Mechanical Tyre Recycling Fact Sheet
INTRODUCTION

1.1. A Tyre (i.e., a bunch full of raw materials)
   Global State of play of a valuable resource

1.2. ELT Management Systems in Europe
   Legislation and management options

ELT STATE-OF-PLAY

2.1. ELT Management Trends in Europe
   2.1.1. The role of policy & regulatory developments
   2.1.2. Material and Energy recovery

2.2. ELT hierarchy
   Or where to find Mechanical Tyre Recycling

TYRE RECYCLING

3.1. Recycled ELT Rubber
   A high quality raw material

3.2. ELT a valuable resource
   Products and market trends

3.3. ELT mechanical recycling benefits
   Environmental and Economic Benefits

ENVIRONMENTAL AND HEALTH CONCERNS

4.1. Interface ELT-Legislation
   4.1.1. ELT-derived infill – PAHs
   4.1.2 ELT-derived infill – Microplastics

4.2. ELT-derived infill and the Circular Economy
   4.2.1. Estimate of annual consumption
   4.2.2. A key role in a well-functioning circular value chain

TOWARDS A CIRCULAR ECONOMY

Recycled rubber material has a role to play

5.1. Tyre Eco-design
   A key topic to the best ELT management

5.2. Overall ELT flow and circular solutions
   For the best resource efficiency in a Circular Economy
Tyres are very complex products composed of different valuable materials such as fiber and steel, all cured within the boundaries of rubber compounds and other unique materials to fulfill 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.

It is for this reason that proper management of used tyres represents a technological, economic and ecological challenge but also a global opportunity to improve circularity that only professional tyre recyclers can meet.

What are used tyres and end-of-life tyres (ELT)?

Used tyres should not be confused with tyres reaching end-of-life (EoL) because:

1. A used tyre is not legally a waste (used/part-worn tyre) and can be re-used or reconstructed for its original purpose.

2. Only used tyres which can neither be used to perform their original function nor reusable and are discarded become an ELT, legally classified as non-hazardous waste.

... and annually more than 25 Mt reach the end of their useful lives.

China, the countries of the European Union (EU), the USA, Japan and India produce the largest amounts of tyre wastes – almost 88% of the total number of withdrawn tyres around the world.
1.2. ELT Management in Europe
Legislation and management options

EU policy for used tyres is based on the “waste hierarchy” which places prevention, re-use and recycling at the top of the management options. In the first place, waste should be prevented, but if this is not possible, waste should be re-used following recovery and recycling, and prevent stockpiling in landfill. When tyres have reached end-of-life stage, mechanical tyre recycling is the preferred option to recover efficiently raw materials.

Annually in EU, > 5 Mt of tyres are produced and ≈ 3 Mt of ELT are generated.

Three models for EU management of used tyres
EU countries have developed three models to regulate used tyre management:

1. **Extended Produced Responsibility (EPR)**. Collection of used tyres are the responsibility of the producers and importers who put them on the market. They have to ensure the legally required levels of recovery and recycling of ELT. This can be done directly by the producer or through the mediation of specialized recovery/recycling organizations acting on their behalf.

2. **A tax system.** The management of used tyres is the responsibility of the collectors and recyclers and is financed by the state from the funds obtained from customers purchasing new tyres.

3. **The free market system.** The legislation sets objectives to be met but does not designate those responsible and assumes that management (recovery and recycling of tyres) is profitable to the firms involved as tyres are a source of valuable raw materials.

No specific EU obligations exists for the recovery of used tyres and each member state is free to choose its management system, where the annual cost of handling ELTs is around 600 million euros.

EPR is the most popular option in EU
Producer responsibility covers more than 60% of the annual ELT arisings; the free market system covers about 38% of the market, while the tax system only covers 2% of the annual ELTs arising. The success of this approach is measured by the high (even 100% in some countries) recovery of ELT tyres achieved.
2 ELT STATE-OF-PLAY

2.1. ELT Management Trends in Europe

2.1.1. The role of policy & regulatory developments

Constant technological progress achieved by the recycling industry in the processing of ELT enables to recover the valuable materials of which tyres are made of, resulting in both environmental and socio-economic benefits. Targets and obligations to divert end-of-life tyres from landfill and incineration set either at European or national levels are key in providing the legal certainty needed to invest in innovative processes and scale-up capacity to further increase material recovery of ELT.

