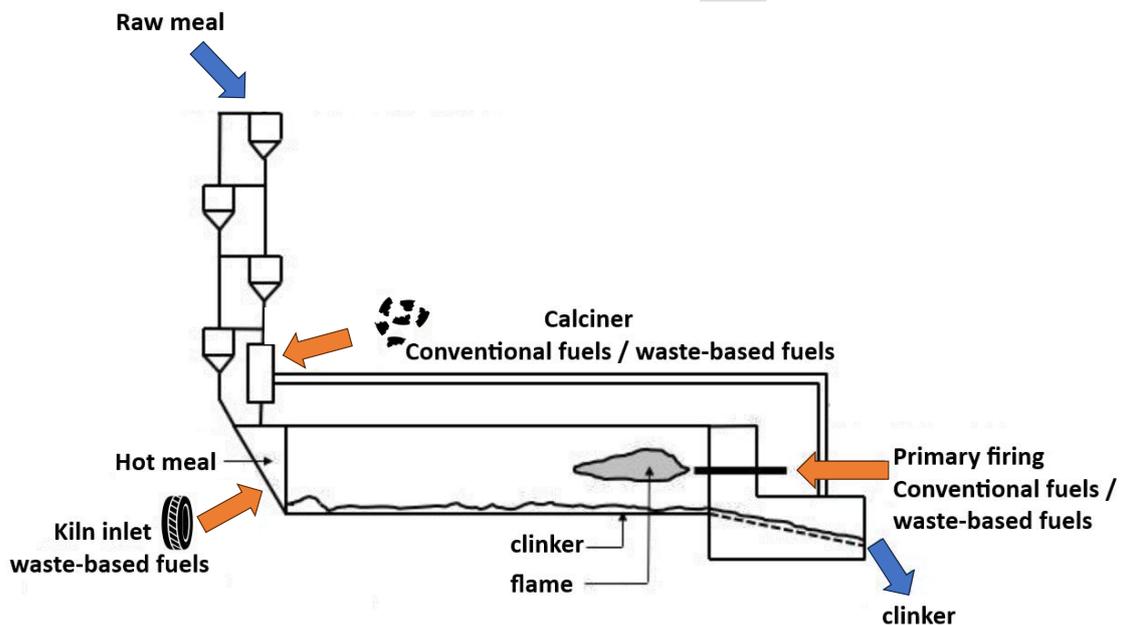
6044 In addition, the steel wires from tyres contain **high carbon content**, generally ranging from 0.7 %
6045 to 0.95 % (Polyakova & Stolyarov, 2021), which is significantly higher than that of standard low-
6046 alloyed steels. Due to both the elevated copper and carbon levels, steel from tyres must be
6047 direct to steel batches that match these specifications. Alternatively, it could be diluted with
6048 cleaner, low-alloyed scrap to meet the desired specifications of the final steel product. According
6049 to EuRIC (EuRIC, personal communication, 20.08.2025), tyre steel from ELT is in demand and
6050 neither copper nor carbon contents restrict sales.

¹¹¹ BOF can only use as much as 20 % scrap input.

6051 7.6.1.8. Treatment in cement kilns

6052 According to CEMBUREAU, (2024) 53 % of the thermal energy consumed in cement kilns in 2021
 6053 was derived from waste fuels (measured in MJ/MJ) in the EU. Of this, 12 % originated from ELT,
 6054 indicating that approximately 6 % of the total fuel demand in cement kilns was met using ELT.

6055 In cement kilns, waste-based fuels are introduced either at the primary firing stage (main flame)
 6056 or at the secondary firing stage, which comprises the calciner or kiln inlet. In most cement kilns
 6057 whole tyres, i.e. not chopped, are typically placed at the kiln inlet (Waltisberg & Weber, 2020;
 6058 Zeschmar-Lahl et al., 2020). Alternatively, chopped tyres (5-10 mm chips) may also be
 6059 introduced in the pre-calciner combustion chamber.¹¹² **Figure 7-29** shows the tyre feed points.



6060

6061 **Figure 7-29: Introduction of tyres in cement kilns.**

6062

Source: Graphic based on Zeschmar-Lahl et al (2020).

6063 ELT are often considered a desirable waste stream for the cement industry because:

- 6064
- 6065 • Their high energy density (LHV ~ 28 MJ/kg¹¹³) supports the high combustion
 6066 temperatures required (material temperature of ~ 1450 °C in the sintering zone of the
 rotary kiln) (Bernhardt et al., 2022).
 - 6067 • Tyre carbon is partially bio-based (typically 25–50 % of total carbon), primarily from
 6068 natural rubber, reducing net fossil CO₂ when used as fuel. Given net-zero fossil carbon
 6069 targets and EU ETS cost pressures, ELTs can partially mitigate CO₂-related costs.

¹¹² Introducing fuels at the calciner generally requires “flyable” fuels to be carried by hot rotary kiln gases—“non-flyable” fuels like scrap tyres are therefore used sparingly, though finer processing of scrap tyres could improve their usability (Hoyer, 2022)

¹¹³ The LHV of waste rubber is 35 MJ/kg

- 6070 • Steel and other non-combustible components are incorporated into the cement matrix.
6071 Steel supplies iron—a critical mineral for clinker formation—thereby reducing demand
6072 for primary raw materials (e.g. iron ore, mill scale). Other inorganics such as silicon or
6073 zinc are likely used in aggregates/fillers (i.e. minerals used for volume, strength and
6074 stability).
- 6075 • ELT composition is well known and relatively constant, reducing sampling efforts and
6076 easing operational management.
- 6077 Conversely, the use of ELT is declining in some cement plants, which can be attributed to
6078 advances in plant technology. In modern cement kilns a significant portion of the calcination
6079 process occurs in the preheater or calciner, and rotary kilns are becoming shorter. As a result,
6080 whole tyres introduced at the kiln inlet no longer have sufficient residence time to burn
6081 completely before reaching the clinker cooler. Tyres may still be fed into the calciner, which
6082 however requires shredding. Shredding of tyres is energy-intensive and may result in economic
6083 inefficiencies. Additionally, tyre shredding causes high wear on the shredding equipment (Hoyer,
6084 2022).
- 6085 From an environmental perspective, the incineration of tyres in cement kilns leads to gaseous
6086 emissions. The quantity and composition of emissions is dependent both on the tyre
6087 composition, the incineration process and the flue gas treatment system. On the EU level
6088 emissions stemming from cement kilns are regulated under the Industrial Emissions Directive
6089 and transposed into national law in the Member States. For NO_x, SO₂, CO, HCl, HF, heavy metals,
6090 particulate matter (PM₁₀) as well as dioxins and furans limit values are in place. The emissions
6091 of polycyclic aromatic hydrocarbons (PAH), specific volatile organic compounds (VOC) or fine
6092 particles (PM <2.5µm) are not covered. There are no limit values for greenhouse gas emissions
6093 (CO₂, N₂O¹¹⁴ are of relevance), even though the (fossil-based) CO₂-emissions are regulated by
6094 the EU-ETS.
- 6095 The CO₂-emission factor for the incineration of tyres shows large deviations. According to the
6096 Guidance Document “Biomass issues in the EU ETS” (European Commission, 2025d) the
6097 “composition of tyres varies widely across manufacturers and tyre type (car, truck, tractor). [...]”
6098 *Typical values informally reported are in the range of*
- 6099 • *Carbon content = [60...75] %*
6100 • *NCV = [25...35] GJ/t*
6101 • *Preliminary emission factor = [80...90] t CO₂/TJ*
6102 • *Biomass fraction = [20...30] %”.*
- 6103 Based on this information, the CO_{2,fossil}-emissions amount to 55-70 t CO₂/TJ NCV¹¹⁵ or 1.5-2.0 kg
6104 CO_{2,fossil}/kg of tyre.

¹¹⁴ Laughing gas emissions (N₂O) are not released from the tyre material itself but instead formed during the combustion process and, in particular, during flue gas treatment. Significant N₂O formation can occur during flue gas treatment in the DeNO_x stage (especially if urea is used for SNCR/SCR).

¹¹⁵ (Carbon content x (44 g/mol/12 g/mol) x (1-Biomass fraction) / NCV).

6105 **7.6.2. Material flow and collection effort at end-of-life (post-**
 6106 **consumer waste) and for preparation for reuse**

6107 **7.6.2.1. Current state of preparation for reuse and End-of-Life Management**

6108 **Preparation for reuse** in the tyre sector essentially refers to retreading, with regrooving being
 6109 considered as part of maintenance. In the European scope retreading is currently (mainly)
 6110 limited to truck tyres and other C3 tyres, airplane tyres and OTR tyres (1st Stakeholders
 6111 consultation, 2025). According to ETRMA data, for every 100 new truck tyres, 37 retreaded truck
 6112 tyres are introduced to the European market in 2022¹¹⁶. The ratio of retreaded to new truck
 6113 tyres peaked at 61 in 2012 and has since then been decreasing (Borchers, 2023b). For other
 6114 tyres, statistics from ETRMA are not readily available, however, **Section 5.2** contains details on
 6115 the retreading market of other tyres.

6116 **ELT** are made up of tyres replaced during the use phase of a vehicle as well as tyres removed
 6117 from vehicles that reach the end of their useful life. In line with Directive 2000/53/EU tyres must
 6118 be removed from end-of-life vehicles as part of depollution activities, i.e., prior to vehicle
 6119 shredding. Vehicle tyres removed from ELVs are checked and when still in decent shape can be
 6120 sold for reuse. The remainder is then transferred to ELT waste management facilities.

6121 Though the ELV Directive requires that tyres are removed from passenger cars (class C1) and
 6122 treated separately, there appears to be no sector-specific legislation that governs the EoL
 6123 treatment of other types of tyres. ELV tyres are collected due to the Directive at authorised ELV
 6124 treatment facilities but then sent to treatment at ELT facilities. The Waste Framework Directive
 6125 applies to ELT but does not detail specific provisions. It could not be clarified why the EoL
 6126 treatment of tyres developed in a way that it focuses on Class C1-C2-C3 tyres.

6127 ETRMA consolidates national data on the whereabouts of ELT for 32 European countries (EU-27,
 6128 UK, NO, RS, CH, TR). The entire tyre market is covered by this data, with few exceptions (i.e.
 6129 Ireland excludes the truck and bus market¹¹⁷). Given that bicycle and airplane tyres are not
 6130 within the scope of European EPR schemes or take-back systems, the data does not cover these
 6131 types of tyres.

6132 The most recent comprehensive statistical data refers to the year 2022 (ETRMA, 2025a),
 6133 indicating that approximately 2.7 million tonnes of end-of-life tyres (ELT) were generated across
 6134 the EU-27. Notably, the data shows a collection and treatment rate of 104 % for ELT in the same
 6135 year. This figure, exceeding 100 %, is attributed to the treatment of tyres that had been
 6136 stockpiled in previous years and not processed within the year they arose.

¹¹⁶ Proportion of retreads in Europe in 2022: 37.1 compared with total new truck tyres, 25.1 compared with total new truck tyres, inc. imports, 20.1 compared with total new truck tyres, inc. imports and retreads.

¹¹⁷ Ireland will include the truck and bus tyre market within the EPR scope as per 2025.

6137 Historical trends reveal a substantial improvement in traceability: the share of tyres with
 6138 unknown whereabouts has declined significantly—from roughly 80 % in 1995 to around 5 % by
 6139 2008. Since then, this figure has remained relatively stable at approximately 5 % (Braithwaite et
 6140 al., 2021)¹¹⁸. This progress has been strongly driven by EU waste legislation—particularly the
 6141 Landfill Directive—and by national ELT management systems, such as extended producer
 6142 responsibility (EPR) schemes and take-back programs, which have effectively banned the
 6143 landfilling of tyres.

6144 Today collected ELT undergo the following treatment paths:

- 6145 • 3.4 % of ELT are used for backfilling or for engineering applications. For example, whole
 6146 tyres are used for “coastal protection, erosion barriers, artificial reefs, breakwaters,
 6147 avalanche shelters, slope stabilisation, road embankments, landfill construction, sound
 6148 barriers, and insulation.” and shredded tyres are “[u]sed as foundation for roads and
 6149 railways, drainage material, landfill construction, subgrade fill and embankments,
 6150 backfill for walls and bridges, and subgrade insulation for roads” (ETRMA, n.d.-a).
- 6151 • 58.2 % of ELT are co-processed in cement kilns. The combustible part of tyres is used as
 6152 fuel (energy recovery) and the combustion residue (steel, ash etc.) is incorporated into
 6153 the cement matrix. For cement kilns ETRMA allocates treatment in cement kilns to
 6154 energy and material recovery according to a standard factor of 75 % (energy recovery)
 6155 and 25 % (material recovery).
- 6156 • 42.2 % of ELT are treated via mechanical recycling. ELTs are shredded and separated into
 6157 three main fractions, i.e. rubber, steel and textiles. The rubber granulates are “used in
 6158 products like wheels for caddies, dustbins, wheelbarrows, lawnmowers, urban furniture,
 6159 signposts, playground flooring, athletic tracks, shock-absorbing mats for schools and
 6160 stables, paving blocks or tiles, and roofing materials” (ETRMA, n.d.-a), the steel fraction
 6161 is sent to steel mills and the textile fraction is incinerated. Mechanical recycling steadily
 6162 increased until 2007, reaching a plateau at around 40 %. It then experienced a sharp rise
 6163 between 2013 and 2014, climbing to approximately 55 %, but its share has decreased in
 6164 recent years again.
- 6165 • Other treatment paths are (still) of minor importance with regard to the current market
 6166 situation especially for treatment within the EU. They include using the combustible part
 6167 of tyres in steel mills/foundries both as carbon substitute and as a metal source or
 6168 emerging technologies, such as pyrolysis, thermolysis or gasification as well as
 6169 reclaiming and devulcanisation. In recent years, however, tyre pyrolysis has become
 6170 increasingly relevant, but is still “limited to a couple of 100,000 tons of ELTs” (1st
 6171 Stakeholders consultation, 2025). However, this share translates into several
 6172 percentage points of ELT arriving in the EU-27.¹¹⁹

6173 **Figure 7-30** shows an overview on the treatment of ELT in 2021, based on ETRMA data (ETRMA,
 6174 2025a).

¹¹⁸ For reference year 2022, the amount of treated tyre is higher than those arising for the first time.

¹¹⁹ 100,000-200,000 ELT translate to a share of ~4-7 % (0.1-0.2 Mio. ELT/2.6 Mio. ELT)

| | | | |
|--|--|------------------------------------|--|
| | | free-riders / stock (3.8%) | |
| 2,664,087 t of ELT arising in the EU-27 in 2022 100 % | | | |
| Treatment of tyres (in the same reference year) 103.8 % | | | |
| material recovery 56.8 % | | energy recovery 43.7 % | |
| mechanical recycling (granulation) 42.2 % | | Treatment in cement kiln 58.2 % | |
| Civil engineering, public works & backfilling (3.4 %) | | | |

6175

6176 **Figure 7-30: Overview on the collection and treatment of tyres in 2022. Other treatment**
6177 **paths are not covered in ETRMA data and depicted in this graph. It is assumed that pyrolysis**
6178 **is covered under mechanical recycling, given that granulation is a prerequisite for pyrolysis.**

6179

Source: (ETRMA, 2025a).

