The road to sustainability

The Swedish Tyre Industry Association

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White paper 2020-2030

The Swedish Tyre Industry Association

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Fredrik has held executive positions in both Swedish and international companies. Since 2003, he has focused on identifying the links between recycling and the economy, as well as sustainability at a systemic level. Fredrik advocates risk management to enable resource use that is both safe and non-wasteful. His aim is to see a thriving circular economy working within the regenerative boundaries of the planet.

Fredrik is the co-founder of the Circular Economy Recycled Rubber (CERUB), which created the International Certification for Recycled Tyre Material. He is also a speaker and moderator at international sustainability conferences.

Jonas Roupé has been a board member of The Swedish Tyre Recycling Association since 2017. Jonas holds an M.Sc. in business administration, a B.Sc. in political science and a degree in Engineering.

Jonas has held positions as head of Business Development, Chief Strategy Officer and Chief Marketing Officer with companies such as Ericsson and Skanova. He has also worked with business renewal and sustainability issues since 1995 and recycling and circular economy since 2013.

Jonas is the founder of the Swedish advisory firm Insiktsbolaget.se and works nationally and internationally as an advisor and consultant. He is also recognised for his work with the network 'End Ecocide Sweden', which campaigns for international law to protect ecosystems. This will then lay the foundation for a circular economy.

Executive summary and readers guide

Responsibility extended by necessity

This white paper outlines the pioneering efforts of The Swedish Tyre Industry (Däckbranschen) in the persuit of sustainability within and beyond the tyre industry. The principles behind these efforts, and as they become applied by more and more sectors of society, would alleviate most – if not all – of the environmental sustainability challenges that our modern societies are facing with the usage of tyres.

Extended Producer Responsibility (EPR), (a term defined by the European Union) can be summarised as *"responsibility for the product and its material, extended to the post-consumer stage of a product's life cycle"*. Extended Producer Responsibilty applies to end-of-life tyres in Sweden, which fortunately, consist of materials ideally suited for recycling within a circular economy.

How this document applies to those involved in the tyre industry

This white paper will provide an overview of the many areas of paradigm shifting[1] efforts that are already underway within the industry, as well as serve to highlight the substantial improvements made during more than a century of tyre development, improvements that continue unabated.

How this document could apply to other sectors of industry

This white paper is designed to inform and serve as a launchpad to take sustainability efforts to the next level. We have outlined a systemic approach[2] to sustainable development, with several models that optimise the positive impact on the most pertinent challenges that industries may face.

Maximising impact

It is not possible for anyone to do everything at the same time. To maximise positive environmental impacts we need to act now, especially in areas where the consequences are irreversible.

There are two key questions.

1. Which areas can we focus on for maximum benefit?
2. Which areas are irreversible and need to be addressed now?

The most fundamental areas we can contribute to are:

- Resource decoupling[3].
- Reduced land use.
- Reduced pressure on ecosystems /slowdown of species extinction.
- Achieving drawdown of greenhouse gases from the atmosphere.

Sustainability is not a luxury, it is about altering the course of our society to one that is in harmony with life on this planet. The Swedish Tyre Industry Association advocates a systemic approach to sustainability as it singles out where the greatest contributions can be made. It may also serve to highlight areas for change relevant to your organisation.

How this document could be informative for those interested in sustainability

We have devoted several pages in this white paper to describe how the environment and sustainability challenges are interlinked. This knowledge is essential for any organisation that wants to reach the Sustainable Development Goals[4] of a truly circular economy.

We advocate a systemic approach to sustainability as it highlights where the greatest contributions can be made by any given sector. We have analysed this within The Swedish Tyre Industry Association and we believe that all sectors need to do the same.

We cannot shift to a sustainable pathway by ourselves. We can do it, however, if we work together. A good first step is to share our thoughts and experience, in order to learn from each other as we venture ahead.

[1] *paradigm shift can be defined as an important change that happens when the usual way of thinking about doing something is replaced by a new and different way*

[2] *systemic approach is a selection of priority areas based on the understanding of 1) how the sustainability challenges are interrelated and 2) where we can make the largest positive impact on sustainable development*

[3] *resource decoupling: minimising the use of resources needed for economic development*

[4] *sustainable development goals: a collection of 17 global goals for a sustainable future*

"Motorism has a crucial influence on the environment and sustainability issues of the future. Much has improved, but much more has to happen. Most attention has traditionally been given to the change, in terms of energy and fuels, but many other areas are now moving in the right direction: tyres, material choice and design, drivers' knowledge and behavior among other things. The tyre industry's partial responsibility is not at least related to the potential of recycling. As this white paper so clearly illustrates, we are talking about huge volumes that must be handled responsibly. A broad perspective is taken in this white paper; from biodiversity to the sustainable use of planetary resources. The white paper is well-written, positive and is an important contribution to building the industry's long-term development whilst safeguarding our environment."

Professor Lars Kristoferson

former Secretary General of the
World Wildlife Fund, WWF (Sweden)

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The road to sustainability

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Sustainability and 100 years of tyre development

When it comes to safety, tyres are one of the most important components of a vehicle.

The tyres we use today are the result of over 100 years of development:

- 1839 – Charles Goodyear developed vulcanisation of natural rubber.
- 1887 – John Boyd Dunlop invented the pneumatic tyre.
- 1891 – The Michelin brothers made the tyre removable from the rim.

Since then, numerous improvements have been made such as the invention of alternative tread patterns, radial, tubeless and studded tyres.

The modern tyre is developed in accordance with statutory requirements and new designs are driven by safety and the market's demands for dry/wet traction, lower rolling resistance, comfort, cabin noise, resistance to punctures and service life.

Energy saving

Let us consider the example of 'rolling resistance', which arises through the viscoelastic properties of the rubber compound. When the tyre is rolling, the tyre is compressed. This is where energy is used. Manufacturers work with the components in the rubber compound to reduce the amount of material in the tyre in order to reduce the energy loss. A reduction in rolling resistance of 10%, reduces fuel consumption by 1.6% which in turn reduces motoring costs as well as greenhouse gas emissions, from the engine.

Digital tyres

Electronics and various forms of tyre management technology have also improved safety, fuel efficiency and service life. This will increase in importance as vehicles become more and more autonomous.

Manufacturing large truck and bus tyres in the 1920s

Tyre factory today

A balanced view on sustainability and safety

From a sustainability perspective, it is desirable that tyres are used for as long as possible.

Correct air pressure reduces rolling resistance

It is important to check the air pressure at least once a month, even if a Tyre Pressure Monitor System (TPMS) is installed. Correct air pressure minimises rolling resistance and tyre wear. The air pressure is specified for each individual vehicle and its load but pressure also changes depending on the surrounding air temperature.

Repair and reuse

Tyres that are punctured are carefully inspected on the inside for damage and only those deemed safe are repaired in order to avoid disposal.

Lower tread depth

The tyre tread's primary function on wet surfaces is to evacuate road water in order to maintain optimal contact and eliminate, where possible, the risk that the tyre will slide on the water's surface (aquaplaning).

Different manufacturers work to develop products that maintain road grip down to as low tread depth as possible, but caution and adjustment of speed on wet surfaces is always recommended.

Winter Tyre Storage

Sweden's winter tyres legislation requires that vehicles are equipped with special winter tyres during the period from December 1 to April 15 each year.

A large proportion of wheel changes are made at tyre workshops, which also offer storage of the winter/summer sets of wheels that are not mounted on the vehicle.

Balanced wheels – less fuel use

When a tyre is changed the wheel is balanced, with small, flat weights. This reduces wear and tear on the tyres, the vehicle's suspension as well as reduces fuel consumption.

End-of-life tyre recycling

When tyres are worn out, they are brought in for recycling via The Swedish Tyre Recycling Association.

Bus and lorry tyres – retread, regroove and reuse

Larger tyres, often used for construction machinery, tractors, etc., require special handling due to their size and weight. These tyres are very expensive, making repair more commercially viable.

Tyres from buses, trucks and trailers can, in some cases, be retreaded so that a new contact surface is applied and the tyre is given a new life. Approximately 45% of tyres sold are retreaded. The tyre industry also organises retreading via The Swedish National Association of Tyre Specialists.

Regrooving is also an important resource saving measure. When the tread of certain lorry tyres reaches approximately 2-4 mm in depth, they can be regrooved. Regrooving entails carving out rubber in the grooves of a lorry tyre which saves a new tyre being fitted.

Tyre recycling can help off-set greenhouse gases

Greenhouse gas emission from tyres

Tyres contribute to the release of greenhouse gases in three ways:

1. During the raw material extraction/production
2. During manufacturing
3. During a vehicles useage

Advancements in technology have led to the drastic lowering of greenhouse gas emissions over the years.

- The use of raw material has been reduced considerably in standard tyres, by optimising the strength of the tyre by using finite element design methods and a matrix of rubber, textile and steel, the tyre weight.

Several manufacturers have been able to reduce their greenhouse gas emissions by 95% during manufacture.

During the last 20 years, tyres designs have been modified to reduce rolling resistance by over 20%. This saves fuel without sacrificing safety or performance. This is important as the majority of emissions can be attributed to the vehicles fuel consumption.

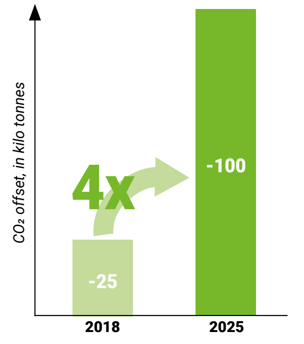
Tyre recycling in Sweden

Greenhouse gases are emitted during transport, shredding, granulation and the combustion of tyres. However, more emissions can be saved than have been released, if end-of-life tyres are put to a use where they can replace products that normally would cause an even greater level of release of greenhouse gases emissions in their own production.

In Sweden, for example, fossil fuels are replaced by recycled tyres in the production of cement. Sweden offsets 0.5% of its total greenhouse gas emissions by recycling end-of-life tyres. This is why The Swedish Tyre Recycling Association is now investing more than ever before in developing environmentally friendly, climate-smart and resource-efficient ways to reuse tyre rubber materials.

End-of-life tyres and greenhouse gas savings

There are extensive scientific studies about the environmental impact of tyres and there are good examples, around the world, where the levels of material recycling are significantly higher than Sweden's. If we succeed with our aims, we will be able to quadruple Sweden's greenhouse gas savings by 2025.

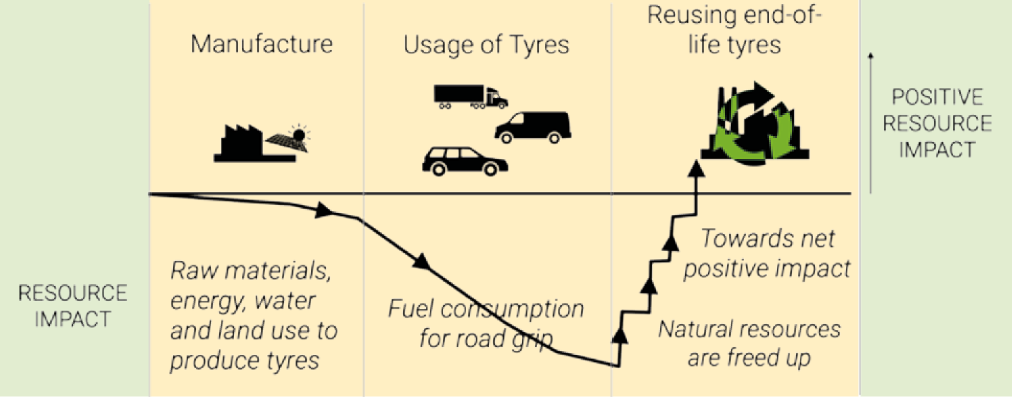


Mitigating greenhouse gas emission will not be enough

Greenhouse gas emissions are not the only sustainability challenge that must be addressed in order to shift to a circular economy within Planetary Boundaries.

There are both environmental and socio-economic benefits to create a completely circular flow of tyre material, that protects the environment, reduces greenhouse gas emission and utilises resources better. In this white paper we will look at some of these products and their benefits beyond greenhouse gas savings such as using rubber asphalt for softer cycling, walkways and water purification.

Reusing end-of-life tyre materials reduces the need for raw materials



The industry's contribution to sustainability

The current 'linear' economy is not sustainable

A shift to sustainability is fundamental in stopping the extinction of species and the destabilisation of the planet's life-sustaining systems. However, the extinction of species as well as climate change are symptoms of a greater issue which involves how we handle the planet's resources.

The main force behind the extinction of species and many other sustainability challenges, is society's over exploitation of natural resources. We have specifically chosen to develop paths for the tyre industry to contribute to the reduction of raw material exploitation.

In order to reach the much needed Sustainable Development Goals (and beyond), and to become a society which thrives within Planetary Boundaries – we simply need to make the best possible use of the resources we already have.

The Tyre Industry has already taken many initiatives to meet these challenges, from responsible sourcing and the reduction of water usage, to minimising rolling resistance and the collecting and recycling of end-of-life tyres.

The environment needs international legal protection

Natural resource savings, for example the reduction of raw material extraction, typically occurs in places far away from the passenger. Many developing countries have been made dependent upon income from extractive industries but lack laws and legal systems to ensure that any extraction takes place in a responsible manner. International communities and governments need to take responsibility and upgrade the laws, committing to the protection of human rights and nature.


1

Sustainability advancements in manufacturing

Tyre manufacturers strive to make continuous improvements for environmental issues, from sourcing to the recycling of tyres. The numerous activities, analysis and their results are presented in detailed company sustainability reports; references are provided at the end of this white paper. Here are a few examples.

Natural rubber: certified, traceable, sustainable

The tyre industry uses about 70% of the world's natural rubber and demand is growing. For this reason, tyre manufacturers and other companies have joined forces in the Global Platform for Sustainable Natural Rubber (GPSNR), which actively works to ensure respect for human rights, prevent land grabs, protect biological diversity, water resources and increase transparency and traceability throughout the process.

Raw material: consumption and greenhouse gases

The areas of focus in production are raw material consumption and the release of greenhouse gases. Some of the key data for the 11 global tyre manufacturers' developments in sustainability are shown in the figure below.

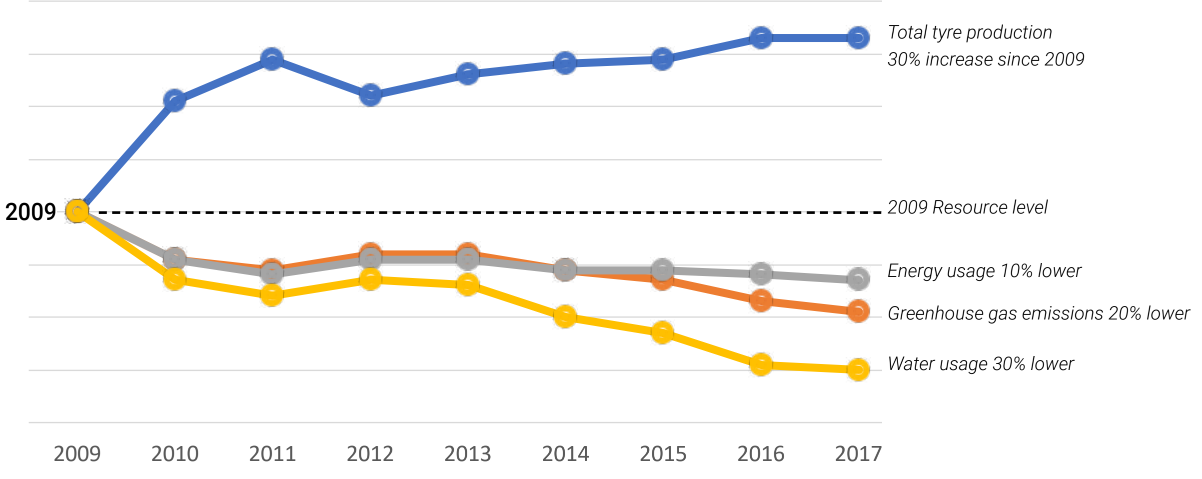
Alternative materials

About half of a tyre's rubber is synthetic rubber. Intensive development is in progress to reduce this further and to find more sources for alternative types of natural rubber that could be produced in Europe and are more easily recycled.

Rolling resistance

Rolling resistance plays a major role for fuel usage when a tyre is used and it is also one of the areas that is constantly evolving.

Resource reduction during tyre production



Key performance indicators compiled by TIP [Source: 26]

Autonomous vehicles and life

A paradigm shift in transportation is around the corner

In this white paper we discuss how advancements in tyre technology and professional servicing is essential to allow the widespread use of autonomous vehicles. The increased usage of autonomous cars can reduce traffic congestion and free up urban spaces, such as car parks, for other uses. This benefit increases further when the autonomous cars are shared. When shared, they become a form of transport that is dramatically more sustainable and less raw material intensive than individually owned vehicles. Car sharing will be easier when cars become autonomous.

More room for life

A shared car can replace between 9 and 13 individually owned cars [44] and the reduction in the number of vehicles could be able to free up about 90% of parking areas. Half of the entire area of a city is used for vehicles. This is broken down into 30% used for roads and 20% used for parking spaces [44, 45]. The areas released from vehicle usage could be utilised in a variety of ways, such as recreation, urban farming, tree planting or as community gardens.

Who changes a flat tyre on an autonomous vehicle?

Vehicles and tyres that perceive and can communicate with each other make it possible to adjust service intervals and help prevent tyre incidents. Many of these tyre systems are already on the market.

With these tyre systems, vehicles and their passengers would be able to get to the nearest workshop safely instead of being stranded. This means that more tyres will be fitted at professional tyre workshops than at the side of the road.