So far, at EU level, the implementation of the waste hierarchy and the ban on the landfilling of tyres imposed by the EU landfill directive since 2006 have directly contributed to investments into modern tyre sorting and collection systems in Europe. Yet, the lack of targets and incentives be it in terms of material recovery or incorporation of recycled materials from ELT into products constitute a lasting obstacle to further improve ELT recycling.

2.1. Landfill/unknown

Although landfilling is banned in EU since 2003 (EC Directive 1999/31), landfill/unaccounted tyres are either illegally landfilled or represent gaps in the data where more new tyres are put on the market than waste tyres are accounted for.

2.2. Reuse & export

In the EU, there is no standard for minimum tread depth for all types of tyres. Consequently, if the tread depth complies with national legislation, a used tyre can be reused in that country.

When used tyres are exported outside the EU, they often become ELT in countries with less stringent treatment obligations or even not any in practice. In this circumstances, ELT are often managed under less strict environmental conditions and usually landfilled (becoming an environmental concern and a health risk) or co-incinerated (i.e., loss of valuable materials).

2.3. Retreading

A process for extending the lifetime of tyres by stripping off its tread and then applying a new one. In practice, retreading of automobile tyres is not an established practice, because of their uncompetitive cost vis-a-vis new tyres. However, truck and aircraft tyres are regularly retreaded because it is economically very profitable: it requires only 30% of the energy and 25% of the raw materials needed to produced new tyres which also allows to significantly reduce the amounts of rubber waste.

At EU level, very great emphasis is being placed on the development of new technologies and the improvement of existing ones for recycling tyres and their retreading.
2.1. ELT Management Trends in Europe

2.1.2. Material and Energy recovery

2.4. Energy recovery

Used tyres have a calorific value that makes them competitive with other types of fuel, especially with coal, which has a far lower calorific value\(^\text{10}\) and causes higher CO\(_2\) emissions compared to rubber combustion, as well as of dusts, carbon dioxide, nitrogen oxides and heavy metals (except zinc). For this same reason, used tyres are also used as a fuel for the production of steam, electrical energy, paper, lime and steel. The cement industry is one of the greatest consumers of shredded tyres, and are also able to use whole tyres (without previous shredding) as fuel thanks to complete combustion. In some EU countries, these tyres are used in urban heating power plants.

Therefore, energy recovery can contribute to the minimization of waste and economic impacts but this is a form of recovery of the second order, because in a Circular Economy priority should be given to recovering a material. In Europe, there is limited capacity in energy recovery for this waste stream as incineration can only take place in cement mills due to the high energy content of the tyres and more and more of these ELTs are being substituted by alternative fossil fuels and biomass fuels.

2.5. Material recovery

Material recovery is the most common (approx. 60%) treatment option for ELT. In this regard, whereas the use of ELT in civil engineering applications falls out of the definition of recycling, processes such as granulation, use of ELTs in steel mills and foundries as well as use as dock fenders, blasting mats, pyrolysis (e.g., metal recovery, carbon black) and the incorporation of the inorganic content of ELTs in cement manufacturing are considered recycling. The most widespread route option for quality material recovery is ELT recycling via granulation\(^6\).

Unfortunately, with the lack of sufficiently developed end-markets for materials recovery, energy from recovery from ELTs is often the cheapest and most straightforward option to treat ELTs. However, tyre grinding should be prioritized and incineration should only take place in those cases where the lack of ecodesign (e.g., foam and sealants) hampers material recycling.
2.2. ELT hierarchy
Or where to find Mechanical Tyre Recycling

The waste hierarchy is a key element of the EU Waste Framework Directive 2008/98. It requires Member States to look for waste disposal solutions as high up in the hierarchy as possible.

- **Best Solution**: REDUCTION Policy
- **Temporary solution**: RETREADING-REUSE
- **Essential to the Circular Economy**: MATERIAL RECOVERY
- **Worst Solution**: LANDFILL

**MATERIAL RECOVERY**
- Incineration and loss of raw materials

**ENERGY RECOVERY**
- Loss of raw materials and energy
3.1. Recycled ELT Rubber

A high quality raw material

What is recycled rubber?
Recycled rubber is rubber which has been derived from discarded products such as ELT. As such, recycled rubber gives society innovative ways to reduce waste while meeting societal needs in demanding applications and lowering environmental footprint – from facilitating softer playground surfaces, to reducing the chance of injuries for athletes, to building lower-impact hospital floors for health care personal.

