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End of Life Tyre Rubber: Assessment of Waste Framework Directive End-of-Waste Criteria

European Recycling Industries' Confederation
European Tyre and Rubber Manufacturers Association

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1. Introduction and Scope

The Waste Framework Directive empowers the European Commission to clarify when a waste that has undergone a recovery, including recycling, operation obtains end-of-waste (EoW) status. The Commission is intending to develop 'end-of-waste criteria' that certain waste types would have to fulfil to cease to be waste.

The end-of-waste criteria for a specific type of waste have to be developed according to the conditions set out in Article 6 of the Waste Framework Directive:

a. the substance or object is commonly used for specific purposes;

b. a market or demand exists for such a substance or object;

c. the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products;

d. the use of the substance or object will not lead to overall adverse environmental or human health impacts.

Additionally, the criteria shall include limit values for pollutants where necessary and shall take into account any possible adverse environmental effects of the substance or object.

The Commission is considering candidate materials for an EU-wide end-of-waste criteria (of the type already existing for iron scrap, copper scrap and glass cullet).

The EuRIC and ETRMA consider that it would be advantageous to have such an EU-wide EoW criteria for end-of-life tyre (ELT) rubber, and this report presents relevant information to the EC and makes the case that ELT rubber is a suitable candidate material for this EU-wide EoW criteria.

This report is structured to address the conditions of Article 6 as follows:

- Section 2 summarises the existing national end-of-waste criteria for ELT rubber.
- Section 3 describes the uses of ELT rubber, and demonstrates how it is commonly used for specific purposes.
- Section 4 describes the market for ELT rubber.
- Section 5 considers the technical requirements for ELT rubber in specific uses, and describes the regulatory context for its use.
- Section 6 summarises the current position status on potential adverse environmental or human health impacts.
- Section 7 presents a summary and conclusion of the report.

This report assumes that the use of ELT rubber for co-incineration would not be covered under an EU-wide EoW criteria, and ELTs managed for co-incineration would continue to be considered as waste.

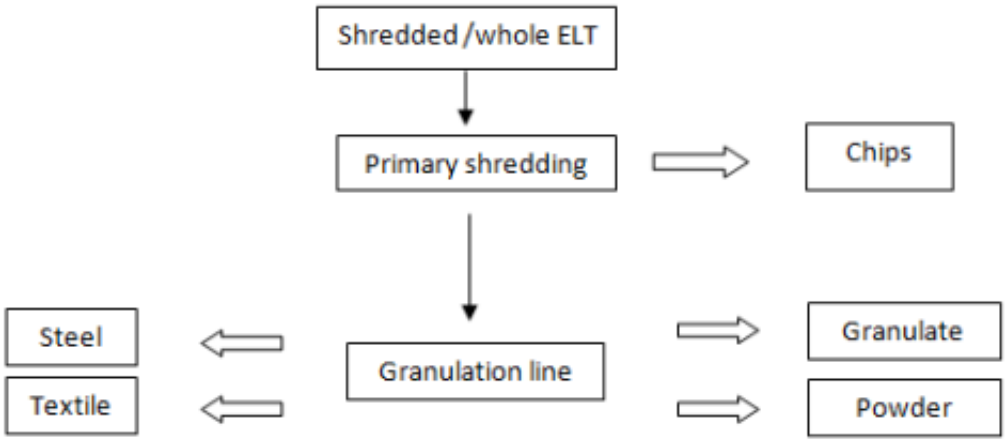
2. Sector Overview

2.1 ELT Management Process

Tyres are essential to road mobility, fitted on our many transport vehicles and being the only contact point with the ground. Simple in appearance, tyres are in fact very sophisticated products. A typical tyre includes dozens of different components, using more than a hundred primary raw materials, which must be precisely assembled and processed to achieve the right balance between many competing factors of which grip, energy efficiency, handling, comfort and noise are but a few.

Once tyres reach their end-of-life and cannot be re-treaded any further, they are collected for recycling. The mechanical recycling process is summarised in Figure 2-1 below.

Figure 2-1: Schematic of ELT Mechanical Processing



The main categories of materials from end-of-life tyres produced at different stages of the treatment process, primarily by size reduction, are as follows: cuts, shreds, chips, granulates, powders, steel and textiles.

2.2 Composition of ELT Rubber

The main components of passenger car and truck tyres are as follows:

Material	Car	Truck
Rubber/Elastomers	43%	42%
Carbon black & silica	28%	24%
Metal	13%	25%
Textile	5%	-
Zinc oxide	2%	2%
Sulphur	1%	1%
Accelerators/anti-degradants	2.5%	N/A
Stearic acid	1%	N/A
Oils	7%	N/A

2.3 Applications

ELT granulates, powder and chips are used in a wide range of applications to manufacture end products but also in processes as raw materials.

2.3.1 ELT granulates

ELT granulates have a wide variety of possible applications and size range. They can be used as filler in artificial sport fields (size range between 0.5 and 2.5mm for synthetic turf), soft children playgrounds (size range between 2.5mm and 5 mm), plain rolls, acoustic protections, etc.

2.3.2 ELT powder

ELT powder is for example used in asphalt rubber applications (bituminous mixtures), carpet underlay and floor tiles, moulded products (tiles, street furniture and level-crossing platforms).

2.3.3 ELT chips

The main non-destructive applications of ELT chips is in mulch (landscaping, various horticultural applications), equestrian floors and pathways (i.e. rubber mixed with sand or sawdust used in the horse industry as ground in the stable or at the tracks) and as a sub-base for children playgrounds.

Although there are a range of beneficial end uses for chips (also referred to as shreds), the focus of the current application for an EU-wide EoW criteria is on granulates and powders.

3. Existing Tyre Rubber End of Waste Criteria

3.1 Introduction

The Waste Framework Directive (2008/98/EC) defines the point at which waste is no longer considered to be waste. Some countries have developed End of Waste Criteria to align with the WFD. But statutory structure differs among European countries, leading to some countries developing national criteria, others dealing with End of Waste on a regional or case by case basis.

This section describes and compares some of the national EoW protocols regulations for ELT rubber. There are some additional specific end-of-waste determinations for certain applications (e.g. in the Netherlands), but because they are of limited applicability, they are not considered further in this section.

3.2 United Kingdom Quality Protocol

Although the UK has left the EU, the UK end-of-waste criteria (referred to as a Quality Protocol in the UK context) was prepared whilst the UK was still a member of the EU[1].

The UK's Quality Protocol (QP) presents end of waste criteria for the production and use of tyre-derived rubber materials. in consultation with industry and other regulatory stakeholders. It is applicable in both England and Wales. The QP sets out end of waste criteria for the production and use of tyre-derived rubber materials from source-segregated waste tyres. If these criteria are met, tyre-derived rubber materials will normally be regarded as having been fully recovered and to have ceased to be waste. Producers and users are not obliged to comply with the Quality Protocol. If they do not, the tyre derived rubber materials will normally be considered to be waste and waste management controls will apply to their handling, transport and application.

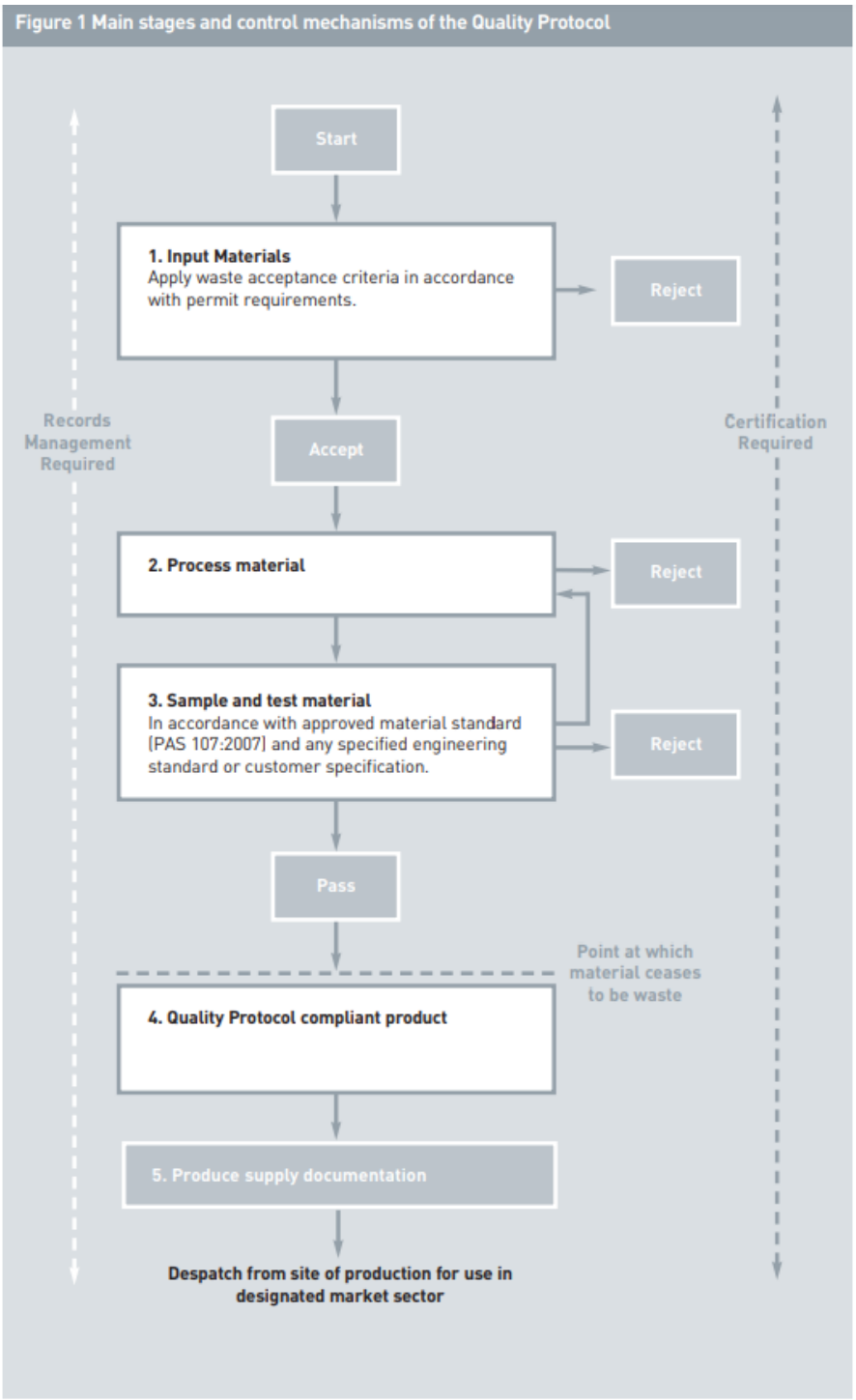
It has four main purposes:

1. clarifying the point at which tyre derived rubber materials cease to be waste and waste management controls are no longer required;
2. providing users with confidence that the tyre-derived rubber materials they purchase conform to an approved material standard;
3. providing users with confidence that the tyre-derived rubber materials are suitable for use in designated applications including by conforming with engineering standards where required; and
4. protecting human health and the environment (including soil).

Figure 1 below shows the mechanism by which materials can reach the End of Waste Criteria.

[1] UK Quality Protocol. Tyre-derived rubber materials - End of waste criteria for the production and use of tyre-derived rubber materials, WRAP/Environment Agency

Figure 1 Main stages and control mechanisms of the Quality Protocol



Source: UK Quality Protocol. Tyre-derived rubber materials - End of waste criteria for the production and use of tyre-derived rubber materials

The Quality Protocol describes acceptable good practice for the use of tyre-derived rubber materials (in Appendix D of the Quality Protocol).

3.2.1 Input materials

Source-segregated waste tyres classified under List of Waste Codes (LoW) code 16 01 03 end-oflife tyres are the only acceptable input materials. Specifically these are waste tyres that have been removed from road vehicles, and off-road vehicles such as agricultural and earth-moving equipment, but excluding aircraft tyres.

Tyres which contain small amounts of contamination arising from their use or handling, such as earth and stones, or grease and oils are considered to be acceptable inputs, tyres which have been contaminated with foreign matter or contaminants as a result of being fly-tipped or buried are not acceptable inputs.

3.2.2 Permitted uses

To comply with the UK QP, the tyre-derived rubber materials must be destined for use in one of the designated applications within the designated market sectors listed below. In some cases, within these designated applications, example final end uses are noted. These example end uses are not intended to be exhaustive and other similar final end uses may be appropriate.