Tyre advancements

Tyres and vehicles have also improved extensively. They can communicate the risk of aquaplaning to the stearing system when driving conditions are changing. This ensures maximum safety.

Technology is also creating the possibility of harnessing the energy created in steel ply whilst the tyre is in motion. This can be used to charge tyre electronics.

Self-sealing tyres allow a vehicle to operate without tyre pressure decreasing, even if the tyre has been punctured. 85% of all pressure loss is due to punctures.

Run Flat technology, also known as 'safety tyres', is based on reinforced tyre walls which resist both vertical and horizontal forces in the event of a puncture. It makes it possible for the vehicle to continue moving for up to 80km and to arrive at the nearest tyre workshop. Sensors are becoming more common in both tyres and vehicles and are adapted to specific challenges.

Autonomous vehicles to be standard before 2050

According to The Ellen MacArthur Foundation[1], fully autonomous[2] vehicles are expected to constitute a major share of most vehicle fleets by 2030 and will dominate the roads before 2050. It is not only resource efficiency that drives this development, but also other advantages, such as cost, comfort and safety.

This development will require cross-sector and societal collaboration and the technical development of tyres is an integral part.

[1] *The Ellen MacArthur Foundation – a leading authority on circular economy*

[2] *Fully autonomous vehicles are defined by The National Highway Safety Administration (NHTSA) as Level 4: 'The vehicle is designed to perform all safety-critical driving functions and monitor the driving conditions for the entire trip.' This requires that the driver specifies the destination or navigation input only.*

Sustainability Goals and Planetary Boundaries

In September 2015, at an historic UN Summit, world leaders adopted the 2030 Agenda for Sustainable Development. Within the Agenda there were 17 Sustainable Development Goals (SDGs) which officially came into force on the 1st January 2016.

The agenda follows several important principles:

1. The Agenda is universal, which means that all countries bear a collective responsibility.
2. The Goals are integral and inseparable. No goal can be achieved at the expense of another and success is required within all areas.
3. No one shall be left out. Special consideration must be given to people and societies with the worst conditions.

Over-exploitation affects people and animals

The driving force behind biodiversity loss and species extinction – and most other sustainability challenges facing us – is our society's overexploitation of natural resources. This is evident when looking at how UN's Sustainability Goals are related to each other.

Goal 12 – Responsible Consumption and Production

This is the goal that affects most of the other goals [2]. This is due to the fact that we obtain resources from both land and sea. Our activities affect water, air and land, the living space for other life forms and the living conditions for local populations. We mine ore with increasingly lower metal content, which brings about greater destruction [13]. Our food production requires large land areas and industrial food production is dependent on input such as mineral fertilisers, which in turn, require large areas for extraction of the minerals. This is then transported over great distances.

These are not sustainable practices.

The clear impact of our need for resources

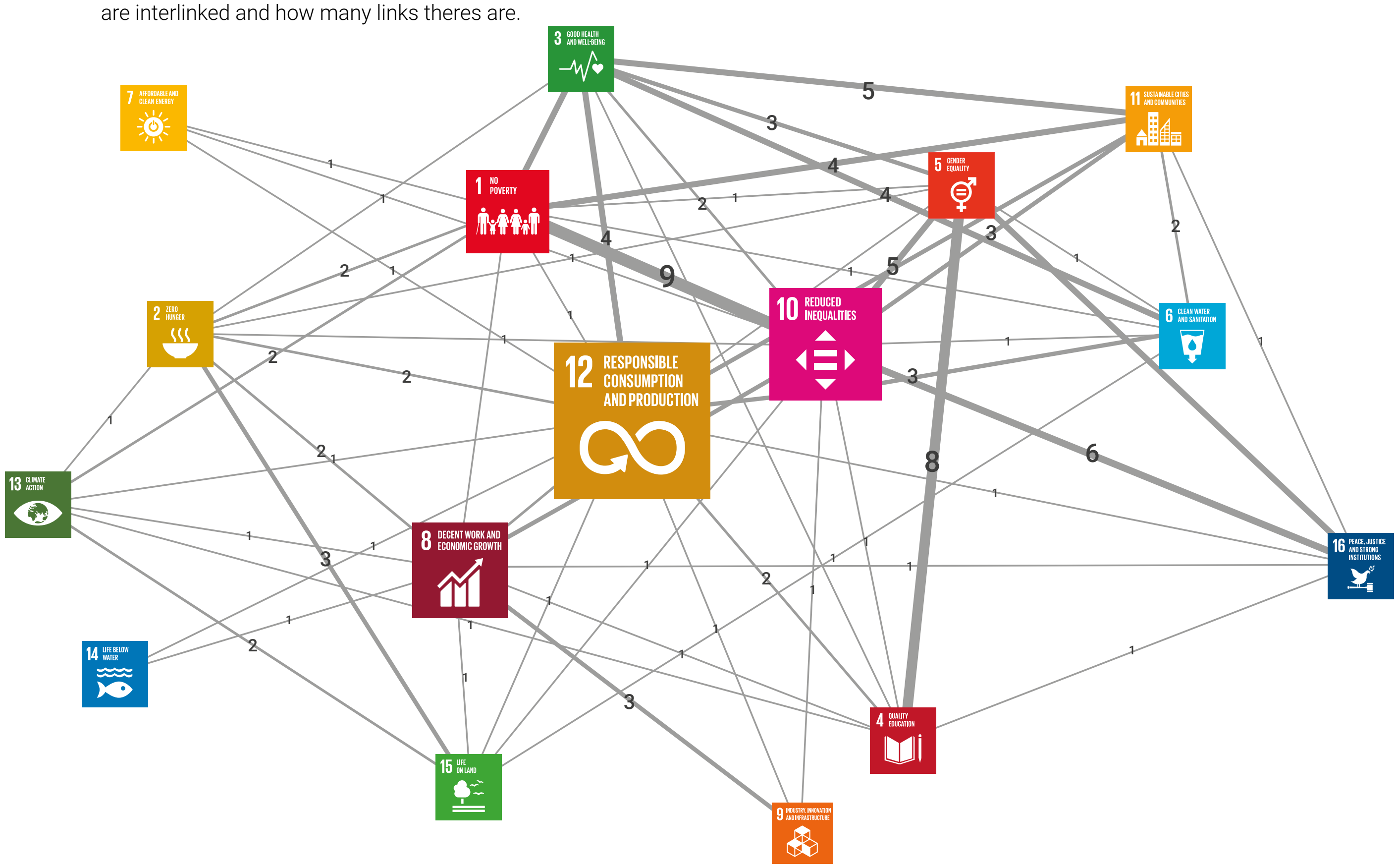
Less than 5% of the world's *total* land surface is *unaffected* by mankind and 81% has multiple stress factors from human activities [10]. Even in sparsely-populated Sweden, the natural environment is marked by our need for resources. Sweden's forested areas are now covered by trees that are *less* than 40 years old. Of the 27 million hectares of forest, 85% are planted productive forests, and only 3% are protected as nature reserves or national parks.

Unlike the rest of the natural world, our societies do not apply regenerative nor circular principles. Only 9% of the natural resources which are taken from the planet are recycled in some form and the trend is heading in the wrong direction. [3] The wealthier that countries become, the greater their negative ecological footprints. If the entire world's population would handle resources as poorly as Sweden does, we would need more than 4.2 planets to survive.[4]. These calculations are not included in the National Statistics for greenhouse gas emissions nor is the total resource requirement of nations summarised. Resource extraction and the corresponding footprint on climate and living systems are instead, reported only in the country that extracts, processes or produces the goods, if at all.

The circular economy is a part of a larger movement that has arisen as a reaction against poor practices. It is in favour of working with more natural systems that are in harmony with nature's principles and to uphold an inherent value for all life.

How the goals are interlinked

This chart shows how the targets for each goal are interlinked and how many links theres are.



Heading the wrong way

Goal 15 from the Sustainable Development Goals is 'Life on Land' defined as – *"Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss."* Currently the trend isn't just heading in the wrong direction, it is accelerating [30].

In addition to overexploitation and loss of habitats, there is also a relationship between extractive activities on land and the extinction of life forms in water. This is perhaps a less obvious consequence.

The loss of a water based living environment can take place through direct interference or indirectly, for example, by interrupting the flow of a river. The loss of a living environment such as a forest, can increase a river's level of sedimentation, which leads to increased erosion of river banks which leads to subsequent changes in water quality and water flow, thus altering both land and water habitats.

Extinction is irreversible and is intimately related to the life-sustaining systems upon which all life depends.

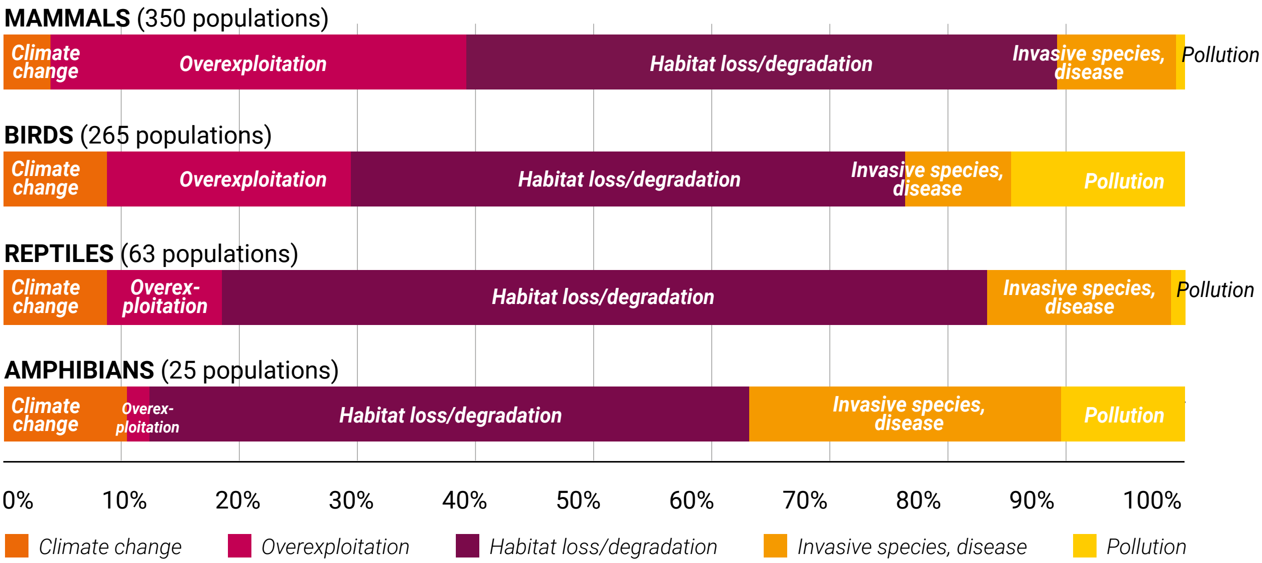
Change of direction

Sweden's appetite for resources (around 4 times the planet's regenerative ability) is a substantial reason to increase the degree of recycling of existing resources by at least the same factor. Passenger vehicle tyres are a good example. They last five years on average, but ***our goal is for tyres to continue to provide a societal benefit for an additional 15 years at least*** *before being decommissioned (a total of 20 years of material use, which equals 4 times the original use). This reasoning should apply to all sectors of society.*

The number of wild animals has declined 60% since 1970, World Wildlife Fund (WWF). Of all life forms identified, 1 out of 8 is now under threat of extinction.

Source: The Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Service (IPBES)

The direct link between unsustainable land, resource use and species extinction

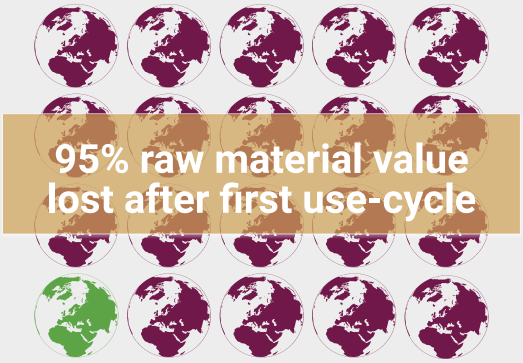


Source WWF/ZSL 2016

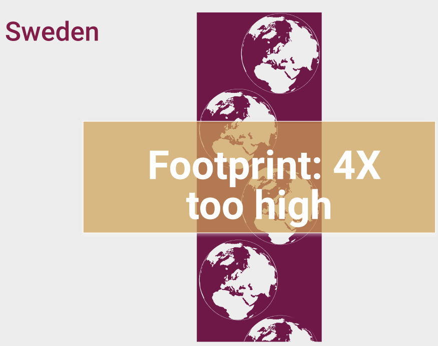
Large net-importers of resources

The level of natural resources used by many countries, including Sweden, is unsustainable. We need to identify why these resources are extracted and alter the end usage in order to minimise raw material extraction. By reducing the need at source, we can reduce our footprint on the planet.

In Europe, 95% of the raw material value of our infrastructure and goods are lost after one use-cycle. [16] The figure for Sweden is even worse. If all the material value was intact for 1 more cycle, this is an improvement by a factor of 20 which can be improved upon even further if more use cycles were to happen. According to WWF's footprint calculations, Sweden's footprint is 4 times too high. [4] The global average is 1.7.



Source: A Circular Economy Vision for a Competitive Europe, The Ellen McArthur Foundation, 2017.



Source: World Wildlife Fund, Living Planet report 2018

On average we generate 1kg of household waste per person per day and require from 160 to 300 tonnes of natural resources per person per year to keep our society functioning. The higher level is including resources for export as well as resources that we consume ourselves. [27]

Natural rubber is a 'critical' material

Europe is currently the world's largest net importer of natural resources, approximately 800 billion tonnes per year.[16] Europe imports about 60% [17] of its fossil fuels and metal resources and has pushed 27 materials [18] onto the critical list with respect to security of supply. Natural rubber is one of the materials on the critical list.

Our high dependency on imported resources exposes us to price volatility and geopolitical uncertainties.[19]

More efficient use of materials and goods provides a substantial saving, compared with using only raw resources.

This does more than just increase the likelihood of meeting the Sustainable Development Goals and Planetary Boundaries. It also helps to stimulate business growth opportunities and employment.

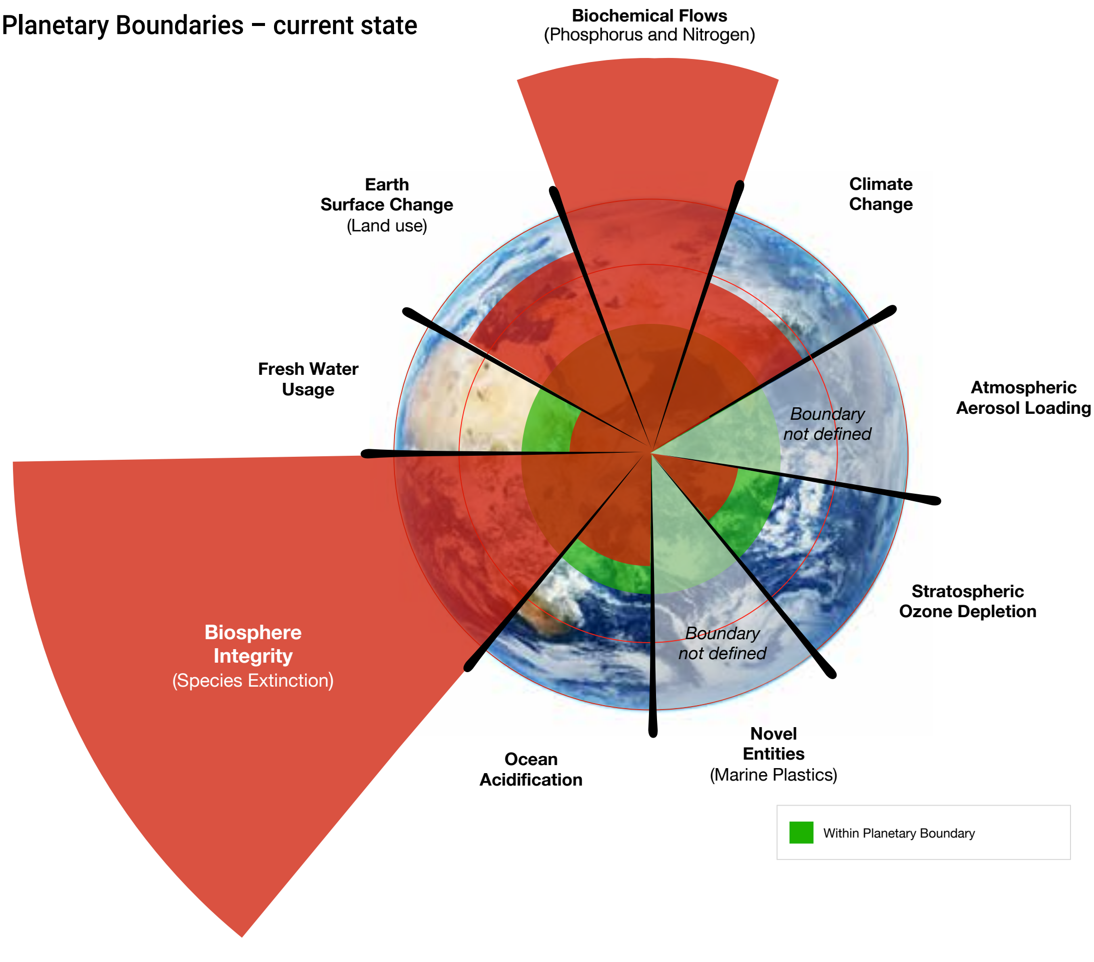
Consequently, the tyre industry is intensifying its efforts to provide circular economy solutions with the end goal of using the end-of-life tyre material many times.