How is ELT-recycled rubber made?
Recycled rubber is produced from ELT thanks to special machines and equipment of a high mechanical strength capable of shredding and granulating materials. With a fully automated grab the shreds are further separated into rubber, steel and textiles. The steel is taken to metal companies to produce new high-quality steel products for the industry, where new steel would otherwise be required. Whereas the textile cord, is either combusted (energy recovered) or used in thermal insulation materials for the construction industry.

The rubber (75% of the tyre composition) is processed into granulates and powder by using two different techniques:

- **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.

After that, all possible residual impurities are then removed from the granulates and powders. Finally, the rubber powders and granulates achieving 99.99% purity are packed at different grain sizes in bags of different sizes and ready for transport, where rubbers find a new life determined primarily by the grain sizes of the various fractions.

While only 30-38% of the energy initially invested in the production of the tyre is recoverable, the amount of energy needed to recycle tyres by grinding is barely 2–4% of the energy expenditure required to produce them.1

Furthermore, in cooperation with scientific centers, new devulcanization processing technique technologies are being developed. A processing technique where granulate rubbers are modified into high quality recovered virgin rubber compounds. The high quality devulcanized rubbers and recovered carbon black enables the tyre industry to process current tyres in a unique circular way.

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1. **European mechanical tyre recyclers process approx. 150 million tyres annually – or 1 tyre for every 3 EU citizens.**
3.2. ELT a valuable resource

Products and market trends

EuRIC MTR Members keep investing in innovative recycling processes and hence play a key role in turning ELT management from a linear to circular model. They produce rubber products of the highest and most consistent quality, while striving for a greener planet and a sustainable future.

Granulate and rubber powder

- 75% rubber
- 15% steel
- 10% textile fibers

Extracted very clean and thus very well suited for remelting at steel works.

Excellent insulation properties with new product applications in the test phase.

Market trends

The ELT rubber granulation market trends in EU have been relatively stable for the last years, with ELT recycling into artificial turf pitches accounting for 37% of the actual market. It needs to be taken into account that due to lack of demand in other applications within the recycled ELT rubber market, there are already more than 1 Mt of ELT devaluated annually, being incinerated in energy recovery processes.
ELT rubber granulation market

The best available infill alternative in terms of circular economy and sustainability to grant:

- High levels of use 7/7
- Safe, durable playing areas
- Full benefits of playing sport: health and social inclusion
- Resistance to all weather conditions
- Sustainable, easy and cheap to maintain

Many varied sustainable and durable goods (edgings/boundaries, rubber-to-metal bindings, lamps, ramps, vases, playground accessories, rail blocks, hoses ...) used in different sectors such as agriculture, automotive, construction, decoration, textile ...

ARTIFICIAL TURF (INCL. INFILL) 37%

- Offering the ultimate performance and putting safety first thanks to perfect impact absorbance

MOULDED OBJECTS 22%

- Adding value to rubber scrap in its country of origin and exporting it only after processing

UNDETERMINED (EXPORT, TRADE) 17%

- Source: adapted from ETRMA, 2017 data.

SPORTS & CHILDREN PLAYGROUND 18%

- Many environmental benefits, incl. savings in raw materials and CO₂

OTHER USES 4%

- Asphalt & Road Paving 2%

... and the potential application for recycled rubber into technical rubber goods will further increase thanks to technological developments such as activated rubber powder (e.g., Functionalized Micronised Rubber Powder, FMRP).

However, to increase the demand for recycled rubber its end-markets must be stimulated. The current state of play shows that due to lack of demand for recycled rubber, more than one million tonnes of ELT are being annually incinerated in energy recovery processes (i.e., loss of valuable raw materials). Therefore, market-based incentives and ambitious recycling and recycled content targets are necessary to drive the demand for recycled rubber and materials from tyres.