- Construction
  - Noise insulation/acoustic barrier material;
  - Thermal insulation;
  - Composite boards and sheets; or
  - Rubberised adhesives and mastics.
- Civil engineering (unbound applications)
  - Replacement aggregate in construction of road infrastructure, as roadbed stabiliser, slope stabiliser, bridge abutments and as an additive for rubberised asphalt;
  - Low-weight soil replacement for embankments over compressive terrain; or
  - Loose (unbound) material in surfacing of footpaths, nature trails, cycle paths, bridleways, roads and railways as ballast.
- Civil engineering (bound applications)
  - Replacement aggregate in the construction and building industry, e.g. use in block fabrication;
  - Bound material in surfacing of footpaths, nature trails, cycle paths, bridleways, roads and railways as ballast;
  - Rubber replacement aggregate in concrete for architectural applications;
  - Compressible rubber sheet for alleviation of subterranean ground movement alongside buried structures;
  - Bound rubberised product, e.g. wall and floor boarding, street furniture (e.g. seating and signposts); or
  - Marine reefs.
- Landfill engineering
  - as a replacement aggregate in the construction of landfill sites (e.g. drainage layer).
- Landscaping
  - Walkways; or
  - Turf/ground reinforcement.
- • Equestrian
  - Bedding/floors; or
  - Ménage and gallops.
- Play surfaces
  - Unbound material in sports surfacing, e.g. rubber playground mulch;
  - Unbound material in recreation and safety surfacing, e.g. playground surfaces; or
  - as bound material in safety surface matting.
- Sports surfaces

  - Unbound material in sports surfacing, e.g. artificial turf, racecourses, equestrian surfaces and running tracks;
  - Unbound material in recreation and safety surfacing, e.g. nature trails, bridleways, cycle trails; or
  - Bound material in anti-vibration matting and impact protection barriers.
- Home Products
  - Footwear;
  - Carpet underlay; or
  - Mouse mats.
- Automotive
  - Vehicle bumpers, floor mats, insulation, vehicle components; or
  - New tyre raw material.
- Industrial
  - Safety surfacing;
  - Belting, matting, Membranes, air-conditioning mats;
  - Sealants; or
  - Adhesives and mastics.
- Transport/traffic
  - Asphaltic rubber wearing course road surfacing/Surface Matting;
  - Street furniture rubber planters, traffic management barricades; or
  - Boat fenders;.

3.2.3 Processing and quality requirements

ELT rubber must be processed in accordance with the following:

- have been produced using only those input materials specified in Section 2, namely source segregated waste tyres;
- meet the requirements of an approved material standard or specification (e.g. PAS 107:2012)
- meet the requirements of engineering standards if specified for the specific end use;
- meet any additional requirements specified by the customer;
- have been produced using either ambient or cryogenic processing technologies; and
- have been processed to one of the size categories and in accordance with one of the options in Section 2 of the Quality Protocol.

The QP includes requirements to comply with specified engineering standards when the intended end use is in either the civil engineering (unbound applications) or landfill engineering market sectors.

Producers of ELT rubber are required to be certified and as part of the certification process, the producer must:

- keep and retain records for a minimum of four years;
- make them available to the certification body for certification purposes

The QP also includes requirements for record keeping and production of a Quality Statement which should contain, as a minimum, the following information:

- the approved material standard to which the tyre-derived rubber materials comply (PAS 107:2007);
- the engineering standard to which the tyre-derived rubber materials supplied comply;

- a statement that the tyre-derived rubber materials supplied were produced in conformance with this Quality Protocol; and
- information on good practice relating to the storage and use of the tyre-derived rubber materials supplied.

3.3 Italian End of Waste Decree for Vulcanized Rubber from End of Life Tyres.

The Italian “Decree of the Minister for the Environment - Regulation containing "End of Waste" rules for vulcanised rubber deriving from end of life tyres (pfu)” establishes the specific criteria under which the vulcanised rubber deriving from end of life tyres ceases to be classified as waste.

3.3.1 Input materials

The following waste is allowed for the production of granular vulcanised rubber:

- Entire or crushed end-of-life tyres also following mechanical processing.
- Scraps of vulcanised rubber coming both from the production of new tyres and from the activity of re-treading tyres.

However, the following are not allowed:

- Solid rubber wheels or tyres for bicycles.
- Air chambers, the relative protectors (flaps), tracks or rubber gaskets.
- End of life tyres with evident signs of burning.
- End of life tyres, which by means of carrying out a visual check using the human sensorial capacities or any non-specialized equipment, present evident signs of contamination or foreign materials such as, by way of example, inert materials, metallic rim or with snow chains mounted. The aforesaid end of life tyres are allowed following adoption of adequate techniques to eliminate the contaminations or the inert materials.
- End of life tyres as defined at article 2, paragraph 1, letter m) of the decree of the Minister for the Environment and the Protection of the Land and the Sea, of 11 April 2011, no. 82 and abandoned or buried end of life tyres.
- Mixes and scraps of unvulcanised or partially vulcanised rubber.
- Discards of production of technical articles in rubber.

3.3.2 Permitted uses

Annex 2 identifies specific purposes for which the granular vulcanised rubber (GVG) can be used:

- Production of articles and/or components of articles in rubber, rubbery conglomerates, mixes of rubber and rubber-plastic on condition that the same are destined to structural elements and finishing elements for building, mechanical industry, components of means of transport external to the cabin, railway and port constructions and infrastructures, signage and road systems, weights and counterweights;
- Lower layers of sports playing surfaces;
- Infill material for sports surfaces;
- Bituminous composite materials such as modified bitumen, bituminous membranes, rubber based additives for asphalts, sealant glues;
- Bituminous conglomerates or cementitious conglomerates;
- Foaming agents for steelworks.

The use of the granular vulcanised rubber must comply with the following legislation where pertinent:

- Regulation (EC) no. 178/2002 of the European Parliament and of the Council of 28 January 2002, which establishes the general principles and requirements of food law and of the regulation (EC) 1935/2004 of the European Parliament and of the Council of 27 October 2004, regarding materials and objects destined to come into contact with food products.

- Directive 93/42/EEC of the Council of 14 June 1993, as modified by directive 2007/47/EC of the European Parliament and of the Council of 5 September 2007 concerning medical devices.
- Directive 2009/48/EC of the European Parliament and of the Council of 18 June 2009, on the safety of toys, implemented by legislative decree of 11 April 2011, no. 54, and legislative decree of 6 September 2005, no. 206, on the general safety of products in relation to products for childcare.
- Regulation (EC) no. 1907/2006 of the European Parliament and the Council approved on 18 December 2006 as modified by regulation (EC) no. 1272/2013 of the European Parliament and of the Council approved on 6 December 2013 concerning the registration, the evaluation, the authorisation and the restriction of chemicals (REACH).
- Article 242 of legislative decree of 3 April 2006, no. 152, which imposes the prohibition on using GVG for environmental remediation and in dissolved form upon agricultural soil given that said use would cause the contamination of the site with materials which exceed the analytical limits already envisaged by Table 1 of Annex 5 to Part four, Title five of the legislative decree of 3 April 2006, no. 152.

3.3.3 Processing and quality requirements

Limits in Annex 1 describe chemical and physical characteristics the EoW must have and are shown in Table 3-1 below.

Table 3-1: Parameters and limits (EoW regulation Italy)

Parameters	Analytical method	Limit values
Metals (to be verified by means of a disposal test)	DIN 18035	DIN 18035-7
DOC	DIN 18035	DIN 18035-7
EOX	DIN 18035	DIN 18035-7
Total content of the following IPAs: Benzo(a)pyrene (BaP) Benzo(e)pyrene (BeP) Benzo(a)anthracene (BaA) Chrysene (CHR) Benzo(b)fluoranthene (BbFA) Benzo(j)fluoranthene (BjFA) Benzo(k)fluoranthene (BkFA) Dibenzo(a,h)anthracene9 (DBAhA)	Method envisaged by ISTI-SAN 16/13 Reports of the Italian Institute of Health	below or equal to 20 ppm

Physical-geometric characteristics of the granular vulcanised rubber (GVG) specifications:

- Percentage of free steel: Class 3 UNI 11610 or lower (i.e. ≤0.5%).
- Percentage of free textiles: Class 3 UNI 11610 or lower (< 0.1 % in granulates and < 0.35% in powders).
- Percentage of impurities: Class 3 UNI 11610 or lower (i.e. < 1.25% in granulates and < 3% in powders).

Specifications to be adopted from the third year of application of this regulation:

- Percentage of free steel: Class 2 UNI 11610 or lower (i.e. <0.1%).
- Percentage of free textiles: Class 2 UNI 1610 or lower (i.e. <0.02% in granulates and <0.2% in powders.
- Percentage of impurities: Class 2 UNI 11610 or lower (i.e. < 0.75% in granulates and < 2% in powders).

3.4 Portugal

The Portuguese national criteria proposal for granting end of waste status (EOW) to rubber material derived from used tyres (Portarianº20/2018, January 17)[2] are set out in a Ministerial Implementing Order which

[2] A project called NEUVIA, sponsored by Signus is a design of a slabtrack system using ELT and polyurethane mixture.

establishes the criteria for granting End of Waste (EOW) Status to rubber material derived from used tyres, in particular rubber powder, rubber granulate, chips, shreds and cuts.

Rubber material derived from used tyres ceases to be waste at the time of transfer from the producer to the holder, if the following conditions are met:

e. The material resulting from a recovery operation complies with the criteria laid down in point of Annex I

f. Waste used as input in the recovery operation complies with the criteria laid down in point 2 of Annex I;

g. Waste used as input in the recovery operation has been previously treated in accordance with the criteria laid down in point 3 of Annex I;

h. The producer meets the requirements set out in Articles4 to 7;

i. The rubber material derived from used tyres is not intended for the following applications:

   i. Combustion, with or without energy recovery;

   ii. Pyrolysis, plasmolysis, gasification and related technologies;

   iii. Landfill and other disposal operations; and

   iv. Abandonment.

3.4.1 Input materials

Only the types of tyres used identified in paragraph 6 of Order Appendix No. 31203/2008 of 4 December 2008 (LER Code 16 01 03) may be used. Tyres contaminated with hazardous substances shall not be used.

3.4.2 Permitted Uses

The rubber material derived from used tyres is not intended for the following applications:

- Combustion, with or without energy recovery.
- Pyrolysis, plasmolysis, gasification and related technologies.
- Landfill and other disposal operations.
- Abandonment

3.4.3 Processing and quality requirements

Rubber material derived from used tyres shall comply with the requirements laid down in the technical specifications and specific engineering standards, in order to be used directly for its intended purpose and shall also comply with additional customer requirements.

Rubber material derived from used tyres shall not present any of the hazardous properties indicated in Annex III of Directive 2008/98/EC and shall not exceed the concentration limits laid down in Annex IV of Regulation (EC) No. 850/2004.

It is a requirement that used tyres shall be treated using methods or processes that are not likely to result in adverse effects on the environment.

For each consignment of rubber material derived from used tyres, the producer/person responsible for the introduction into the national territory shall issue a Declaration of Conformity in accordance with the Model in Annex II to this Ministerial Implementing Order, which forms an integral part thereof.

3.5 Spain

The Spanish Government has prepared a Draft Ministerial Order establishing the criteria for determining when granulated rubber and rubber powder, obtained from the treatment of end-of-life tyres intended for certain

applications, cease to be waste in accordance with Law 22/2011 of 28 July 2011 on contaminated waste and soils.

Granulated rubber and rubber powder shall cease to be waste at the time of transfer from the producer to another holder and where it complies with the following:

- Waste under treatment must only be waste which meets the criteria set out in paragraph 1 of Annex I;
- Waste submitted to the recovery process has been treated in accordance with the criteria set out in paragraph 2 of Annex I;
- Granulated rubber and rubber powder resulting from recovery operations meet the criteria set out in paragraph 3 of Annex I;
- Granulated rubber and rubber powder are intended for the uses referred to in Article 1(1).
- The producer or importer has fulfilled the obligations set out in Articles 5, 6 and 7.

3.5.1 Input materials

The only waste eligible for entry to this treatment are end-of-life tyres, both whole and fractional, and rubber waste from the manufacture of tyres or the re-treading thereof, classified under the following EWC codes:

- 16 01 03 'End-of-life tyres'
- 19 12 04 'Plastic and rubber' coming from mechanical treatment of end-of-life tyres
- 07 02 99 'Waste not specified in another category' means rubber waste generated in the manufacturing processes of new or re-treaded tyres

The following items are excluded:

- Bicycle tyres and solid wheels.
- Tyres with obvious signs of having been burnt or exposed to very high temperatures.
- Tyres from abandoned or buried bundles.
- Tyres from landfills.
- Tyres showing obvious signs of contamination from hazardous waste, bio-waste, sanitary waste or municipal waste.
- Tyres accompanied by foreign materials, such as inert materials, metal rims, snow chains or other waste.

3.5.2 Permitted uses

The uses covered under the EoW criteria are:

- Artificial turf fields and bases for other sports grounds.
- Surfacing for children's playgrounds, sports fields and safety surfacing.
- Castings and rubber articles.
- Bituminous mixtures.

The use of granulated rubber or rubber powder shall not be permitted in articles whose purpose requires permanent contact with the skin, unless the thresholds set out in Annex XVII of Regulation (EC) 1907/2006 of the European Parliament and of the Council of 18 December 2006 referred to in Article 7(2) are met for the intended use, such as:

- Sports equipment, such as bicycle or golf club grips and rackets.
- Household utensils, such as kitchen utensils or walking frames.
- Household tools, items clothing, gloves and sportswear.
- Watch straps, bracelets, masks, hair ribbons.
- Toys and child care articles.

- Materials for the pharmaceutical industry.
- Materials in contact with food.

The Spanish ELT EoW criteria specifically excludes the use of granulated rubber in applications in which it is used as unbound material in artificial turf fields or in bases for other fields where there are not adequate containment measures to reduce and control the release of particles into the environment – i.e. there is a specific requirement for risk management measures to be implemented for this application to be permitted.