6180 **Remark on ELT-exports under the Basel Convention and export of pre-treated ELT:** For
6181 reference year 2022, waste shipment data recorded by Eurostat (Eurostat, 2025i) show that
6182 ~135,000 t of ELT were shipped from France and to a significantly smaller part from Sweden to
6183 Morocco for recovery (R1). Other extra-EU exports are not recorded for waste code 16 01 03
6184 (i.e. *end-of-life tyres*). According to Euric on the basis of an AECOM report “up to a third of the
6185 treatment of ELTs occurs outside of Europe” in reference year 2019 (Braithwaite et al., 2021;
6186 EuRIC, 2025b). This statement is based on the evaluation of waste code HS 400400 “Waste,
6187 parings and scrap of soft rubber and powders and granules obtained therefrom”, so more
6188 precisely this does not refer to ELT, but pre-treated ELT. "In 2024, out of approximately 1 million
6189 tonnes of Extra-EU exports of the specified waste stream, 41 % went to Turkey, 32 % to India,
6190 and 15 % to Morocco (Eurostat, 2025f).

6191 **Remark illegal exports and littering:** Comprehensive data on illegal exports and dumping across
6192 other EU member states is missing. In Germany, the German Rubber Industry Association
6193 reported a shortfall of 87,000 tonnes in ELT statistics (European Rubber Journal, 2024). Illegal
6194 dumping within Germany is documented by the ZARE initiative. For 2023 they found that over
6195 31,000 tyres were illegally discarded (ZARE, 2024).

6196 7.6.2.2. Stakeholder’s view on future trends in preparation for reuse and 6197 End-of-Life management

6198 Future trends in ELT treatment were investigated as part of the stakeholder consultation (1st
6199 Stakeholders consultation, 2025). Significant changes are expected on how ELT will be treated
6200 over the next decade.

- 6201 • **Retreading:** Responses from all stakeholders involved in retreading indicate that they
6202 see this method as very important for extending the lifetime of tyres. It reduces raw
6203 material consumption and emissions, allowing the tread to be reused several times.
6204 Currently tyres considered suitable for retreading are commercial truck and bus tyres,
6205 aircraft tyres, off-the-road and speciality tyres (e.g. tyres used on large mining trucks,
6206 construction vehicles, and agricultural machinery). The vast majority of retreading

- 6207 currently occurs on C3 tyres, however, the retreaded C3 tyres market has declined
6208 during the past years due to competition with new budget tyres. Without intervention,
6209 this market could continue to decline. Retreading of C1 and C2 tyres used to be more
6210 common in the past, but activity has dropped significantly so that it now represents
6211 more of a niche activity in the EU. A retreader stated that the market for these tyres
6212 could be generated through changes to the legal framework and accompanying
6213 communication campaigns.
- 6214 • The future trend in **mechanical recycling** is unclear. The REACH regulation, in
6215 conjunction with Commission Regulation 2023/2055, imposes restrictions on
6216 intentionally added microplastics and prohibits the utilisation of polymeric infill
6217 materials in artificial pitches. The current contribution of this outlet market to the total
6218 mechanically recycled rubber from ELT is approximately one third. The prohibition will
6219 come into force in 2032 following a transition period and is expected to result in a
6220 decline in demand for mechanical recycling. Concurrently, a shift in the role of
6221 mechanical recycling is anticipated. It has been hypothesised that this could serve as a
6222 preliminary treatment step for a range of other treatment methods, including
6223 devulcanisation, reclaiming and pyrolysis. These methods require shredded rubber that
6224 is potentially free from steel and textiles, which, in turn, would require sorting and
6225 granulation in a suitable manner. This necessitates considerable endeavours to enhance
6226 the preparation of suitable feedstock materials for both technologies. The following
6227 elements are to be considered:
 - 6228 ○ (i) advanced and automated sorting of ELTs, and
 - 6229 ○ (ii) industrial-scale ELT dismantling technologies for the production of more
6230 homogeneous materials (e.g. tread, inner liner, sidewalls, bias-plyes, etc.).
 - 6231 • **Thermochemical recycling (particularly pyrolysis)** is considered an emerging
6232 technology with the potential to treat a significant share of ELT in the future. However,
6233 pyrolysis remains under development and has not yet been widely commercialised in
6234 many regions. Whether the technology will be economically viable and can be deployed
6235 at an industrial scale in the future is dependent on the market for downstream products
6236 (i.e. recovered carbon black and pyrolysis oil), the quality of the products and the
6237 operational scale.
 - 6238 • In addition to the aforementioned treatment routes, **devulcanisation** is also emerging
6239 as viable option. Despite the longer history of devulcanised rubber, its utilisation is not
6240 yet a priority for tyre manufacturers (nor for General Rubber Goods manufacturers).
6241 However, it can be assumed that a significant increase in scientific works, R&D, and
6242 investment in this technology will increase the chances of its development in the next
6243 decade.

6244 • **Treatment in cement kilns** is expected to **decline or remain stable**. Although it remains
6245 dominant in some EU countries, energy recovery¹²⁰ is the lowest-tier recovery method
6246 among current treatment technologies.

6247 With regard to constraints of certain treatment technologies for tyres the following main points
6248 are:

6249 • **Material Challenges in mechanical recycling:** Self-sealing tyre technologies complicate
6250 mechanical recycling and cannot be recycled. The viscous gel employed in the tyres clogs
6251 (or fouls) the cutting tools of mechanical recycling. Silent tyres produce an increased
6252 amount of fluff (foam from inlets), and tyres reinforced with aramid fibred cannot cut
6253 by shredder blades when treated mechanically. Also, high steel contents in tyres require
6254 pre-treatment such as bead removal for effective mechanical treatment. A risk is also
6255 seen in mounted sensors that may contain lithium-ion batteries that must be removed
6256 prior to treatment, otherwise they may cause fires.

6257 • **Homogenous feedstock for pyrolysis:** While in general all tyres can undergo pyrolysis,
6258 a homogenous feedstock quality enables effective treatment. ELT that would jeopardise
6259 a defined quality of recycled carbon black or pyrolysis need to be removed from the
6260 feedstock or require extensive pre-treatment. These include tyres with high textile
6261 contents, silent or self-sealing tyres but also aspects such as the remaining tread depth
6262 and tyre type (summer, winter, studded).

6263 • **Costs and uncertainty in material recovery** value are considered main drivers for the
6264 economic viability of mechanical and chemical recycling methods. Thereof there is a
6265 need for the development of a strong European end-market for recycled rubber and
6266 other recycled materials.

6267 7.6.3. Alternative tyre materials

6268 The production of tyres, and especially rubber compounds suitable for tyres, is a complex
6269 industrial process with significant implications for global supply chains. As the tyre industry
6270 moves toward more sustainable practices, there is a growing need to re-evaluate traditional
6271 petroleum-based materials that have long dominated tyre manufacturing. Identifying,
6272 investigating, and implementing new sustainable materials is essential for future EU
6273 competitiveness and environmental responsibility of the industry.

6274 The transition to sustainable materials is closely linked to reducing material waste and
6275 minimising environmental pollution from both production and end-of-life disposal.
6276 Consequently, the development of eco-friendly tyres and environmentally responsible
6277 manufacturing technologies has become a critical priority. Many tyre manufacturers have

¹²⁰ Treatment in cement kilns would also add to material recovery as the non-combustible part of the tyres would be integrated into the cement matrix. Still tyre treatment in cement kilns is viewed mainly as energy recovery.

6278 already outlined strategies for sustainable development, reflecting a shift in industry-wide
6279 objectives.

6280 • The following sections summarise research on alternative materials capable of replacing
6281 traditional inputs while meeting environmental and sustainability criteria. These materials
6282 are broadly categorised into **recycled and recovered (Section 7.6.3.1)** and **bio-based and**
6283 **renewable (Section 7.6.3.2)** sources.

6284 The following **terms, defined in Subsection 4.2.4**, are essential for understanding the research
6285 on alternative materials:

6286 • ‘Recycled material’ is derived from post-consumer or pre-consumer (post-industrial)
6287 materials that have been reprocessed from a discarded material by means of a
6288 manufacturing process and made into a final product or a component for incorporation
6289 into a product. Examples include recycled PET fibres from plastic bottles and recycled
6290 rubber from ELTs.

6291 • ‘Recovered material’ is a general term for materials extracted from waste products. In
6292 the context of tyres, this primarily refers to recovered carbon black (rCB), which is
6293 obtained through the pyrolysis of ELTs. While rCB is a recovered material, it may also be
6294 considered recycled if it is reprocessed and used in a new product.

6295 • ‘Bio-based material’ is a resource derived from biomass, excluding any materials
6296 embedded in geological formations or transformed to fossilised material. Examples
6297 include trees, crops, grasses, algae, microorganisms, animals and wastes of biological
6298 origin (e.g., manure).

6299 • ‘Renewable material’ is defined as bio-based resources that return to their previous
6300 stock levels by natural growth or replenishment processes at a rate in line with use
6301 cycles. Therefore, they are replenished or regrown at a faster rate than harvested or
6302 extracted materials.

6303 • ‘Sustainable material’ is an umbrella term used by manufacturers. For this section, the
6304 term is treated as meaning materials that are e.g. bio-based, recycled, in general
6305 produced via processes demonstrably improving environmental performance via, e.g.
6306 certified chain of custody, LCA vs baseline (when “mass balance” allocation is used). In
6307 the tyre industry, it has been used as a term associated with sustainable Carbon Black
6308 (sCB), a type of carbon black produced from tyre pyrolysis oil (TPO), making it a more
6309 advanced and sustainable alternative (see **Section 4.2.4.2**).

6310 The next subsection summarises in a table the identified alternative materials with their possible
6311 applications in tyre production and indicates follow-up steps.

6312 A significant number of scientific studies, e.g. (Bardha et al., 2024; S. Deng et al., 2023; Tang et
6313 al., 2022; Thomas & Patil, 2023), have indicated that the use of alternative materials in the
6314 production of new tyres offer benefits for reducing environmental impacts from tyres. However,
6315 in most cases, these materials are still being tested and require further research. One example
6316 are novel types of bio-based and recycled fibres, such as lyocell fibre, r-PET fibre and bio-based
6317 PA56. Though they can be manufactured and incorporated into new tyres, there remains a
6318 discrepancy in mechanical properties in comparison to traditional cords. In many cases, these
6319 novel fibres must be combined with other materials to achieve adequate reinforcement (S. Deng

6320 et al., 2023). Thus, the development of new materials for tyres often involves balancing a
6321 complex set of properties, such as rolling resistance, wet grip, and abrasion.

6322 Tyre manufacturers emphasise that tyre production is an extremely complex process, and the
6323 composition of rubber compounds is finely tuned, allowing very little tolerance. While the use
6324 of bio-based or recycled materials is generally feasible in tyres, it may not be suitable for all
6325 types—particularly premium tyres—due to the very tight tolerances. For example, incorporating
6326 alternative materials, even at a limited extent, could affect handling characteristics. It is not
6327 always straightforward to replace virgin materials with recycled ones; in some cases, bio-based
6328 materials may be more appropriate, and in others, recycled materials may be preferable. Finally,
6329 developing new tyre formulations requires years of research and development, meaning that
6330 the process of incorporating bio-based or recycled materials and bringing them to industrial-
6331 scale production can take up to ten years (1st Stakeholders consultation, 2025; *Stakeholder*
6332 *Interview SR8*, personal communication, 2025).

6333 7.6.3.1. Application of recycled and recovered materials in tyres

6334 Tyres containing recycled materials are becoming increasingly important in the drive towards a
6335 more sustainable and circular economy within the automotive industry. Thus, manufacturers
6336 strive to find ways to use valuable recycled materials in new tyre production.

6337 It has been posited by stakeholders that micronised vulcanised rubber powder (below 450
6338 microns), obtained from mechanically recycling ELT, has been used for many years to some
6339 extent in the manufacture of new tyres. This material corresponds to approximately 1% of the
6340 rubber compound mass. A reduction in the size of this rubber powder results in an increase in
6341 its incorporation within new tyres (1st Stakeholders consultation, 2025).

6342 According to an ELT recycler, a stakeholder involved in the screening study, the use of **recycled**
6343 content in **rubber** mixtures for new tyres has been practiced. However, it was also noted that
6344 manufacturers generally exhibited reluctance in incorporating recycled rubber in their products.
6345 The recycler further noted that, in the future, more advanced sorting will be needed to separate
6346 the rubber crumb into three fractions: crumb from inner liners, which is high in butyl; crumb
6347 from side walls, which is low in silica; and crumb from the tyre tread, which is high in silica and
6348 natural rubber. Using more precisely sorted material from ELT makes it more likely that the
6349 recycled material will be of a higher quality. This means it can be used to make new tyres
6350 (Stakeholder SR7, personal communication, 2025 2024).

6351 According to the outcomes of the project Life Green Vulcan, which involved Bridgestone,
6352 Stellantis and Rubber Conversion, among other parties, it may be feasible to develop and
6353 industrialise a PCR tyre tread with a 10 % content of **devulcanised rubber**. Also, it has been
6354 determined that the incorporation of 20 % content of devulcanised rubber is a possibility in
6355 industrialised elastomeric spring pads ('Life Green Vulcan', 2024).