State of play or 1:1 ratio

ELT rubber burned for energy recovery = ELT rubber used for product applications
3.3. ELT mechanical recycling benefits

Environmental and Economic Benefits

Environmental Benefits

Mechanical tyre recycling is both resource efficient and environmentally respectful. The recovery of valuable materials from ELT contributes to reduce the dependency on natural resources while saving significant amounts of energy and greenhouse gas (GHG) emissions. Using recycled rubber in new products creates a substantially smaller carbon footprint when compared to using virgin rubber\textsuperscript{11,12}.

Economic Importance

In addition to being an environmental steward, the rubber recycling industry plays a prominent role as both an economic leader and job creator. Furthermore, it is estimated that the granulation sector’s turnover is approx. €140-200 million annually\textsuperscript{13}.
As opposed to co-incineration, mechanical tyre recycling allows to recover rubber, steel and textiles and therefore to substitute raw materials in new products.

In the EU, policy-makers may in fact only choose between recycling or incineration. Tyres which cannot be processed for recycling purposes be it in terms of lack of market outlets or due to lack of ecodesign, will instead be burnt.

Currently, more than 1 million tonnes of tyres are annually incinerated in the EU. This means that approximately half of the ELT-derived rubber is used for product applications and the other half is used for energy recovery (i.e., cement production).

The tool most often used by decision-makers when assessing and comparing climate and environmental alternatives, is called LCA (Life Cycle Assessment). LCA shows that recycling is a better option than co-incineration from an environmental point of view.

For each tonne of ELT going through material recycling instead of co-incineration, the environment is spared from 700 kg of CO₂ emissions. Thus, taking into account the EU incineration trends of ELT, there is a great untapped potential for CO₂ savings by mechanically recycling tyres.

Furthermore, LCA also shows that compared to tyre incineration, recycling also reaps substantial benefits in a number of other environmental categories, mitigating for example not only global warming but also acidification (terrestrial and freshwater) and granting better air quality by avoiding production of nitrogen oxides and dusts emissions.
4 Interface ELT-Legislation

4.1. ELT-derived infill - PAHs

Artificial turf systems offer significant benefits to society due to their ability to sustain levels of high use throughout the year, in most weather conditions; and to provide suitable sporting characteristics minimizing the risk of injury through carpet burns and abrasions. Besides, when made with ELT infill, a lot of savings can be accounted in greenhouse gases (GHG) emissions and raw material consumption. Appropriate alternatives, be it in terms of technical performance or environmental sustainability, are not yet available for the whole of Europe.

Polycyclic aromatic hydrocarbons (PAHs)

Carbon black (22% of the tyres composition) is a form of elemental carbon used by the tyre manufactures to give the tyre abrasion resistance and tensile strength. Although PAHs are not added intentionally, these chemicals are a by-products of the pyrolysis of hydrocarbons to produce the carbon black introduced in new tyres.

As concerns human health and exposure to PAHs, the European Chemical Agency (ECHA) has evaluated the potential effect of PAHs in infill material on players, concluding after rigorous scientific evaluation that infill material made from ELT is safe at levels below 20 mg PAH/kg infill (Annex XVII of Regulation (EC) No. 1907/2006). This was in accordance with other relevant risk assessment evaluations.

Furthermore, the average concentration of PAH in EU artificial pitches is lower than the safe threshold. On top of that, exhaustive scientific research like the three-year, Europe-wide project ERASSTRI (European Risk Assessment Study on Synthetic Turf Rubber Infill), has shown that PAH availability to the final user exposed to the artificial turfs is minimal, and, thus, migration of PAH (incl. migration of other substances present in the rubber matrix) does not represent a hazard for human health or the environment.

Taking into consideration not only infill but also other rubber products (incl. children playground, sport flooring ...) made from ELT-recycled granules, it has been shown that human exposure to any possible PAH migration from these applications is harmless from a toxicological point of view with even a lower quantitative risk than daily ingestion of usual food items containing safe PAH limit levels.
**4.2. ELT-derived infill - Microplastics**

**Microplastics**

Microplastics (MP) are small (i.e., ≤5 mm for particles and ≤15 mm for the longest dimension of a fibre-like particle) solid particles made of a synthetic polymer. In Europe, microplastics are emitted into the environment annually by different sources\(^\text{18}\). Present focus on MP is given to its accumulation in the marine environment and its consequences. Artificial turf pitches have been overestimated as contributors of approx. 3% of that total amount of microplastics emitted\(^\text{18}\). The implementation of standardized risk management measures (RMM) can drastically reduce those low emission levels to neglectable values\(^\text{19,20}\).