3.5.3 Processing and quality requirements

The criteria requires that ELT are subjected to the following processes for obtaining the rubber fraction:

- Primary crushing for obtaining pieces and fragments.
- Secondary crushing, in which the process of reducing the dimensions of the previous fragments continues, to obtain chips of between 10 and 50 mm in size.
- Tertiary crushing in granulation mills and fine mills for the production of granulated rubber particles (with particle size distribution between 0.8 mm and 20 mm) or rubber powder (with particle size distribution of less than 0.8 mm).
- Separation of textile fibres, through densimetric tables or suction systems, and of steel by magnetic separators.

The processes indicated in the preceding points may be replaced by other mechanical processes provided that the fraction of rubber obtained from the treated waste complies with the requirements set out in paragraph 3 for the resulting material.

- Classification of rubber particles according to their particle size distribution, in accordance with the categories set out in UNE-EN 14243-2.2

ELT rubber must comply with the requirements contained in the technical specifications and in the technical standards or other specific rules applicable to them, so that they can be used directly for the specific purpose. They must also comply with the additional specifications that could be established by the recipient of those products.

They shall not exceed the following maximum impurities limits determined in accordance with UNE-EN 14243-23.

Impurities	Granulated rubber and powdered rubber (mass percentage)
Ferromagnetic materials	Less than or equal to 1
Textile fibres	Less than or equal to 0.25
Other	Less than or equal to 0.25

They must comply with the provisions of Entry 50 (Polycyclic aromatic hydrocarbons) and any other restrictions set out in Annex XVII to Regulation (EC) No 1907/2006 (REACH), and must be free of visible lubricating oils and grease[3].

During the process of obtaining granulated rubber intended to be used as an unbound material in artificial turf fields or in bases for other sports grounds, water must have been used continuously to wash away impurities.

Physical and chemical characterisation, sampling procedures and any other determinations and controls to be carried out on granulated rubber and rubber powder shall be carried out in accordance with the provisions of the following standards:

[3] The requirement to comply with REACH Entry 50 only applies to those uses to which Entry 50 is relevant; and can be considered as redundant, in that REACH compliance is mandatory, regardless of whether or not it is included in an EoW criteria.

- UNE-EN 14243 ‘Materials produced from end of life tyres’;
- UNE-CEN/TS 17188:2019 "Materials obtained from end-of-life tyres (NFU). Sampling method for granulates and powders stored in big-bags’; and
- The Spanish experimental standard UNE 53936 EX ‘Materials from end-of-life tyres. Rubber granules. Determination of textile fibre content by visual index’ (noting that this standard has yet to be released).

The producer is required to establish a management system to demonstrate compliance with the criteria referred to in Article 3 which must also include the specific control requirements in relation to the established criteria. The management system shall include the sampling design and sampling methodology for granulated rubber and rubber powder resulting from recovery, in accordance with standard UNE-EN 14243-2.

A conformity assessment body accredited to carry out such certification, in accordance with Regulation (EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation and repealing Regulation (EEC) No 339/93, shall certify that the management system implemented by the producer complies with the requirements of this Article.

3.6 Summary

The main requirements of European ELT EoW criteria are presented below.

There are broad similarities in that:

- Each country has similar requirements for quality assurance and control, including the need for declarations of conformity, although the specific requirements vary between countries;
- The input materials are generally similar, predominantly waste tyres;
- None of the existing ELT EoW criteria apply to the use of ELT rubber as a fuel for co-incineration.

However, there are differences such as:

- The descriptions of suitable input materials are not aligned – for example, Spain allows a broader range of EWC codes than other countries.
- Some countries specify permitted end-uses in some detail whilst others (e.g. Portugal) do not.
- Some countries (e.g. Spain and the UK) require third-party certification of the quality management system and declaration of conformity.
- Not all of the standards set out specific quality criteria (in terms of permitted level of contamination in general, or for specific uses).

Table 3-2: Summary of EoW criteria requirements for selected countries (UK, Italy and Portugal and Spain recently notified criteria).

Criteria/Country	UK	Italy	Portugal	Spain
Input material	• Only source-segregated waste tyres classified under European Waste Catalogue (EWC) code 16 01 03 end-of-life tyres • Tyres which contain small amounts of contamination arising from their use or handling, such as earth and stones, or grease and oils are considered to be acceptable inputs, tyres which have been contaminated with foreign matter or contaminants as a result of being fly-tipped or buried are not acceptable inputs.	The following waste is allowed for the production of granular vulcanised rubber: • entire or crushed end-of-life tyres also following mechanical processing; • scraps of vulcanised rubber coming both from the production of new tyres and from the activity of reconstructing tyres. The following are not allowed: • solid rubber wheels or tyres for bicycles; • air chambers, the relative protectors (flaps), tracks or rubber gaskets; • End of life tyres with evident signs of burning; • End of life tyres, which by means of carrying out a visual check using the	• Only waste streams Code 16 01 03 may be used. • Tyres contaminated with hazardous substances shall not be used.	The only waste eligible for entry to this treatment are end-of-life tyres, both whole and fractional, and rubber waste from the manufacture of tyres or the retreading thereof, classified under the following EWC codes: • 16 01 03 'End-of-life tyres' • 19 12 04 'Plastic and rubber' coming from mechanical treatment of end-of-life tyres • 07 02 99 'Waste not specified in another category' means rubber waste generated in the manufacturing processes of new or retreaded tyres It is excluded from entry to this treatment:

		human sensorial capacities or any non-specialized equipment, present evident signs of contamination or foreign materials such as, by way of example, inert materials, metallic rim or with snow chains mounted. The aforesaid end of life tyres are allowed following adoption of adequate techniques to eliminate the contaminations or the inert materials; • End of life tyres as defined at article 2, paragraph 1, letter m) of the decree of the Minister for the Environment and the Protection of the Land and the Sea, of 11 April 2011, no. 82 and abandoned or buried end of life tyres; • mixes and scraps of unvulcanised or partially vulcanised rubber; • discards of production of technical articles in rubber.		• Bicycle tyres and solid wheels. • Tyres with obvious signs of having been burnt or exposed to very high temperatures. • Tyres from abandoned or buried bundles. • Tyres from landfills. • Tyres showing obvious signs of contamination from hazardous waste, bio-waste, sanitary waste or municipal waste. • Tyres accompanied by foreign materials, such as inert materials, metal rims, snow chains or other waste.
Processes/Treatments	• must meet the requirements of an approved material standard or specification (e.g. PAS 107:2007) • have been produced using either ambient or cryogenic processing technologies; • have been processed to a specific sizes (details under the UK EoW criteria)	• Not specified	• Previous cleaning of materials accompanying the used tyres, such as stones or metal pieces, various waste or other contaminants. • Used tyres shall be treated using methods or processes that are not likely to result in adverse effects on the environment. • Legislation applicable to waste shall be complied with.	• Primary crushing for obtaining pieces and fragments. • Secondary crushing to obtain chips of between 10 and 50 mm in size. • Tertiary crushing in granulation mills and fine mills for the production of granulated rubber particles or rubber powder. • Separation of textile fibres, through densimetric tables or suction systems, and of steel by magnetic separators. During the process of obtaining granulated rubber intended to be used as an unbound material in artificial turf fields or in bases for other sports grounds, water must have been used continuously to wash away impurities.

Acceptable uses	Includes: • Civil engineering (unbound applications) • Civil engineering (bound applications) • Landfill engineering • Sports, recreation and leisure applications – as unbound material in sports surfacing and recreation and safety surfacing or as bound material in safety surface matting, anti-vibration matting, impact protection barriers and street furniture. • Industrial and consumer applications (bound applications)	Includes: • Production of articles and/or components of articles in rubber, rubbery conglomerates, mixes of rubber and rubber-plastic on condition that the same are destined to structural elements and finishing elements for building, mechanical industry, components of means of transport external to the cabin, railway and port constructions and infrastructures, signage and road systems, weights and counterweights; • Lower layers of sports playing surfaces; • Infill material for sports surfaces; • Bituminous composite materials such as modified bitumen, bituminous membranes, rubber based additives for asphalts, sealant glues; • Bituminous conglomerates or cementitious conglomerates; • Foaming agents for steelworks.	Excludes: • Combustion, with or without energy recovery; • Pyrolysis, plasmolysis, gasification and related technologies; • Landfill and other disposal operations; and • Abandonment	Includes: • Artificial turf fields and bases for other sports grounds; • Surfacing for children's playgrounds, sports fields and safety surfacing; • Castings and rubber articles; • Bituminous mixtures.
Quality assurance	• Quality Protocol (compliance must be demonstrated by obtaining a certificate from an approved certification body and by maintaining records) • Produce supply documentation/Records management (records incoming wastes, all inspections and testing carried out for compliance with PAS 107:2007, etc.) • Quality Statement	• Declaration of conformity and arrangements for possessing samples • Environmental management system	• Declaration of conformity • Product should be labelled • Management system in place (monitoring, verification, record keeping, etc.)	• The producer is required to establish a management system • The management system shall include the sampling design and sampling methodology for granulated rubber and rubber powder resulting from recovery, in accordance with standard UNE-EN 14243-2. • A conformity assessment body accredited to carry out such certification shall certify the management system.

3.7 Conclusions

Several countries have developed national EoW criteria for ELT tyre rubber, and there are additional regional-level EoW criteria in other Member States. Whilst broadly similar, there are differences between them, and only a fraction of EU countries have any form of national-level EoW criteria. Some countries specify end-uses, whereas others do not. Where end-uses are specified, this may have a negative impact on innovation in the sector, by favouring those specified end-uses against emerging end-uses which may be environmentally preferrable.

The lack of alignment (at the detailed level) between national-level EoW criteria is a potential hinderance to trade within the EU since ELT rubber meeting EoW criteria in one country may not do so in another country, or may not be permitted for particular uses in that country.

An example is that the Italian EoW criteria allows the import of vulcanized rubber may be imported with a EoW classification if it complies the criteria set by the decree; but there is not clear mechanism whereby non-Italian ELT recyclers can submit declarations of conformity to local authorities in their own country, who are not equipped to determine whether the material complies with the Italian criteria.

The difference in national EoW criteria imposes unequal costs on ELT recyclers, depending on the testing requirements of the national criteria. Some countries have more stringent requirements for chemical testing of batches whereas others do not.

The lack of alignment and absence of EoW criteria in some Member States also leads to issues with exports from the EU: those Members States with ELT EoW criteria are able to export ELT as a product without the need to comply with waste shipment regulations and hence have a competitive advantage.

4. Uses

4.1 Introduction

Article 6 Criteria (a) of the Waste Framework Directive requires that for end-of-waste materials:

> *"(a) the substance or object is commonly used for specific purposes"*

This section describes how ELTs are processed, and the common uses for rubber from ELTs. Further details are available in the EURIC publication "Mechanical Tyre Recycling Factsheet".

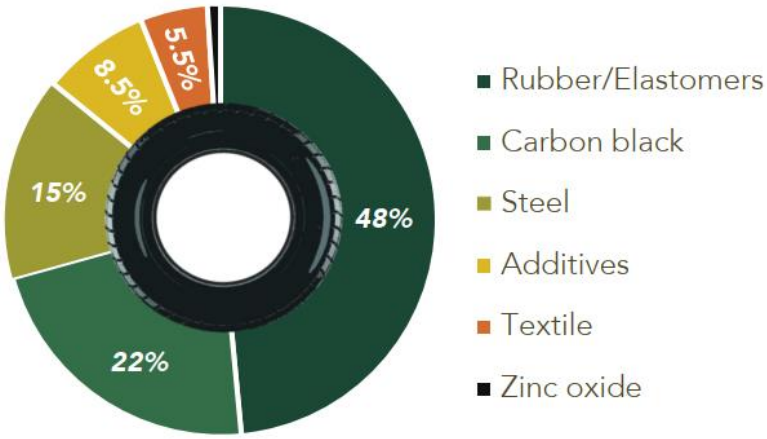
4.2 Tyre Composition

Tyres are very complex products composed of different valuable materials such as fibre and steel, all cured within the boundaries of rubber compounds and other unique materials to fulfil their primary purpose, namely safe and efficient mobility.

The different chemical compositions and the cross-linked structures of rubber in tyres enable them to be highly resistant to biodegradation, photochemical decomposition, chemical reagents and high temperatures.

The composition of a typical tyre is shown in Figure 4-1.