The Planetary Boundaries and a safe operating space for humanity

The 'Planetary Boundaries' as defined by the Stockholm Resilliance Centre, provide another vantage point on today's sustainability challenges. Nine boundaries have been identified and are set out below. [5] They define a safe operating space for humanity with respect to Earths systems and are associated with the planet's bio-physical subsystems. When a threshold is crossed, important subsystems, for example, the monsoon seasons, could shift into a new pattern, with serious or even disastrous consequences for humans. As yet, not all processes or subsystems on Earth have well-defined thresholds. Human actions that undermine the resilience of such processes or subsystems can increase the risk of thresholds being crossed in other areas, such as the climate system.

The loss of genetic diversity due to species extinction is already out of control and could have catastrophic effects. [38] International law provides only a weak protection of nature [9]. This means that the natural resources that Sweden imports – (70% of Sweden's resource extraction takes place in other countries) [7] – come to us at a planetary price that does not give adequate consideration to the Planetary Boundaries, either locally or globally. Simultaneously, in developing countries, where the resources are extracted, there is a significant lack of exisiting laws, legal systems and societal structures that ensure that extraction activities take place in a responsible manner [8].

Planetary Boundaries – current state



A Circular Economy within Planetary Boundaries is our aim

The Swedish Tyre Recycling Association encourages, supports and contributes to:

- Reducing impact during tyre production by means of responsible natural rubber production, reduced use of water and reduced energy usage.
- Developing alternatives to raw materials with lower environmental impacts.
- Creating tyres with a longer service life and reduced rolling resistance.
- Issuing specification sheets about content and recyclability of new products.
- Recommending 'best practices' with respect to management and environmental matters in the distribution chain.
- Interviewing customers/consumers and adapting recommended products based on current safety requirements, and taking into account environmental influences.
- Promoting re-treading and regrooving of tyres where possible.
- Optimising the collection of end-of-life tyres and recycled material with a systemic approach and in combination with economic realities.
- Supporting open research towards sustainability.

Circular Economy Rubber

How do we find the best applications for using materials from end-of-life tyres? Which processes are preferable? How do we know if the use of recycled tyres contributes to the sustainability goals?

The Swedish Tyre Industry Association aims to enhance the positive impact of end-of-life tyre recycling. We have therefore developed a number of models to serve as guidelines in this work.

The two areas we have selected are:

- Resource efficiency
- Species extinction

By examining and monitoring them side by side, not only are we able to see the results in the individual catagories, we are also able to measure and analyse if an improvement in one area is having a detrimental effect on another.

Systemic Impact Analysis

Systemic Impact Analysis is where checks need to be made against all sustainability targets. It is within this context that we discuss how the extraction of raw materials and their usage and technical material usage, impacts upon Planetary Boundaries. We then look at how the use of recycled materials could relieve this impact. We also analyse the results of end-of-life-tyre material recycling, which helps define the criteria for future recycling methods.

Furthermore, within this context, we define the need for a Life Cycle Analysis (LCA) at a systems level. The LCA is widely used across industries today but *not* from a systems level. This is an essential element that The Swedish Tyre Industry Association brings to the table. Today's LCAs examine environmental performance in only a single application and compare that to different solutions, processes or materials that could be utilised. However, it can be the case that the best material selected for use in one application could actually bring about an even greater environmental benefit in a completely different application and therefore, that different application should be prioritised. This is why the eight point Systemic Impact Analysis needs to be applied prior to determining the most suitable application.

Risk management

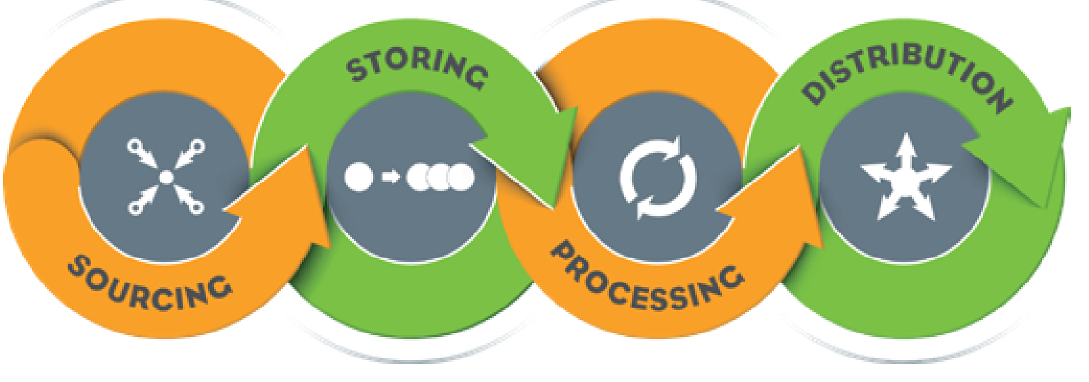
We also consider the need to shift focus from not only the content of the material within the analysis, but to the question of how (and with which actions) can any potential environmental risk be managed. Through measuring and managing risks, instead of only looking at the content of any given material, it is possible to increase recycling opportunities and thus increase resource efficiency.

New certification system – CERUB

The Swedish Tyre Industry Association has defined the need for a certification system; to identify and allocate responsibility for tyre material and its use across various application life cycles. This new certification system is called CERUB (Circular Economy Rubber).

Certified production chain

The CERUB certification system is built for tyre recycling companies and other companies that produce and deliver rubber products derived from end-of-life tyres. By using the CERUB label, the organisation commits to executing a responsible and transparent production chain. The chain includes several stages from sourcing of old tyres to delivery of the produced rubber materials.



A certification system for Circular Economy Rubber CERUB®

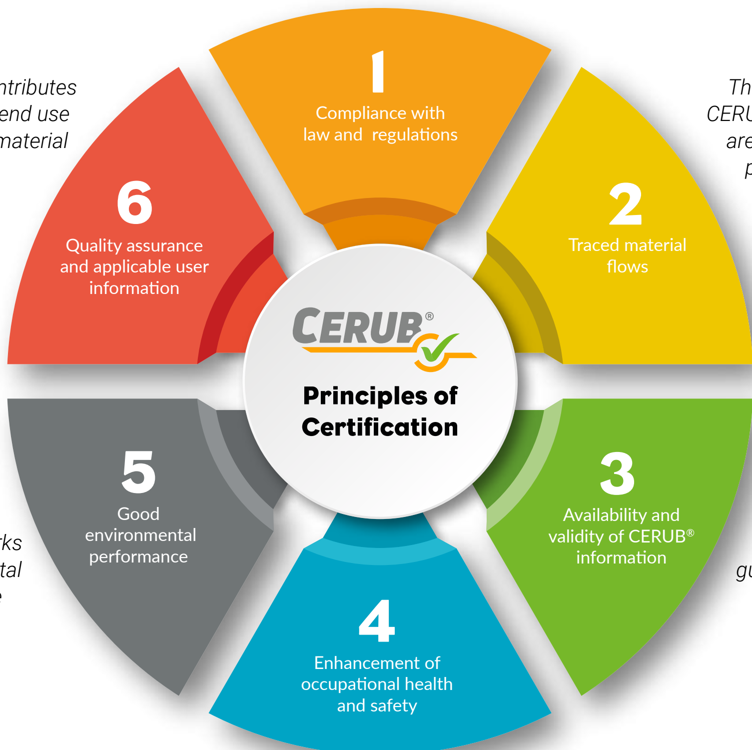
In 2019 The Swedish Tyre Recycling Association, together with the corresponding organisations in Norway, Finland and the Netherlands, initiated an international certification for responsible rubber material recycling. It sets the industry standard for suppliers of recycled tyre material to meet all the relevant requirements for a desired application. The international description of the guiding principles of the certification reads as follows:

'The principles and criteria in CERUB specify the conditions for granting certification and allowing the use of the CERUB logotype. It guarantees that the material is manufactured and delivered in accordance with the six principles below. CERUB supports legislators, authorities, councils and purchasers of material by offering a transparent and audited evaluation of recycled tyre material and the relevant documentation for each application.'

Principle 1
The organisation shall be and use subcontractors that are legally established.

Principle 6
The organisation contributes actively to the safe end use of recycled rubber material from tyres.

Principle 2
The material flows of CERUB-certified materials are tracked within the production chain.



Principle 5
The organisation works for good environmental performance in the materials chain.

Principle 3
The organisation guarantees the availability and validity of CERUB information.

Principle 4
The organisation enhances occupational health and safety in the production chain with primary hazard prevention.

Tyre value chain

Design to production

3 billion tyres are produced every year

Design, materials and production

Tyres contain varying proportions of natural rubber and new compounds are often created with the addition of various types of synthetic rubber.

Synthetic rubber, (regardless of the source being fossil or renewable), cannot replace all natural rubber, which has properties that are unique and so far, irreplaceable. One example is rubber's capacity to handle heat, which is important as it allow the vehicle to carry heavy loads. Natural rubber products can also be made elastic and energy-absorbing.

Tyre material development is evolving fast and new functionalities are being incorporated into the long chains of rubber molecules.

	Car and light lorry tyres	Lorry tyres	Recycled tyres
Natural rubber	19 %	34 %	24 %
Synthetic rubber	24 %	11 %	19 %
Steel	12 %	21 %	16 %
Textile	4 %	0 %	3 %
Fillers (Carbon black, silica)	26 %	24 %	26 %
Antioxidants, accelerators, antiozonants	14 %	10 %	12 %
Total *(rounded up)*	**100 %**	**100 %**	**100 %**

Vulcanisation

When a tyre compound is developed, sulphur reactants and accelerants are added to bond the compound together chemically. This is called vulcanisation. During the vulcanisation process, sulphur bonds develop between the rubber's long carbon chains and thereby pulls the material together. It then becomes resistant to wear, ages more slowly and is chemically stable. The finished tyre also contains steel and textiles to provide additional stability.

Biological materials

Natural substances are being introduced to reduce the use of fossil oils and synthetic rubber. One of the interesting alternatives for the silica used in tyres are husks of rice.
The husks are mixed into the rubber that is to be used for the treaded areas to: increase strength, reduce rolling resistance and improve fuel economy. This blend also has a positive effect on the tyre's traction and braking force on wet surfaces. Also dandelion and rape seed oil is being used to substute.

Rolling resistance and energy efficiency

The rolling resistance of a tyre changes the level of energy efficiency and therefore the vehicles operating costs, as well as carbon dioxide emissions. The lower the rolling resistance, the lower the fuel consumption. Rolling resistance is caused primarily by the tyre changing shape. The wheel's radius and the vehicle's speed also have an influence [21], as well as grip[1] and slip[2] between surfaces.

The rolling resistance can be altered by modifying the tyre's material composition and tread pattern. Energy efficient tyres have a 20% lower roller resistance than standard tyres and can reduce a car's fuel consumption by about 5%. As a car's CO_2 emissions are directly proportional to its fuel consumption, using energy efficient tyres on a medium size car can also reduce greenhouse gas emissions by a further 5%. [22]

EU energy label

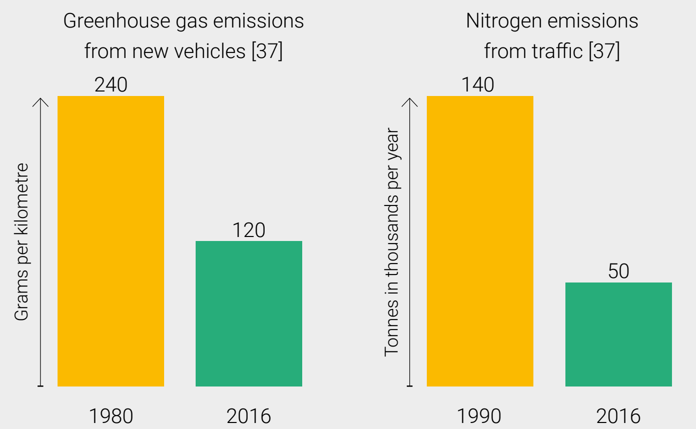
The EU energy label shows the extent to which tyres affect the vehicle's energy use. Passenger vehicles with combustion enginesand with energy efficient B rated tyres consume approx-imately 0.1 litres less fuel per 100 kilometres than a car that has tyres rated as C.

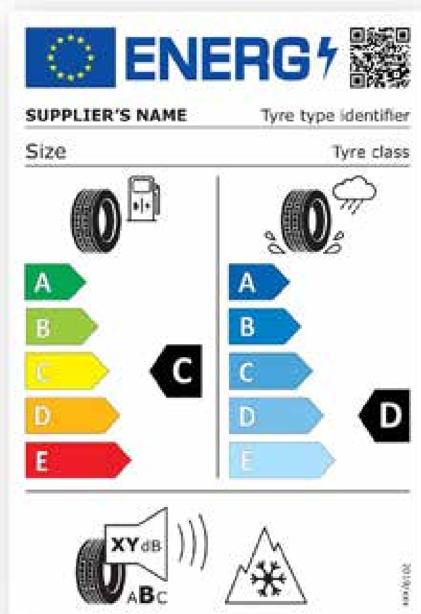
A car's greenhouse gas emissions are proportional to its fuel consumption in combustion engines. In those cases greenhouse gas emissions are directly influenced by the tyres' design.

The electrification of vehicles is a development that increases energy efficiency drastically, and tyre design is important for extending range also for electric vehicles.

Progress both in terms of safety and environmental impact

Safety has improved simultaneously with environmental impact, as illustrated below. Tyres' contribution to this is by development and design.





[1] *grip – is a consequence of molecular contact that can be measured to an increasingly small degree, about 100th of a micron – and is amplified when a car slides*

[2] *slip – can be latitudinal or longitudinal. Longitudinal is slip in the direction of the movement of the vehicle and latitudinal slip is due to lateral forces on a vehicle*

Anatomy of a tyre

A tyre can be divided into eight parts

1. Inner liner

An air tight layer of synthetic rubber (the modern equivalent to an inner tube).

2. Ply

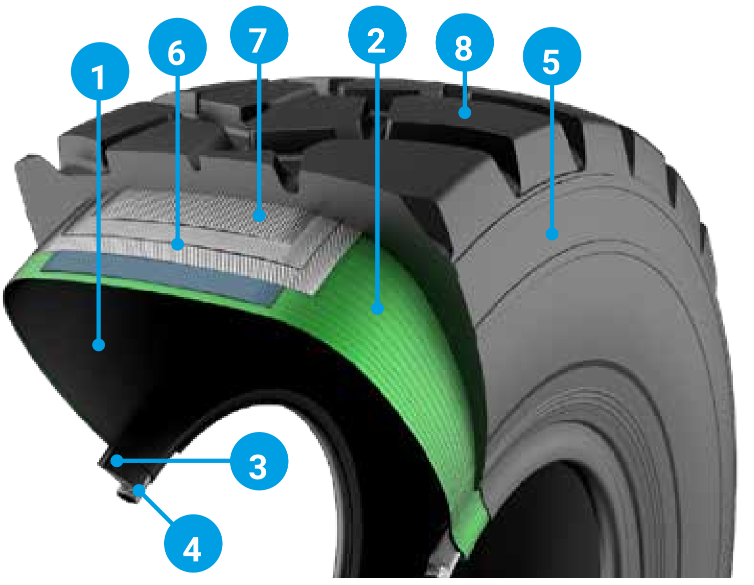
The layer above the inner lining consisting of thin fibre wires (or cables) incorporated into the rubber. These cables are largely responsible for determining the tyre's strength and help to resist pressure. Standard tyres contain 1400 wires, each of which can resist a force of 15 kg.

3. Bead Chaffers

This is where the tyre grips the metal rim. The force from the output of the engine and the application of the brakes are transferred from here to the tyre's edge and to the area that is in contact with the road's surface.

4. Bead wire

The bead wire grips against the tyre's edge to ensure there is an air tight fit and holds the tyre on the rim correctly. Each wire can withstand a load of up to 1,800kg without the risk of breaking. There are 8 per vehicle (two per tyre). This equals a massive 3,600kg resistance of strength per tyre. An average car only weighs about 3,300kg in total.



5. Sidewall

The sidewall protects the tyres side against impact. Important details about the tyre are also stamped on the sidewall, such as its size and speed rating.

6. Casing ply

Largely responsible for determining the tyre's strength. Casing ply consists of numerous fine, strong steel cables bound in the rubber. This makes the tyre adaptable for steering and prevents them from expanding due to driving speed. It is also sufficiently flexible to absorb impact, jolts and other obstacles on the road.

7. Cap ply

This important safety layer reduces friction heating and helps the tyre retain its shape when driven at speed. In order to prevent centrifugal expansion of the tyre, reinforced nylon based cables are embedded in a layer of rubber and arranged around the circumference of the tyre.

8. Tread

The tread's function is to provide good traction when coming into contact with the road and it must be durable. The contact surface also contains scientifically researched and designed patterns which repel water between the road's surface and the tyre so that contact is maintained even in wet road conditions. It is also designed to have resistance to heat, cold and wear and tear.

Physics of the tyre

Mechanism of road grip

There are two primary effects responsible for road grip.