In artificial turfs the material used as ‘infill’ is in the form of small particles (i.e., from 0.8 to 5mm size) distributed throughout the turf surface under the artificial grass pile. Such a design allows the infill to be able to absorb impacts from players into the field thus helping to prevent potential injuries. In the case of artificial turf pitches, more than 80% of the infill used in EU is from styrene butadiene rubber (SBR) granulate from ELT rubber\(^\text{21}\).

By use, as the artificial turf ages the rubber becomes consumed. Consumption of rubber is estimated based on how much rubber granulate is added to artificial turf fields annually but this doesn’t imply loss of rubber into the environment. It has been demonstrated that almost most of the microplastics are being compacted (i.e., compressed by players/ball impacts) and, thus, MP remain within the pitch\(^\text{22}\).

**MP losses from artificial infill into the environment can be effectively controlled by RMM.**

MP release from rubber infill turfs can be effectively avoided by implementation of RMM in the form of containment features, such as those described in European Standards Committee (CEN) Technical Report CEN/TR 17519\(^\text{23}\), into the design of artificial turf sports fields or those adopted by the industry\(^\text{19,20}\).

The ELT infill market is by far the largest and cannot be substituted, as there are no mature market alternatives. Thus, a ban on ELT-infill will have major socio-economic impacts. Besides, from the environmental point of view, ELT-derived infill is among those infills with the lowest carbon footprint and the lowest environmental impacts\(^\text{24}\). Furthermore, a ban on ELT-infill will have a major negative impact on the environment in the form of increased CO\(_2\) emissions\(^\text{14}\).
4.2. ELT-derived infill and the Circular Economy

4.2.1. Estimate of annual consumption

Approx. 2.6 million tonnes\(^a\) of ELT infill are currently installed for the application as infill in artificial turf pitches, and as a consequence each year:

- 527,000 tonnes of ELT upcycled\(^b\)
- 400,000 tonnes of ELT granulate\(^c\) produced and used as high-performance infill in artificial turf pitches, substituting virgin rubber materials
- ELT annual recycling into artificial turf offsets CO\(_2\) emissions comparable to the CO\(_2\) absorbed by 231,000 hectares of forest land in the EU\(^{25,26}\)
- 371,000 tonnes of CO\(_2\) emission avoided when compared to incineration

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\(^a\) 39,000 pitches in EU, at least 75% of which contain 80-100 tonnes ELT-derived infill

\(^b\) 527,000 tonnes of ELT, including rubber, steel and textile\(^2\). Corresponding to more than 50 million ELT units each weighing approx. 10 kg

\(^c\) ~75% intake
4.2. ELT-derived infill and the Circular Economy

4.2.2. A key role in a well-functioning circular value chain

Banning infill from ELT recycling would be the worst option in terms of risk-management or socio-economic impacts.

Artificial turf is a major ELT granulation end-market. Without this artificial turf pitch application, 527,000 tonnes² of ELT will have to find another alternative route. Due to stable granulation market trends, other end-markets for rubber granulate cannot absorb the production currently supplied to artificial turf pitches. If such unsaturated markets existed, then the more than 1 million tonnes of tyres, which are today incinerated in energy recovery processes, could instead be recycled. Therefore, these excess tyres falling under the restriction would end up stockpiled or exported outside EU. In consequence, Member States reliance on natural resources will increase and the large environmental benefits of tyre recycling will disappear together with jobs and industrial growth opportunities. To avoid this, a derogation under the implementation of risk management measures (RMM) is the best compromise in both environmental and economic terms to preserve a well-functioning circular tyre value chain.

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Recycled rubber material has a role to play

As much as 91% of total end-of-life tyres (ELT) across Europe were collected and treated for material recycling and energy recovery in 2018. From these more than 3 million tonnes (Mt) of ELT, around 2 Mt (approx. 60%) were used in material recovery applications. Whereas more than 1 Mt were combusted in energy recovery processes\(^{28}\). This means that more than 30% of the treated ELT follow within a linear economy model, involving combustion (i.e., no savings in GHG emissions) and a loss of valuable raw materials.