Figure 4-1: Typical Tyre Composition



Source: Mechanical Tyre Recycling Fact Sheet, EURIC

4.3 Tyre Reprocessing

The current recycling process for ELT comprises:

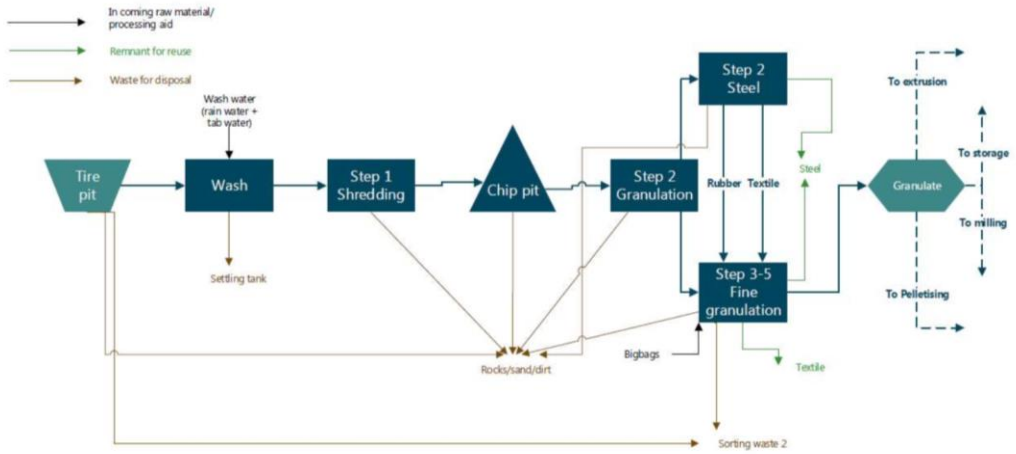
- Shredding to separate rubber from textile and steel
- Processing separated rubber intoto generate granulates and powder. This can be done by either:
  - Ambient process, where rubber is granulated and sieved at ambient temperatures and separated into granulates and powders.
  - Cryogenic process that uses liquid nitrogen to freeze the rubber at sub-zero temperatures (approx. -120°C), followed by milling and sieving.

Residual impurities are then removed from the granulates and powders. Finally, the rubber powders and granulates are packed at different grain sizes in bags of different sizes and ready for transport.

The main outputs of the recycling processes are rubber granulate in various sizes, a steel scrap fraction and a residual fraction consisting of textile and rubber.

The process flow for an example ELT processing facility is shown in Figure 4-2 (note that this facility includes a washing stage which is not typical practice in the sector).

Figure 4-2: ELT recycling flow diagram



Source: Life cycle assessment of waste tyre treatments: Material recycling vs. co-incineration in cement kilns, Force Technology (for Genan Holding A/S, May 2020)

4.4 Uses for ELT Rubber

End of life tyre rubber is a high-quality source of secondary raw materials within the EU. It has financial advantages, is easy to source and with a reliable and European supply. These qualities have enabled a strong industrial network that creates sustainable and non-outsourceable jobs across the EU.

The technical criteria relating to these end uses are discussed in Section 4.

The following sections discuss some of the main uses for ELT rubber.

4.4.1 Artificial Turf

ELT rubber is used as an infill material to provide resilience and shock absorbance to artificial turf pitches. The physical properties of the materials have the capacity to dissipate vibration and absorb impact therefore protecting the muscle-skeletal structure of athletes.

This accounted for 30% of ELT use in the EU in 2019.

4.4.2 Moulded Objects

This category includes many varied sustainable and durable goods (edgings/boundaries, rubber-to-metal boundings, lamps, ramps, vases, playground accessories, rail blocks, hoses etc.) used in different sectors such as agriculture, automotive, construction, and decoration.

There are a lot of vehicle components that require the use of polymers to create plastic trays, mouldings, etc. The blending of recycled rubber material with polymers and elastomers can create new, mouldable materials, e.g. for use in the automotive sector. ELT derived rubber granulates and powders mixed with polyurethane binders can be used to produce “re-moulded” rubber articles such as stable mats, wheels for trolleys (e.g. caddies, dustbins wheelbarrows, etc.), urban furniture and safety corners among others.

This accounted for 26% of ELT use in the EU in 2019.

4.4.3 Artificial Surfaces

ELT rubber is used for sport surface for athletic tracks or as underlayer in sports areas (volley, basket, etc). ELT rubber is also used for the production of shock-absorbing floorings for other outdoor applications such as children playgrounds, as it is proven to be weather-resistant, permeable to water and durable.

4.4.4 This accounted for 20% of ELT use in the EU in 2019.Building Construction and Furnishings

Rubber in concrete is an emerging market with some active commercial applications and various research taking place. The rubber has the potential to reduce the weight of the concrete and potentially increase its performance and durability.

Other construction applications include:

- Carpet/floor underlays
- Patio tiles
- Insulation material to reduce noise and vibration
- Construction materials – replacement aggregate/block fabrication
- Civil engineering (bound applications)

This is amongst the “other uses” that accounted for 12% of ELT use in the EU in 2019.

4.4.5 Transport Engineering

ELT rubber has a variety of applications in transport engineering.

“Transports In-tercommunaux de Bruxelles” used ELT rubber on their tramway systems in 1998, initially as filler blocks, then during upgrade as sleepers both made from 97% recycled rubber, and later the use of vibration dampening mats.

Use of rubber in rail construction can be found in the Swiss National Rail system’s ballast-free trackbed, which has been in use since 1978, where each sleeper lies on a rubber pad.

Mats made from ELT rubber are widely used (e.g. in Germany) for securing loads on road vehicles, utilising the high friction coefficient of the mat to prevent loads moving in transit.

Creation of sleepers is another emerging development. Greenrail has manufactured sleepers moulded from a blend of recycled rubber granulate and recycled plastics. For every km line equipped with these sleepers 35 tonnes each of tyres and plastics will be used according to the manufacturer.

A project called NEUVIA, sponsored by Signus is a design of a slabtrack system using ELT and polyurethane mixture.

ELT rubber can be used as a replacement aggregate in construction of road infrastructure, as roadbed stabiliser, slope stabiliser, drainage fill, culverts, drainage channels, bridge abutments.

This is amongst the “other uses” that accounted for 12% of ELT use in the EU in 2019.

4.4.6 Rubber Modified Asphalt

ELT rubber can be incorporated into asphalt used for road surfacing. A State of Knowledge report was prepared for the US Tyre and Rubber Manufacturers Association[4] provides an up-to-date review of rubber-modified asphalt (RMA), including its historical development and use, production methods, field performance, economics, safety, driver comfort, environmental impact, and sustainability benefits.

The report found that:

- The overarching research shows that rubber modified asphalt extends pavement life; resisting early pavement failures modes such as rutting and cracking. Additionally, RMA was also found to significantly mitigate noise from traffic, and enhance ride quality and safety.
- RMA has been shown to be a cost-effective option as it increases the service life of a pavement and reduces and/or delays the occurrence of maintenance activities. This leads to significant cost savings when evaluated using life cycle cost analysis techniques.

[4] State of Knowledge Report on Rubber Modified Asphalt, ATRM, Final Report May 25, 2021

- The use of RMA results in the reduction of CO2 emissions and lower energy consumption over the lifetime of a pavement. Additionally, since RMA pavements are stiffer and smoother, they reduce the generation of tire wear particles and improve water quality in roadway runoff.

The report concluded that:

> *RMA is a well-studied material that delivers significant, proven benefits in terms of pavement durability, economics, and environmental sustainability. It is hoped that the findings and recommendations of this report will help to facilitate the rapid growth in RMA usage in the United States and beyond. RMA is a proven and mature technology that is poised to play a key role in increasing the sustainability and resilience of America's highway and airfield pavement infrastructure as it is rebuilt and modernized in the coming years.*

Within the EU, rubber-modified asphalt has had limited adoption to date (predominantly in Spain), this is an application with future growth potential.

Rubber-modified asphalt is relatively well-established in the US, but there are barriers to wider uptake in the EU – these include the end-of-waste status of ELT-derived rubber, but also those associated with reluctance to adopt new approaches and lack of incentives to recognise the whole-life benefits of the material. The increasing move towards increased recycled content in public procurement may help in addressing these barriers.

This accounted for 2% of ELT use in the EU in 2019.

4.4.7 Tyre Manufacturing

The process of vulcanisation is used in primary rubber production to cross-link the polymers, forming a durable material. In order to achieve a true circular process and recycle used tyres back into new tyre production, it is necessary to reverse this process by devulcanization (although a smaller proportion of fine ELT powder can be incorporated into new tyre manufacture without devulcanization). Research and development of this process is on-going, but it is yet to be fully commercialised. Deployment of devulcanization at commercial scale would open up opportunities for a more circular business model for the tyre industry, allowing ELT to be recycled as a component of new tyres, thereby helping to "close the loop". However, successfully achieving this is technically challenging, and it does not at present represent a significant outlet for ELT-derived rubber.

4.5 Summary

Table 4-1 shows the main markets for ELT tyre rubber in the EU in 2019.

Table 4-1: EU Recycling Applications for ELT

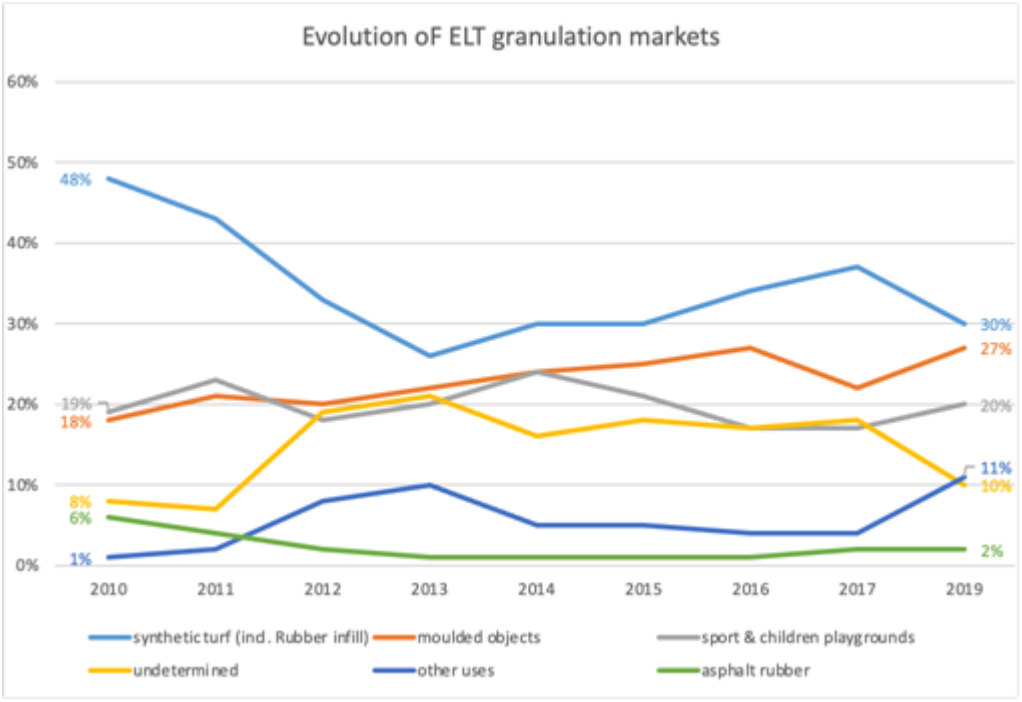
Mechanical recycling market	2019
Synthetic turf including infill	30%
Sport and children playground	20%
Moulded objects	26%
Asphalt and road paving	2%
Other uses	12%
Undetermined (export, traders)	10%

Table 4-1 shows that the synthetic turf infill market is the largest but far from the only market for recycled ELTs.

The success of the industry in collected ELT and hence their availability has enabled mature recycling markets to be established. There is scope for further development of higher-value applications and innovative approaches, and end-of-waste status can help facilitate this development by removing barriers.

Figure 4-3 (from ETRMA) shows that the size of these markets have varied over recent years between 2010 and 2017.

Figure 4-3: Annual variation in ELT rubber recycling destinations



Source: ETRMA

4.6 Conclusions

This review of the uses of ELT rubber demonstrates that:

- There is a well-developed European industry for ELT processing.
- The processed ELT rubber has many well-defined uses.
- There are a number of emerging uses for ELT rubber, including use in asphalt and devulcanization.
- Fully closed-loop recycling of ELT rubber into new tyres is not yet commercially feasible for techno-economic reasons, but the existing markets retain the value of rubber by utilising its properties (e.g. shock-absorbancy).

5. Markets

5.1 Introduction

Article 6 Criteria (b) of the Waste Framework Directive requires that for end-of-waste materials:

> *" (b) a market or demand exists for such a substance or object".*

This section describes the size of the EU market for ELT.

5.2 Total Market Size

The ETRMA collects data on the European-wide management of ELTs. The data covers the EU-28[5] as well as Norway, Serbia, Switzerland and Turkey (referred to here as "EU28+4")

Data for 2019 (Table 5-1) shows that in the EU28+4, a total of over 4 million tonnes of used tyres were generated in 2019, and of this total approximately 3.5 million tonnes comprised ELT.

Of this 3.5 million tonnes of ELT:

- 3% was used in civil engineering applications;
- 52% was recycled;
- 40% was used for co-incineration.

The remaining 5% went either to stock or unknown uses.