- **Molecular adhesion**

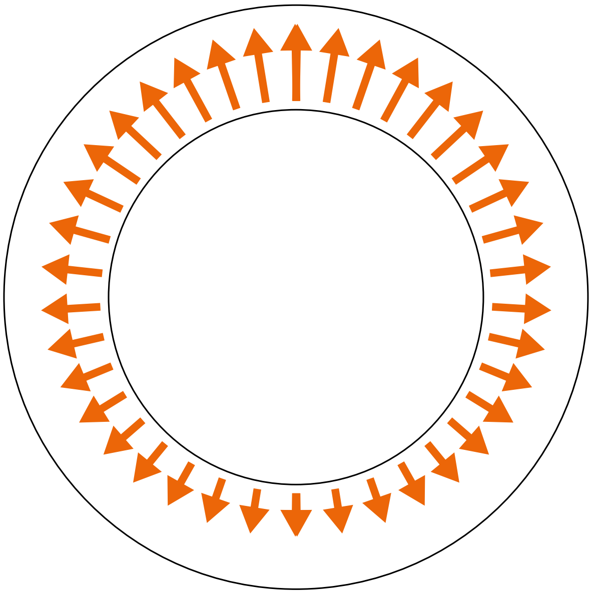
  Molecular adhesion is the force resulting from interactions at a molecular level of the tyre/road interface. It is generally known as 'friction' between two surfaces, Static[1] and Kinetic[2].

- **Hysteresis grip**

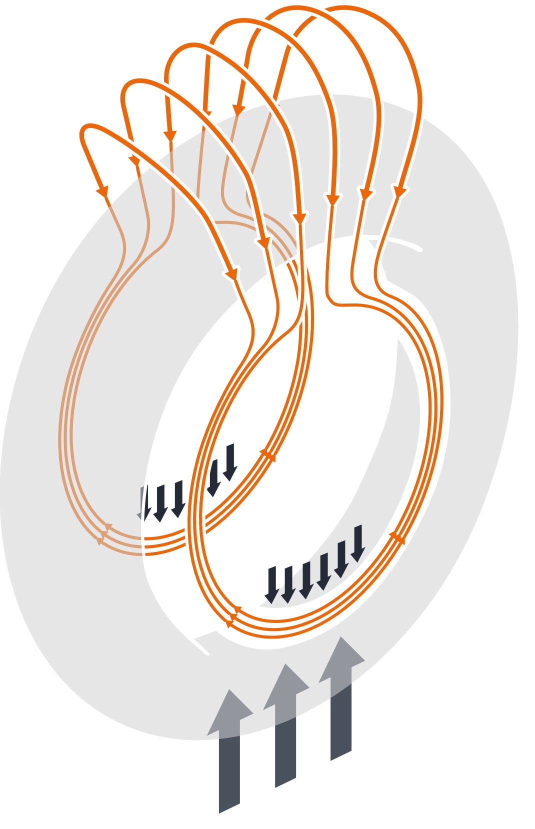
  Rubber is a material that can absorb a lot of energy during compression and expansion. When a tyre is under load, the path that the rubber follows during compression is different compared to during expansion. Hysteresis grip occurs when the rubber is changing its state. It creates additional grip, (especially in wet conditions) and the amount of grip can differ from tyre to tyre depending on how the tread is designed.

It is not only the air in the tyres that carry the vehicle

The mechanism of load carrying in tyres is quite sophisticated. The air does not carry any load on its own, but the inflation pressure creates tension in the tyre wall and when the tyre is loaded it creates a difference in tension. The difference in tension carries the load onto the rim, so that the upper part of the tyre's sidewall is under the maximum tension which lifts the rim using the bead [25]. In an ideal case all the load is carried by this difference in tension and not directly by the sidewall close to the contact patch.



Load path in a tyre



Tension in a tyre

[1] *static – a frictional force between surfaces that are NOT moving related to each other*

[2] *kinetic – a frictional force between surfaces that ARE moving related to each other*

Tyres are often taken for granted, until an incident puts them to the test...

A tyre must perform a number of functions on a vehicle. The primary concern is the road holding quality for maximum safety. It should also cushion impacts, dampen sound, assure good directional stability and provide a long service life.

A well designed tyre must be able to transmit strong lateral and longitudinal forces during acceleration, braking and cornering manoeuvres in varying road conditions.

Due to this wide range of demands, optimising tyre design is paramount.

The number of types of tyres in use has increased drastically over recent years and tyres are now often developed and designed for specific vehicles and conditions.

An example is aquaplaning, where noise sensors now monitor road conditions. If there is a high risk of aquaplaning, the vehicle goes into 'wet mode'. The vehicle will start to prepare itself for potential aquaplaning. Engine torque buildup is reduced and its distribution biased to the front wheels for greater stability. Aeroflaps also open to create greater downforce.

The importance of the tyre rim

The rim plays an essential role for safety and the environment. A correctly designed tyre rim reduces air resistance during rotation, cools the brakes and helps saves fuel.

Recycling of rims

Rims are predominantly produced in aluminium, a metal suitable for recycling. However, recycling rims can be complicated due to the alloys mixed with the aluminium. Steel rims are easier to recycle as they are not mixed with other substances. Carbon fibre and magnesium rims contribute to reduced fuel consumption by being lightweight and therefore creating less CO_2 emissions but they bring about more challenges for recycling. The rim manufacturers are working systematically with these issues.

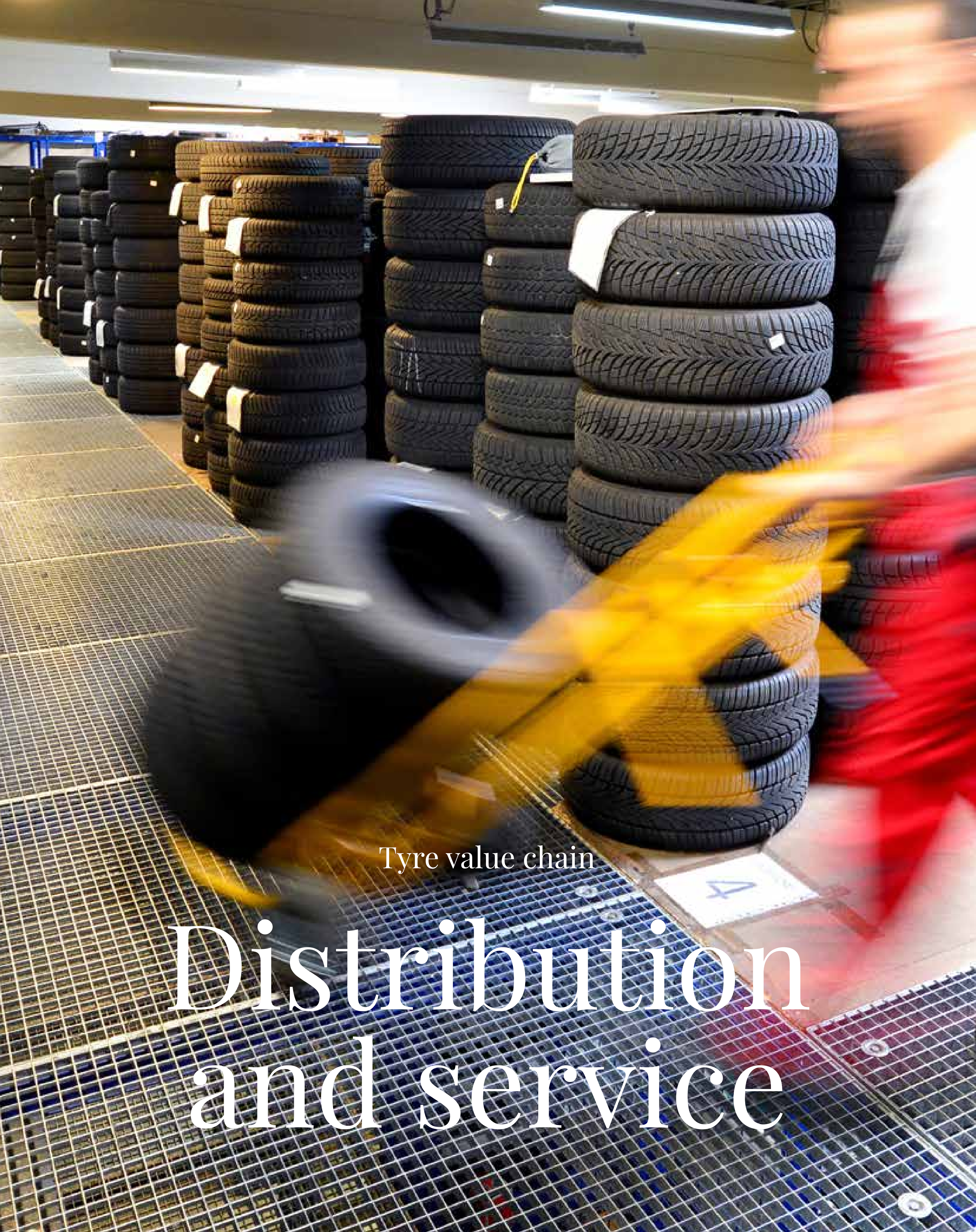
Interplay between vehicle and tyre

In addition to the rim, the vehicle has several points of interaction with the wheel. The suspension plays an important role in ensuring that the vehicle rolls correctly, the tyres incur minimal wear and fuel consumption is minimised. The vehicle and tyres are both designed to minimise in vibrations and sound.

Tyres and vehicles communicate to an increasing extent via sensors and electronics. This white paper does not delve further into these functions in this edition, but it should be pointed out that they will have a future influence on environmental and sustainability matters for tyres and vehicles alike.

Tyre value chain

Distribution and service



Working with tyres

Once tyres have been distributed to their sales locations, (usually tyre fitters or car dealerships), they are often put into storage and can be stored for many years without any of their physical properties changing.

Mandatory EU tyre label

Customers select tyres based on the advice of the tyre salesperson/fitter and to assist consumers with their purchase decision, the EU has created an Energy label. This label is mandatory and denotes the tyre's rolling resistance, wet grip and noise level on a scale (from A to G). The requirements for classifying tyres are monitored constantly in order to aid the development of better tyres.

Safety first

Recommendations to the customer are based on safety aspects. There are a number of parameters, such as road conditions, general driving characteristics, cabin noise, rolling resistance, expected service life, load capacity, speed and type of vehicle, all of which affect the recommendation.
The authorised tyre specialist will discuss these points with the customer in order to establish which type of tyre best fits their requirements.

Tyre workshops – the key to the future

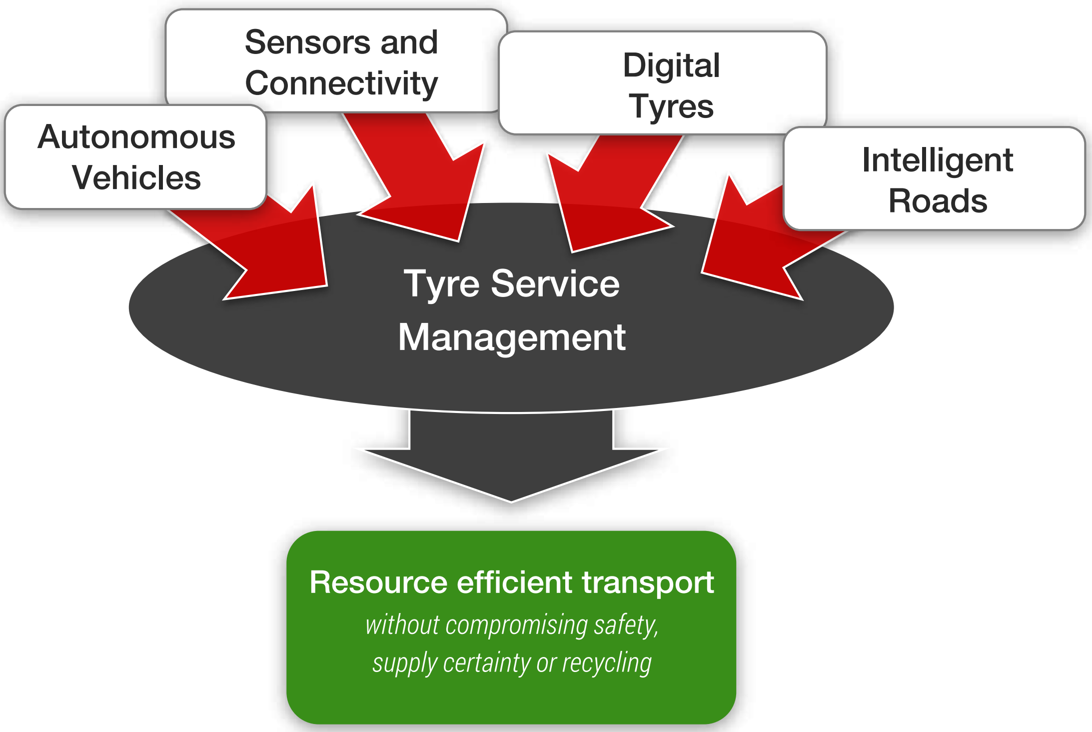
The paradigm shifts[1] within the tyre service chain are primarily associated with tyre development. Intelligent functions are now being introduced into tyres but they still have to be interpreted by the car in order to leverage their potential.

It is at the workshop that the real future begins. The combination of tyre data from sensors, visual inspections and interviews with drivers can be collated and analysed to create an overall picture. This can then be used as a basis for optimisation from a sustainability perspective, whether it relates to minimising wear and rolling resistance or recommending a different type of tyre.

In our view, it is of major importance that tyre data is made accessible and is available to different developers within the industry who can advance new solutions and concepts for increased future sustainability.

The importance of tyre service management

A service network of professional tyre workshops that can handle autonomous vehicles is essential and will enable increased resource efficiency and help free up areas of land currently occupied with parked vehicles.



[1] *Paradigm shift – a fundamental change in approach*

Regrooving extends the life of commercial tyres

Regrooving is when a second layer of tread is cut into a tyre when the first is worn down.

Regrooving is an important resource saving measure, performed on truck tyres when there is only approximately 2-4 mm remaining tread depth. Regrooving improves the grip of the tyre whilst maintaining safety.

The tread of a lorry tyre may be regrooved provided the tyre is marked ”regroovable” or with the letter ”U” on its sidewall and that the pattern cut is performed by a specialist according to the manufacturer’s recommendations.

The lifespan of the tyre is extended when the rolling resistance is at its lowest, the tread is not deep and therefore it wears more slowly. The shallower tread is less compressed when in the contact with the road which results in lower rolling resistance, which in turn, leads to reduced fuel consumption.

Regrooving facts

- Regrooving four tyres saves 70 kg of new material being used.
- The life span of the tyre is extended by up to 25%.
- On average, fuel consumption is reduced by 2 litres per 100km, reducing costs.
- Regrooving saves the release of 6.5 tonnes of greenhouse gases, per set of tyres. [28]

Consumer responsibility

Maximising the life of a tyre

1. Life span of a tyre

Life span and mileage depend on several factors:

- Tyre design
- Driver habits
- Climate
- Road conditions
- Tyre management

After five years of using a tyre, it must be carefully inspected, at least annually, by a tyre expert. If you take care of your tyre's air pressure, you can increase the average life span of your tyres.

2. Regular inspection

Inspecting tyres regularly to detect wear or damage avoids a lot of sudden difficulties. It is also best practice to have an expert inspect the tyres annually.

3. Putting the wheels in balance

In Sweden, tyres are changed according to the season. When winter tyres are no longer needed, summer tyres are put back on. The wheel then usually needs to be balanced to allow for weight differences. A wheel is unbalanced when an area is heavier or lighter than another and the result is tyre bouncing or wobbling. This can reduce the life of the tread, cause vibrations and be stressful for the vehicle. To rectify this, a service professional would use a balancing machine that detects the heaviest points. Weights are then attached to the lightest areas on the inside or outside of the wheel to create balance.

4. It's time to balance tyres when:

- One or more tyres are replaced.
- A balance weight is moved or removed.
- When you change back to used tyres, eg summer or winter tyres.
- You feel any vibration or unusual wobbling whilst driving.

These numbers indicate the load index and the letter speed index

The DOT[1] number indicates the week and year the tyre was manufactured

[1] *DOT – Department of Transport*

8. Nitrogen use

Nitrogen is air after oxygen has been removed. Air naturally contains almost 79% nitrogen. When nitrogen replaces oxygen it has been demonstrated that a tyre's level of pressure stays correct for longer. Nitrogen and compressed air can be mixed and most tyres can be filled with air or nitrogen or a combination of both, as long as the recommended air pressure from the vehicle manufacturer is respected. Pressure and general tyre conditions must still be checked regularly.

9. Check the air pressure

Driving with incorrect air pressure in your tyres can affect the vehicle's handling and braking, especially in wet conditions and may endanger your safety. Driving on tyres with very low air pressure can also make the likelihood of a puncture higher.

Tyres with a too high or too low air pressure also wear unevenly and do not last as long. 20% lower air pressure in a tyre, (than specified), literally withstands 20% less mileage. This equates to a loss of 8,000km of a possible mileage of 40,000km. It is prudent to check the tyre pressure every month and before any long trip.

10. Respect the load capacity:

It is not recommended to exceed the load capacity in relation to the maximum tyre loading index. Tyres that are over burdened can accumulate additional heat and this can result in sudden breakage.

11. Keep to the speed limits

At higher speeds, the risk of tyres being damaged by obstructions in the road or heat generation increases excessively. High speeds can also cause sudden loss of air or a sudden tyre burst, which may result in losing control of the vehicle.

12. Repairing a tyre

Tyre repair is done by first dismantling the tyre from the wheel for examination on both the inside and outside. A puncture can be patched from the inside and the puncture hole filled. Do not plug a tyre. It is an unreliable way to make a repair, even temporarily. Tyre repairs should always be done by a tyre expert.

13. Tyres can be repaired if:

- The tyre has not been used in a punctured state.
- The damage is only on the contact surface of the tyre (damage on a sidewall destroys a tyre).
- The hole is not larger than 6mm.

14. Use the spare tyre

If you see damage on a tyre, replace it with your spare tyre and get an expert to check the damage.