A landfill ban for ELT is far from sufficient to boost tyres circularity. The EU needs to consider further measures to closing the loop of the Circular Economy of tyres. In particular, incentives and recycled content targets to drive the demand for recycled materials from tyres, especially rubber, be it in new tyres, asphalts, moulded products and construction materials.

**ELT sector and the circular economy – Key requirements**

- Increased material recycling rates
- Decrease the use of natural resources
- Save in CO\(_2\) emissions
- Controlled exports
- Stable markets
- Improve eco-design
- Harmonization End-of-Waste (EoW) criteria
5.1. Tyre Eco-design
A key topic to the best ELT management

If framework conditions allow, producer responsibility organisations will be inclined to find the cheapest (i.e., energy recovery), not the environmentally most favorable solution for waste management. Therefore, to maximize the use of resources in the most sustainable way possible, new tyres placed on the market need to be entirely recyclable thanks to proven best-available technologies.

Material recycling the only option that excels at obtaining raw materials from ELT
Economically, tyre combustion and energy recovery is more attractive than material recycling. However, less optimal: the energy obtained from combustion process of waste tyres is less than the energy needed for production of tyres. Therefore, material recycling of ELT and using them as a source of raw materials is the best management option and for this design requirements should be based on promoting competitiveness between both management options.

In a Circular Economy, all products placed on the market should be recyclable using proven recycling techniques from design stage. Tyres should not be the exception, therefore, it is necessary to improve the interplay between tyre manufacturers and tyre recyclers in the field of eco-design.

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Learn more about tyre eco-design ➔ EuRIC comment on tyre Eco-design to boost Circular Economy
5.2. Overall ELT flow and circular solutions

For the best resource efficiency in a Circular Economy

To achieve the targets set by the European Green Deal and the new Circular Economy Action Plan, mechanical recycling of end-of-life tyres (ELTs) should be considered as a strategic opportunity for the circularity of valuable secondary raw materials (rubber, steel and textile fibres). Although the EU management of ELT has improved over the years, there is still room for improvement for a better Circular Economy. From optimised product-design to end-of-waste criteria or incentives to stimulate end-markets, a number of measures and incentives are needed to accelerate the transition towards circularity across the tyre value chain.

Raw materials market

Expand green public procurement: Support and develop end-users for markets for ELT-derived products; green public procurement should be more integrated in both national and EU policies. Governments are in a strong position to stimulate the demand for recycled materials. Furthermore, standards or specifications ensuring that ELT-derived products can be used as a substitute for virgin raw materials already exist and could be further developed to stimulate the use of recycled materials in a variety of applications (incl. in new tyres).

Promote eco-design for circularity (R&D)

Avoiding the use of materials that prevent recycling by best proven techniques available (e.g., polyether-based polyurethane foam for noise reduction or puncture-free sealants). Financial support and closer multi-stakeholder collaboration along the tyre value chain are central to increasing material recycling.

Waste logistics and management systems:

Exchange of best practices of used tyres management to further promote mechanical tyre recycling under the three ELT management models.

End-of-Waste (EOW) criteria

Setting up EU-wide EOW for tyre-derived materials is essential to alleviate obstacles impacting circular uses of materials derived from ELT recycling into a variety of applications benefiting society, the environment and industrial symbiosis. While national criteria are supported, harmonization at EU level is key for the well-functioning of the internal market.

Monitoring technological development and market for recycled material:

Assess the processing capacity, technologies for material recycling and competitiveness concerning such material recycling and energy recovery.

Linear Economy

Circular Economy

Alternative ELT market

Products such as artificial turf, playgrounds, athletic fields, flooring, thermal insulation, acoustic insulation, paint, technical rubber compounds, asphalt modification, new tyres... made from recycled ELT rubber should be evaluated taking into account ELT-intrinsic properties and their contribution to a more circular economy. When restrictions are considered, they must be stable in time to provide legal certainty and proportionate to the target pursued. Furthermore, general, time-limited and usage-limited derogations should apply when sound risk-based assessment demonstrates that those products pose no danger for human health and the environment.
References


27. ETRMA contribution to the public consultation on ECHA Annex XV dossier, dated 05/2019.