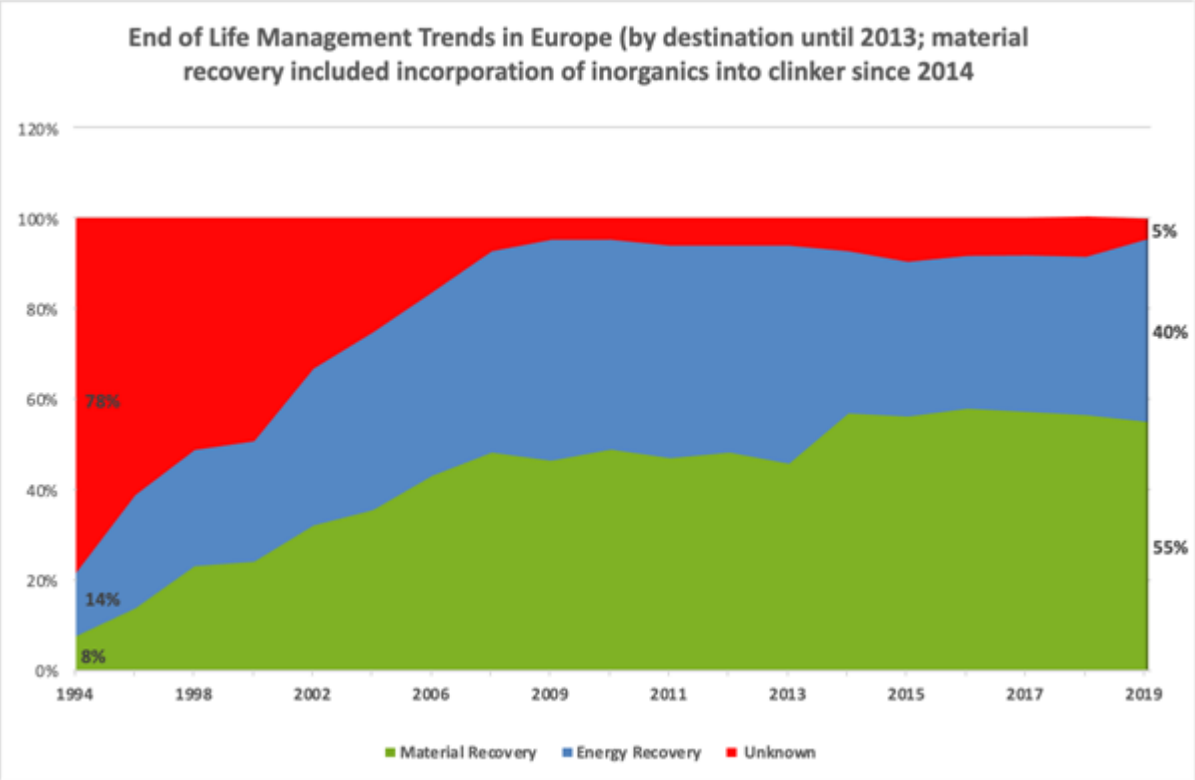
Table 5-1: Summary of EU28+4 market for used and end-of-life tyres (figures in tonnes) 2019

	Used tyres generated	Reused	End-of-life tyres	Use in civil engineering	Recycling	Co-incineration
EU28	**3,638,917**	**474,636**	**3,164,281**	**112,507**	**1,652,219**	**1,254,796**
Norway	*67,620*	*1,000*	*66,620*	*447*	*19,763*	*47,410*
Serbia (est.)	*53,500*	*3,500*	*50,000*		*39,000*	*11,000*
Switzerland (est)	*60,700*	*13,500*	*47,200*		*600*	*46,600*
Turkey (estimate LASDER + EUROSTAT)	*264,205*	*36,696*	*227,509*		*129,619*	*69,009*
EU28+4	**4,084,942**	**529,332**	**3,555,610**	**112,954**	**1,841,201**	**1,428,815**

Historic data (Figure 5-1) shows how the sector has evolved over the last 20 or more years, from a position where only 20% of ELTs were recovered, to the current situation where virtually all ELTs are recovered.

[5] Data includes the UK, which left the EU at the end of January 2020

Figure 5-1: Management of ELT over time



The number of ELTs has increased significantly over this timeframe, from 1.38 Mt in 2002 to 3.5 Mt currently.

5.3 Imports and Exports

There is a considerable flow of ELTs within and outside of Europe. Table 5-2 and Table 5-3 below summarise imports and exports of ELT in Europe in 2019. This data has been collected by the ETRMA from Eurostat by a search of the relevant Commodity Code Lists listed by Eurostat in the Combined Nomenclature (CN) which are used for the description of the traded goods. This Combined Nomenclature contains the commodity classification prescribed by the European Union for the statistics of International Trade in Goods. The GN is an 8-digit format.

The relevant code is shown in the table below.

Code GN	Code HS	Description
40040000	400400	Waste, parings and scrap of soft rubber and powders and granules obtained therefrom

Table 5-2 below shows the total quantity of ELT exported from countries in Europe in 2019. The data shows that the main exporters are the UK, France, Italy, Germany and Belgium. The main importers are Germany, the UK and the Netherlands. The data shows that Europe is a net exporter of ELT (i.e. the quantity exported exceeds the quantity imported).

Table 5-2: ELT shreds and granulates - Exports from and Imports to European Countries, 2019

Country	Exports (tonnes)	Imports (tonnes)
United Kingdom	293,651	64,217
France	228,983	3,977
Italy	183,936	1,556
Germany	135,720	100,225
Belgium	87,668	14,200
Poland	40,557	29,690

Denmark	38,166	3,859
Sweden	34,873	9,460
Spain	32,106	2,493
Netherlands	31,167	54,376
Ireland	28,512	560
Austria	10,209	8,335
Lithuania	9,938	614
Portugal	9,034	29,289
Greece	8,732	152
Estonia	4,642	4,882
Czechia	4,433	30,098
Slovenia	3,297	84
Slovakia	3,000	423
Hungary	1,901	13,400
Latvia	1,624	1,790
Romania	1,605	19,071
Finland	925	4,724
Luxembourg	541	3,206
Malta	287	176
Bulgaria	286	78
Croatia	286	3,218
Cyprus	-	335
Grand Total	**1,196,079**	**404,488**

Table 5-3 below shows the destinations of the tyres exported from European countries, and the sources of tyres imported to European countries. The data shows that the main destination of exports of ELT from Europe are India, Turkey and Morocco. The main sources of imports were all from within Europe – with Germany, the Netherlands and Denmark being the largest source. This latter point demonstrates the sizeable inter-European trade in ELT.

This data shows that

Table 5-3: Major Destinations and Sources of Exports and Imports of ELT shreds and granulates -

Destination of Exports from Europe countries	Tonnes received as exports	Source of Imports to European countries	Tonnes sent as imports
India	427,640	Germany	113,647
Turkey	172,477	Netherlands	44,736
Morocco	109,518	Denmark	42,020
Germany	64,078	Italy	23,102
Rep. of Korea	45,970	Spain	22,232
Netherlands	37,323	Austria	19,814
United Kingdom	33,339	Poland	19,624

France	28,970	Norway	13,005
Belgium	24,390	Croatia	12,386
Czechia	23,264	Belgium	11,384
Belarus	19,814	United Kingdom	9,382
USA	19,663	France	7,131
Poland	18,803	Greece	6,948
Pakistan	15,929	Slovakia	6,816
Ukraine	13,630	Czechia	6,796
Switzerland	11,376	Switzerland	4,044
Denmark	10,496	Portugal	3,520
Austria	10,457		

Many exports will fall under the reporting threshold, and hence the totals do not correspond (e.g. the UK reports that it imports more material to Germany than Germany reports receiving from the UK), Nevertheless, it provides a clear picture of the importance of international trade for the ELT rubber market.

5.4 Material prices

According to ETRMA, the price for ELT granulate and powder is (in general terms) as shown below:

- Granulate for infill: € 120-150 /tonne
- Granulate for moulded products etc: € 100-250 /tonne
- Fine powder (cryogenically ground): € 500-1200 /tonne

The fact that there is a positive price for this material (i.e. users pay tyre processors for the material) demonstrates that there is a market demand for this material and that it is treated by the market as a legitimate product with a positive value, and that if ELT rubber were not available, the market would need to seek other alternatives to fulfil the need.

5.5 Conclusions

The data shows that there are active markets for ELT, for a variety of end uses.

ELT rubber has a positive market value: ETRMA estimates that prices for the different grades of ELT rubber range between € 100 and 1200 per tonne: this demonstrates the market demand for the product.

6. Technical Properties

6.1 Introduction

Article 6 Criteria (c) of the Waste Framework Directive requires that for end-of-waste materials:

> *"(c) the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products;"*

The main concern in relation to the possible use of rubber tyres with EoW status is the potential risk that the materials may contain substances that can cause unacceptable impacts on soil, surface water or groundwater and/or on human health.

In order to meet the requirements with regard to classification, labelling and customer information, recyclers must know the technical properties and hazard profile of the substances put on the market. This implies that to comply with legislation recyclers have to determine whether the substances manufactured (including any impurities) have hazardous properties (e.g. corrosive, acutely toxic, chronically toxic, carcinogenic).

The technical properties of rubber tyres with EoW status would need to be defined, measured and controlled by a so-called "product quality criteria".

The main focus should be on the following properties:

- Physical-chemical composition
- Content of impurities
- Physical size and shape
- Grading and classification of consignments
- Safety requirements

6.2 Standards

The technical properties of the ELT rubber are addressed Technical Specifications or Standards.

There are several European Technical Committees that work on creating new Standards related either to ELT-derived materials (CEN TC 366) and to products that commonly use ELT rubber (e.g. CEN TC 217 for sport and leisure surfaces). The list of standards below gives examples:

- EN 14243-1:2019 (WI=00366004) Materials obtained from end of life tyres - Part 1: General definitions related to the methods for determining their dimension(s) and impurities 2019-02-13
- EN 14243-2:2019 (WI=00366006) Materials obtained from end of life tyres - Part 2: Granulates and powders - Methods for determining the particle size distribution and impurities, including free steel and free textile content 2019-02-13
- EN 14243-3:2019 (WI=00366007) Materials obtained from end of life tyres - Part 3: Shreds, cuts and chips - Methods for determining their dimension(s) including protruding filaments dimensions
- CEN/TR 17511:2020 (WI=00366012) Materials obtained from End-of-Life Tyres - Odour of ELT granulates - Origin and remediation possibilities 2020-07-08
- CEN/TS 16916:2016 (WI=00366002) Materials obtained from End of Life Tyres - Determination of specific requirements for sampling and determination of moisture content using the oven-dry method 2016-03-16
- CEN/TS 17045:2020 (WI=00366017) Materials obtained from end-of-life tyres - Quality criteria for the selection of whole tyres, for recovery and recycling processes 2020-10-07
- CEN/TS 17188:2018 (WI=00366003) Materials obtained from end of life tyres (ELT) - Sampling method for granulates and powders stored in big-bags 2018-06-13
- CEN/TS 17189:2018 (WI=00366011) Materials obtained from end of life tyres (ELT) - Determination of the true density of granulates - Method based on water pycnometry 2018-06-13

- CEN/TS 17307:2019 (WI=00366009) Material derived from End-of-Life tyres - Granulates and powders - elastomers identification: Gas-chromatography and mass-spectrometric detection of pyrolysis products in solution 2019-03-27
- CEN/TS 17308:2019 (WI=00366013) Materials produced from end of life tyres - Steel wire -Determination of the non-metallic content 2019-04-03
- CEN/TS 17510:2020 (WI=00366014) Materials obtained from end-of-life tyres - Determination of the specific surface area of powders - Method based on krypton adsorption 2020-10-07

6.3 Non-waste Regulatory Controls

Whilst it is still waste, ELTs are regulated by the extensive EU waste regulatory regime. The following regulations are of relevance to ELT rubber which has achieved EoW status.

- Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)
- The Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures (CLP Regulation) and Regulation (EU) 2020/740 on the labelling of tyres with respect to fuel efficiency and other parameters

6.3.1 REACH

The REACH regulation (EC No 1907/2006) of the European Parliament and the Council) lays down specific duties and obligations on manufacturers, importers and downstream users of substances on their own, in mixtures and in articles.

When rubber derived from tyres ceases to be waste according to Article 6 of the WFD, the exemption under Article 2.2 of the REACH Regulation no longer applies. A benefit of EU-wide EoW criteria will therefore be to clarify when whether ELT derived rubber has to be considered a substance, mixture or article under REACH.

REACH stands for Registration, Evaluation, Authorisation and Restriction of Chemicals. It is a regulation of the European Union which entered into force on 1 June 2007, and aims to:

- improve the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry;
- acquire greater toxicological and eco-toxicological knowledge for about 30,000 substances (produced / imported in quantities> 1 tonne/year) (registration process)
- restrict the manufacture and/or placing on the market for certain uses of chemicals (restriction process);
- guarantee some uses for "very high concern" substances, ensuring that the risks related to them are properly controlled (authorization process).

To do this, REACH Regulation establishes procedures for collecting and assessing information on the properties and hazards of substances and concerns all chemicals, specifically it deals with:

- substances
- mixtures (of two or more substances)
- articles.

Companies' obligations established by the REACH Regulations are linked to three factors:

- the type of activity that is actually carried out by the company in relation to each specific substance used, as such or in a mixture or in an article, that defines its role in the supply chain;
- the classification, in accordance with the REACH and CLP Regulations, of substances produced/used as such or in a mixture or in an article;
- the quantity of substances produced/used or contained in articles/mixtures.

Once ELT derived rubber granule/powder achieves EoW status it is considered a mixture under REACH, and companies in the supply chain have an obligation to:

- identify their role in the supply chain of the products deriving from the recovery of ELTs and, in particular, whether they there are manufacturers, downstream users or distributors of ELT-derived rubber (granule/powder);
- know which chemicals within the product are of concern for the compliance with the REACH Regulation, with particular regard to:
  - those classified as carcinogenic, mutagenic or toxic for reproduction (CMR);
  - those classified as persistent, bioaccumulative and toxic (PBT) or very persistent and very bioaccumulative (vPvB);
  - those subject to the authorisation obligations or included in the list of substances candidate for authorisation (candidate list);
  - those that are not registered;
  - those covered by restrictions required by REACH on the manufacture/placing on the market/use of substances as such or in mixtures/articles;
  - those that must be specified in the safety data sheet (SDS) of the mixture when it is placed on the market;
  - those to be specified in the information provided to the recipients pursuant to Article 32 of REACH;
  - those to be specified in the information provided to the recipients pursuant to Article 33 of REACH.
- know the quantities in which the above-mentioned substances are present in the product, which determine the classification of the product globally under CLP and the application of other obligations and restrictions of the REACH Regulation.