Tyre value chain

Recycling

Recycling

In Europe, 95% of the material value of infrastructure and goods are lost after one use-cycle [20]. The percentage for Sweden is even worse. The potential for change is enormous even if the material value was only intact for a further cycle.

To reduce Sweden's environmental footprint, it is not enough to merely replace fossil materials and fossil fuels with biological ones. We also need to reduce the consumption of biological materials.

The key to shift a society like Sweden's to operate within Planetary Boundaries, is to make more use of the resources we already have and to avoid materials that are not durable and recyclable. With Planetary Boundaries and resource consumption in the spotlight we can support society in separating development from resource extraction.

Principles for reduced planetary appetite

- Apply a systemic approach and Planetary Boundaries
- Value-cycles that safeguard the value of goods and their material, application after application
- Value-cycles that put people and planet first

Recycled tyre rubber

The rubber from recycled tyres has a number of environmental, functional and economic benefits, which were outlined in a recent report [14] by the Swedish National Road and Transport Research Institute (VTI). Tyre rubber is a high-tech material that, after serving as a tyre, still has a lot to offer society.

Rubber can suppress noise, it is cushioning and insulating, it tolerates large temperature fluctuations, UV-radiation and even drains water. Rubber also provides an attractive surface for microorganisms, which, in turn can purify water. Once processed, tyres have many uses such as moulding, extruding and glueing.

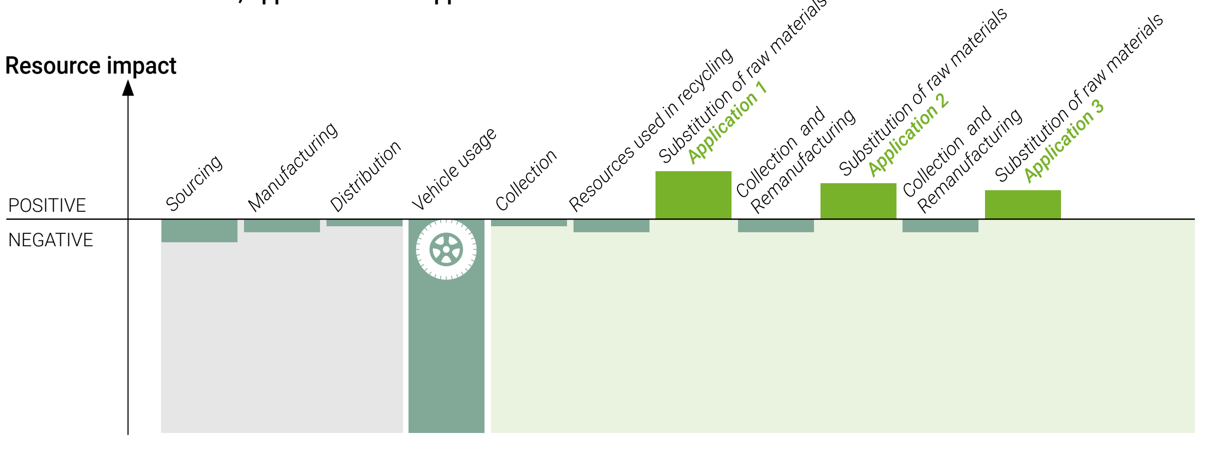
Other areas of utilisation

The many good qualities of rubber make it in demand from a number of organisations in several areas of application, including: the concrete industry, district heating, asphalt producers and wastewater treatment. Products moulded from rubber are also of growing interest. Using recycled tyre material several times over, reduces the need to extract new rubber as well as saving the other materials used in their production.

Recycling of tyres means less resource extraction

The recycling of tyres can be of benefit towards meeting Sustainable Development Goals and could help bring society's activities within Planetary Boundaries.These benefits are not very visible for societies as they typically occur in areas far from where the applications are used.

Tyre materials, shown in green, save resources when used to reduce the need for raw resources, application after application



How the Swedish recycling system works

The Swedish Tyre Recycling Association was founded by the Tyre, Rim, and Equipment Suppliers' Association (DFTF) and the Tyre Specialists' Association (DRF).

The tyre recycling system in Sweden started in 1994.

Extended producer responsibilty

Extended producer responsibility (EPR) can be summarised as *"an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle."*

Tyres that are fitted to new vehicles under 3.5 tonnes are not subject to the Producer Responsibility for Tyres Regulations and should be handled under the Producer Responsibility for Vehicles under the ELV[1] directive and the corresponding Swedish regulations.

It is not about profit

The Swedish Tyre Recycling Association is managed independently. The association is constructed as a an "SVB" Company, which by law may not pay dividends or otherwise benefit the founders. A majority of the directors of the board are external experts. The company is a non-profit-organisation, and one of the few EPR companies that have created a fund from recycling fees in order to ensure the optimisation of tyre recycling.

Small central organisation coordinates

The Swedish Tyre Recycling Association uses an independant contractor that coordinates the logistics, processing of end-of-life tyres (ELT) and markets the recycled material. The Swedish Tyre Recycling Association has taken the initiative to further advance development issues for new products and markets for recycled tyre materials.

95,000 tonnes of tyres collected every year in Sweden

The tyre importers pay an eco-fee for all tyres released into the Swedish market. This fee is used to finance the recycling system and therefore the end-of-life tyre collections are made without charge to the tyre workshops. In 2018, on behalf of the Swedish Tyre Recycling Association, 94,508 tonnes (approximately 10 million) end-of-life tyres around Sweden were collected, transported, sorted, treated and reused whole, shredded, granulated or powdered. In the granulation process, rubber, textiles and steel are separated for other uses.

[1] *ELV – End of Life Vehicles Directive*

Different types of tyres for different types of uses

Tyre sealants complicate the picture

A growing challenge is that new types of tyres may contain liquids for the purpose of sealing a puncture, repairing damage or generally as protection against punctures. The latter is especially common for lorries with trailers, where the tyres are often filled pre-emptively, as it reduces commercial downtime.

There are two main methods, self-sealing tyres and sealants:

1. **Self-sealing tyres** contain an extra inner lining filled with a thick sticky rubber compound. If the tyre is punctured, the compound stops the tyre deflating. This compound hampers the shredding of end-of-life tyres during the recycling process.
2. **Sealants** are thinner compounds that are usually injected through the tyre valve. Once moving, the rotating force of the tyre distributes the compound onto the inner surface of the tyre to repair the damage. These fluids can also affect the recycling processes and may cause health and environmental problems.

Tyres with tyre sealants need to be separated and alternative recycling methods must be developed for them.

An important way to realise the potential to increase tyre recycling would be to define and further sort different tyres for different types of usage. Whilst the tread of a passenger car tyre contains silica, other parts of the tyre use carbon black as a filler. The same applies to larger tyres as a whole. New technology of puncture fluids, run-flat systems, sensors, noise reduction, etc, also increases the number of tyre variants. Each manufacturer has its own recipe to bring about the desired properties in their products. The continued development of recycling will require tyres to be sorted, both on the basis of their suitability for material recycling and their specific applications, both technically and commercially.

Industrial and small scale processes on the horizon

The sorting of tyres is not yet developed as an industrial process and in most cases, tyres still require manual handling. 'Artificial Intelligence Aided' sorting projects are underway in several countries, including Sweden. However, tyres are marked on the tyre walls and the technology has not advanced sufficiently to be able to accurately read from worn black surfaces. The technical processes for the decomposition of tyres is evolving and this technology currently permits both local and mobile units to cut and granulate tyres.

Sealant injected through the tyre valve

[1] *Energy extraction – The rubber in tyres has a high energy content. When a tyre is worn out, that energy can be released and utilised in Steelworks, District Heating or Foundries and Cement works.*

Why can’t we make new tyres out of old tyres?

This question has been high on the tyre industrys agenda since the invention of vulcanisation. There are two main obstacles.

1. The chemical bonds are extremely hard to break

The sulphur bonds that tie the carbon chains together in vulcanised rubber are very difficult to break in a manner suitable for revulcanisation[1].

2. The variety of tyres in use

Each manufacturer has its own recipie of ingredients in their tyres and if different tyres are recycled together, the resulting granulates or powder will contain all the different substances from all the different tyres. This could interfere in ways that are hard to foresee. The age of a tyre and even tyres from different production sites from the same manufacturer may also have different contents.

Advancements are being made

Experiments have shown the possibility of mixing up to 25% devulcanised rubber or 10% micro-granulated rubber into some new tyres. More advanced sorting, testing and logistics are being developed to enable this to become a reality.

Pyrolysis to recycle carbon black, rCB

Through pyrolysis carbon black can be extracted from rubber and mixed into retread for lorry tyres. This market is very small and in addition, the recycled carbon black only constitutes a fraction of the tyres weight. Pyrolysis so far is an inferior method from the viewpoint of making new tyres out of old, in comparison to revulcanised or micro-granulated rubber. Additionally it destroys the rubber entirely. A unique material that otherwise would be suitable for reuse within a circular economy and reduce the need for new raw material extraction.

EU critical raw material list

Natural rubber is now listed on the EU critical raw material list, it is clear that reducing dependency on raw materials is an important objective towards sustainability.

[1] *revulcanisation – a chemical process used to harden rubber*

Recyling end-of-life tyres – a wide range of uses

Rough shreds

Tyres can be shredded into pieces of 50-250 mm and can be used as drainage material and as an alternative for natural gravel.

Rough shreds

Fine shreds

Tyres can be shredded into pieces of 15-50mm and used as bases in ground beds for water purification and as an alternative for natural gravel.

Granulates

After the separation of steel, textiles, studs and gravel, granulates are made with selected grain sizes up to 6mm. Granulates have sought after properties and are used in many ways such as in rubber asphalt, foundry-tails or as infill for artificial turf.

Powder

The finest granulates can be blended into paint for sound attenuation or used as a sub-component in the manufacture of new tyres and other moulded products.

Devulcanisation[1] and revulcanisation

Most often, only the tread is used for devulcanisation. Using various processes (mechanical, microwave, chemical or biological), the sulphur bonds of the vulcanisation are broken. This recycled material can then be mixed into new tyres (in low percentiles) and other rubber products which can be used for sound, vibration and shock absorption.

Pyrolysis

By heating the tyre material in an oxygen free enviroment, the steel, textiles, oil and carbon black are released from their bonded forms within the rubber, as well as retrieving oil. This method has been used to recycle carbon black from tyres. However in a Systemic Impact Analysis, pyrolysis does not currently yield higher benefits than using the rubber in other ways, for example, in cement works. Pyrolysis is still in the development stage. It also destroys rubber and all its unique properties are lost.

Moulded and cast rubber products

Cast products of recycled rubber are well established in some markets, for instance in Germany, but have not yet picked up momentum in Sweden.

Reuse whole tyres

If tyres that are brought in for recycling are in a good enough condition they can often be reuseable. Entire tyres can also be used in shipping, as fenders, playgrounds and in the cement industry.

Tractor tyre fenders

[1] *Devulcanisation – the processing by which polymer attributes of vulcanisation are reversed, so as to restore the materials that were present prior to vulcanisation*

Varied demands for new uses of recycled tyre material

The potential for using recycled goods is high but is currently being slowed down as the rules in Sweden favour the use of raw materials over recycled, even when the contents and characteristics are identical.

Recycled tyre material is classified as 'waste' in Sweden, and comes with associated restrictions in handling; it is also subject to transport and permit requirements for its use.

The Swedish Tyre Recycling Association has defined criteria for when and how recycled tyre materials may be used.

This is to optimise the benefits for the Swedish economy, for public health through applications such as sports facilities and the environment by reducing the need for new raw material extraction.

Environmentally friendly water treatment using tyre rubber

Tyre rubber has been successfully used internationally for sewage treatment for over 20 years. Now there is also increasing interest in Sweden. One Swedish company conducts research on systems where wastewater is purified in a bed of shredded tyres. Shredded tyres replace natural gravel, a finite resource that is now increasingly being protected. New studies have shown that there is also a possibility of recycling phosphorus with the help of end-of-life tyres.

Water purification

Other tyre material uses

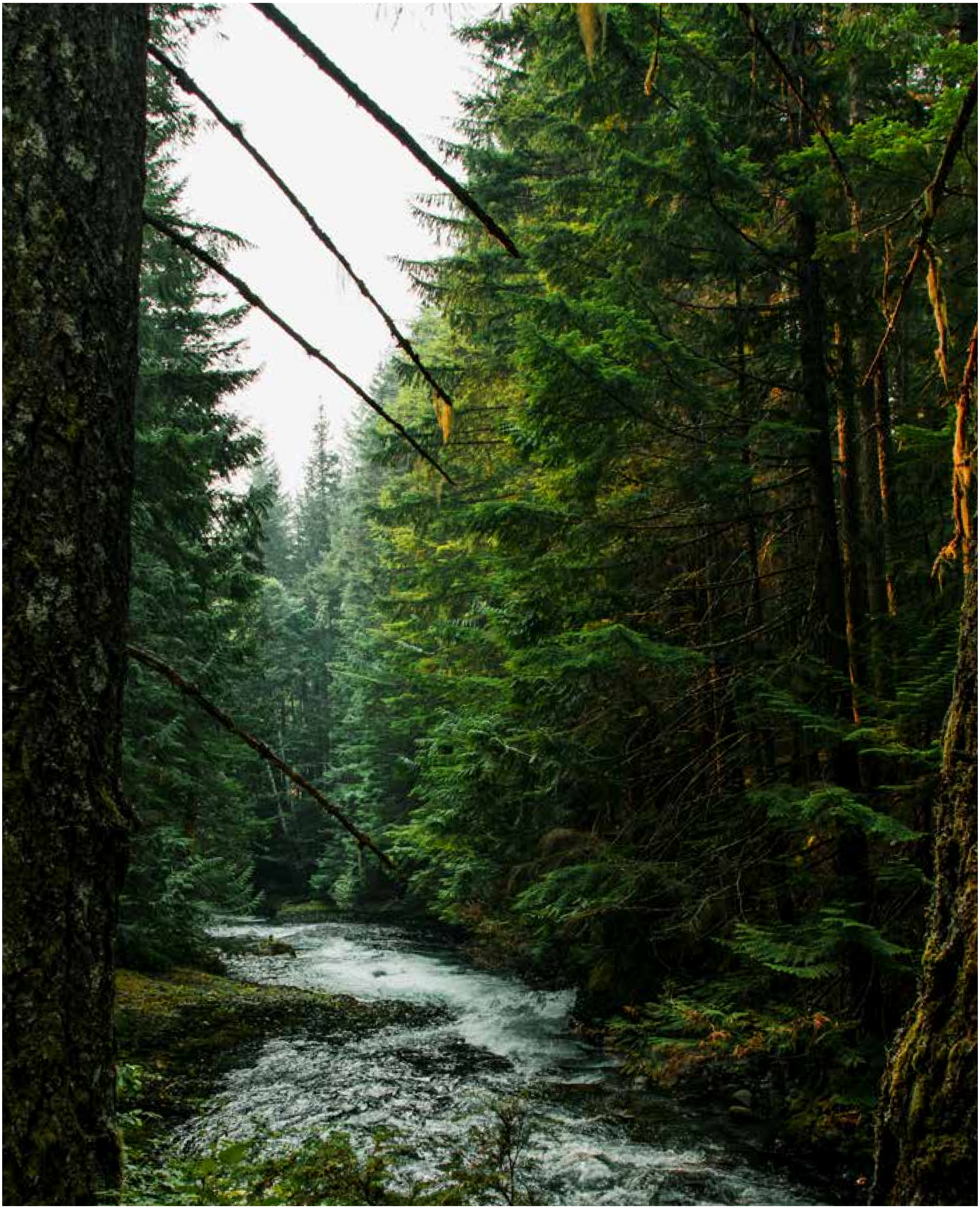
1. Ground and construction works
2. Asphalt
3. Industrial and consumer products
4. Drainage
5. Artificial turf pitches
6. Water purification
7. Playground surfacing
8. Sports and leisure facilities

Shock absorbing cycle lanes

In Sweden the amount of cyclists injured in traffic has increased. Over 23,000 people per year visit an acute care hospital after being injured whilst cycling. To reduce injuries, the bicycles lanes' properties can be modified. This would result in safer cycling and limit the severity of head injuries. This means modifying pavements and cycle lanes by replacing coarse aggregates and sand with rubber chips and rubber crumbs to increase the shock absorbent capacity and therefore, safety.

Cycle lanes

Running tracks



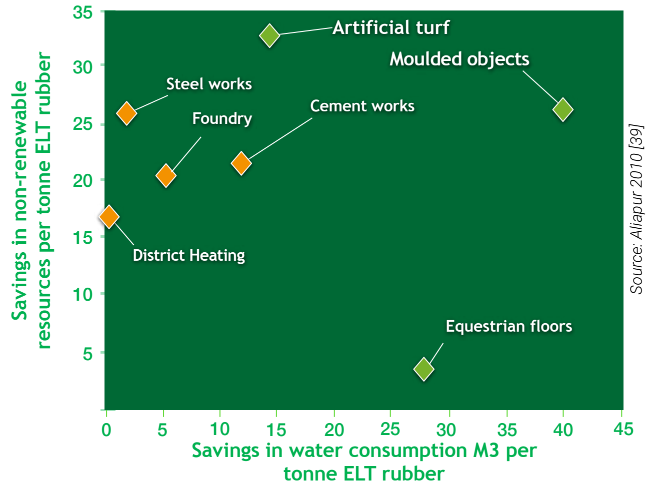
Maximising environmental and social benefits

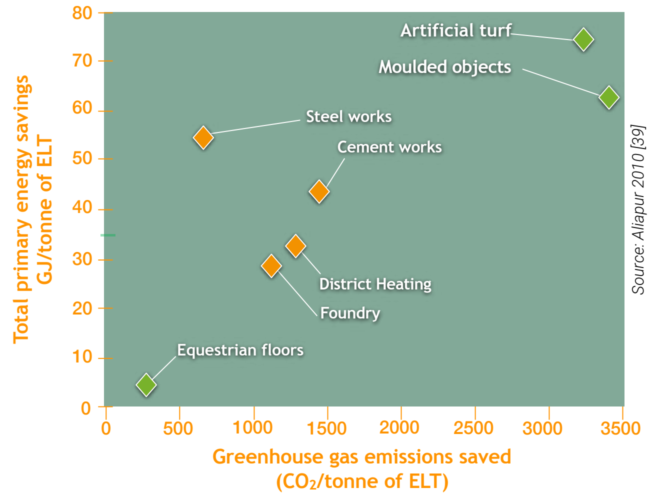
There are many applications for recycled tyre derived material which could have community and environmental benefits. Saving raw materials by using the rubber from end-of-life tyres (ELT) provides a host of benetifs.