6356 **Recycled carbon black (rCB)** is a material recovered from ELTs through a process called pyrolysis.
6357 While rCB can be used as a replacement for virgin carbon black, its use is currently limited due
6358 to technical constraints and the need to improve its quality. The substitution is confined to
6359 specific grades and small quantities. Research is underway to enhance the quality of the

- 6360 pyrolysis product to allow for a higher proportion of rCB in new tyres, e.g. (Fraunhofer, 2021;
6361 Laithong et al., 2025; T. Li et al., 2023).
- 6362 An additional development in this area is **sustainable carbon black (sCB)**, which is produced
6363 from pyrolysis oils rather than the solid char. This material is considered more sustainable than
6364 virgin carbon black. Unlike rCB, sCB has the potential to replace all grades of primary carbon
6365 black, though its economic viability is currently impacted by a lower yield.
- 6366 Some stakeholders have suggested a possible target of 50% for carbon black substitution.
6367 However, a stakeholder involved in a screening study, noted that while rCB can substitute virgin
6368 carbon black, it is currently limited due to technical constraints. A pyrolysis facility explains that
6369 CB and rCB have quality tiers ranging from N100 (highest quality) to N900 (lowest quality).
6370 Currently, rCB can fully replace N900–N600, 50 % of N500, and 25 % of N300. If the feedstock is
6371 only truck tyres, N300 and N400 can also be fully replaced. Different CB qualities are used in
6372 different tyre components: sidewalls mainly use N600 and N500, inlays use N600 and N700, and
6373 treads use N100 and N200, which are hardest to replace. The ongoing developments are
6374 expected to help the industry move toward a more sustainable and circular economy for tyres
6375 (Stakeholder SR7, personal communication, 2025 2024).
- 6376 Stakeholders noted also other limitations regarding the use of rCB and sCB, including current
6377 production capacity in Europe (around 100,000 tonnes per annum, expected to rise to 1 million
6378 tonnes by 2030), economic considerations, and the need for end-of-waste (EoW) approval.
6379 Another stakeholder highlighted the importance of verifying chemical contents of substances of
6380 concern in rCB, a relevant factor for all recycled content in tyre manufacture (Stakeholder SR7,
6381 personal communication, 2025 2024).
- 6382 A tyre manufacturer has identified a strong potential for using **tyre pyrolysis oil (TPO)** in the
6383 production of new tyres. Specifically, they see its value as a feedstock for synthesising base
6384 chemicals like **butadiene**, which is a key component of synthetic rubber (1st Stakeholders
6385 consultation, 2025).
- 6386 Continental's ContiRe.Tex technology, launched in 2021, replaces conventional polyester **in tyre**
6387 **casings with high-performance yarn made from recycled PET bottles**. This innovation is being
6388 expanded globally, with mass production starting in mid-2024 and implementation in all
6389 Continental tyre plants by 2025. The company's tests have shown that the recycled PET fibres
6390 have the same quality, stability, and suitability for tyre production as traditional polyester. Each
6391 set of standard passenger car tyres using this technology incorporates material from
6392 approximately 40 recycled PET bottles, which significantly reduces the carbon footprint of tyre
6393 production. This expansion is part of Continental's larger goal of increasing the share of
6394 sustainable materials in its products (Continental, 2025a).
- 6395 Tyre cords can be made from steel wire, polyester, polyamide, adhesive or aramid. Steel wire
6396 cords are the most produced and consumed, with polyester cords in second place (S. Deng et
6397 al., 2023). So far, companies like Teijin Fibers, Michelin, Continental, and Goodyear have started
6398 using **recycled PET (r-PET) tyre cords** to make tyres.

6399 7.6.3.2. Application of bio-based and renewable materials in tyres

6400 Currently, a significant proportion of the organic compounds used in the production of synthetic
6401 rubber, an artificial elastomer, including butadiene, are derived from petroleum-based
6402 monomers. To reduce reliance on fossil fuels, some tyre manufacturers are exploring methods
6403 to produce similar compounds from biomass sources, such as tree bark and kudzu.

6404 Bio-based alternatives to synthetic rubber are sourced from renewable resources, including
6405 plants, algae, and other bio-derived materials. Companies such as Genencor, Amyris, Lanxess,
6406 and Goodyear have developed bio-based monomers through biomass fermentation, producing
6407 compounds such as isoprene-based phosphoric acid esters, ethanol, propanol, isobutanol, and
6408 butanediol. These monomers can then be converted into traditional synthetic monomers,
6409 including isoprene, ethylene, propylene, isobutylene, and butadiene, which are subsequently
6410 used to manufacture conventional synthetic rubbers, such as polyisoprene, ethylene-propylene
6411 rubber, IIR, and SBR. Finally, these bio-based rubbers can be incorporated into tyre production,
6412 resulting in bio-based rubber tyres (S. Deng et al., 2023).

6413 According to one stakeholder involved in public consultations, **biobased butadiene** represents
6414 a promising technology (1st Stakeholders consultation, 2025). In January 2024, Michelin, IFP
6415 Energies Nouvelles (IFPEN), and Axens inaugurated the first industrial-scale demonstrator plant
6416 in France for producing bio-based butadiene from bioethanol. This is part of the "BioButterfly"
6417 project, which aims to develop and commercialise a bio-based alternative to the petrochemical-
6418 derived butadiene currently used in synthetic rubber. Butadiene is a key chemical intermediate,
6419 with about 40 % of its production going into elastomers for the tyre market and the remaining
6420 60 % used for other products like varnish, plastic, and nylon. According to Eric-Philippe Vinesse,
6421 a Michelin executive, this technology is a "wonderful opportunity" to help the company achieve
6422 its goal of using 100 % renewable or recycled materials in its tyres by 2050 (Michelin, 2024a).

6423 Another strategy involves **expanding the sources of natural rubber**. By now, natural rubber has
6424 been derived in a large-scale commercial production from the Hevea Brasiliensis tree (Hevea).
6425 The industry has historically been dependent on a single plant species, but companies are now
6426 exploring alternatives. Bridgestone Americas has invested significantly in developing **guayule**, a
6427 **desert shrub**, as a viable source of natural rubber. Unlike traditional rubber trees, guayule can
6428 be grown in United States of America's desert southwest¹²¹, requiring less water and effort to
6429 cultivate. Guayule is part of the Bridgestone plan to achieve carbon neutrality and make tyres
6430 from 100 % renewable materials by 2050 (Trigui, 2022). This material is already being tested on
6431 IndyCar street circuits to demonstrate its performance capabilities (Stevens, 2023). Alternatives
6432 such as **fig tree milk** offer a more sustainable option in terms of land usage, transportation and
6433 cultivation requirements. Medium-chain-length polyhydroxyalkanoates (**mcl-PHA**) are
6434 biodegradable and can be produced from carbohydrates or via photoautotrophic
6435 microorganisms using CO₂ as the sole carbon source. This could lead to biodegradable tyres,
6436 which would be significantly less environmentally harmful due to their shortened degradation
6437 lifetime after product use. Additionally, microbial production of mcl-PHA would not require

¹²¹ Guayule is a heat tolerant, woody shrub that thrives in desert settings, particularly in United States of America's desert southwest.

6438 arable land, thus avoiding competition with food and feed production—an argument often used
6439 against biofuels and bioplastics (Markl & Lackner, 2020). Further alternatives of natural rubber
6440 are, for instance, **dandelion rubber** and **eucommia ulmoides gum** (S. Deng et al., 2023).

6441 The principles of a circular economy have an increasingly significant impact on the rubber
6442 industry, with applications extending beyond the use of recycled rubber. One notable
6443 development is the increasing use of **bio-based plasticisers**, which are valued for their
6444 exceptional properties and renewable nature (Mohamed et al., 2023). These plasticisers can be
6445 sourced from recycled materials, such as plastic or rubber processed through pyrolysis, or from
6446 various **vegetable oils**, including palm, soybean, castor, sunflower and linseed oils. Vegetable
6447 oils are the most common category of bio-based plasticisers and are frequently used to enhance
6448 the flowability of rubber compounds (Nun-Anan et al., 2021). They are also a focus in other
6449 industries, particularly in the synthesis of novel polymers (Perez-Nakai et al., 2023). Soybean oil
6450 (SBO) in particular has emerged as a promising candidate due to its cost-effectiveness and the
6451 ease with which its properties can be tailored (Mohamed et al., 2022). These bio-based
6452 plasticisers are primarily used in silica-based rubber compounds, where they improve
6453 compatibility by interacting with unsaturated bonds (Kaesaman et al., 2022).

6454 A similar effect has also been observed in carbon black-based compounds (Shafranska et al.,
6455 2023). Görbe et al. (2024) studied the possibility of replacing synthetic oil with soybean oil and
6456 aromatic oil from renewable sources. The results demonstrated that soybean oil was the most
6457 effective. The oils in the compounds reduce their crosslink density. This reduction was more
6458 significant for soybean oil, likely because soybean oil contains unsaturated bonds that can bind
6459 sulphur, such that less of it is available for crosslinking the rubber. Outcomes of the study shall
6460 step towards inserting soybean oil alongside rubber waste to create more sustainable rubber
6461 compounds suitable for high-quality applications, including tyres.

6462 Van Elburg et al. (2025) showed the potential of finding a balance between optimal performance
6463 and sustainability by using **plasticiser blends** comprised of **oil and resin** that perform
6464 comparably to a common petroleum-based plasticiser (TDAE). However, the study recommends
6465 future research focussed on how these new blends affect the rubber's processing properties.

6466 Continental is also aiming to increase the use of renewable and recycled materials in tyre
6467 production, aiming to raise the share from 26 % in 2024 to over 40 % by 2030 (Continental,
6468 2025f). Key to this effort is the use of more **sustainable fillers**: silica and carbon black. Silica is
6469 traditionally made from quartz sand. Continental is now increasingly using **silica** derived from
6470 the **ashes of rice husks**. This agricultural by-product is processed into a material that supports
6471 the circular economy and requires a more energy-efficient production method. According to
6472 (Nzereogu et al., 2023), rice husk ash is produced from the rice husk, a byproduct of the rice
6473 milling process and one of the most widely available agricultural wastes in many rice-producing
6474 countries. Burning rice husk results in an ash composed of 87 %-97 % silica. Alternative methods
6475 for extracting silica from rice husks are being researched, with the objective to reduce emissions
6476 and hazardous wastes related to incineration (Nzereogu et al., 2023). Thus, rice husk ash is
6477 understood to be an alternative that would need more thorough investigation to understand its
6478 potential replacing primary carbon black and/or silica, also comparing it from a carbon footprint
6479 perspective with other alternatives such as rCB.

6480 **Silica** furthermore exhibits considerable potential for **substitution of carbon black**.
6481 Incorporating silica into tyres has been demonstrated to reduce rolling resistance, thereby
6482 enhancing fuel efficiency. Moreover, silica in tyres has been demonstrated to improve grip, thus
6483 enhancing performance (Michelin, 2014). Researchers partially replaced CB with highly
6484 dispersed silica (HDS) nanofillers extracted from agricultural waste products, such as rice husk
6485 ash, resulting in a significantly smaller carbon footprint of the material. However, in the
6486 composition of tread rubber used for passenger car tyres, HDS from rice husk ash has been
6487 shown to have a lower Mooney viscosity¹²² than conventional silica but demonstrates better
6488 dispersion. Furthermore, HDS from rice husk ash demonstrates a higher enhancement factor¹²³,
6489 higher tensile strength, and greater elongation at the breaking point (Lolage et al., 2020).

6490 **Biochar** and **silica** derived from **biowaste** show promise as reinforcement fillers in rubber,
6491 potentially replacing **carbon black**, a major component in tyres. Techniques to harness
6492 antioxidants from nutrient-rich food waste are also being explored for rubber applications.
6493 While research is promising, further studies are needed to optimise these biowaste-derived
6494 additives and ensure their commercial viability in tyre production. Areas like alternative coupling
6495 agents and biorefinery approaches also need exploration (Bardha et al., 2024).

6496 Continental also uses **bio-based carbon black** produced from organic sources like **tall oil**
6497 (Continental, 2025f) in its tyre production. Bio-based carbon black (also known as renewable
6498 carbon black) can be produced from a variety of sources utilising bio-based or recycled materials,
6499 including vegetable oils, wood, and waste products from agriculture and forestry. Renewable
6500 carbon blacks are manufactured from industrial-grade vegetable oils or other feedstocks derived
6501 from waste and residues of biological origin from agriculture or forestry. According to (Orion,
6502 2023) at present, the majority of these feedstocks are utilised for biodiesel production.

6503 Traditional tyre cord materials include steel, polyester, polyamide, adhesive, and aramid fibres.
6504 Steel cords are the most widely used, followed by polyester. Next to replacement of original
6505 material with r-PET, further advancements in **lyocell fibre** may replace viscose tyre cords or even
6506 other tyre cord types (S. Deng et al., 2023). Also, bio-based **PA56**, a polymer made from
6507 renewable plant materials such as starch, straw, and corn, can be used to replace tyre cords.
6508 Lyocell fibre is being developed as alternative to traditional petroleum-based polyamides like
6509 PA66, as it has been noted to have comparable properties to PA66, with a lower carbon
6510 footprint.

6511 The objective of bio-based materials in tyre manufacturing is twofold: firstly, to **substitute for**
6512 **petroleum-based synthetic rubber**, and secondly, to ensure that the **performance**
6513 **characteristics of the new materials are comparable** to those of the existing products.
6514 Developing bio-based materials for tyres faces challenges in balancing performance, cost, and
6515 sustainability. While offering environmental benefits, bio-based materials need to match or

¹²² Mooney viscosity is a measure of a material's resistance to shear deformation, commonly used in the rubber industry to characterise the flow properties of uncured rubber compounds. It indicates how easily a rubber compound will flow during processing, influencing mixing, extrusion, and moulding operations.

¹²³ Enhancement factor in rubber refers to how much a particular property of rubber is improved by adding something to it, such as a filler or a specific treatment. This improvement is often quantified as a ratio, comparing the property's value in the modified rubber to its value in the unmodified rubber.

6516 exceed the performance characteristics of traditional materials like synthetic rubber in terms of
6517 rolling resistance, wet grip, and abrasion resistance. Furthermore, the production of these
6518 materials can be more expensive, and consumer awareness and acceptance of bio-based tyres
6519 are still developing (Fraunhofer, 2024).

6520 The tyre manufacturers association reported in the public consultation for this study that bio-
6521 based or renewable alternatives to rubber and other materials have the highest potential to be
6522 used in tyres production. These materials are:

- 6523 • Bio-based polybutadiene from plant-derived feedstock.
- 6524 • Methane-derived carbon black and bio-based polyamide from plant-derived feedstock.
- 6525 • Sustainable silica from rice husk, a circular waste material that can immediately replace
6526 mineral silica.
- 6527 • Processing oils from sources like soybean oil or rape seed oil.

6528 Some bio-based materials, like dandelion rubber, are being explored, but at the moment they
6529 are only used in small amounts; dandelion production requires a lot of land, so they are not
6530 realistic for large-scale demand. As natural rubber is required for production, other options must
6531 be considered. Current studies are looking into using natural rubber or other materials rubber
6532 (e.g. from pyrolysis oil) instead of synthetic but use of such materials for tyres is still quite rare.

6533 The overall possible share of bio-based materials in tyres is 20 %. This target could be applied
6534 across the tyre production industry for year 2040 and would allow for commercial and
6535 technological advancements in materials. Depending on the exact tyre application, the bio-
6536 based materials rate could be adapted (1st Stakeholders consultation, 2025).

6537 7.6.3.3. Tyre manufacturer initiatives

6538 This chapter provides an overview of selected tyre manufacturers' initiatives and long-term
6539 sustainability goals. Companies including Michelin, Goodyear, Bridgestone, and Continental
6540 have invested in research and development to explore sustainable resources, aiming for
6541 milestones such as fully sustainable tyres and carbon neutrality by 2050. The Tire Industry
6542 Project (TIP), established under the World Business Council for Sustainable Development
6543 (WBCSD), also plays a key role in coordinating sustainability efforts across the sector.

6544 Tyre manufacturers are increasingly incorporating bio-based and recycled materials into their
6545 production processes, which they often refer to as "sustainable tyres". When launching such
6546 products, manufacturers typically disclose the proportion of sustainable materials used. These
6547 statistics, however, are not necessarily indicative of the environmental impact of tyre
6548 production, which would have to be checked and certified. The following examples highlight
6549 initiatives from various tyre producers in developing and promoting different types of
6550 "sustainable tyres".