Under the REACH Regulation, manufacturers, importers or users of each individual substance, as such or contained in mixtures or articles, may be subject to specific obligations depending on the role performed in the supply chain for this specific substance. These include obligations relating to:

- Registration of chemicals
- Authorisation of substances
- Compliance with the restrictions defined in Annex XVII of REACH
- Transmission of information through the supply chain

Commission Regulation (EU) 2021/1199 of 20 July 2021 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council addresses the issue of polycyclic aromatic hydrocarbons (PAHs) in granules or mulches used as infill material in synthetic turf pitches or in loose form on playgrounds or in sport applications. This decision prohibits the placing on the market and use of granules and mulches as infill if they contain more than 20 mg/kg of the sum of the eight PAHs. Granules or mulches placed on the market also have to be batch labelled to ensure safe use.

6.3.2 CLP

The REACH Regulation is connected to the European Union Classification, Labelling and Packaging (CLP) Regulation ((EC) No 1272/2008). The CLP Regulation, entered in force on 20 January 2009, was adopted in order to meet the request of the European Community to contribute to the global harmonization of the classification and labelling criteria not only in the United Nations, but also by incorporating into EU laws the criteria of the United Nations' Globally Harmonised System (GHS) 6.

The methodology introduced by CLP, based on GHS, aims to introduce:

- a harmonised classification of substances and mixtures, to identify their hazard;
- a harmonised labelling of substances/mixtures (phrases and pictograms for the communication of hazards in a language that is unique on an international level

[6] UN Globally Harmonized System of Classification and Labelling of chemicals

Specifically, the CLP applies to substances, mixtures and some articles, without limits on the quantity produced per year, and has the following obligations:

- Classify, package and label substances and mixtures according to the provisions of the CLP before placing them on the market (art 4) (use of literature data);
- Notify the classification and labelling elements of substances to ECHA for the maintenance and updating of the classification and labelling inventory (Classification and Labelling -C & L) (art.40);
- Update the labelling and classification of the substance in case of new technical and scientific information (art.15, art.30);
- Keep available all the information required for the purposes of classification and labelling under CLP for a period of at least 10 years (art.49).

The obligations under REACH Regulation are intrinsically connected to the content of the CLP Regulation, with reference to the harmonized classification of chemicals, in the general framework relating to the definition of the obligations of the producers of granule/powder and of the actors of the supply chain of the products deriving from the treatment of ELTs, it is not possible to avoid considering the two Community Regulations jointly.

6.4 ELT Obligations under REACH and CLP

Due to the complexity of these legal acts (REACH, CLP) the UNI/CT 04/GL14 Working Group defined the procedures to ascertain the compliance of these products to the fulfilments of the REACH and CLP Regulations.

Furthermore, to achieve this objective, the CONFOREACh-GVG Project aimed at facilitating the realization of the aforementioned UNI/TR by carrying out tests on ELTs granules and powders.

This project identified that ELT rubber is classified as a “mixture” under REACH and drew the following conclusions from a comprehensive mapping out of the substances that could be found in theses mixtures.

- Regarding **REACH registration obligations**: there is currently no obligation to register any substance present in the ELT derived rubber granule and powder but it is necessary to certify the existence of the registration exemption conditions referred to in art. 2.7 (d) of the REACH for those substances which have been assumed to be manufactured in quantities exceeding 1 ton/year and which are not exempt from registration due to their nature in the finished product and their function in the rubber production process. This requirement can be complied by preparing and keeping available in the production plant a dossier that certifies the sameness of the recovered substances with other registered substances and collects information on these recovered substances that allow their safe use.
- Regarding the **REACH authorization obligations**: there is no obligation to request authorization for the use of the substances present in the ELT derived rubber granules and powder, as all the substances included in the candidate list and in Annex XIV of the REACH comply with the conditions of article 56.6 of REACH.
- Regarding the **REACH restrictions obligations**: the restrictions that to date could potentially affect the ELT derived rubber granule and powder are Entries 28 and 50 of REACH. If the granule / powder is used, without altering its chemical composition, to realize a product that is classified, according to REACH, as an article and which falls within the scope of the restriction, it would not be allowed to be placed on the market if the concentrations of the listed PAHs exceed the limits imposed by the restriction.
- Regarding to **REACH communication obligations** along the supply chain: the ELT derived rubber granule / powder is a mixture under REACH and is not classified as hazardous according to CLP. Therefore, the supply of the SDS is not mandatory (even without request) pursuant to 'art. 31, paragraph 1 (a) of the REACH. However, the conditions provided for by art. 31 paragraph 3 of the REACH apply and, consequently, it is necessary to prepare an SDS of the ELT derived rubber granule/powder to be transmitted on request to the recipients. Furthermore, pursuant to the CLP Regulation, the availability of this SDS must be indicated on the label on the packaging.

6.5 Conclusions

There are numerous existing technical standards relating to the technical properties of ELT rubber.

ELT rubber achieving EoW status would be managed as a “mixture” under REACH. Tests have demonstrated that ELT rubber is not classified as hazardous under CLP.

There is an existing limit under Entry 50 of REACH setting a maximum PAH concentration of 20 ppm for ELT rubber infill material. Articles that come into direct as well as prolonged contact or short-term repetitive contact with human skin or the oral cavity, under normal or reasonably foreseeable conditions of use, must also not contain more than 1 mg/kg of any of the 8 PAHs listed under Entry 50 (noting that this restriction applies to all such articles, not just those made from ELT-derived rubber). . There is no requirement to obtain additional REACH registration or authorisation for substances in ELT rubber.

7. Environment and Health Impacts

7.1 Introduction

Article 6 Criteria (d) of the Waste Framework Directive requires that for end-of-waste materials:

> *"(d) the use of the substance or object will not lead to overall adverse environmental or human health impacts.".*

This section describes and discusses the potential environmental and human health impacts associated with the use of ELT rubber.

Recycling of ELT rubber contributes towards the objectives of the circular economy, by maintaining the material in use, and utilising the properties of the material (e.g. shock absorbency, in the case of artificial turf infill). This is in contrast to co-incineration, which (whilst preferrable to disposal) ultimately leads to a loss of resources, since the raw material in ELT rubber is destroyed in the combustion process.

In the markets for recycled ELT rubber, the material replaces virgin materials that would otherwise be used to serve the same purpose (e.g. for the most part, this would be virgin rubber).

7.2 Life Cycle Impacts

The most widely used way to assess overall environmental impacts of an activity is to carry out a life cycle assessment. This process is defined as the systematic analysis of the potential environmental impacts of products or services during their entire life cycle.

A number of LCA studies have been carried out for ELT rubber, and are discussed below.

7.2.1 Comparison of destructive and non-destructive ELT management routes

A life cycle assessment study carried out in 2010[7] compared five "non-destructive" ELT recycling routes and four "destructive" co-incineration and energy recovery routes. The routes considered were:

Destructive methods:	Non-destructive methods:
• cement works	• retention basins
• foundries	• infiltration basins
• steelworks	• moulded objects
• urban heating	• synthetic turfs
	• equestrian floors

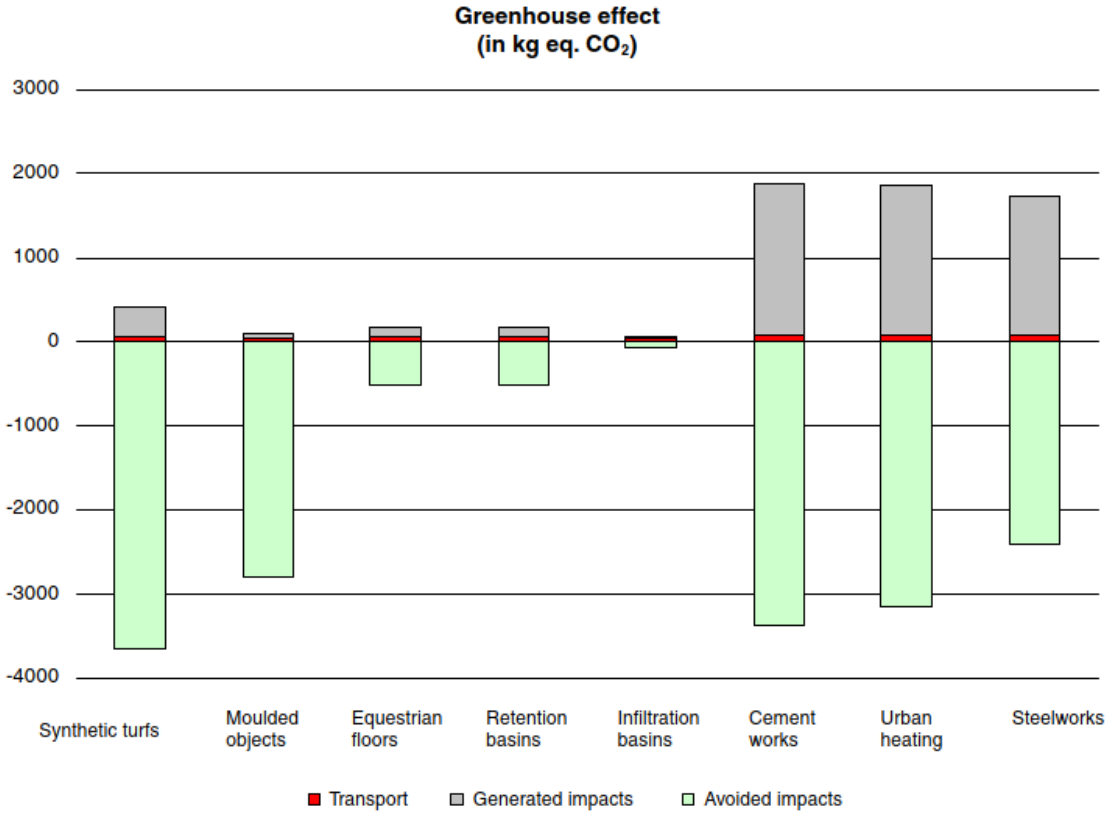
This evaluation was based on the Life Cycle Assessment approach and conformed to the methodological prescriptions developed in the ISO 14 040 (2006a) and ISO 14 044 (2006b) standards. It was carried out by PricewaterhouseCoopers Ecobilan (2009) a consulting firm specialising in life cycle assessments, and was reviewed by a committee of European LCA experts and interested parties.

The study took into account both the direct impacts associated with the recovery method and the impacts avoided through the substitution effect (the recovered used tyres were used as a replacement for "traditional" products such as energy or raw materials).

The results for greenhouse gas emissions (shown in FIG below) indicate that the two best-performing recycling routes (synthetic turf and moulded objects) performed significantly better than the best "destructive" route of co-incineration in cement works.

[7] Clauzade, C., Osset, P., Hugrel, C. et al. Life cycle assessment of nine recovery methods for end-of-life tyres. Int J Life Cycle Assess 15, 883–892 (2010)

Figure 7-1: Comparative GHG Emissions for Selected ELT Management Routes



Source: Clauzade, C., Osset, P., Hugrel, C. et al. Life cycle assessment of nine recovery methods for end-of-life tyres. Int J Life Cycle Assess 15, 883–892 (2010)

7.2.2 Comparison of ELT rubber infill with co-incineration

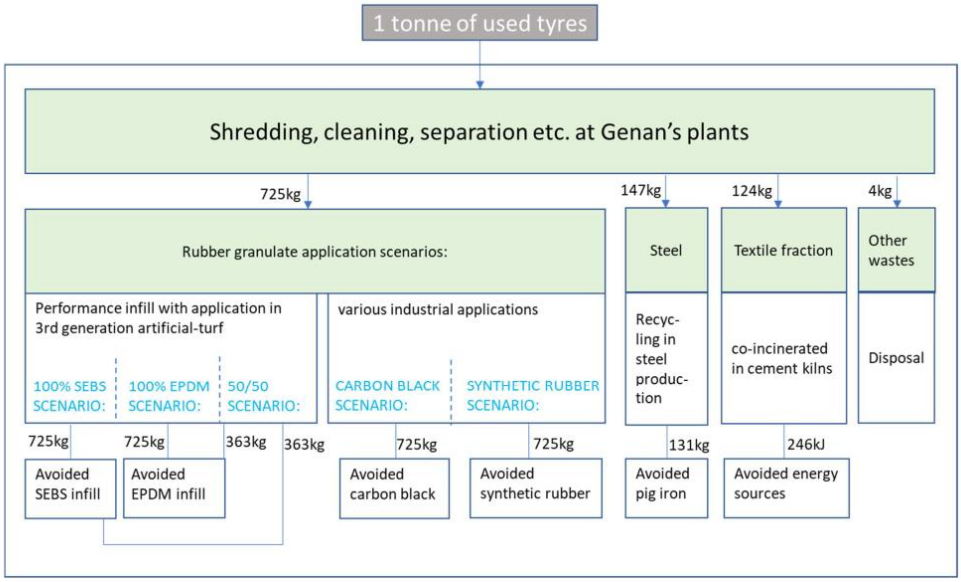
In May 2020 a life cycle assessment was commissioned by Genan (a tyre recycler) and prepared by Force Technoology (Denmark) and IFEU (Germany)[8]. The report was peer-reviewed by three independent researchers, and prepared in compliance with international standards ISO 14040 and ISO 14044, and is based on the EU methodology from the International Reference Life Cycle Data System (ILCD) programme relating to LCA analyses.