Here are examples of raw material savings from using ELT-rubber instead of raw materials. [39]

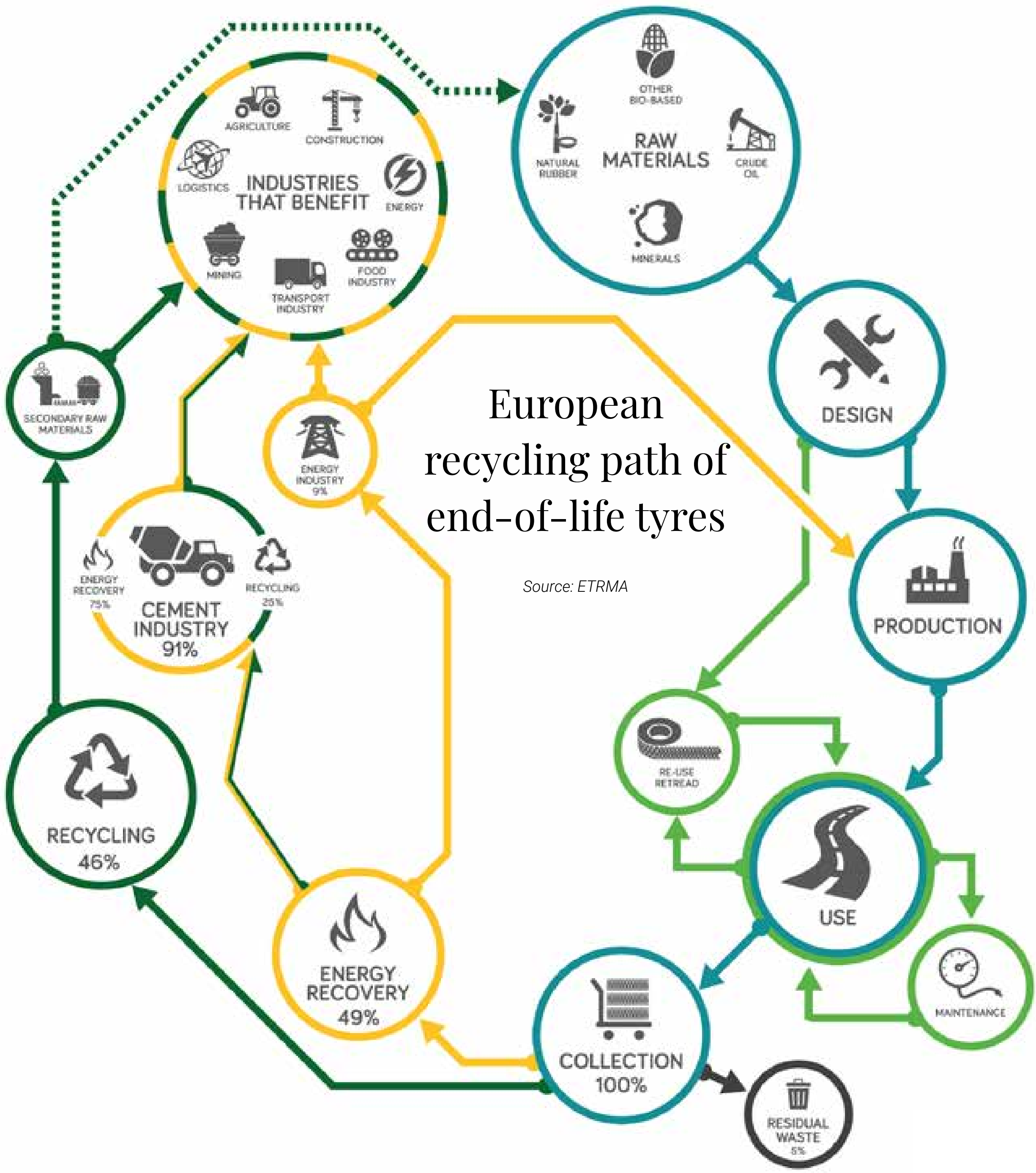
- **Rubber backing for riding paddocks**
  saves the use of 44 tonnes of sand per 1 tonne of rubber.
- **Cement production**
  each tonne of rubber saves 700kg of coke and 300kg of coal.
- **District heating**
  each tonne of rubber saves 1.15 tonnes of carbon or the equivalent amount of oil.
- **Artificial turf with ELT rubber**
  yields large savings, regardless of whether it is natural grass, cork or EPDM[1] rubber that is replaced. In the case of EPDM, the ELT rubber saves 0.5 tonnes of raw EPDM and 2 tonnes of chalk in an artificial turf.

The below graphs show the savings in terms of energy and raw materials and which application provides the highest environmental benefit





[1] *EPDM – Ethylene Propylene Diene Monomer Rubber (synthetic rubber)*



European recycling path of end-of-life tyres

Source: ETRMA

Industrial and small scale processes on the horizon

The sorting of tyres is not yet developed as an industrial process and in most cases, tyres still require manual handling. 'Artificial Intelligence Aided' sorting projects are underway in several countries, including Sweden. However, tyres are marked on the tyre walls and the technology has not advanced sufficiently to be able to accurately read from worn black surfaces. The technical processes for the decomposition of tyres is evolving and this technology currently permits both local and mobile units to cut and granulate tyres.

The vision for the future of recycling in Sweden

In line with the objective of reducing Sweden's appetite for raw materials by at least a factor of 4, the life span of end-of-life-tyre materials needs to increase. A car tyre is typically used for 4-6 years, however, if used in other ways, it can extend its life many times over.

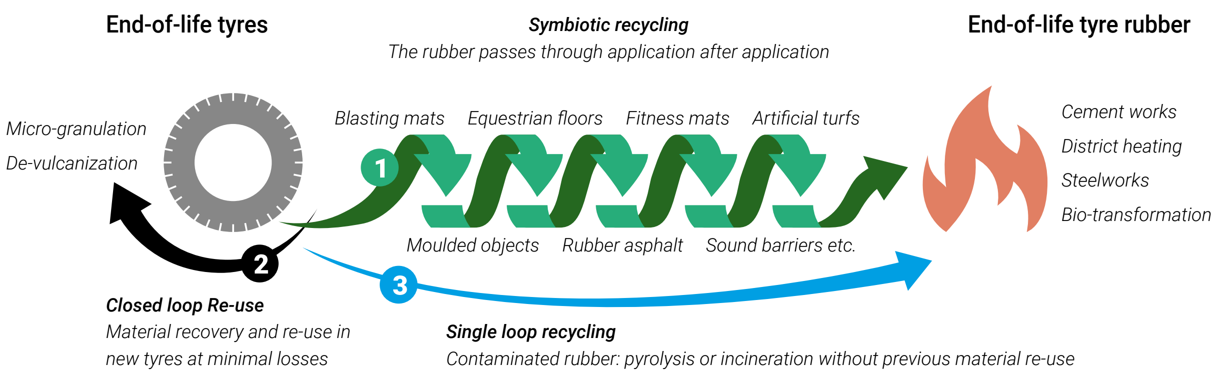
Development accelerates

The challenge lies in finding uses for the material that both contributes to sustainability goals and is commercially viable. Fortunately, the development of new applications for recycled tyre materials in Sweden is accelerating.

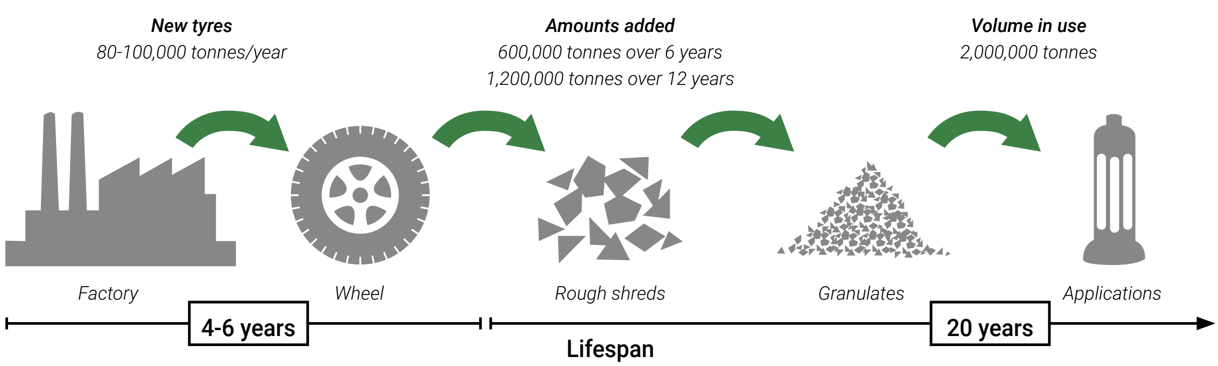
The future

The work that is done within The Swedish Tyre Recycling Association and its international equivalents is geared to increase tyre material recycling. With the support of politicians and authorities, material recycling can increase many-fold, reducing our societies' need for raw resources each time.

The tyre can take three recycling routes



1 The symbiotic path – the volume of recycled tyre material increases over time



Optimised recycling loops

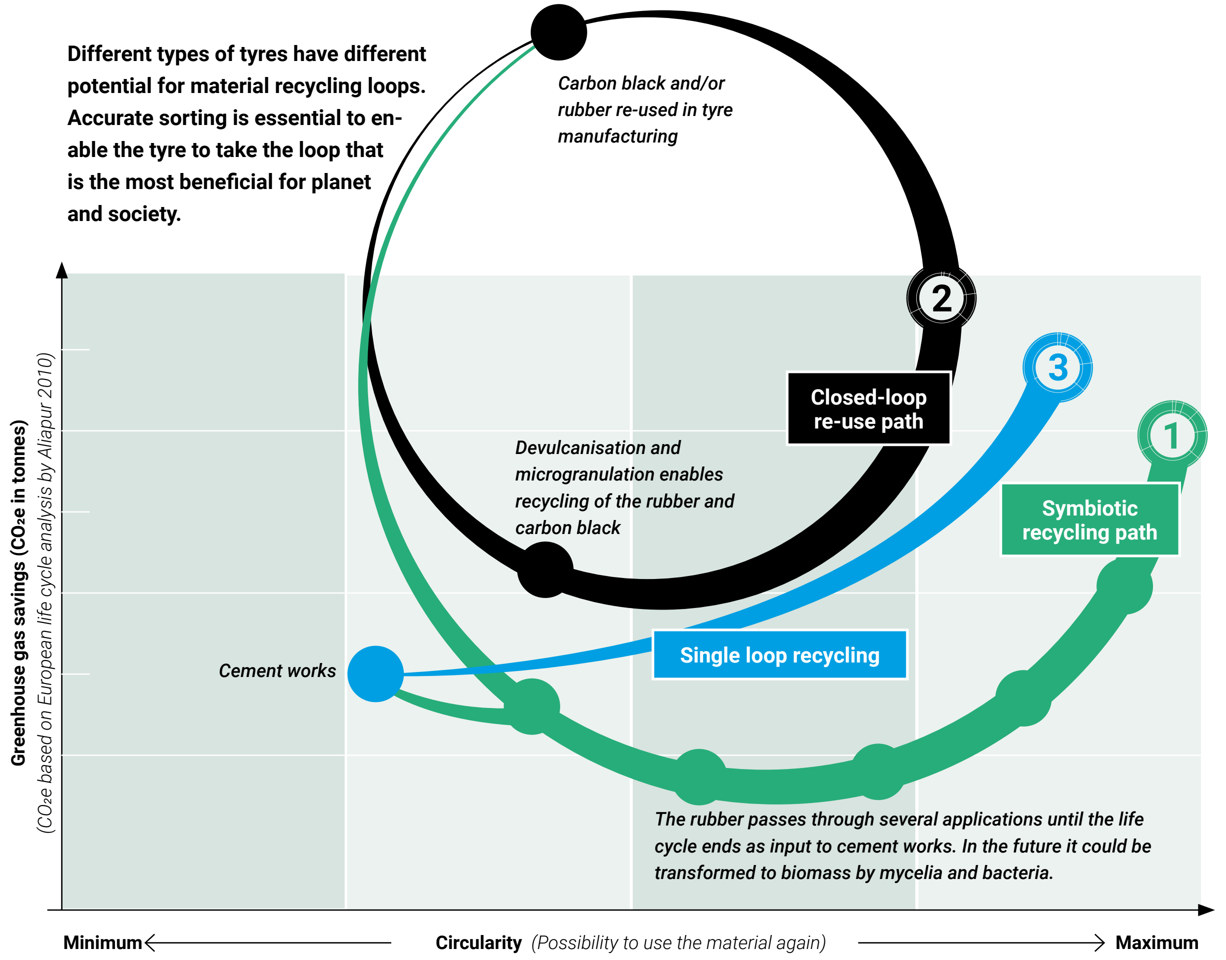
There are three different types of recycling paths.

1. **Symbiotic recycling path**
   The raw tyre material is recycled in a wide range of applications before the rubber is worn out and in this example, it completes its life cycle at a cement works or through pyrolysis.

2. **Closed loop reuse path**
   Tyres are selected for devulcanization or micro-granulation.

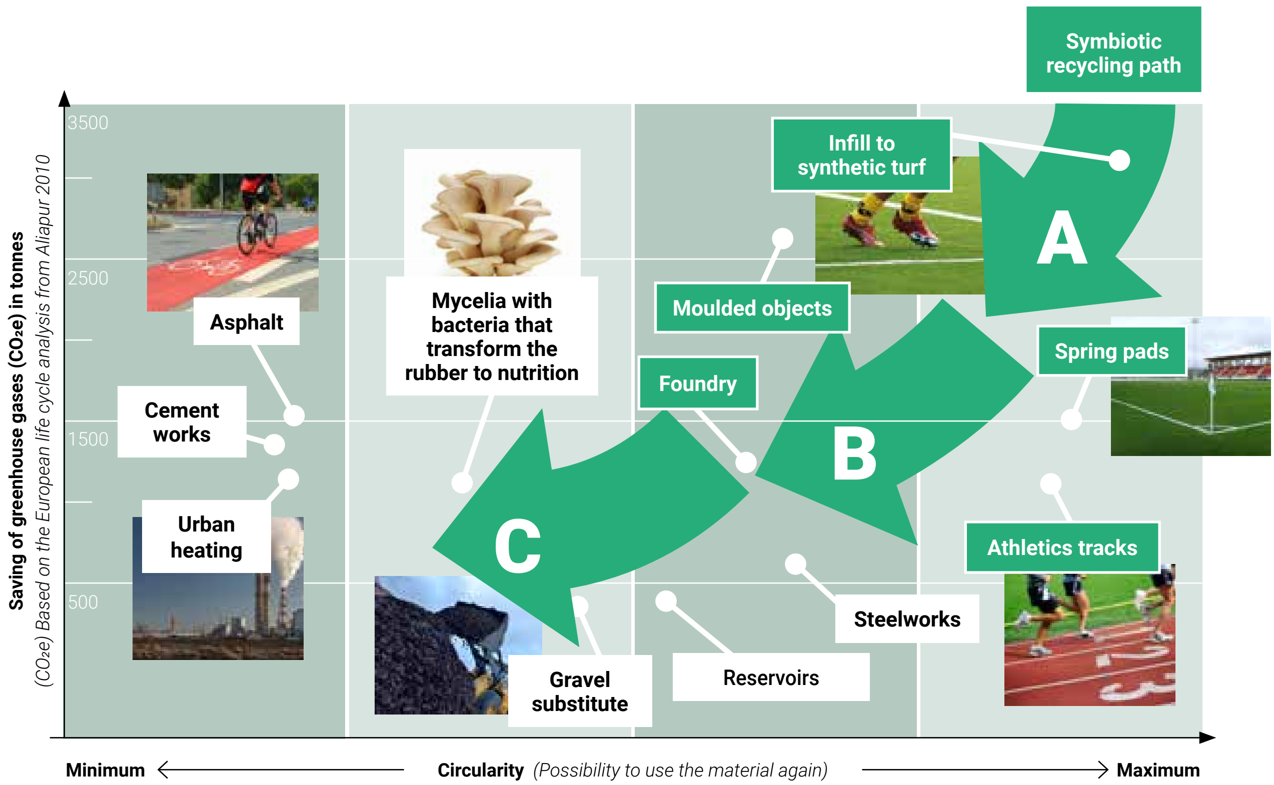
3. **Single loop recycling**
   Tyres containing anti-puncture systems make the rubber material difficult to use in new products. These tyres are sent directly to be incinerated, most likely at a cement works.

Different types of tyres have different potential for material recycling loops. Accurate sorting is essential to enable the tyre to take the loop that is the most beneficial for planet and society.