6551 In May 2023, **Goodyear** announced a new tyre tread formulation for its ElectricDrive™ GT tyre
6552 that includes Monolith carbon black produced by methane pyrolysis (also called thermal plasma
6553 process). Goodyear states that the process uses renewable energy to convert methane into
6554 carbon black and hydrogen, with no combustion. Goodyear is currently also exploring the use of

6555 carbon black produced from methane derived from waste sources (Goodyear Tire & Rubber
6556 Company, 2023). To obtain Monolith carbon black, electricity is used to create a superheated
6557 plasma that breaks down hydrocarbon molecules, such as natural gas or renewable natural gas,
6558 into their basic elements: carbon and hydrogen (Monolith, 2025). In early 2024, Goodyear
6559 introduced the ElectricDrive 2, an all-season EV tyre with 50 % “sustainable materials” by weight,
6560 improved rolling resistance and long-lasting tread life to maximise performance (Goodyear,
6561 2025).

6562 In November 2024, Goodyear presented its Electric Drive Sustainable-Material Tire that contains
6563 over 70 % sustainable material. Goodyear defines “sustainable material” as “a bio-based/
6564 renewable, recycled material or one that may be produced using or contributing to other
6565 sustainable practices for resource conservation and/or emissions reductions including mass-
6566 balance materials” (Goodyear, 2023). The company also states that it aims to obtain a 100 %
6567 sustainable-material tyre by 2030. Goodyear declares that it uses the following sustainable
6568 materials for tyre production: rice husk ash silica (RHA) silica, bio-based oils, Monolith carbon
6569 black, and other materials. In January 2023, Goodyear presented a 90% Sustainable Material
6570 Demonstration Tire with 17 ingredients across different tyre compounds, including four
6571 different types of carbon black (produced from methane, carbon dioxide, plant-based oil and
6572 end-of-life tyre pyrolysis oil feedstocks), soybean oil, RHA silica, polyester recycled from PET
6573 bottles, bio-renewable pine tree resins, steel with high-recycled-content (Goodyear, 2023). In
6574 addition, Goodyear has more than doubled its use of RHA silica in its product lines since 2018.

6575 **Continental's** tyre group has a series of ambitious sustainability targets; by 2030, it aims to
6576 achieve more than a 40% share of renewable and recycled materials in its tyres and by 2050 at
6577 the latest, all new tyres from Continental are to be made entirely from "sustainable materials."
6578 This is a distinct goal from the company's broader aim of becoming "climate-neutral by 2050."
6579 Continental is using a variety of innovative materials to meet its goals, with an average share of
6580 26 % of renewable and recycled materials in its tyre production in 2024 (Continental, 2025e).
6581 The company expects this figure to increase by two to three percentage points in 2025. These
6582 materials include synthetic rubber made from renewable or circular oils, polyester from recycled
6583 PET plastic bottles, recycled steel for components like bead cores, and casing reinforcements,
6584 new fillers such as silica from rice husk ash. A specific example of this effort is the UltraContact
6585 NXT tyre, which is made from up to 65 % renewable, recycled, and mass-balance certified
6586 materials (Continental, n.d.-c). Within this, renewable materials account for up to 32 %, and
6587 recycled materials for up to 5 % (Continental, 2023a). In addition to using new materials,
6588 Continental has also changed its manufacturing processes. Since 2019, the company has used a
6589 proprietary textile coating called 'COKOON' to bond textile components and rubber. This
6590 innovative substance is used in place of the conventional substances formaldehyde and
6591 resorcinol, making it a more environmentally friendly alternative. To ensure transparency and
6592 traceability of its sustainable materials, Continental uses the mass balance approach. This
6593 system, often certified by third parties like ISCC Plus, allows the company to physically mix
6594 certified and non-certified materials while keeping a verifiable record of the exact quantities of
6595 sustainable ingredients used in its products.

6596 In September 2023, Continental announced use of recovered carbon black in its solid tyres like
6597 the SC20+, which are used primarily in material handling vehicles like forklift trucks and airport
6598 vehicles (Continental, 2023b). Solid tyres such as Continental’s SC20+ already contain around 60
6599 percent renewable and recycled materials thanks to their high natural rubber content. The rCB

6600 has been supplied at this time by Pyrum Innovations AG, which uses a special pyrolysis process
6601 to break down end-of-life tyres into their individual components (Pyrum, 2023). In January 2025,
6602 the plant in Korbach received the International Sustainability and Carbon Certification (ISCC)
6603 PLUS sustainability certification, indicating that Continental meets specific sustainable materials
6604 requirements (Continental, 2025d).

6605 In 2021, **Michelin** produced a new racing tyre for the MotoE World Cup that contains between
6606 33 % (front tyres) and 40 % (rear tyres) recovered material (Weibold, 2021). The tyre's recovered
6607 content includes carbon black produced using the recycling technology of Scandinavian Enviro
6608 Systems (Enviro). This development aligns with Michelin's ambitious goal of manufacturing all
6609 its tyres using only sustainable materials by 2050. The company's intermediate target for 2030
6610 is to have 40 % of all constituent materials be sustainable. In October 2022, Michelin unveiled
6611 two tyre types approved for road use containing 45 % and 58 % of sustainable materials
6612 (Michelin, 2022). Sustainable materials in these tyres include natural rubber, together with the
6613 recycled carbon black, oils such as sunflower oil and bio-sourced resins, silica from rice husks
6614 and recycled steel. In 2024, Michelin, Antin and Scandinavian Enviro Systems (Enviro)
6615 announced plans to build an end-of-life tyre recycling plant in Uddevalla, Sweden (Michelin,
6616 2024b). The plant will use Enviro's patented pyrolysis technology to extract raw materials, such
6617 as recovered carbon black and pyrolysis oil, from used tyres. Michelin has signed a multi-year
6618 supply agreement for these materials.

6619 In August 2023, **Hankook Tire** was the first company in the Korean tyre industry to have its mid
6620 to long-term greenhouse gas reduction goals for achieving "Net Zero by 2050" approved by the
6621 Science Based Targets initiative (SBTi). In 2024, Hankook Tire has begun mass production of tyres
6622 using three types of ISCC PLUS certified carbon black, which are derived from end-of-life tyre
6623 pyrolysis oil. The company developed this through its "Tire-to-Tire Circular Economy Model"
6624 consortium and aims to apply these materials to meet global sustainability requirements
6625 (Hankook Tire, 2024).

6626 In July 2025, **Pirelli** released the first standard production tyre for the global market that is made
6627 with over 70 % bio-based and recycled materials. The materials used in the tyre include:

- 6628 • FSC™-certified natural rubber, which ensures the natural rubber supply chain is
6629 managed responsibly from the plantation to the factory.
- 6630 • Recycled steel sourced partially from melted scrap metal, it maintains the same
6631 mechanical properties as virgin steel.
- 6632 • Silica from rice husks derived from rice processing waste, this silica is used in the tread
6633 compound to ensure high performance in wet conditions
- 6634 • Circular carbon black, which is produced from pyrolysis oil obtained from ELT.
- 6635 • **Bio-circular polymers** that are manufactured from monomers derived from sources like
6636 used **cooking oil**, replacing fossil-based polymers.
- 6637 • **Bio-resins** that are plant-based plasticisers helping optimise the balance between dry
6638 and wet performance (Pirelli, 2025).

6639 7.6.3.4. Overview of alternative tyre materials and follow-up steps

6640 The tables below list alternative materials with their possible applications in tyres.

6641 **Table 7-18: Overview of alternative tyre materials – recycled/recovered.**

| Material | Target component / Replaced material | Application |
|---|---|--|
| Micronised vulcanised rubber powder (<450 µm) | Functional filler and compound extender / Replaces various virgin rubber compounds | Used to a small extent in new tyre manufacturing, corresponding to approximately 1 % of the rubber compound mass. A reduction in particle size allows for a higher incorporation rate. |
| Devulcanised rubber | Tread (limited), elastomeric parts (pads, inserts) / Replaces virgin rubber | ~ with a 10 % content in PCR tyre tread ~ with a 20 % content in elastomeric spring pads |
| Recovered carbon black (rCB) | Sidewall, inner components; limited in tread / Replaces virgin carbon black in a limited manner | The substitution is currently limited to specific grades (fully replaces N600-N900, 50 % of N500, and 25 % of N300). rCB from truck tyres can fully replace N300 and N400. |
| Sustainable carbon black from TPO (sCR) | Broad virgin carbon black grades / Replaces virgin carbon black | Has the potential to replace all grades of primary carbon black, but its economic viability is affected by lower yields. |
| Tyre pyrolysis oil (TPO) | Petrochemical feedstock (e.g. for butadiene) | Under development - a strong potential for its use as a feedstock for synthesising base chemicals for new tyres. |
| r-PET yarns | Replaces conventional polyester in tyre casings | Industrial scale since 2024. Each set of standard passenger car tyres uses material from approximately 40 recycled PET bottles. |
| r-PET cords | Replaces e.g. steel cords (virgin steel) | Industrial scale |

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6643 **Table 7-19: Overview of alternative tyre materials – bio-based/renewable.**

| Material | Target component / Replaced material | Application |
|-----------------------------|--|--|
| Bio-based synthetic rubber | Elastomer / Replaces petroleum-based synthetic rubber (e.g. polyisoprene, SBR) | Research and development stage developing bio-based monomers for conversion. |
| Bio-based butadiene | Elastomer / Replaces petrochemical-derived butadiene | Industrial-scale demonstrator plant in France to develop and commercialise the technology. |
| Natural rubber from Guayule | Elastomer / Replaces natural rubber from the Hevea Brasiliensis tree | Being tested on IndyCar street circuits to demonstrate performance capabilities. Part of Bridgestone's plan to achieve its sustainability goals. |

| Material | Target component / Replaced material | Application |
|---|--|--|
| Natural Rubber from Dandelion | Elastomer / Replaces natural rubber from the Hevea Brasiliensis tree | Currently used in small amounts due to high land requirements, making it not yet realistic for large-scale commercial demand. |
| Fig tree milk | Elastomer / Replaces natural rubber from the Hevea Brasiliensis tree | Requires less land usage and is potentially easier to cultivate. Rubber content rather low. |
| Medium-chain-length polyhydroxyalkanoates (mcl-PHA) | Conventional tyre materials | A developmental concept that could lead to biodegradable tyres. Production is via microorganisms, avoiding competition with food and feed crops. |
| Bio-oils (vegetable oils, e.g. palm, soybean, castor, sunflower, linseed, rape seed oils) | Plasticisers, processing oils / Replace petroleum-based plasticisers (e.g. TDAE) | Currently used in silica-based rubber compounds to improve flowability and compatibility. Research is ongoing to increase their use with soybean oil showing significant potential. |
| Rice husk ash | Fillers / Replaces traditional silica (from quartz sand) and potentially carbon black | Increasing use by companies like Continental and Pirelli. It is considered a that it can replace silica and potentially replacing virgin carbon black with highly dispersed silica (HDS) nanofillers extracted from agricultural waste products. |
| Biochar and biowaste-derived silica | Fillers, additives / Replaces carbon black | Research is promising, but further studies are needed to optimise these additives and ensure commercial viability for tyre production. |
| Bio-based carbon black (e.g. tall oil or bio-feedstock) | Fillers / Replaces virgin carbon black | Continental uses this material, which is produced from organic sources like tall oil and other bio-based or recycled feedstocks. |
| Bio-based PA56 (from e.g. starch, straw, and corn) | Replaces traditional tyre cords from e.g. petroleum-based polyamides like PA66 | Bio-based PA56 can be used to replace tyre cords, and recycled PET is used for polyester components. These materials are part of Continental's plan to increase the share of sustainable materials. |
| Lyocell fibre | Replaces traditional tyre cords e.g. viscose tyre cords or other tyre cord types, petroleum-based polyamides | Being developed as a high-performance, lower-carbon-footprint alternative. |

6644 **Section 7.6.3** presents a set of alternative materials (e.g. recycled and bio-based) that could
6645 potentially be integrated into tyres, along with their actual implementation in specific tyres.
6646 Regulation through the ESPR could incentivise and/or define the increased application of
6647 recycled and bio-based/renewable materials. When setting targets for the content of alternative

6648 materials (e.g. recycled and bio-based), further aspects need to be investigated. To this end, the
 6649 project team formulated questions for stakeholders in this regard, which are listed in **Section**
 6650 **7.8.**

6651 7.6.4. End of Waste criteria

6652 Once materials cease to be designated as waste, they reach an End-of-Waste (EoW) status.
 6653 Defining EoW criteria at a European level enables a level-playing field among member states.
 6654 The establishment of harmonised EoW criteria is crucial for facilitating the re-entry of secondary
 6655 raw materials into the market, as the respective products would need to adhere to specified
 6656 quality standards. Currently there is no EU-wide EoW rule for tyres or ELT-derived rubber; Article
 6657 6 of the Waste Framework Directive lets member states set their own national EoW criteria.
 6658 Several member states have defined EoW criteria for ELT or granulates derived thereof, which,
 6659 however these may vary across Member States, as shown in **Table 7-20** (Orveillon et al., 2022).
 6660 National EoW status isn't automatically recognised in other member states. When ELT granulate
 6661 leaves the country where it obtained EoW, the receiving authority may still treat it as waste
 6662 unless acceptance is clear. In this context several standards are defined for materials from ELT
 6663 in general¹²⁴, and standards for rubber derived from ELT used in sports surfaces¹²⁵.

6664 **Table 7-20: Overview on the existence of national or regional end-of-waste or by-product**
 6665 **criteria for rubber recovered/recycled from ELT.**

Rubber recovered/recycled from ELT: Existence of national or regional end-of-waste or by-product criteria

National end-of-waste criteria in **Estonia** and **France**.

National end-of-waste criteria in **Portugal** and the **United Kingdom** for recycled tyres.

National end-of-waste criteria in the **Czech Republic, Denmark, Italy, Portugal, Slovakia**, and the **United Kingdom** for granulates derived from end-of-life tyres, and in the **Netherlands** for granulates used in infill applications.

National end-of-waste criteria in preparation in **Greece, Spain, Estonia, and Latvia**.

6666 Source: (Orveillon et al., 2022).

6667 For the tyre industry, adopting EoW criteria could be a key step in unlocking the full potential of
 6668 Europe's tyre recycling market. EoW-criteria that apply to ELT derived materials, whether from
 6669 mechanical or (thermo-)chemical recycling provide regulatory clarity. As a result EuRIC and
 6670 ETRMA (EuRIC, 2025b) argue that EoW criteria allow for:

- 6671 • Promoting cross-border trade, as it provides regulatory certainty and a level playing
 6672 field, required to allow for market access, and thereby reducing administrative burdens,
- 6673 • Incorporating recycled materials into new products, especially because safety and
 6674 quality criteria are met.