The scope of the LCA compared the use of ELT rubber as artificial turf infill with co-incineration of ELT rubber. In the infill scenario, ELT rubber was considered to substitute for virgin rubber (either styrene ethene butene styrene copolymer (SEBS), or ethylene propylene diene monomer (EPDM)). The functional unit is defined as the treatment of one tonne of tyres in Europe.

The scenarios evaluated are shown in Figure 7-2 and Figure 7-3 below:

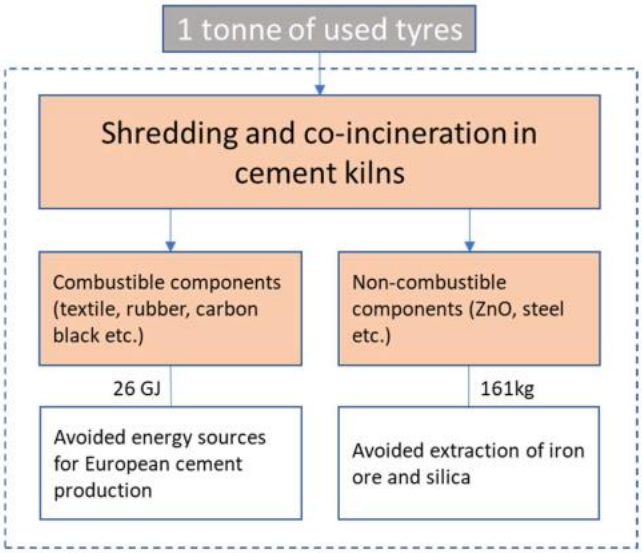
[8] Life cycle assessment of waste tyre treatments: Material recycling vs. co-incineration in cement kilns, Force Technology (for Genan Holding A/S, May 2020

Figure 7-2: LCA recycling scenario



Source: Life cycle assessment of waste tyre treatments: Material recycling vs. co-incineration in cement kilns, Force Technology (for Genan Holding A/S, May 2020)

Figure 7-3: LCA co-incineration scenario



Source: Life cycle assessment of waste tyre treatments: Material recycling vs. co-incineration in cement kilns, Force Technology (for Genan Holding A/S, May 2020

The LCA showed that ELT rubber infill has lower impacts than co-incineration in 13 or 14 of the 16 impact categories in the LCA (depending on whether comparing with SEBS or EPDM infill): impacts in the potential climate change category are 76-80% lower for the infill scenario compared to the co-incineration scenario.

In summary:

- The LCA analysis shows that for each tonne of end-of-life tyres processed into ELT rubber and used as infill in artificial turf pitches, there is a reduction of 700 kg of CO2e compared to co-incineration of ELT.
- The current total volume of tyres processed in the EU for application as infill in artificial turf pitches (400,000 tonnes annually) corresponds to annual savings of 280,000 tonnes of CO2e.
- The report furthermore shows that compared to the incineration of tyres, recycling also provides substantial benefits in a number of other environmental categories . These include e.g. acidification (terrestrial and freshwater) and respiratory inorganics.

7.2.3 Comparison of ELT rubber infill with alternative infill materials

Ragn Sells, a tyre recycling company in Sweden and Norway, commissioned an LCA for artificial turf infill.

The functional unit for rubber infill is are defined:

- 1 football field (defined as 7881 m^2 with an expected life span of 10 years)

The different scenarios for the infill scenario (in terms of materials used and lifespan) were as follows:

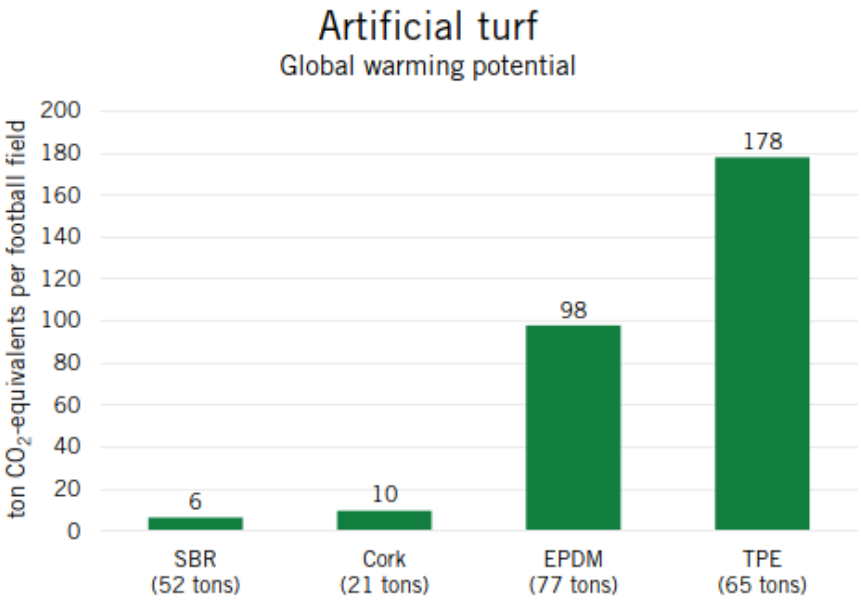
Infill material	Amount of infill needed per football field	Life span
SBR	52 tons	10 years
Cork	8.3 tons	4 years (i.e. 21 tonnes over 10 years)
EPDM	77 tons	10 years
TPE	65 tons	10 years

In terms of artificial turf infill, the LCA concluded that:

- Granulated tyres (referred to in the reports as SBR (styrene-butadiene) rubber derived from ELT tyres) used as an infill in artificial turfs have the lowest environmental impact compared to expanded cork, and the non-waste derived alternatives of thermoplastic elastomers (TPE) and ethylene propylene diene monomer (EPDM).
- Cork infill has the highest land use footprint: approximately 35 hectares of cork forests are needed to produce infill for one football field.
- EPDM and TPE have the highest carbon footprints, releasing between 15 and 28 times as much greenhouse gases as granulated tyres.

Figure 7-4 below shows the comparative global warming potentials of ELT rubber (referred to as SBR) compared with comparator materials for this application.

Figure 7-4: Comparative global warming potential of ELT and alternatives for artificial turf infill



Results for the artificial turf comparison in the impact category global warming potential. The results are expressed as ton CO_2-equivalents per football field.

7.2.4 Comparison of asphalt rubber pavement with conventional asphalt

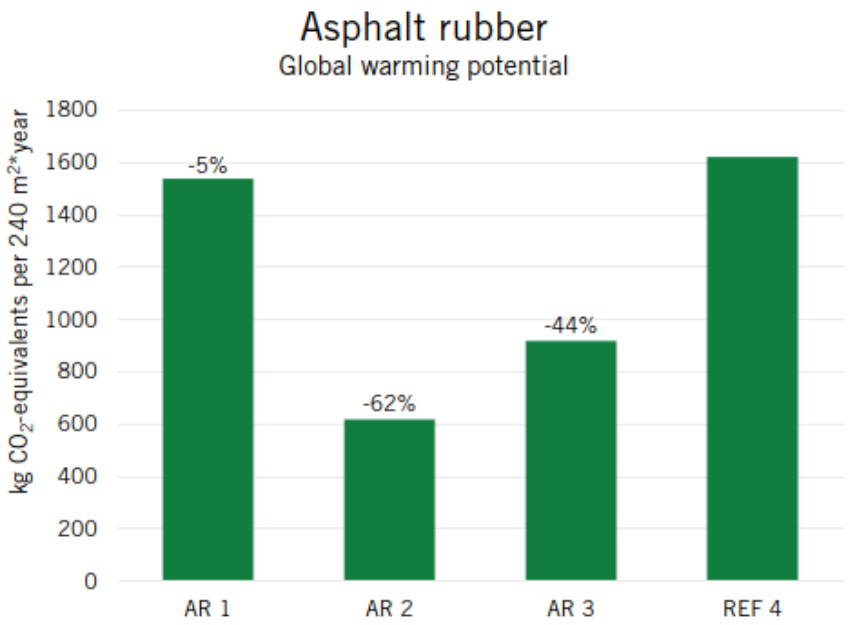
The Ragn Sells LCA also considered the application of asphalt rubber. The functional units is defined as:

- 1 stretch of road (defined as 240 m^2*year)

The study concluded that asphalt rubber pavements have lower environmental impact than pavements constructed entirely from conventional asphalt: this is dependent on the capacity to construct thinner pavements when using asphalt rubber, or to construct pavements which have a longer life than conventional asphalt pavements.

Figure 7-5 below shows the comparative global warming potentials of ELT rubber (referred to as AR in the case of asphalt) compared with comparator materials for this application.

Figure 7-5: Comparative global warming potential of ELT and alternatives for asphalt pavement



Comparison of three asphalt rubber pavements and one conventional in the global warming potential category. The results are expressed as kg CO_2-equivalents per functional unit.

7.3 Risks to Environment and Human health

Studies have been carried out into the potential for releases of substances from ELT rubber, mainly focussed on the artificial turf infill market.

7.3.1 Human health risk assessment

7.3.1.1 ERASSTRI Study

A large study has been carried out into the potential human health risks of the use of ELT as artificial turf infill: the European risk Assessment on synthetic turf infill (ERASSTRI).

In Part 1 of ERASSTRI[9], substances of potential concern were identified. The groups of substances included polycyclic aromatic hydrocarbons, phthalates, metals, amines and alkaline phenols: substances were selected based on a literature review, and emissions chamber experiments. Starting from an extensive literature search, including official reports and adding substances suggested by tyre manufacturers based on sector-specific knowledge, an initial list of substances to be examined for their presence in the rubber infill material was compiled. In addition, samples were screened for unknown substances evaporating from the rubber matrix. Samples were taken at recycling companies producing infill materials as well as from sports fields with synthetic turfs. The substances included in the sum parameters of the 16 US EPA PAHs, 8 REACH PAHs, and 8 EFSA PAHs: means for the sum of 8 REACH PAHs were below 10 mg/kg in all types of samples.

Part 2 of ERASSTRI[10], generated data on relevant exposure characterisation parameters, namely migration rates of dermal exposure, bio-accessibility in the gastrointestinal tract, air concentration at synthetic turfs and dermal loads. Migration studies on sweat and gastric fluids were conducted for targeted substances. In addition, air samples were collected in the vicinity of fields and during events of live use involving players, to understand the

[9] Klaus Schneider, Manfred de Hoogd, Maria Pelle Madsen, Pascal Haxaire, Anne Bierwisch, Eva Kaiser, ERASSTRI - European Risk Assessment Study on Synthetic Turf Rubber Infill – Part 1: Analysis of infill samples, Science of The Total Environment, Volume 718, 2020, 137174

[10] Klaus Schneider, Manfred de Hoogd, Pascal Haxaire, Arne Philipps, Anne Bierwisch, Eva Kaiser, ERASSTRI - European Risk Assessment Study on Synthetic Turf Rubber Infill – Part 2: Migration and monitoring studies, Science of The Total Environment, Volume 718, 2020, 137173

potential present of substances in airborne particles. Wipe samples of sweat from skin on players were also collected.

Finally, Part 3 of ERASSTRI[11] studied whether the presence of those substances could pose a risk to the human health of professional users and consumers of ELT derived rubber granules. The risk scenarios included professional users and players and considered patterns of use on synthetic turf infills from 1.5 years old until retirement age. The study concluded that:

- Cancer risks for exposure to PAHs were below 1 in a million.
- Risk characterisation ratios (RCRs) for non-carcinogenic substances were below 1.
- No health concerns were found for synthetic turfs with ELT-derived infill material.

7.3.1.2 RIVM Study

A separate study by researchers at the Dutch National Institute for Public Health and the Environment (RIVM)[12] examined the health risks associated with ELT rubber infill. Rubber granulate samples from 100 Dutch synthetic turf pitches were analysed for a range of substances, and a subset of samples was additionally analysed for migration of polycyclic aromatic hydrocarbons (PAHs), phthalates and metals into sweat and the gastrointestinal tract, and for evaporation of volatile substances into air. Exposure scenarios were developed to estimate the exposure of amateur football players via the oral, dermal and inhalation route to the most hazardous substances in rubber granulate.

Risks to human health were assessed by comparing toxicological reference values for these substances with the exposure estimates. The study concluded that that the exposures for all substances studued, including PAHs, were at or below the levels associated with adverse effects on health and posed negligible risk. The authors noted that the findings for a representative number of Dutch pitches are consistent with those of prior and contemporary studies observing no elevated health risk from playing sports on synthetic turf pitches with recycled rubber granulate.