1 The symbiotic recycling path

The diagram compares different applications for end-of-life-tyres from two perspectives, greenhouse gas savings and circular economy. The goal is for the rubber to be reused in as many ways as possible, starting with the use that has the highest environmental benefit. For every new step of reuse, we reduce the impact on our planet's resources and reduce greenhouse gas emissions.



2 Closed loop recycling options - limited potential

Devulcanisation: reusing the rubber compounds

- Up to **25%** of rubber, including carbon black, can be used in some types of tyres.
- 100% of an end-of-life tyre is recycled. The steel can be recovered and sold as commodity, only the textile may be destroyed.
- The market for devulcanised rubber is limited. Currently it is primarily used for off road tyres and other rubber products.

Micro-granulation: using old rubber for new tyre

- Up to **10%** of rubber, including carbon black can be used in some types of tyres.
- 100% of an end-of-life is recycled. The steel can be recovered and sold as commodity and only the textile may be destroyed.
- The market for micro-granulated rubber is limited. It is primarily used for off road tyres and other rubber products.

Pyrolysis

- Carbon black is extracted from rubber and mixed into new components. **10%** of the new carbon black can be replaced by recycled carbon black.
- Pyrolysis is an inferior method. The rubber is destroyed and cannot be reused.
- Significant development is needed before recycled carbon black quality improves.

3 Single loop recycling options

Devulcanisation is preferable, but there is no volume market yet

Devulcanisation is preferable when:–

- there is an established 'commodity' market for recycled devulcanised rubber.

Cement works are the best option for rubber that cannot be reused in new products

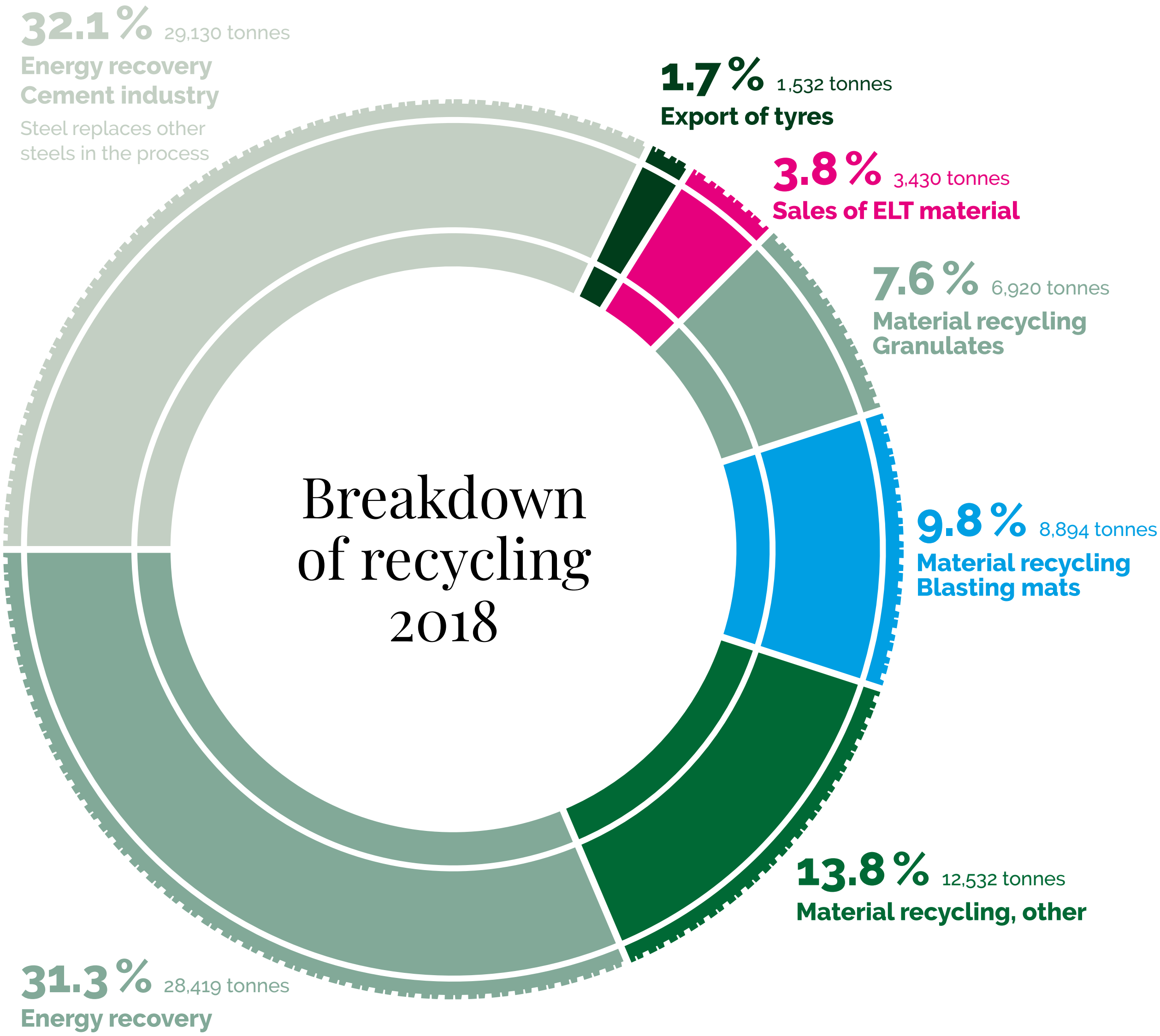
Cement works are preferable when:–

- the economy or material content is not suitable for granulation and/or when the symbiotic recycling path is over.
- when the bio content of tyres is valuable as energy.

District heating when other options are not possible

District heating is preferable when:–

- other recycling options are not feasible due to market constraints or unreasonable economic conditions.
- it replaces fossil fuel or biomaterials.
- there are temporary environmental benefits, based on life cycle analysis.


32.1 % 29,130 tonnes
Energy recovery
Cement industry
Steel replaces other steels in the process
1.7 % 1,532 tonnes
Export of tyres
3.8 % 3,430 tonnes
Sales of ELT material
7.6 % 6,920 tonnes
Material recycling
Granulates
Breakdown of recycling 2018
9.8 % 8,894 tonnes
Material recycling
Blasting mats
13.8 % 12,532 tonnes
Material recycling, other
31.3 % 28,419 tonnes
Energy recovery

Pioneering products

Tyre materials have a wide range of potential uses based on their characteristics, that have been optimised over the past 100 years.

Tyre rubber is:

1. Elastic
2. Shock absorbing
3. UV-resistant
4. Weight-optimised
5. Vermin-resistant

Tyre rubber also:

6. Isolates against electrical currents
7. Insulates against heat and cold
8. Withstands chemical exposure
9. Withstands mechanical abrasion
10. Handles high and low temperatures
11. Does not emit undesirable substances
12. Handles sudden and extreme variations of temperature

Creativity and innovation

The Swedish Tyre Recycling Association is involved in a number of highly innovative projects. It is still too early to evaluate how successful the projects will be, but they may serve as examples of how to approach future sustainability issues with recycled materials.

Capturing and recycling phosphorus

It has been demonstrated that tyre shreds, with a special pre-treatment, can bind phosphorus[1] within their structure. The shreds can later be made to release the phosphorus they bind allowing it to be recycled. The tyre shreds can also be used again.

Soil enhancement

Tyre granulates are already used as soil improvers as they increase the porosity of soil, giving air and water the opportunity to reach plant roots, even in packed soil. There is also science showing how the use of mycelium[2] as well as bacterias, can purify and restore the carbon in synthetic and natural rubber.

Lighter, stronger concrete

The rubber from recycled tyres and the steel retrieved from it (it is retrieved as a thick steel wool) can make the strength and weight of cement constructions significantly lighter and stronger. This enhanced cement can often replace other products, such as plaster (resulting in less greenhouse gas emissions) and reduce water and raw material consumption than the existing alternatives.

New types of materials

As shown in the case of adding recycled tyre material to cement, the compound materials then have properties that exceed the constituent components. A cement wall, with rubber granulate is lighter, stronger, absorbs sound, insulates and also stores excess heat. A cement construction containing steel wool from tyres is strong, conductive and resilient, in ways that are unlike other cement compounds. The same type of effect occurs when combining end-of-life tyre materials with other products. Molecules can bind tyre material and other substances together, such as cellulose, wood fibres and polyethylene. There are experiments being made which examine whether tyre material can be made fully biodegradable by means of activating a dormant bacteria.

Water purification

Tyre shreds provide an excellent surface for naturally occurring microorganisms to establish a biofilm that purify water from pollutants, heavy metals and more. This application has been proven successful for drainage water purification from landfills as well as grey and black household waste water.

[1] *Phosphorus – one of the most important building blocks for living organisms*

[2] *Mycelium – a fungi which produces enzymes that can break down the tough, aromatic hydrocarbons found in rubber*

Fact or fiction?

The way forward

We are all aware, whether we choose to believe it or not, that as a species we are using our habitat's resources faster than nature can replenish them. At some point a line has to be drawn and changes have to be made.

Television, social media and the internet spread a great deal of false information. Tyres are an easy target and they are frequently blamed for environmental issues that the industry and its products are not responsible for. Many reports inaccurately blame tyres and rubber tyre material for polluting the sea, the air, endangering health and putting the planet at risk. This white paper is based on the latest available research and information regarding tyres, tyre rubber and end-of-life tyre recycling and highlights the methods that can be used to determine its best use.

Who has produced this white paper and why?

The Swedish Tyre Industry Association has produced this white paper to put forward ideas, goals and opportunities in recycling and to outline how the industry may work towards a sustainable future and a circular economy. A part of this white paper is also dedicated to explaining *and where necessary*, counteracting the volumes of widespread information and misinformation about end-of-life tyre material recycling and use.

To achieve this, the authors needed to analyse hundreds of documents and reports and cross reference the data. They are confident that the information presented in this report is balanced and accurately portrays the risks and remedies for the tyre industry to move forward into a sustainable future.

Rubber is a valuable natural resource. The tyre industry relies on it and has both a responsibility and an opportunity to make significant improvements as to how rubber is used and reused.

The aim of this document is to demonstrate rubber's safety and attributes, whilst encouraging policymakers, the tyre industry and even the general public to recognise the substantial value of this natural resource. It is vital that we embrace the use of natural rubber, value it, use it and maintain its value by recycling and reusing it, thus reducing the need for raw materials.

Are the facts in this white paper based on scientific evidence?

Yes! And every fact is referenced. This detailed approach has been essential to be able to recommend a way forward for the industry and our association members.

Government, councils, legislators

Policy and decision-makers can also rely on the accurate analysis contained within this white paper which contains the answers to many questions and hypotheses regarding the future of rubber as a raw material, tyres and their recycling uses.

Sample questions:

- What is the supporting data and where has it come from?
- What are the potential adverse affects of not recycling?
- What are the alternative solutions that achieve the same results but in more sustainable ways?
- What are the risks of inaction and are these risks verified?
- Is it possible to act immediately and how/where do we start?
- What are the potential adverse affects of not moving into a circular economy?

8 point Systemic Impact Analysis

The Swedish Tyre Industry has developed this analysis as a valuable tool to use when analysing the best application of recycled tyre material. In the next section there is an example of its use in analysing the use of recycled rubber as infill for artificial turf pitches.

When assessing information or an application, it is prudent to begin with these three questions:

- What is the risk?
- Is it substantiated?
- Taking into account sustainable goals and Planetary Boundaries, what is the remedy?

Then apply the 8 point Systemic Impact Analysis to your selected application.

This white paper is a signal of the beginning of a new era in the tyre industry and its recycling processes which contribute to the stability of the planet. We are fully supportive of the messages presented here and want to encourage the industry to move forward into a more sustainable future.

Tyre and Road Wear Particles Fact or fiction?

What are Tyre and Road Wear Particles?

The primary function of tyres is to grip a vehicle to the road, which is a vital aspect of road safety. To create this grip, friction needs to be made. Friction leads to an abrasion effect between the tyre and road. This abrasion effect generates particles known as Tyre and Road Wear Particles (TRWPs).

TRWPs are a mixture of tyre tread fragments and road surface particles, such as minerals, sand and road dust.

The TRWPs generated are influenced by a variety of external factors such as: road surface materials, road topology, the type of tyre in use, vehicle characteristics and driving behaviour. There are many ongoing areas of investigation and analysis addressing road and tyre TRWPs, which are referred to as 'unintentionally released microplastics'.

The ETRMA leads a multi-sectorial forum which aims to create an open and inclusive dialogue amongst all relevant stakeholders, build scientific knowledge and investigate the creation and release of TRWPs into the environment. [52]

The difficulty with analysing the causes and effects of TRWPs is that they require us to look at the picture as a whole. There are numerous factors that need to be taken into consideration. Here is an example regarding the difference between winter and summer tyres that demonstrates the complexities of the analysis.

Fiction

Unstudded winter tyres create *less* dust than studded tyres.

Fact

On roads that are gritted during the winter months, unstudded winter tyres create aproximately 150% *more* road dust than studded tyres. This is because the more spacious tread patterns of unstudded tyres, create a vacuum that pulls the dust into the tread and then flicks it up into the air. Unstudded tyres produce *less* dust than studded tyres *only* when the roads are entirely free of sand. In icy conditions, studded tyres improve road grip for unstudded winter tyres, which would reduce the amount of sand needed to be spread on the roads. To reduce the dust levels, other measures could be taken such as, less gritting in winter, shifting to more environmentally friendly substances other than sand or grit and by reducing speed limits.

Winter studded tyres

Rubber contains high levels of polycyclic aromatic hydrocarbons (PAH) – Fact or fiction?

The Swedish Tyre Industry Association has looked into the potential health risks from PAH in great detail and studied many reports which highlight, analyse and explain varying truths, myths, and misconceptions about PAH and tyres.

Due to the level of misinformation published, over recent years many Government Health Ministries around the world have also looked into this subject. Their findings mirror those of the analysis that the Swedish Tyre Industry Association has undertaken and they conclude that rubber is a stable and safe material to work with. It is in fact, quite a remarkable natural substance and we rely on rubber more than we realise. Our children use it to correct pencil mistakes, it is present in millions of everyday products and we even rely on rubber to save our lives... in the form of tyres.

On this page we have highlighted the points which occur most frequently in the media, surrounding tyres and their suitability for use, along with the researched and documented, scientifically proven replies.

Fiction

Tyres and recycled tyre materials are responsible for considerable health risks to tyre industry workers, the general public and the environment, from the release of high quantities of PAH.

Fact

Tyres have been a target of much speculation regarding PAH and have been blamed and linked to harmful health conditions. Tyre rubber has a very low PAH content level, even lower than grilled red meat. Tyres are produced in accordance with European regulations to ensure the health of the workers producing the tyres, where people are exposed to the material on a daily basis. The material is just as safe for other persons coming in contact with it. This is verified by several national health ministries, independent researchers and also by ECHA.

Fiction

Rubber releases high levels of PAH into the environment.

Fact

Tyre rubber is a very stable material. Stringent tests performed worldwide, have shown that the trace amounts of PAH currently found within tyre rubber comes from the carbon black and oils produced by oil refining. It is as a consequence that PAH ends up in a tyre, it is not a purposeful addition and the amounts contained are extremely low. Notwithstanding this fact, tyre rubber when vulcanised, acts like a safe, binding any PAH both physically and mechanically deep within its molecules. Even abraded tyre particles do not release PAH into the environment and therefore have no detrimental health effects. Historically, the PAH content of tyres was higher due to the use of high-aromatic (HA) oils. These oils were prohibited for use in Europe in 2010.

Fiction

Tyre granulates release large quantities of PAH when chopped, ground or burned.

Fact

Even when ground to a powder, PAH remains stable and is maintained within the molecular structure of each tiny microscopic spec. It is not released into the environment.

When tyres are burned in cement kilns or in household rubbish incinerators, the PAH is eliminated in the combustion.

End-of-life tyres are harmful – Fact or fiction?

One of the Swedish Tyre Recycling Association's tasks is to change these erroneous images by being an active voice within the industry and by refuting incorrect facts about tyre materials. They also promote a systemic approach to thinking about tyre usage and the recycling of end-of-life tyres.

Fiction

When end-of-life tyres, shreds and granulates are stored outside for long periods of time, heavy metals and other harmful substances can leak out and are harmful to health and the environment.

Fact

There are more than 100 studies that have analysed the potential risk of harmful substances leaking from tyres and there has been no level of concern identified regarding health or the environment. Initially, Zinc (which is not considered a hazardous metal) may be released from tyre material but the amounts released are so low that they are even below the limits allowable to be present in children's toys in Europe.

Fiction

Tyres left outside or stored outside are hazardous and unregulated.

Fact

Outdoor tyre storage is regulated by local authorities and a part of this is to ensure that there is little fire risk. Tyre storage areas need to be separated by fire gates of sufficient width, so that a fire engine could enter the area if needed.

Fiction

End-of-life tyre granulates are often described in the media as both harmful to health and a source of microplastics in the sea.

Fact

Recycled tyre material is one of the most carefully controlled materials on the market and there have been a number of independent Swedish and international studies in terms of health and the environment.

It is a misconception that products from recycled end-of-life tyres would be harmful for health or a source of microplastics in lakes or in seas.

End-of-life tyre granulates are safe for artificial turf Fact or fiction?

A number of international studies, including one by the European Chemicals Agency (ECHA) and other Public Health Ministries worldwide have examined the case of rubber granulates when used as a filler material for artificial turf football pitches. Their reports have concluded that the granulates do not cause any health risks.