¹²⁴ EN 14243-1:2019; EN 14243-2:2019; EN 14243-3:2019; CEN/TR 17511:2020; CEN/TS 16916:2016; CEN/TS 17045:2020; CEN/TS 17188:2018; CEN/TS 17189:2018; CEN/TS 17307:2019; CEN/TS 17308:2019; CEN/TS 17510:2020

¹²⁵ EN 15330-1:2013; EN 14836:2018; EN 14955:2005

6675 Additionally, EoW criteria foster investment in industrial infrastructure, and align certification
6676 schemes to ensure traceability and safety across the value chain. As a consequence, harmonised
6677 EoW criteria would not only increase the use of recycled materials but also assist in
6678 differentiating between used tyres and ELTs, thereby averting the premature classification of
6679 reusable tyres as waste. Furthermore, the granting of EoW status to tyre pyrolysis oil (TPO) could
6680 accelerate its market integration and indirectly strengthen the recovered carbon black (rCB)
6681 sector, as both are co-products of the pyrolysis process. The absence of EoW criteria for these
6682 materials hinders the utilisation of rCB and sCB as substitutes for primary materials. Moreover,
6683 competition from the energy sector has the potential to divert feedstock and elevate prices,
6684 thereby underscoring the necessity for the establishment of a stable and transparent
6685 framework. Furthermore, synergies emerge with the implementation of DPPs, which offer a
6686 promising solution to trace material status changes and uphold the waste hierarchy (see **Section**
6687 **7.6.7**) (1st Stakeholders consultation, 2025; EuRIC, 2025b; Stakeholder SR7, personal
6688 communication, 2025 2024).

6689 7.6.5. Potential substances of concern

6690 Though the subject of substances of concern shall be covered in detail as part of Task 5 of the
6691 preparatory study, a first effort has already been made to identify substances that are associated
6692 with potential impacts in the various life phases of tyres. The preparation of this section thus
6693 has not included a detailed screening of substances addressed and/or regulated under chemical
6694 legislation and their presence in tyres and their waste fraction. Rather the section is based on
6695 the identification of problematic substances (and materials) that are present in tyres. The
6696 information has been collected through the exchanges with stakeholders (manufacturers,
6697 retreaders, recyclers, up-takers or secondary materials of tyre origin), the review of results of
6698 the 1st stakeholder consultation and through the course of the literature review of other aspects.

6699 ESPR defines substances of concern in Article 2(27) as follows: “a substance that:

- 6700 (a) meets the criteria laid down in Article 57 of Regulation (EC) No 1907/2006 and is
6701 identified in accordance with Article 59(1) of that Regulation;
- 6702 (b) is classified in Part 3 of Annex VI to Regulation (EC) No 1272/2008 in one of the following
6703 hazard classes or hazard categories: [...]
- 6704 (c) is regulated under Regulation (EU) 2019/1021; or
- 6705 (d) negatively affects the reuse and recycling of materials in the product in which it is
6706 present” (REACH Regulation, 2006).

6707 The first three groupings refer to the various substances listed and/or regulated in the REACH,
6708 the CLP Regulation¹²⁶ and the POPs Regulation¹²⁷. These shall be considered during Task 5 to see
6709 whether they are used in tyre manufacture and present in tyres placed on the EU market.

6710 In various exchanges, retreaders, waste operators and their associations have raised the
6711 importance of being informed as to the composition of tyres that are received for treatment in
6712 their facilities. Detailed information on composition and on substances of concern is of
6713 importance for ensuring that waste fractions processed into products do not contain substances
6714 that are restricted or prohibited for use in materials and products to be placed on the market.
6715 However, it is also of relevance for the sorting of ELTs to allow better specification of the
6716 composition of secondary raw materials that result from the waste processing.

6717 From the manufacturers side, providing full information on composition would violate
6718 intellectual property rights and could furthermore affect the competition on the market. EU
6719 chemical legislation requires economic operators who place tyres on the EU market to make
6720 information available on the contents of regulated substances such those restricted under
6721 REACH or prohibited by the POPs Regulation. However, where a substance is only regulated after
6722 the product has been placed on the market but before it has reached EoL (i.e., waste
6723 management), information on the content of so-called legacy substances is currently not
6724 obligatory to provide. Though manufacturers may be able to provide such information from the
6725 data obtained for manufactured tyres in their systems, there may be certain limitations. As
6726 raised in an exchange with a stakeholder, though various substances may be used in the
6727 manufacture of tyres, some of these undergo transformation during the manufacturing process
6728 or during the use phase. In other words, it is noted that not all substances that are used in tyre
6729 manufacture shall actually be present in the products that are then placed on the market. This
6730 was raised to explain the difficulties of specifying at the individual product level all substances
6731 that are contained in the tyre and its components both to begin with but also retroactively, when
6732 a new substance used in tyre manufacture is restricted.

6733 Though Article 2(27) of ESPR refers to substances, and stakeholders generally interpret this to
6734 mean single chemical compounds, the presence of certain materials in a tyre can also be
6735 disruptive for the waste management of tyres, affecting the potential for reuse and recycling of
6736 materials in the product. This section thus details not only substances but also materials that
6737 have been identified as problematic in the following:

- 6738 • **Poly Aromatic Hydrocarbons (PAH)** are compounds that have been found to be
6739 carcinogenic and that are categorised as an SVHC under REACH. In the far past these
6740 substances were present in extender oils used in large amounts in the production of tyre
6741 rubber. It was found that their presence in rubber material that was emitted as abrasion

¹²⁶ Classification, Labelling and Packaging Regulation (Regulation (EC) 1272/2008) is a European Union regulation that implements the United Nations' Globally Harmonised System (GHS) for identifying and communicating the hazards of chemical substances and mixtures, ensuring they are classified, labelled, and packaged correctly before being placed on the market (<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008R1272-20250901>).

¹²⁷ POPs Regulation (Regulation (EU) 2019/1021) is a European law that implements international agreements such as the Stockholm Convention on Persistent Organic Pollutants and the Aarhus Protocol (<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02019R1021-20250804>).

6742 was harmful to the aquatic environment. In parallel to the development of a restriction
 6743 of such compounds, tyre manufacturers turned towards extender oils with reduced
 6744 amounts of PAHs (European Commission, 2003). A restriction came into effect in 2010,
 6745 limiting the levels of PAHs in tyre rubber. However, Hoyer et al. (2022) explain that
 6746 carbon black is also an important source of PAH in tyres, the content of which is not
 6747 regulated at EU level and there is also no limit for the total content of PAH in tyres (Hoyer
 6748 et al. & Hoyer, S., Kroll, L., Lippert, K., Seidel, A., 2022). Though PAH levels in tyres have
 6749 decreased significantly, they are still relevant as an impurity, affecting the mechanical
 6750 recyclability of tyres as the PAHs remain present in resulting secondary substances.
 6751 Furthermore, REACH Annex XVII restriction 50 for PAHs specifies different levels for
 6752 rubber in tyres and for secondary raw materials. Entry 50(1)¹²⁸ sets limits for the
 6753 concentration of 8 PAHs in oils used in tyre manufacturing at a threshold of 0.001 % by
 6754 weight, while entry 50(5)¹²⁹ and 50(9)¹³⁰ set limits for the PAH content in rubber articles
 6755 (0,0001 % by weight) and rubber infill/mulch (0.002 % by weight). While entry 50(1)
 6756 refers to the PAH content in oil, the other restrictions refer to the total content of PAH,
 6757 regardless of the material/component used in their manufacturing. This allows tyre
 6758 manufacturers to use carbon blacks that contain PAHs at a level of up to 0.1%. As a
 6759 result, ELT recycled rubber can fail at complying with the limits set by Restrictions 50(5)
 6760 and 50(9), and therefore cannot be used in several applications. Harmonised legislation
 6761 would be preferable, as it would prevent the use of PAH-contaminated raw materials in
 6762 the first place, thus allowing recycled rubber to be used in a wider range of markets.

- 6763 • **Foams and noise absorbing materials** are included in “**noise reduction tyres**” within the
 6764 tyre and have been reported by retreaders and waste operators as problematic for both
 6765 mechanical and chemical recycling. Usually, polyurethane foams are used. One
 6766 stakeholder explained that due to the foam, noise reduction tyres lower ELT recyclability
 6767 due to the increased amount of scrap textile/fluff that is produced during granulation
 6768 (1st Stakeholders consultation, 2025). The foam can be removed; however, this would
 6769 increase treatment costs and would also require quick identification of such tyres so that
 6770 they could be sorted out for foam removal or for diversion to other routes.

¹²⁸ REACH Annex XVII Entry 50(1): “From 1 January 2010, extender oils shall not be placed on the market, or used for the production of tyres or parts of tyres if they contain:

— more than 1 mg/kg (0,0001 % by weight) BaP, or,
 — more than 10 mg/kg (0,001 % by weight) of the sum of all listed PAHs. [...] (REACH Regulation, 2006).

¹²⁹ REACH Annex XVII Entry 50(5): “Articles shall not be placed on the market for supply to the general public, if any of their rubber or plastic components that come into direct as well as prolonged or short-term repetitive contact with the human skin or the oral cavity, under normal or reasonably foreseeable conditions of use, contain more than 1 mg/kg (0,0001 % by weight of this component) of any of the listed PAHs. Such articles include amongst others:

— sport equipment such as bicycles, golf clubs, racquets
 — household utensils, trolleys, walking frames
 — tools for domestic use
 — clothing, footwear, gloves and sportswear
 — watch-straps, wrist-bands, masks, head-bands.”(REACH Regulation, 2006).

¹³⁰ REACH Annex XVII Entry 50(1): “9. Granules or mulches shall not be placed on the market for use as infill material in synthetic turf pitches or in loose form on playgrounds or in sport applications if they contain more than 20 mg/kg (0,002 % by weight) of the sum of all listed PAHs.”.

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- **Sticky gel materials used in self-sealing tyres** to gauge punctures have been reported by retreaders and waste operators as problematic for both mechanical and chemical recycling. In both cases, tyres are shredded at the beginning of these recovery processes at which time the sticky gel materials can adhere to the shredder blades disrupting the process. These materials clog up the shredder blades and decrease shredding efficiency. More importantly, these materials can also ignite due to the temperatures that occur during the process, causing serious fires in shredding units as tyre shreds are highly flammable. For this reason, it was explained that such tyres would need to be sorted out of batches and sent to incineration. However, in cement kilns still accepting tyres, these products are sometimes also shredded into smaller pieces to enable a more consistent process. Thus, the demand of ELTs for incineration processes in the EU may also decrease in coming years. Though manufacturers have stated that such tyres can be processed as long as they are included in the shredding process in small amounts (e.g. below 1 %), retreaders and waste operators object to this view. Recyclers stated that even a single tyre of this type may cause fires that are hard to control and lead to material losses and workplace risks (1st Stakeholders consultation, 2025). The exact materials used for the sealing function are not specified in public sources and are understood to be proprietary. Here too, as a minimum waste operators need a means of quick identification of a tyre as a self-sealing one to allow for sorting and diversion to other treatment routes.
 - A few stakeholders referred to tyres reinforced with **aramid fibres** that cannot be recycled as the aramid fibres cannot be cut by the shredder blades. Teijin (2025) is a supplier of an aramid fibre-based reinforcement material that is applied in tyres. On their webpage they state that the material can be used in many parts of the tyre to add strength and reduce weight. Example applications given include cap ply and the carcass reinforcement cords. In addition, the same material “can be added to rubber compounds of tyres to improve the balance between grip, wear, and rolling resistance or to reinforce sidewalls against sharp edge damage from road debris or kerbs. Aramid inclusion in tyre design improves safety and lowers carbon emissions”. Such materials can be understood to be used only in selected tyres.
 - The pyrolysis of tyres using high amounts of **silica** (more common in the C1, C2 tyre classes) produces a low-quality recovered carbon black that is too high in ash content and cannot be used again in the production of new tyres. The high silica **or other non-volatile additives** end up in the rCB (1st Stakeholders consultation, 2025). Currently, a large share of truck tyres is preferred in these processes to deal with this problem, however, it is to be investigated whether higher silica contents could pose a problem in the future when the practice of pyrolysis is expected to expand, leaving less opportunities to “cherry pick” tyres with lower silica content.
 - **Halobutyl** can include both **chlorobutyl** or **bromobutyl** rubber (with bromo being worse) (1st Stakeholders consultation, 2025). These materials have low air permeability and as such are applied in various tyre compounds to maintain air pressure in the tyre. Both materials can cause extensive damage via corrosion during the pyrolysis process and during the use of TPO as a feedstock for material re-use. One stakeholder suggested inclusion of the chlorobutyl and bromobutyl content in the DPP to allow sorting out of tyres with high levels. In parallel, it was proposed to consider limiting the chlorobutyl content to the minimum necessary (cannot be completely avoided) but prohibiting the
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- 6817 bromobutyl compounds which are more problematic (1st Stakeholders consultation,
6818 2025),
- 6819 • Many of rubber additives, such as **benzothiazoles (BTHs)**, **guanidines**, and **p-**
6820 **phenylenediamines (PPDs)**, are designated as high-production-volume (HPV)
6821 chemicals. Zhang et al. (2025) state that rubber additives and their transformation
6822 products (RATPs) have become emerging pollutants of concern due to a recent discovery
6823 that N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine quinone (**6PPD-Q**), which is a
6824 transformation product of N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine
6825 (**6PPD**), is associated with the acute mortality of adult *Oncorhynchus kisutch* during
6826 substantial rainfall events (H Zhang, H., Han, Y., Hu, L., Chen, Y., Ying, G., Zhao, J., 2025).
6827 According to the Tyre Industry Project (TIP) "6PPD is used in tyres and in other rubber
6828 products due to its antioxidant and antiozonant effects which slow the aging process".
6829 In December 2020, research was published suggesting a link between 6PPD-quinone and
6830 mortality in coho salmon (Tyre Industry Project, 2024). Additional studies are being
6831 conducted on the exposure routes and risks related to these substances and the
6832 Netherlands and Austria have communicated that they are working on a joint restriction
6833 proposal for 6PPD.
 - 6834 • **Diphenylguanidine (DPG)** is used as a vulcanisation accelerator to increase curing and
6835 improve cross-linking. Though a few stakeholders mentioned it, limitations of use were
6836 not explained. According to Zhang et al. (2025) DPG is a rubber additive transformation
6837 product (RATP) of 6PPD and it has been detected in maternal and umbilical cord blood
6838 (H Zhang, H., Han, Y., Hu, L., Chen, Y., Ying, G., Zhao, J., 2025). Further investigation is
6839 needed to understand if this substance disrupts waste management of tyres or of the
6840 concern is due to ongoing investigations of 6DPP transformation products.
 - 6841 • Recyclers explained that in some cases tyres are equipped with **Tyre Mounted Sensors**
6842 that may contain a **lithium-ion battery**. The sensor including the battery must be
6843 removed before the tyre is disposed of, recycled or retreaded as they can cause damage
6844 to the recycling equipment. In particular, during shredding processes many cases of
6845 thermal runaway of the Li-Ion battery have been documented in various sectors, leading
6846 to explosions and severe fires (1st Stakeholders consultation, 2025).
 - 6847 • Though energy recovery is not the preferred route for treatment of tyres at end-of-life
6848 it is still a route applied in practice and could remain relevant for tyres that cannot be
6849 processed with shredders. In this respect, recyclers warn that **Electronic sensors**
6850 integrated into new tyres could reduce the TDF value if made with materials considered
6851 as "pollutants" for the cement manufacturing process (1st Stakeholders consultation,
6852 2025).