7.3.1.3 CONFOREACh-GVG project

As part of the CONFOREACh-GVG project, samples of ELT rubber were tested for a range of substances. The groups of substances tested included PAH, benzothiazoles, phenols, phthalates, PBC and mineral oils, aromatic halogenated organic compounds and nitrosamines. A total of 20 samples from recycled facilities were collected and further processed in the study. Of 167 substances investigated, only 66 substances showed results above the Limit of Detection. Based on the 75 substances that were detected in the assessment and the content of those in weight, it was concluded that:

- Only one substance presenting a risk to human health has a concentration greater than 1% by weight, (Sulfur, H315 Skin Irrit. 2 (Irritating to skin)).
- No substance classified as carcinogenic cat. 2, toxic for reproduction cat. 1A, 1B, 2, skin sensitizer cat. 1, respiratory sensitizer cat. 1, which has effects on breastfeeding, is present in concentrations higher than 0.1% by weight;
- No substance is present in concentrations higher than the limits relevant for its hazard class referred to in notes 1 of tables 3.4.6, 3.6.2, 3.7.2, 3.8.3 and 3.9.4 of Annex I of CLP;
- No substances of very high concern (SVHC), persistent, bioaccumulative and toxic (PBT), or very Persistent and very Bio-accumulative (vPvB) substances are present in concentrations > 0.1%.

7.3.1.4 ECHA Study

In response to concerns about the risks posed by substances in plastic and rubber granulates used on synthetic turf pitches, the European Commission requested ECHA on 29 August 2017 to examine the available data on substances of concern to human health or the environment in plastic and rubber granulates used as infill in synthetic turf pitches. The aim of the review was to identify whether any such substances should be subject to risk management. The assessment does not include PAHs in rubber and plastic granules.

[11] Klaus Schneider, Anne Bierwisch, Eva Kaiser, ERASSTRI - European risk assessment study on synthetic turf rubber infill – Part 3: Exposure and risk characterisation, Science of The Total Environment, Volume 718, 2020, 137721
[12] Pronk MEJ, Woutersen M, Herremans JMM. Synthetic turf pitches with rubber granulate infill: are there health risks for people playing sports on such pitches? Journal of Exposure Science & Environmental Epidemiology, 19 Dec 2018, 30(3):567-584.

ECHA (i) gathered information on substances in infill material, (ii) performed a prioritisation exercise to identify, of those substances reported to be present in infill, those that are likely to be of greatest potential concern for human health or the environment and (iii) conducted preliminary human health and environmental risk assessments to identify candidates for potential risk management.

The conclusions of the report[13] are:

- The preliminary human health risk assessment does not exclude a potential for cobalt and zinc to pose risks to human health in infill and that these substances should therefore be considered for risk management.
- The preliminary environmental risk assessment does not exclude the potential for cadmium, cobalt, copper, lead, zinc, 4-tert-octylphenol, 4,4´-isopropylidene diphenol (BPA), bis(2-ethylhexyl)phthalate (DEHP), benzyl butyl phthalate (BBP) and benzothiazole-2-thiol to pose risks to the environment and that these substances should therefore be considered for risk management.

The ECHA recommended that any further work to establish whether there is a risk for human health or the environment from these substances in rubber infill that is not adequately controlled should be done within the context of the preparation of a REACH Annex XV restriction proposal.

7.3.2 Ecotoxicity testing

The results of the CONFOREACh-GVG study confirmed the presence of 20 substances that could potentially trigger a concern for the aquatic environment. In order to study whether the presence of those substances could lead to show aquatic toxicity of the mixture, leaching studies in 6 representative worst case samples were performed, in accordance with OECD Guidance N. 237.

The suspensions of ELT granulate and powder used for the preparation of leachates were prepared following the OECD 23 (2019; Guidance Document on Aquatic Toxicity Testing of Difficult Substances and Mixtures),

The majority of substances that would potentially be a concern were not detected in the solution. Zinc was found in all samples at detectable levels but a correlation between its content in rubber and the concentration in water could not be established.

Based on the leaching studies, acute and chronic toxicity tests were selected and performed.

Acute toxicity tests on Daphnia and fish were carried out as limit test, with a single dose of 100 mg/L. Doses for the test on algae and for the chronic tests were chosen taking into account guidelines, results of non-GLP preliminary tests and results of acute toxicity tests. A stock solution at 100 mg/L was prepared and this solution was diluted when lower concentrations had to be tested. The stock solution was mixed for a period of time sufficient to achieve an equilibrated concentration of dissolved and dispersed or emulsified components in the aqueous phase (at least 72 hours). Following cessation of mixing and a period of settling to allow phase separation (at least 48 hours) the aqueous phase was drawn off by mid-depth siphoning for testing.

Acute and chronic toxicity testing was carried out using the following organisms and methods:

Organism	Methodology
Acute aquatic toxicity	
Danio rerio	Acute toxicity: OECD 203
Daphnia magna	Immobilization: OECD 202
Pseudokirchneriella subcapitata	Growth inhibition: OECD 201[14]
Chronic aquatic toxicity	
Daphnia magna	Chronic toxicity OECD 211
Danio rerio	Chronic toxicity: OECD 210
Pseudokirchneriella subcapitata	Growth inhibition: OECD 201[15]

[13] Annex XV INVESTIGATION REPORT: Investigation Into Whether Substances in Infill Material Cause Risks to the Environment and Human Health That Are Not Adequately Controlled – Prioritisation and Preliminary Risk Assessment, European Chemicals Agency (10 May 2021)
[14] for classification according to Regulation(CE) No 1272/2008, the results on biomass are not considered.
[15] for classification according to Regulation(CE) No 1272/2008, the results on biomass are not considered.

All the endpoints for both acute and chronic toxicity are >1 mg/L and hence it is concluded that ELT derived rubber granules and powders do not meet the requirements for either acute or chronic aquatic toxicity.

7.4 Microplastics

The issue of microplastic relates primarily the use of ELT in artificial turf infill.

A recent study[16] reviewed the available literature and identified a false assumption that the annual granulate demand for refilling is necessary because of granulate losses to the environment. In reality, part of the refill is needed because the infill layer settles and becomes more dense (compaction) and that part of the lost infill is collected and reused on the fields. This false assumption, together with issues around improper snow clearance in the past, has led to high estimates of infill dispersal per year.

The study reviews the current state-of-knowledge about ELT granulate dispersal and concludes that approximately 600–1200 kg refill is required annually to compensate for compaction and for some loss of infill to pavements and in drainage sinks. Recommended mitigation measures are containment through optimized field and drainage construction, suitable maintenance equipment and practices and good-housekeeping rules for players and groundkeepers and handling end-of-life pitches. If these recommendations are implemented, the paper concludes that emission of ELT granulates to the environment can be reduced to virtually zero.

The recent Ecoloop study[17] examined the effectiveness of risk management measures to minimise fill migration from artificial pitches. The study identified how infill is lost from artificial pitches, and how these losses can be minimised: it concluded that many of these losses could be eliminated, e.g. by appropriate field boundary barriers, filters in surface water drains etc. and other losses minimised. The study estimated that 97% of potential losses could be controlled, with residual losses estimated at 2g/year/m^2 of surface (equivalent to 15 kg/pitch/year).

The applicable risk management measures are set out in the European Standard CEN/TR 17519:2020 *"Surfaces for sports areas. Synthetic turf sports facilities. Guidance on how to minimize infill dispersion into the environment".*

The European Chemicals Agency (ECHA) has carried out a project looking at how best to manage microplastic releases from artificial turf infill, and has proposed restrictions which may include either a ban (following a transition period) or implementation of risk management measures. Whatever approaches the European Commission decides to recommend can be implemented regardless of whether an EU-wide EoW criteria is in place, in the same way that the ECHA can regulate the use of any other non-waste products.

7.5 Critical Raw Materials

The European Commission carries out a criticality assessment at EU level on a wide range of non-energy and non-agricultural raw materials.

The main parameters used to determine the criticality of the material for the EU are:

- Economic importance - aims at providing insight into the importance of a material for the EU economy in terms of end-use applications and the value added of corresponding EU manufacturing sectors. The economic importance is corrected by the substitution index (SIEI) related to technical and cost performance of the substitutes for individual applications.
- Supply risk - reflects the risk of a disruption in the EU supply of the material. It is based on the concentration of primary supply from raw materials producing countries, considering their governance performance and trade aspects. SR is measured at the 'bottleneck' stage of the material (extraction or processing), which presents the highest supply risk for the EU. Substitution and recycling are considered risk-reducing measures.

[16] Verschoor, Anja & Gelderen, Alex & Hofstra, Ulbert. (2021). Fate of recycled tyre granulate used on artificial turf. Environmental Sciences Europe. 33.
[17] Determining the effectiveness of risk management measures to minimise infill migration from synthetic turf sports fields, Ecoloop, August 2020

The 2020 EU list contains 30 materials, one of which is natural rubber. Natural rubber is present in tyres and represents approximately 35% of the composition of heavy goods vehicle (HGV) tyres and approximately 14% of the composition of other tyres.

One of the measures to reduce risks associated with critical raw materials is recycling. It is anticipated that an EU-wide ELT rubber EoW criteria would support the recycling market. Although closed-loop tyre recycling is at a relatively early stage of development, even the current uses of ELT have the potential to substitute for natural rubber.

7.6 Conclusions

Assessments of the environmental benefits of ELT recycling have demonstrated significant benefits when compared with the alternative scenarios of co-incineration of ELT and the substitution of other materials for recycled ELT rubber.

An extensive programme of research carried out under the ERASSTRI project concluded that there are no health concerns associated with synthetic turfs containing ELT-derived infill material. Limits on the PAH content of ELT rubber infill have been set in REACH.

Ecotoxicity testing on both ELT-derived rubber granules and powders have demonstrated that these materials exhibit neither acute nor chronic ecotoxicity.

Research has identified a series of risk management measures that can reduce releases of microplastics from artificial turf infill to a very low level: these measures are applicable to both ELT-derived infill material and other virgin rubber alternatives.

Natural rubber has been categorised by the EC as a “critical raw material”. ELT rubber has the potential to substitute for natural rubber in some applications and an EU-wide EoW criteria would support further development in this area by reducing the overall demand for virgin natural rubber.

8. Conclusions

The Waste Framework Directive states that the end-of-waste criteria for a specific type of waste has to be developed according to the conditions set out in Article 6:

a. the substance or object is commonly used for specific purposes;

b. a market or demand exists for such a substance or object;

c. the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products;

d. the use of the substance or object will not lead to overall adverse environmental or human health impacts.

With respect to conditions a) and b):

- There is agreement throughout the ELT value chain that an EU-wide EoW criteria would be beneficial for the industry: this includes both tyre recyclers and tyre manufacturers.
- There are many current and several emerging markets for ELT rubber: the existing recycling rate is over 50% with a number of very well-established markets (such as artificial turf infill, sport and playground surfacing, moulded objects, asphalt and road paving, and various construction and transportation applications). ELT rubber has a positive market price, indicating that there is a clear demand for the material.

ELT rubber can therefore be considered to meet conditions a) and b).

With respect to condition c):

- There are numerous technical standards relating to the production, testing and use of ELT rubber. Once ELT rubber passes the EoW criteria, it becomes a mixture that is controlled under REACH. Work has been done which demonstrates the ELT rubber can be adequately managed under REACH and CLP: the responsibilities of various parties are clearly defined; there are no substances in ELT rubber that are likely to require new registration or authorisation under REACH; and ELT rubber is not classified as hazardous under CLP.

ELT rubber can therefore be considered to meet condition c).

With respect to condition d):

- Work carried out within the EU to date indicates that the use of ELT in the largest and most sensitive application (rubber infill for artificial turf) does not pose a significant risk to human health or the environment.
- The existence of an EU-wide EoW criteria does not preclude the effective management of ELT rubber. On the contrary, it would make management easier by enforcing consistency across Member States. For example, if at some point in the future the EC wishes to enhance control measures on the uses of ELT rubber, this could be done more effectively if there is a single governing instrument applicable across the EU, rather than the current patchwork of national instruments.
- Concern has been expressed over the potential for release of microplastics to the wider environment from the use of rubber infill in sports pitches. Work done by ESTC, EuRIC & ETRMA, the whole tyre-value chain, indicates that these risks can be adequately controlled by the use of best practice management measures and that infill does not pose any risk for human health or the environment.
- The potential for risk does not preclude the establishment of EU-wide EoW criteria, and in fact is explicitly recognised in Article 6 of the WFD which envisages that “the criteria shall include limit values for pollutants where necessary and shall take into account any possible adverse environmental effects of the substance or object”. Hence it is entirely feasible that the EC can introduce an EU-wide EoW criteria which (either now or in the future) sets out specific requirements and controls for managing the risks from certain applications of EoW materials.
- The existence of a EU-wide ELT EoW criteria would not preclude the introduction of risk control measures in the future. ELT rubber (having achieved EoW status) is controlled under REACH and there are already

restrictions on its use (e.g. the 20 mg/kg PAH restriction). The presence of an EU-wide EoW criteria would make any future risk management measures easier to implement.

ELT rubber can therefore be considered to meet condition d).

Several countries in the EU (Spain, Italy and Portugal) as well as the UK have introduced ELT rubber EoW criteria, after careful consultation and consideration of risks.

These existing EoW criteria (and one in draft) follow similar principles, requirements, and quality assurance/declaration of conformity philosophy, but with differences on (e.g.) input materials and defined processing requirements. An EU-wide EoW criteria would eliminate these differences and facilitate the sustainable management of ELT tyres.

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