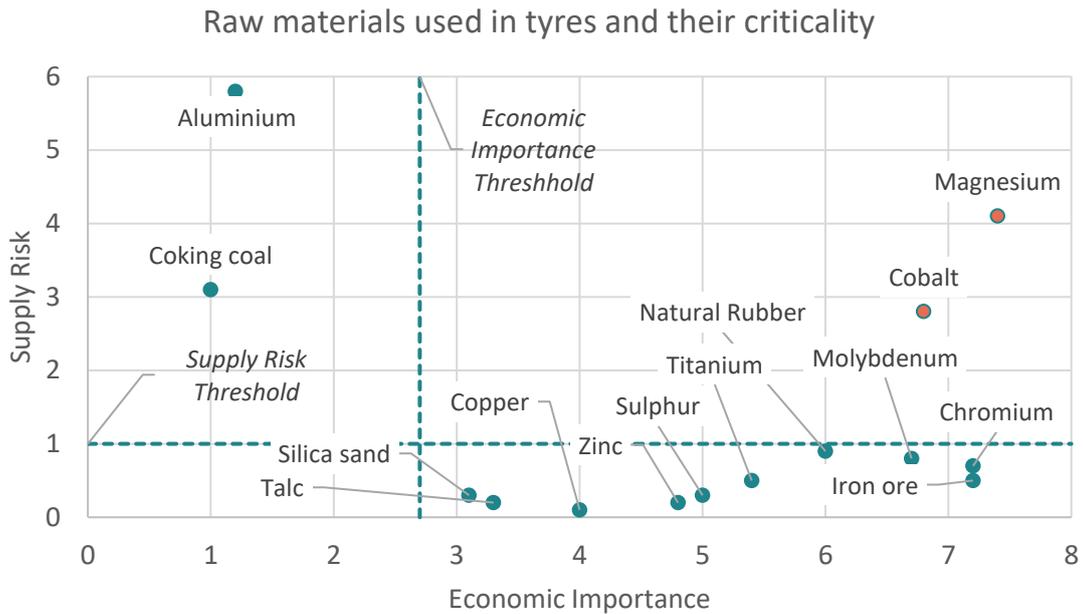
6853 7.6.6. Presence of Critical Raw Materials

6854 Several raw materials (or their derivatives) that are used as processing aids during tyre
6855 production or as materials within tyres are covered in the "Study on the Critical Raw Materials
6856 for the EU 2023" (Grohol & Veeh, 2023). Table 7-21 Shortlists identified raw materials and their
6857 link to tyres. Given the complexity and variance of rubber compound formulations the list may
6858 not be complete but covers relevant materials in terms of share in mass.

6859 **Table 7-21: Raw materials covered in the Study on the Critical Raw Materials for the EU 2023**
 6860 **(Grohol & Veeh, 2023) and their link to tyres.**

| Raw material | Link to tyres | Critical raw material |
|----------------|---|-----------------------|
| Aluminium | Aluminium hydroxide is sometimes added for grip enhancement. Aluminium powder has been used to reduce the curing time in thick rubber compounds | no |
| Chromium | Sometimes used as alloying element in steel used for cords | no |
| Cobalt | Cobalt salts are used as adhesion promotor between rubber and steel | yes |
| Coking coal | Tied to steel production | no |
| Copper | Steel cords are brass or bronze plated (copper-alloys) | no |
| Iron ore | Steel production | no |
| Magnesium | MgO is used as vulcanisation cure activator, acid neutralising agent and crosslinker | yes |
| Molybdenum | Is used as alloying element in steel | no |
| Natural Rubber | Rubber compound | no |
| Silica sand | Processed silica sand is used as filler | no |
| Sulphur | Main vulcanisation agent | no |
| Talc | Processing aid in production (between green tyres) | no |
| Titanium | Used as catalyst and TiO ₂ is sometimes used as filler material | no |
| Zinc | Used for brass plating (copper-zinc-alloy), zinc oxide as vulcanisation activator | no |

6861 Based on supply risk (SR) and economic importance (EI) raw materials become critical if they are
 6862 beyond defined thresholds ($SR \geq 1.0$ and $EI \geq 2.8$). **Figure 7-31** shows the raw materials present
 6863 in tyres that were previously identified and classifies their criticality. Out of the identified
 6864 materials cobalt and magnesium surpass the threshold for criticality.



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6866 **Figure 7-31 Raw materials present in tyres and covered in the Study on the Critical Raw**
 6867 **Materials for the EU 2023.**

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Source: (Grohol & Veeh, 2023).

6869 **Cobalt carboxylates** or similar are used to strengthen the bond between rubber and steel by
 6870 both improving the initial bonding and improving the adhesion retention (Umicore, n.d.). Cobalt
 6871 concentrations are on average found to be 1-2 mg/kg rubber in tyres (O'Loughlin et al., 2023).

6872 **Magnesiumoxide** is used in tyres as acid scavenger and stabilises the rubber compound. (acids
 6873 are produced as by-products during curing and are neutralised by MgO or MgCO₃). Thereby it
 6874 also counteracts corrosion of steel cords. Sometimes it is also used as filler material besides /
 6875 replacing carbon black and silica (O'Loughlin et al., 2023). Magnesium concentrations were
 6876 found to be typically in the range of 100-200 mg/kg rubber in tyres, but may be as high as 1000
 6877 mg/kg (O'Loughlin et al., 2023).

6878 **Natural rubber**, which was included in the EU's 2020 list of critical raw materials, was removed
 6879 from the 2023 list, mainly due to a slightly increased recycling input rate in the EU. However, the
 6880 EU remains 100 % dependent on imports for natural rubber, with Indonesia, Thailand, and
 6881 Malaysia being the main suppliers (Eurostat, 2025f). The geographic concentration (mainly in
 6882 Southeast Asia) could evolve into a supply risk (e.g., local shocks and plant diseases, geopolitical
 6883 factors, climate change induced risks etc.).

6884

6885 **Synthetic latex**, produced by the chemical industry predominantly from fossil feedstock (mostly
 6886 fossil oil), has also faced supply risks, as a significant share of synthetic rubber previously came
 6887 from Russia; the Ukraine war highlighted that such dependencies can strongly affect resource
 6888 costs and, in turn, tyre prices. Tyres are one of the main applications for natural rubber, and
 6889 despite its removal from the CRM list, supply risks and price fluctuations remain likely to affect
 6890 the tyre market due to the material's large share in tyre composition.

6891 7.6.7. Analysis and consideration of DPP-induced requirements

6892 The ESPR justification identifies a DPP as a significant instrument to establish traceability and
6893 information for all stakeholders along the product chain. A DPP has the potential to support
6894 consumers in making informed purchasing decisions, while concurrently enhancing supply chain
6895 efficiency and contributing to the growth of the industry. It is therefore essential that a DPP is
6896 both easily accessible and comprehensible, whilst ensuring that it does not replace existing
6897 product information in non-digital formats, such as product manuals or labels. Annex III of the
6898 ESPR stipulates the mandatory contents of a DPP. In addition to a unique identifier and relevant
6899 commodity codes, it is also required to include information regarding the manufacturer or
6900 operator, user manuals and instructions, warnings, safety information and facility identifiers,
6901 among others. Furthermore, additional requirements that require definition are specified in
6902 Chapter III of the ESPR. This includes the question of whether the DPP should be implemented
6903 on model, batch or item level, how updates are handled, who has access and can add data, or
6904 the accessibility for customers before buying the product. It is also proposed that the following
6905 specifications be made: the data carrier to be used, and the location of said carrier. In
6906 accordance with the initial working plan for the ESPR requirements, tyres are included among
6907 the prioritised product groups.

6908 In addition to the obligatory components, a DPP ought to have the capacity to incorporate
6909 additional information. With regard to tyres, this might include the manufacturing date,
6910 durability, type approval information, as well as information regarding sustainability and EoL.
6911 According to stakeholder consultation (1st Stakeholders consultation, 2025), this could include
6912 the following aspects: recycled content, processability (given that self-sealing tyres cannot be
6913 granulated), substances of concern, carbon footprint, tyre abrasion, use of sustainable material
6914 and general updates about events of the tyre life. Thereof the DPP, in addition to its function as
6915 a digital label, has the potential to provide crucial information and enhance traceability, thereby
6916 facilitating more efficient reuse and recycling of tyres. This would also contribute to the
6917 streamlining of collection and sorting processes. At present, such information is not available for
6918 the manufacturer, which would be beneficial in terms of designing with a more circular economy
6919 in mind (1st Stakeholders consultation, 2025).

6920 One practical challenge is that the information contained in the DPP is lost once tyres are
6921 shredded (or in the future mechanically deconstructed). This loss may become problematic, as
6922 tyres are often transported in shredded form to increase bulk density, potentially breaking the
6923 chain of traceability and limiting the usefulness of DPP data at later recycling stages.

6924 EuRIC (EURiC & Genan, personal communication, 3 December 2024) explain that the waste
6925 operators have little information on the composition of tyres and that it is difficult to anticipate
6926 the presence of hazardous substances or materials that could disrupt the recycling. They refer
6927 to the content of heavy metals or polycyclic aromatic hydrocarbons (PAHs) and to the fact that
6928 by the time a tyre becomes an ELT, it is possible that substances used in its manufacture have
6929 been added to restriction or prohibition lists. Not having such data is an obstacle to ensuring
6930 clean material flows for recyclates in the future. One viewpoint is that the DPP should therefore
6931 be updated whenever substances of concern are identified as such under REACH, in order to
6932 maintain relevance throughout the entire life cycle of the tyre.

6933 While one stakeholder (1st Stakeholders consultation, 2025) proposes full disclosure on
6934 materials and chemical composition, it is a widely shared view that such information should not
6935 be included in the DPP, as it would violate individual manufacturers' intellectual property rights.
6936 As the DPP for tyres should be on an item level, to truly permit traceability, the information
6937 shared in DPPs could also be sensitive in an aggregated form. The individual data should be
6938 accessible only on a "need to know" basis. It is generally accepted that the information
6939 contained within the DPP, as well as the data carrier, must be interoperable, standardised, and
6940 based on established methods. Furthermore, it is imperative to establish distinctions between
6941 various tyre categories. One potential data carrier is radio-frequency identification (RFID) (1st
6942 Stakeholders consultation, 2025) .

6943 The tyre industry is progressively incorporating standardised RFID and smart sensors to share
6944 data of connected tyres, including parameters such as pressure, temperature and identification.
6945 This integration already supports predictive maintenance, reduces downtime, and extends the
6946 tyre life. In addition, the tyre industry is currently engaged in the development of a tyre life cycle
6947 information service within the Global Data Service Organisation for Tyres and Automotive
6948 Components (GDSO). The principle of introducing a DDP is generally endorsed, with its
6949 implementation regarded as a potential means of enhancing traceability. However, this
6950 viewpoint is not universally accepted, as some argue that the DDP is exclusively a tool for
6951 accessing product information, rather than a comprehensive life cycle management solution. In
6952 order to achieve the full potential of the DPP, it is essential that all stakeholders and actors
6953 involved in the value chain are included in the process of developing standards and methods
6954 (1st Stakeholders consultation, 2025).

6955 7.7. Recommendations and preliminary conclusions Task 4

6956 The recommendations presented here are a compilation of the selected main primary
6957 conclusions from the research conducted to date and are not final.

6958 7.7.1. Refined product scope from a technical perspective

6959 Focusing on C1, C2, and C3 tyres from a technical perspective is plausible. They have a similar
6960 structure, use comparable components, and are intended for use on public roads. Thereby they
6961 require compliance with specific safety regulations. Their performance indicators, such as rolling
6962 resistance, wet grip, durability, and noise, are also similar and can be optimised using
6963 comparable approaches. For many of these indicators, including key safety aspects,
6964 standardised testing methods have been developed, and regulatory requirements have been
6965 defined (and are constantly amended), in particular through UNECE regulations but also the EU
6966 Tyre Labelling Regulation.

6967 Moreover, these tyre categories are suitable for reproducible laboratory and on-road testing,
6968 allowing reliable evaluation of their performance. Their consistent usage patterns, load classes,
6969 and operating conditions make it possible to correlate test results with real-world performance.
6970 In contrast, other tyre types—such as agricultural, industrial, or motorcycle tyres—have highly
6971 variable designs and operating conditions, which complicates standardised testing. From a

6972 technical performance standpoint, this makes C1, C2, and C3 tyres the most appropriate
6973 categories for regulatory focus.

6974 For both the manufacturing and EoL phases, aspects of circularity are however not limited to C1,
6975 C2, and C3 tyres. This includes, in particular, the incorporation of recycled or bio-based materials
6976 into tyres other than C1, C2, and C3, as well as recycling and preparation for reuse through
6977 retreading. Retreading is already applied or considered standard for some OTR and aircraft tyres.

6978 7.7.2. Barriers and opportunities for Ecodesign from a technical 6979 perspective

6980 From a technical perspective three aspects can be considered paramount for Ecodesign, (i)
6981 supporting the waste hierarchy in the field of tyres, in particular by boosting preparation for
6982 reuse, (ii) incorporation of recycled and bio-based material, and (iii) restricting the use of tyres
6983 that hinder recycling operations. In this regard (iv) DPP should be looked into as tool for
6984 enhancing traceability and circularity. Finally, with respect to the performance of a tyre in the
6985 use phase, (v) the estimated tyre mileage, which is currently not assessed under the EU Tyre
6986 Labelling Regulation (or any other regulation) could be considered.

6987 7.7.2.1. Supporting the waste hierarchy

6988 Although the Waste Framework Directive 2008/98/EC suggests a hierarchy for handling tyres in
6989 their EoL phases, technical feasibility, economic viability, and most importantly environmental
6990 protection must be determined individually for each treatment option. For the latter, LCA has
6991 become an increasingly important tool to reflect on environmental impacts. LCA should
6992 therefore always be considered when recommending specific treatment options.

6993 **Retreading**

6994 Preparation for reuse (retreading) contributes to waste prevention by extending product life and
6995 reducing the need for new materials. It is thus prioritised in the waste hierarchy. Previous studies
6996 (Mugnier et al., 2016; Rojas, n.d.) demonstrate significant environmental benefits of retreaded
6997 tyres compared to producing new ones: only the tread is replaced, while the carcass is
6998 conserved, reducing material use and emissions.

6999 Successful application of retreading depends on carcasses being in suitable condition. Currently,
7000 no standardised testing method or criteria catalogue exists to determine whether a tyre carcass
7001 will be suitable for retreading, largely because the use phase significantly affects carcass quality.
7002 Consequently, manufacturers' main option is to produce durable carcasses from the outset,
7003 thereby increasing the likelihood that the tyre can be retreaded successfully. Measurable
7004 properties that classify a tyre as suitable for retreading would be needed to define ESPR
7005 measures that can be effectively implemented, but this remains a challenge.

7006 Further assessment on whether action can be taken to support retreading for C1 and C2 tyres is
7007 necessary, in addition to C3 tyres, which are currently the most frequently retreaded. LLCC
7008 becomes useful when comparing retreaded tyres with new tyres. If performance aspects are not

7009 compromised through retreading, LLCC is feasible. LLCC can highlight the cost advantages of
7010 retreading for vehicle operators, while maintaining environmental and resource benefits. In
7011 **Table 5-28** costs of new and retreaded tyres are given which can serve as starting point for the
7012 LLCC. Market prices, in conjunction with resource demands and emission profiles would enable
7013 a holistic comparison.

7014 **Tyre recycling**

7015 Recycling, particularly closed-loop recycling, follows preparation for reuse in the waste
7016 hierarchy. **Devulcanisation** of scrap tyres can conserve resources, reduce environmental impact,
7017 and support a circular economy e.g. (Bockstal et al., 2019b; Haq et al., 2025b; Wiśniewska et al.,
7018 2022). However, most devulcanisation techniques remain at the laboratory scale, and
7019 commercial adoption requires further research, process optimisation, and collaboration
7020 between industry, academia, and regulators. The quality and consistency of scrap tyres are
7021 critical for successful devulcanisation (Tzoganakis & Visaisouk, 2019). Variations in natural
7022 versus synthetic rubber, especially in passenger tyres, affect the properties of the devulcanised
7023 material, which can have lower tensile strength and elongation than natural-rubber-heavy
7024 compounds from truck or OTR tyres. Establishing a system to sort and grade scrap tyres would
7025 improve consistency and enable higher-value applications.

7026 The placement of tyre **pyrolysis** in the waste hierarchy is complex and remains unresolved.
7027 Pyrolysis, through the recovery of carbon black (from char or oil) or precursors for synthetic
7028 rubber, could in principle qualify as a closed-loop recycling option. However, several factors limit
7029 its adoption: (i) the pyrolysis process inherently entails material losses along the value chain; (ii)
7030 applying pyrolysis products in new tyres requires extensive post-treatment; (iii)
7031 commercialisation of pyrolysis technologies is still incomplete; (iv) while mass-balance initiatives
7032 could initially support pyrolysis, they may ultimately result in downcycling, as this would allow
7033 that pyrolysis products are incorporated into applications with lower performance requirements
7034 than tyres; and (v) some stakeholders voice environmental concerns.

7035 **Mechanical recycling** of rubber compounds without additional post-treatment typically results
7036 in downcycling, as the recycled material cannot be reused in tyres and is instead applied in
7037 lower-performance products, such as playground surfaces, turf infill, or asphalt. The demand for
7038 mechanical recycling is increasingly influenced by processes such as pyrolysis and
7039 devulcanisation, since rubber must first be granulated and separated from steel and textile
7040 components before these treatments can be effectively applied.

7041 **7.7.2.2. Incorporation of bio-based and recycled material**

7042 When formulating recommendations regarding tyre composition, it is essential to recognise the
7043 complexity of tyre engineering. The composition of rubber compounds, their reinforcement with
7044 steel and textile materials, and the overall structural design require precise fine-tuning. Every
7045 material selected and each design decision can significantly influence tyre performance—
7046 meaning that even minor changes may lead to reduced efficiency or, in extreme cases, failure.

7047 For this reason, the development of new tyres is a long and iterative process that will take
7048 several years. It typically begins with laboratory-scale material research, followed by prototype

7049 manufacturing, and ultimately progresses to industrial upscaling. At every stage, extensive
7050 testing is carried out to ensure that the tyre meets stringent performance, safety, and durability
7051 requirements.

7052 Similarly, to recommending treatment options for tyres, the incorporation of recycled content
7053 and bio-based material must be technically feasible, economically viable and reduce
7054 environmental impacts, which should be validated via LCA.

7055 A set of alternative materials (e.g. recycled and biobased) that could be potentially integrated
7056 into tyres and their actual implementation in particular tyres is presented in **Section 7.6.3**.
7057 Regulation through ESPR could define and/or incentivise increasing application of recycled and
7058 biobased materials. When considering targets for recycled and biobased material contents in
7059 tyres the following questions should be asked:

- 7060 • Which components should be considered? Recycled or bio-based materials that are
7061 already implemented in most tyres (recycled steel, biobased natural rubber) could be
7062 excluded.
- 7063 • Should a target be defined separately for recycled and bio-based material? Alternatively,
7064 the sum of both recycled and bio-based material could be targeted, given that some
7065 “conventional” materials can either be better replaced by bio-based or recycled
7066 material.
- 7067 • Should the target be defined for each tyre individually or for the whole product portfolio
7068 of a manufacturer? Especially tyres of the premium tyre segment are very sensitive to
7069 the introduction of new materials.
- 7070 • How can the content of recycled and bio-based material be measured or effectively
7071 controlled? A regulation that lacks controlling mechanisms is ineffective, as it cannot
7072 ensure compliance, comparability, or credibility of declared recycled and bio-based
7073 content

7074 7.7.2.3. Tyres hampering the recycling process

7075 Several tyre types or rather materials/components in tyres are viewed as unfavourable with
7076 regard to their EoL behaviour, including batteries from TPMS, the viscous gel contained in self-
7077 sealing tyres, foam in silent tyres and high shares of reinforcing material or certain reinforcing
7078 material such as aramid fibres. Costs and benefits of the respective tyres need to be compared
7079 to determine whether their application should be restricted.

7080 7.7.2.4. Digital product passport

7081 The DPP aims to make information on tyres more transparent and accessible. For consumers,
7082 this would enable more deliberate and informed choices. Waste operators, in particular, would
7083 gain access to data needed to improve reuse and recycling efficiency. Relevant information could
7084 include the presence of substances of concern, specific tyre properties (e.g., TPMS, self-sealant,
7085 or silent tyres), and indicators of EoL processability, thereby addressing the current lack of
7086 information faced in waste treatment.

7087 When designing a DPP for tyres, several aspects require consideration:

- 7088 • Whether and how updates should be made during a tyre's lifetime (e.g., if a substance
7089 is newly classified as a substance of concern),
- 7090 • How to balance information sharing with the protection of manufacturers' intellectual
7091 property, and
- 7092 • How to avoid information loss once tyres are shredded.

7093 In addition, technical solutions such as standardised data carriers (e.g. RFID tags) must be
7094 developed. For successful implementation, the DPP should be based on common standards and
7095 developed in collaboration with stakeholders across the value chain, ensuring that the system is
7096 both practical and widely adopted.

7097 7.7.2.5. Mileage of tyres

7098 Tyre mileage, assuming sudden failures and ageing effects are excluded, can be approximated
7099 as a function of the initial tread depth and the tyre's abrasion rate. With the introduction of
7100 standardised tyre wear measurement methods in UN Regulation No. 117, aligned with the Euro
7101 7 framework, the concept of expected mileage (i.e. kilometres driven from new until reaching
7102 the legal tread depth limit) could in the future be considered as an additional performance
7103 indicator, alongside grip, rolling resistance, and external rolling noise.

7104 7.8. Open questions to stakeholders

7105 Compilation of MEeRP Task 4 questions for stakeholders:

- 7106
- 7107 T4-1: Is there a difference between Reinforced (RF) and Extra Load (XL)? Can you
7108 refer us to standardised definitions?
- 7109 T4-2: Has the mileage of C2 and C3 tyres been consistently tested? If yes, who
7110 carried out the testing and what were the results?
- 7111 T4-3: Do you have reference compositions for tyres other than C1, C2, C3 – e.g. OTR
7112 tyres, airplane tyres, bicycle tyres, motorcycle tyres?
- 7113 T4-4: Can you quantify the amount of primary waste during the manufacturing
7114 phase, e.g. in kg primary waste per t of tyre?
- 7115 T4-5: Which are the main sources of primary waste during tyre production?
7116 Currently we can only rely on a source that may be outdated (reference year=1995).
7117 We would assume uncured rubber and off-spec tyres are the main sources.
- 7118 T4-6: Which potential do you see in reducing primary waste during production?
- 7119 T4-7: Can you confirm the energy use stated during the manufacturing phase (i.e. 2-3
7120 kWh/kg of tyre)? This energy use does not account for production or pre-treatment
7121 phases of raw or semi-finished materials prior to tyre manufacturing (e.g. production
7122 of steel cords or pre-processing of natural rubber to TSNR).
- 7123 T4-8: What is the typical design cycle for developing a new tyre? Which stages are
7124 involved, from the initial concept to a market-ready product, and how long does the
7125 process usually take?
- 7126 T4-9: Can you add to the list of standard improvement design option, the Best
7127 Available Technology (BAT) and Best Not yet Available Technology (BNAT)? Please be

7128 aware that aspects of circularity (EoL-treatment and reuse, as well as use in
7129 alternative materials (substances of concern, critical raw materials, bio-based
7130 materials) are not part of this chapter.
7131 T4-10: Can you provide specific energy demands for the treatment of ELT by means
7132 of ambient and cryogenic grinding and specify what is included in that energy
7133 demand?
7134 T4-11: Can you detail on the energy demands for devulcanisation and reclaiming?
7135 What is the specific energy demand for each technology (e.g. in kWh/t of ground
7136 rubber), not taking into account the previous tyre shredding?
7137 T4-12: Can you confirm that the typical outlet markets for ground rubber and the
7138 preferable grinding method are accurately stated?
7139 T4-13: How are self-sealing tyres and noise reduction tyres treated at EoL and how is
7140 this expected to change in the future?
7141 T4-14: Is the use of aramid fibres for reinforcement in car tyres expected to increase,
7142 for example due to the increasing trend of electric vehicles that tend to be heavier?
7143 T4-15: Are amounts of silica expected to increase in the future? Could this lead to
7144 problems in the usability of rCB in the future due to high levels of ash content?
7145 T4-16: Which components should be considered? Recycled or bio-based materials
7146 that are already implemented in most tyres (recycled steel, bio-based natural
7147 rubber) could be excluded from the response.
7148 T4-17: Should a target be defined separately for recycled and bio-based material
7149 separately? Alternatively, the sum of both recycled and bio-based material could be
7150 targeted, given that some “conventional” materials can either be better replaced by
7151 bio-based or recycled material.
7152 T4-18: Should the target be defined for each tyre individually or for the whole
7153 product portfolio of a manufacturer? Especially tyres of the premium tyre segment
7154 are very sensitive to the introduction of new materials.
7155 T4-19: How can the content of recycled and bio-based material be measured or
7156 effectively controlled? A regulation that lacks controlling mechanisms is ineffective,
7157 as it cannot ensure compliance, comparability, or credibility of declared recycled and
7158 bio-based content.
7159 T4-20: What targets could be introduced? For example, an overall content target for
7160 the use of bio-based, renewable and recycled materials in new tyres, or specific
7161 targets for materials such as a recycling target for styrene-butadiene rubber and
7162 nylon tyre cord? The introduction of such targets must certainly ensure that the
7163 safety and key performance characteristics of tyres made from alternative materials
7164 are maintained.
7165 T4-21: Would it be feasible to introduce separate targets for post-industrial and
7166 post-consumer recycled content? Or should an overall target be set only for post-
7167 industrial materials? If so, would 5% be a realistic target, with the possibility of
7168 increasing to 10% within 10 years and 15% by 2040?
7169 T4-22: Assuming that recycled, bio-based or renewable materials incur higher costs
7170 than their virgin counterparts, could the scale of this increase be determined? Could
7171 bio-based materials be 3–4 times more expensive, for example?

7172

7173 8. Annexes

7174 8.1. Annex I: Third country legislation (EU Member States)

| Country | Subject | Regulatory act |
|---------|--|----------------|
| Austria | Tyre pressure | 1993/9066/A |
| Austria | Rolling noise measurement | 1996/0452/A |
| Austria | Draft 27th Amendment to the Motor Vehicles Act | 2006/0024/A |
| Belgium | Draft Environmental Agreement on the implementation of the VLAREA duty of acceptance for waste tyres | 2010/0116/B |
| Croatia | Draft Proposal of the Ordinance on the metrological and technical requirements for tyre pressure gauges for motor vehicles | 2016/0367/HR |
| Czechia | Draft General Measure number: 0111-OOP-C021-17 laying down the metrological and technical requirements for legally controlled measuring instruments, including test methods for type approval and verification of the following legally controlled measuring instruments: 'Tyre pressure gauges for road motor vehicles' | 2018/0591/CZ |
| Czechia | Draft Measure of a general nature, stipulating metrological and technical requirements for specified measuring devices, including test methods for type approval and verification of specified measuring devices: "road motor vehicle tyre pressure gauges, except for pressure gauges used exclusively for the measurement of tyre pressure by motor vehicle users". | 2011/0590/CZ |
| Estonia | Requirements for tyre chips added to the shale oil production process | 2018/0297/EE |
| Finland | Technical requirements and type-approval for studded vehicle tyres | 2020/66/FIN |
| Finland | Draft Regulation Modifying a tractor's propulsion system, tyres and rims | 2025/0281/FI |
| Finland | Draft Regulation Modifying a tractor's propulsion system, tyres and rims | 2024/0282/FI |

| Country | Subject | Regulatory act |
|-----------|---|----------------|
| Finland | Draft Council of State Decree on the separate collection, re-use and recovery of discarded tyres | 2013/0100/FIN |
| Finland | Council of State decision on amending the Council of State Decision on the Utilisation and Processing of Tyres Withdrawn from Use (1246/1995). | 1997/0643/FIN |
| Finland | Decision by the Cabinet concerning the recovery and treatment of used tyres | 1995/0148/FIN |
| France | Decree amending the provisions of the French Environmental Code relating to the management of waste tyres | 2014/0380/F |
| France | Tyres for motor vehicles and their trailers | 1994/0085/F |
| France | Tyres for motor vehicles and their trailers | 1993/0156/F |
| Italy | Ministerial decree concerning: "Wheel-tyre systems for cars" | 2011/0619/I |
| Italy | Amendments to the Decree of the Minister of Infrastructure and Transport of 10 May 2011: Standards regarding supplementary grip devices of tyres for category M1, N1, O1 and O2 cars | 2022/657/I |
| Lithuania | Draft Order of the Minister for the Environment amending Order No D1 48 of the Minister for the Environment of the Republic of Lithuania of 14 February 2022 on the approval of the description of the end-of-waste criteria for recycled tyre waste | 2024/0442/LT |
| Lithuania | On the approval of the description of end-of-waste criteria for recycled tyres | 2021/0687/LT |

| Country | Subject | Regulatory act |
|-------------|---|----------------|
| Netherlands | Decree amending the Decree on tyre management and the Decree on end-of-life vehicle management, and repealing the Decree on battery management 2008 in connection with the entry into force on 1 January 2023 of general rules on the extended producer responsibility scheme for tyres, end-of-life vehicles and batteries by virtue of the Decree on the extended producer responsibility scheme, and amending the Decree on packaging management 2014 (Collective Decree amending existing EPRs) | 2022/0177/NL |
| Netherlands | Covenant on quieter tyres | 2006/0405/NL |
| Netherlands | Decree laying down rules relating to the management of vehicle tyres and amending a number of Decrees in connection with the abolition of provisions relating to the procedure regulated in section 3.5 of the General Administrative Law Act (Vehicle Tyre Management Decree) | 2002/0425/NL |
| Portugal | Ordinance laying down Regulation on the legal metrological control of tyre pressure gauges for motor vehicles | 2023/0183/P |
| Portugal | Draft Ministerial Implementing Order establishing the criteria for the assignment of end-of-waste status to rubber material derived from used tyres. | 2016/0401/P |
| Romania | Government order on the management of tyres | 2007/0413/RO |
| Slovenia | Rules on metrological requirements for tyre-pressure gauges | 2024/0062/SI |

7175

Source: European Commission, 2025

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8.2. Annex II: Third country legislation (non-EU)

| Country | Subject | Regulatory act |
|-----------|------------------------------|------------------------|
| Argentina | CHAS certification for tyres | Resolution No. 25/2007 |

| Country | Subject | Regulatory act |
|-----------|---|--|
| Australia | Passenger car tyres | ADR 23/00 |
| Australia | Passenger car tyres | ADR 23/01 |
| Australia | Passenger car tyres | ADR 23/02 |
| Australia | Passenger car tyres | ADR 23/03 |
| Australia | Wheels/tyres | ADR 42/05 from 01.07.2019 |
| Australia | Installation of tyres | ADR 95/00 |
| Australia | Commercial vehicle tyres | ADR 96/00 |
| Australia | Discontinuation of tyre Component Registration Numbers (CRNs | Administrator's Circular 0-2-15 |
| Brazil | Production and retreading of tyres with tread-wear indicators | CONTRAN 558 / 1980 |
| Brazil | Requirements for the conformity assessment of new tyres | INMETRO 544 / 2012 INMETRO 538 / 2012 INMETRO 365 / 2015 INMETRO 251 / 2016 INMETRO 398/2019 |
| Brazil | Spare and temporary use wheels, Tyre Pressure Monitoring System (TPMS) and run-flat tyres | CONTRAN 540 / 2015 (amended by CONTRAN 719 / 17) |
| Brazil | Requirement for spare tyre information plate | CONTRAN 540 / 2015 (amended by CONTRAN 719 / 17) INMETRO for wheels and tyres |
| Brazil | Tyres Motor vehicles and their trailers | INMETRO 365 / 2015 INMETRO 251 / 2016 CONMETRO 7 / 2009 Res CONTRAN 558 / 80 Res CONTRAN 14 / 98 INMETRO Ordinance 544/12 INMETRO Ordinance No 379 of 14.09.2021 |

| Country | Subject | Regulatory act |
|----------|---|---|
| Brazil | Collection and final disposal of unserviceable tyres | IBAMA Normative Instruction No 09/2021 CONAMA Resolution No 416/2009 |
| Brazil | Draft of Compulsory Certification of Recycling Tyres applied to vehicles (up to 35,000N), trailers and trolleys | INMETRO Ordinance No 433 of 2022 |
| Canada | Tyre selection and rims for motor vehicles with a GVW of 4,536kg or less | CMVSS 110 |
| Canada | Tyre selection and rims for motor vehicles with a GVW of more than 4,536kg | CMVSS 120 |
| China | Technical standard for tyre testing for passenger car | GB 9743-2015 |
| China | Technical standard for tyre testing for trucks | GB 9744-2015 |
| China | Requirement for tyre pressure control system | GB 26149-2017 |
| China | Requirements for the CCC certification of tyres and tyre products (Implementation rules) | GB/T2978-2014 GB 9743-2015 CNCA-C12-01:2015 |
| China | Requirements, test methods, inspection and evaluation rules, markings and implementation requirements for passenger car tyres | GB9743—200× G/TBT/N/CHN/1703 |
| China | Requirements, test methods, inspection and evaluation rules, markings and implementation requirements for truck tyres | GB9744—20×× G/TBT/N/CHN/1702 |
| Colombia | Tyres | Resolution No. 20223040044455 of 2022 of the Ministry of Transportation |
| Ecuador | Tyres | Resolución No. 13 341, RTE INEN 011 (1R) "Neumáticos " |
| India | Requirement for tyres (PC, M1, M1G) | IS-15633:2005 Amd No 1 Import Licensing requirement as per DGFT Notification No 12 / 2015-2020 AIS-051:2004 |
| India | Requirement for condition of tyres | CMVR 1989 Chapter V Rule No 94 (1), (2), (3) |
| India | Tyres | Pneumatic tyres and tubes for automotive vehicles (quality control) Order, 2009 |

| Country | Subject | Regulatory act |
|-----------|--|---|
| India | Requirement for tyre pressure monitoring system (if fitted) | AIS 154:2018 GSR 457 (E), Dt. 20.07.2020 |
| India | Requirement to provide ready to use spare wheel or temporary spare wheel or tyre repair kit | CMVR 1989 Chapter CR.138 |
| India | Tyres with regard to Rolling Sound Emissions and/or to Adhesion on Wet Surfaces and/or to Rolling Resistance | AIS-142:2019 GSR 479 (E), Dt: 28 June 2022 (Implementation date: New designs of tyres as of 1 October 2022; Existing designs of tyres as of 1 April 2023 for Rolling Resistance & Wet Grip and 1 June 2023 for Rolling Sound) |
| India | Automotive Vehicles- Pneumatic tyres for commercial vehicles- Diagonal and radial ply-Specification | IS-15636:2012 |
| Indonesia | SNI certification and marking of spare parts (rims, tyres, batteries, vehicle glazing, audio / video components) | Law 20 of 2014 on the Standardization and Conformity Assessment (Framework Regulation for the SNI Certification) |
| Indonesia | Rim, with or without tyre | Mol 50/2012 Mol 113/2012 |
| Indonesia | Tyre passenger | Mol No 58 / M-IND / PER / 5 / 201211 Year 2012 |
| Indonesia | Tyre fitted on rim | Mol No 58 / M-IND / PER / 5 / 201211 Year 2012 |
| Indonesia | Implementation of Indonesian national standards for tyres | 76/M-IND/PER/9/2015 |
| Indonesia | Import of tyres | 77/M-DAG/PER/11/2016 (R77) Regulation of the Minister of Trade of the Republic of Indonesia concerning provisions of tyre import |
| Indonesia | Rim, with or without tyre | 59/M-IND/PER/5/2012 SNI 1896:2008 |
| Iraq | Import control of vehicle components (eg, safety glass or tyres) | Pre-Importation Inspection, Testing & Certification Program of Goods to Iraq (ICIGI) |
| Israel | Temporary use of spare wheel and tyre unit and run flat tyres (M1, N1 category) | ECE 64 |
| Japan | Requirement for testing of pneumatic tyres | TRIAS 09-J003-R030-01 Harmonised with UN R30 |

| Country | Subject | Regulatory act |
|-------------|---|---|
| Japan | Requirement for temporary use spare tyres | TRIAS 09-R064-02 Harmonised with UN R64 |
| Japan | Testing of tyres regarding rolling sound emission and / or adhesion on wet surfaces and / or roll resistance | TRIAS 09-R117-01 Harmonised with UN R117 |
| Japan | Testing of tyre pressure monitoring systems (RDC | TRIAS 09-R141-02 Harmonised with UN R141 |
| Japan | Testing of pneumatic tyres mounted on motor vehicles | TRIAS 09-R142-02 Harmonised with UN R142 |
| Japan | During the type approval test of the wheel covers, the tyre width without rim flange protection and lettering or ornamentation is taken into account. | Safety Regulation Art 22 |
| Japan | Tyre for passenger vehicle | TRIAS 09-J003R30-01 Harmonised with UN R30 |
| Japan | Tyre for commercial vehicle | TRIAS 09-J004R54-01 Harmonised with UN R54 |
| Malaysia | Tyres | Trade Descriptions (Marking of Pneumatic Tyre) Order 2012 / Adopted ECE-30 |
| Malaysia | Import to Malaysia, relevant for several automotive products, such as tyres, safety belts, chassis etc | Customs (prohibition of imports) Order 2017 |
| Mexico | Motor carrier - car and light truck tyres - Specifications and test methods | NMX-D-136-CT-1988 |
| Mexico | Valves for inner tubes and valves for rims utilised for tubeless type tyres | NOM-134-SCFI-1999 |
| Mexico | Tyres - trucks, vans, buses and trailers | NOM-086/1-SCFI-2011 PROY-NOM-086-1-SCFI-2018 |
| Mexico | Pressure relief valves (safety, security relief and relief) operated by spring and pilot; made of steel and bronze | NOM-093-SCFI-1994 |
| Myanmar | Pneumatic tyres (passenger car / commercial trucks) | UN R30 / UN R54 (Voluntary) |
| Philippines | Tyres | UN R30 |
| Philippines | Tyres (commercial vehicles) | PNS UN R30 :2008 |

| Country | Subject | Regulatory act |
|--------------|--|--|
| Philippines | Technical regulations concerning the mandatory product certification of automotive product: Motor vehicle brake fluids, Road vehicle safety belts, Pneumatic tyres , Pneumatic tubes, Lead-acid storage batteries, lithium-ion batteries, Audible warning device, Rear view mirrors, Head restraint, Safety glazing materials, Retroreflecting devices, Filament lamps, Headlamps, Front position lamps, rear position lamps, stop lamps, direction indicator lamps, and rear registration plate illuminating devices | Draft Department Administrative Order on Automotive Products as of 10.09.2021 G/TBT/N/PHL/265 |
| Philippines | Rubber inner tubes for pneumatic tyres | Department Administrative Order No 04, Series of 2000 Mandatory PNS for Safety Matches, Rubber Inner tubes and Sanitary wares |
| Philippines | Pneumatic tyres | Department Administrative Order No11-03, Series of 2011 Mandatory PNS for safety glass and pneumatic tyres Department Administrative Order No 6, Series of 1995 Mandatory implementation of Philippine National Standard for pneumatic tyres covered by PNS 25:1994 |
| Philippines | Pneumatic tyres | Planned: PNS/ UN ECE 30:2010 = UN Reg 30 PNS/ UN ECE 54:2010 = UN Reg 54 PNS/ UN ECE 75:2007 (based on UN Reg 75) |
| Saudi Arabia | Vehicle tyres rolling resistance and wet grip requirements | SASO 2857:2016 |
| Saudi Arabia | Technical regulation for auto spare parts (new spare parts for motor vehicles except tyres, vehicles batteries and safety barriers) | SASO TR 02-04-17-162 |
| Saudi Arabia | Energy efficiency requirements for all pneumatic tyres | SASO TR 05-03-16-156 |
| Singapore | Pneumatic tyre (passenger cars) | UN R30 |
| Singapore | Pneumatic tyre (commercial vehicles) | UN R54 |

| Country | Subject | Regulatory act |
|------------------|---|---|
| South Africa | Commercial Tyres | Compulsory Specification Commercial Tyres VC 8059 |
| South Africa | Passenger Tyres | Compulsory Specification Passenger Tyres VC 8056 |
| South Korea | Requirement for pneumatic tyres | KMVSS Art 12 (1) (2011) |
| South Korea | Requirement for blow out test for wheels / tyre | KMVSS Art 88-2 (2016) |
| South Korea | Requirement for Tyre Pressure Monitoring System (TPMS) | KMVSS Art 88-3 |
| Thailand | Passenger vehicle tyres | UN R30 TIS 2718-2560 (2017) |
| Thailand | Commercial vehicle tyres | UN R54 TIS 2719-2560 (2017) |
| Thailand | Tyre noise | UN R117 , TIS-2721-2560 |
| Thailand | Retreaded pneumatic tyres | Draft Ministerial Regulation on retreaded pneumatic tyres for commercial vehicles and their trailers (TIS 2979-2562(2019)) G/TBT/N/THA/588 |
| Thailand | Retreaded Pneumatic Tyres for Commercial Vehicles and Their Trailers | Ministerial Regulation (TIS 2979-2562(2019)) |
| UK (before 2021) | The Road Vehicle (Construction and Use) (Amendment) Regulations 2020 (Setting a tyre age limit for HGVs, buses and minibuses) | 2020/0456/UK |
| UK (before 2021) | Quality Protocol: End of waste criteria for the production and use of tyre-derived rubber materials (TDRM) | 2014/0256/UK |
| UK (before 2021) | Quality Protocol: End of waste criteria for the production and use of tyre-derived rubber materials | 2009/0252/UK |
| UK (before 2021) | The Motor Vehicle Tyres (Safety) (Amendment) Regulations 2002 | 2002/0363/UK |

| Country | Subject | Regulatory act |
|----------------------|--|--|
| United Arab Emirates | Use of repair kit as an alternative to the spare tyre For special sports design and electric vehicles and hydrogen fuel cell vehicles | UAE Notification GSO Model Year 2021 requirements 11.12.2019 |
| USA | New pneumatic and certain specialty tyres | FMVSS 109 |
| USA | Tyre selection and rims and motor home/recreation vehicle trailer load carrying capacity information for motor vehicles with a GVWR of 4,536kg (10,000 pounds) or less | FMVSS 110 |
| USA | Retreaded pneumatic tyres | FMVSS 117 |
| USA | New pneumatic tyres for motor vehicles with a GVWR of more than 4,536kg (10,000Lb) and motorcycles | FMVSS 119 |
| USA | Tyre selection and rims and motor home/recreation vehicle trailer load carrying capacity information for motor vehicles with a GVWR of more than 4,536kg (10,000Lb) | FMVSS 120 |
| USA | New non-pneumatic tyres for passenger cars | FMVSS 129 |
| USA | Tyres pressure monitoring systems | FMVSS 138 |
| USA | New pneumatic radial tyres for light vehicles | FMVSS 139 |
| USA | Regrooved tyres | CFR Title 49: Chapter V Part 569 |
| USA | Tyre identification and record keeping | CFR Title 49: Chapter V Part 574 |
| Vietnam | Tyre (passenger cars) | QCVN 34:2017 / BGTVT Adopted ECE 30 Rev 03 |

| Country | Subject | Regulatory act |
|---------|--|--|
| Vietnam | Tyre (commercial car) | QCVN 34:2017 / BGTVT Adopted UN R54 Rev 03 |
| Vietnam | Tyre (L category) | QCVN 36:2010 / BGTVT Adopted UN R75 Rev 02 |
| Vietnam | Technical And Environmental Safety Inspection Of Imported Motor Vehicles certificates required for auto parts such as tyres, rearview mirrors, front lights, and glasses | Circular 03 / 2018 / TT-BGTVT Decree No. 116 / 2017 / ND-CP |
| Vietnam | Acceptance of ECE certificate or national type approval certificate for component parts (headlight, glass, mirror, tyre) on imported vehicle | EU-Vietnam Free Trade Agreement (Annex 2-B Motor vehicles and parts thereof) |

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Source: ACEA Automotive Regulatory Guide, 2023

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