A major problem is that the available information from many government agencies and media organisations is often outdated and sometimes directly misleading. One such example is the Swedish Environmental Institute's (IVL) often quoted report, from 2016, ”Swedish sources and pathways for microplastics to the marine environment” [51], which states that...

Fiction

...the gross figure for the refilling of rubber granulates for artificial turf football pitches (which in the report is quoted as 3-5 tonnes per pitch per year) is the *actual* amount of microplastics that end up in the sea.

Fact

This opinion is simply incorrect. The volume of granulates that could possibly spread to the natural environment would measure in grams, not tonnes. Rubber granulates do not migrate from a football pitch by themselves nor by the forces of nature. In the event of heavy wind or rain, the granulates stay where they are, due to the fact that they are heavy. The structure of the turf also helps maintain the granulates within its straws.

Subsequent research reports on this topic are also incorrect. A closer inspection of their data reveals that the rubber granulates, referred to as microplastics, all came from other sources.

Fiction

The rubber granulates from end-of-life tyres contain dangerous substances, such as heavy metals, that leech into the environment and poison living organisms.

Fact

Rubber granulates from end-of-life tyres can leech very small amounts of zinc (which is not a dangerous metal) for a few months, if the granulates are not washed during the manufacturing process. Rubber does contain other components which could be considered harmful should they leech into the environment, but they are present in very low amounts. Due to rubber's unique properties and the vulcanisation process, these components are contained in the rubber at a molecular level. Recent European Risk Assessment Studies on Synthetic Turf (ERASSTRI) concluded that end-of-life tyre granulates are non hazardous. Their findings were a result of studies on footballers who regularly play on artificial turf with rubber granulate infill (and have had exposure over a long period of time).

Fiction

When artificial turf pitches' granulates need to be topped up (sometimes annually), it is because the 'missing' granulates must have gone somewhere else.

Fact

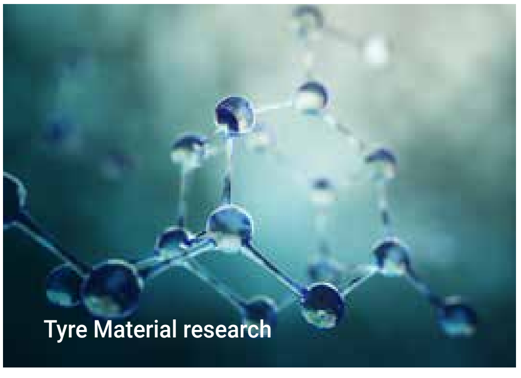
Rubber is a resiliant, durable and flexible substance even when granulated. After a period of use on an artificial turf football pitch the granulates become compacted, in this case by footballers' boots. If the pitch is not properly maintained, the compacted granulates do not give the same level of protection to the synthetic turf straws and as a consequence the ball does not roll as it should. For this reason, additional granulates are added on top. The original granulates, now compacted, remain in their original place.

The Tyre Industry Project

The Tyre Industry Project was formed in 2005 as a voluntary, CEO-led initiative and was implemented by the eleven leading tyre companies[1], who represent approximately 65% of the world's capacity of tyre manufacturing.

The Tyre Industry Project has also established working groups that address the questions of tyre industry such as:

- Tyre recycling
- Tyre and road wear particles
- Nanomaterials
- ISO Standards
- Environmental key performance indicators
- Tyre material as raw material (End-of-Life Tyres, ELT)
- Tyre material research
- Industry environmental impacts and measures



[1] *The eleven largest global tyre manufacturers are:*
Bridgestone Corporation – Continental AG – Cooper Tire & Rubber Company – The Goodyear Tire & Rubber Company – Hankook Tire Co. Ltd – Kumho Tire Company Inc – Michelin – Pirelli Tyre S.p.A – Sumitomo Rubber Industries, Ltd – Toyo Tire & Rubber Co. Ltd – The Yokohama Rubber Co. Ltd

Changing perspectives

"In the field of human environment there is no individual future, neither for human beings nor for nations.
Our future is common.
We must share it together.
We must shape it together."

Olof Palme

Former Prime Minister of Sweden
UN Conference on the Environment 1972

We shape our future together

The Swedish Tyre Industry Association has decided to take nic content make them highly suitable for a circular economy.

Shifting paradigms for resource efficiency

Vehicles are an important cornerstone of modern life. Despite the continuous improvements made by a high-tech vehicle industry, there is still a great deal of potential to dramatically improve the efficient use of resources on a systems level.

On average, over a 24 hour period, passenger vehicles are parked 95% of the time and being used only 5% of time.

Of the 5% of the day that cars are in use:

- 3% is moving.
- 2% is stuck in traffic jams.

Shared vehicles free up urban spaces

Shared fleet cars, car sharing, pool cars and autonomous vehicles will be able to increase the 3% moving rate dramatically whilst simultaneously liberating large areas of land in cities that are used for vehicles. Connected, integrated systems can also help transport systems work better together, where, for instance, public transportation collaborates with autonomous vehicle sharing.

Cities and towns moving forward

The technology for the development of effective public transportation already exists, but their administration and politics have not changed at the same rate, so we continue to sit in traffic.

There are several examples of cities in Europe that are working to optimise their transportation systems. Helsinki and Vienna are both working towards having integrated transport platforms. Stockholm, Malmo, Gothenburg, Zürich, Oslo, Munich and many other cities are investigating various measures for the improvement of transport to simultaneously liberate spaces and resources. Green spaces, pedestrian areas, cafés and parks could replace car parks and this would enable the release of areas of land which can also help to avoid species extinction.

Autonomous and shared cars will drastically reduce congestion, pollution, and fuel consumption. Electric cars will reduce fuel consumption even further.

Traffic jams: resource inefficiency

This is an opportunity for radical change and improvement, for our lifestyle as well as for the planet.

This is how many people start and end their day. A paradigm shift is required to move to efficient resource use.

How to apply the: Systemic Impact Analysis 8 point criteria

The Swedish Tyre Recycling Association strives to ensure that existing technical materials are re-used thus reducing our societal footprint on the Earth's ecosystems. A traditional Life Cycle Analysis (LCA), examines a product's activity or function based on the total environmental impact of different options in individual products. The analysis is developed from a linear approach where a value chain is to be optimised from the perspective of environmental impact. Recycled products often come out as advantageous from this perspective. To avoid sub optimisation it is important that a systemic approach is taken.

The greatest possible benefit to the environment

In the context of a systems approach, we need to ensure how a recycled material can provide the best benefit. Further analysis may show that a recycled material can be of a greater environmental benefit in different application than the one initially studied.

Must be able to be translated into practice

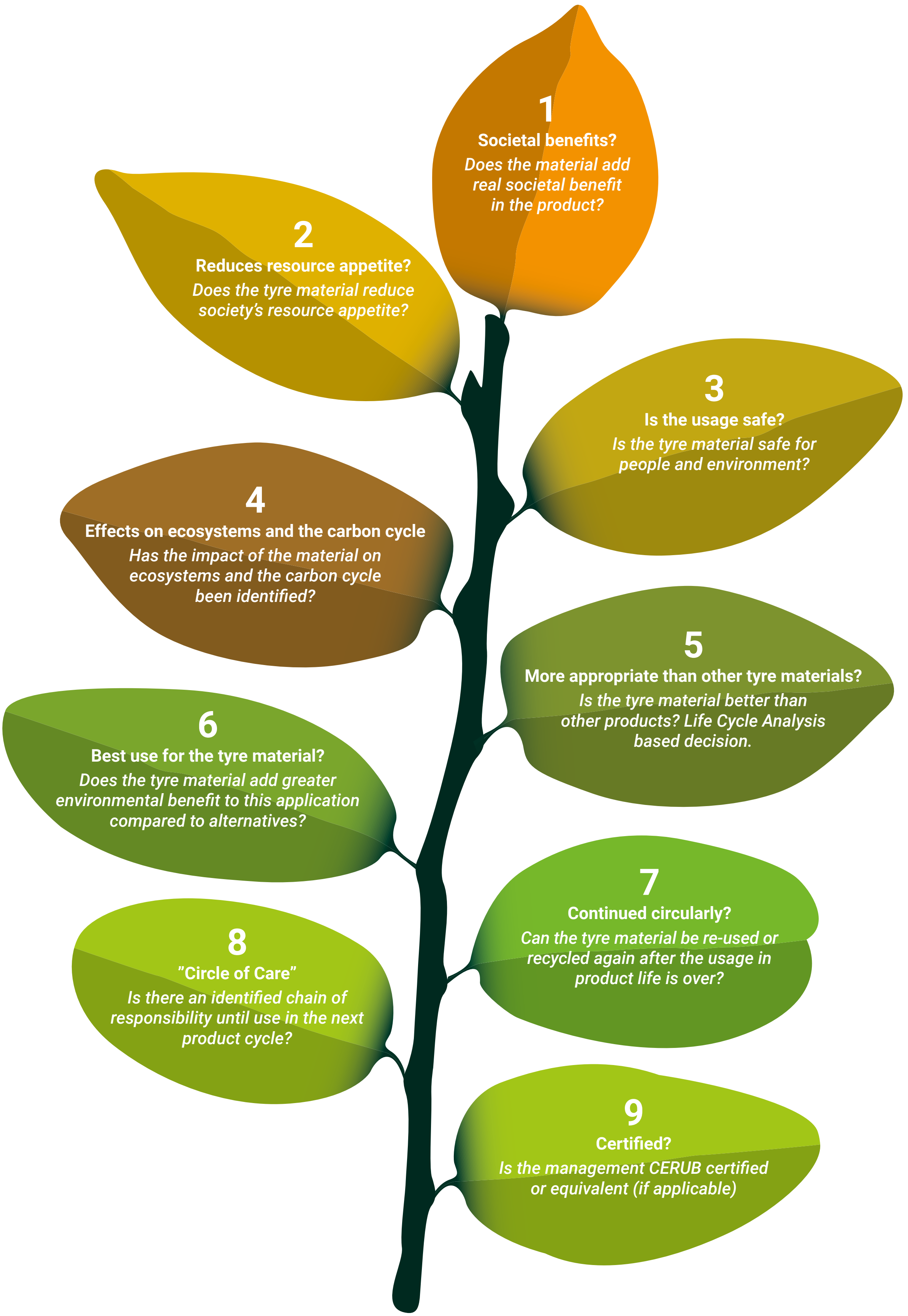
A strategy for sustainability does not have any real value until it is put into practice. The following 8 points are the recycling criteria that the Swedish Tyre Recycling Association have developed based on a systems level approach. The criteria are intended to serve as a guide in selecting the recycling options.

The Swedish Tyre Recycling Association works towards the improvement of commercial and regulatory conditions that would enable the criteria to be applied. This means, amongst other things, that they can provide support for research and development in areas that clarify or facilitate recycling according to the criteria.

The criteria are based on the earlier described systemic approach and sustainability goals. The criteria primarily apply to new applications of recycled tyre material, but in the long run for all types material recycling.

The criteria:

1. ”The tyre material is requested based on real needs for its properties, and on commercial terms.”
   This criteria makes sure that the material will provide a real benefit where its properties are requested.
2. ”The tyre material provides unique benefits or replaces the use of raw material in the product.”
   In order to achieve a contribution to the reduction of the overexploitation of the Earth's resources, the use of raw materials should be replaced by recycled tyre material.
3. ”The tyre material is safe for health and the environment and possible risks can be managed.”
   The product shall comply with applicable laws and regulations. If risks are identified, the application can still be accepted, if the risks can be managed or eliminated.
4. ”The impact of the material on ecosystems and the carbon cycle must have been identified, and a conscious decision regarding its suitability based on this impact must be documented.”
5. ”The tyre material performs on the basis of total environmental impact compared to the alternatives.”
   Life cycle Analysis (LCA) measures how the product is performing based on total environmental impact compared to other options for the same product. The recovered product should not perform decisively worse than other options suitable for use.
6. ”The tyre material does not have a much greater environmental benefit in another use.”
   In order to avoid sub-optimisation, alternative usages should be investigated. Even if a product performs better than other options in a particular use, the environmental benefit may be even better when used somewhere else. This perspective is particularly relevant if resources are limited.
7. ”The tyre material can be re-used or recycled again.”
   It is desirable that the product does not become unusable after being used but can be recycled into a new product. The ability to sort, distinguish and reuse the material again should therefore always be valued.
8. ”The tyre material is covered by an identified and allocated circle-of-care chain of responsibility”.
   In order to enable responsible use in the life cycle of all products, the responsibility must be clarified for the use and any future applications.
9. ”Compliance with CERUB certification or equivalent, where applicable.”


1
Societal benefits?
Does the material add real societal benefit in the product?
2
Reduces resource appetite?
Does the tyre material reduce society's resource appetite?
3
Is the usage safe?
Is the tyre material safe for people and environment?
4
Effects on ecosystems and the carbon cycle
Has the impact of the material on ecosystems and the carbon cycle been identified?
5
More appropriate than other tyre materials?
Is the tyre material better than other products? Life Cycle Analysis based decision.
6
Best use for the tyre material?
Does the tyre material add greater environmental benefit to this application compared to alternatives?
7
Continued circularly?
Can the tyre material be re-used or recycled again after the usage in product life is over?
8
"Circle of Care"
Is there an identified chain of responsibility until use in the next product cycle?
9
Certified?
Is the management CERUB certified or equivalent (if applicable)

How to apply the Systemic Impact Analysis, 8 point criteria

Infill for artificial turf pitches

Artificial turf for football and other sports, both indoors and outdoors, enables activities to continue all year round and in all weather conditions. However, the 'artificial grass' needs a structure around its straws to protect the fibres and to ensure the ball rolls correctly. The infill material consists of granulates from recycled tyre Rubber (SBR[1]), newly manufactured EPDM[2], TPE[3], but also cork, sugarcane, and other forest-based materials.

To decide if this application is a good use for recycled tyre rubber and is also the solution from a total sustainability perspective. We would apply the criteria for material recycling and analyse the result.

1 "Are the product's properties in demand based on a genuine need and on commercial terms."

There are about 1,200 full-sized artificial turf pitches in Sweden and more are being built. This is an indication of a need although the question is not quite that simple. We must first define which function is really being demanded. In the case of artificial turf pitches, the issue can be based on a sports exercise need, or a public health need, where several studies (see, among others, the Swedish Football Federations studies) show how inactivity has increased, especially among children and adolescents and the importance of facilitating opportunities for increased activity.

[1] *SBR – granulates recycled tyre rubber*

[2] *EPDM – Ethylene Propylene Diene Monomer Rubber (synthetic rubber)*

[3] *TPE – Thermoplastic Elastomer*

How could we create the most available exercise hours per individual in a safe and sustainable way, whilst applying the Systemic Impact Analysis points of:

1. Least total environmental impact
2. Least land use
3. Least injuries to players
4. At the lowest cost

Artificial turf offers a solution for this need. The question is how should football fields be designed and managed to maximise usage and minimise environmental impact? Are recycled tyre granulates commercially competitive and do the granulates produced fulfill FIFA specifications?

According to a survey made in connection with a life cycle analysis 2018, SBR is significantly cheaper than EPDM and TPE and has roughly the same price point as cork. Based on this, we can consider the first criterion to be fulfilled.

2 "Does the recycled product add benefits or reduce the use of raw material in the application?"

Whilst not providing unique benefits, several parameters of end-of-life tyre granules (SBR) are considered to be advantageous. For example SBR gives off less dust, does not float, gives better protection for the players and lasts longer. The criteria of replacing virgin material is clearly met if compared with EPDM, TPE and cork. Sugar cane and logging spills can be considered residual and not raw material, however, these materials are new for the raw application and their performance is still under evaluation.

3 ”Is the product safe for health and the environment and can any risks be handled?”

This issue has been the subject of many debates in both politics and the media. The latest scientific studies in this field show that there are no health problems with SBR (ECHA[1], ETRMA[2]) and that concerns about leaching and microplastics have been hugely exaggerated. Real-world measurements in stormwater systems and on players, show small and manageable amounts of granulates that may risk leaving the pitches (technical institute in Denmark, IVL, Kalmar). Risk for larger amounts of granulates leaving pitches through careless snow removal can for example be thwarted by tipping it on a surface specifically intended for the melting of snow, and then taking care of any granulates. Overall, the risks are small and manageable.

4 ”How does the product perform from a life cycle perspective compared to the alternatives?”

The Swedish Environmental Institute, IVL, conducted a life cycle analysis in 2012 which showed that SBR has less overall environmental impact than the alternatives EPDM, TPE and cork. Cork has slightly higher CO_2 impact due to transport from the cultivation sites and much higher land use (equivalent to 130 football pitches in size for supplying one pitch with cork for 10 years). LCA-comparisons cannot be made regarding sugarcane, GROT[3] or natural grass as they are still trial products. We already know however that these three options are all subject to cultivation, irrigation, process, transport and weed control. There is also considerable uncertainty about whether these materials will meet the functional and accessibility requirements. As regards verified working options, SBR performs best in terms of overall environmental impact.

5 ”Has the product significantly more environmental benefit than another product?”

According to the model for resource decoupling and land use savings, artificial turf is outstanding. It is also in line with the sustainability perspectives that this white paper has defined for tyre recycling.

6 ”Can the product be recycled again?”

When it comes to CO_2 saving and circularity, granulates on artificial turf are high on the scale. This is because the product is available in loose form and can be separated out from sand and dirt. A small surface hardening can occur on the granulates grains after a number of years, but often the product can be reused on new artificial turf or it can go to new types of products, such as moulded products and rubber asphalt. The recyclability criterion is considered to be satisfied.

7 “Is the product covered by an identified and assigned ‘circle-of-care’ chain of responsibility?”

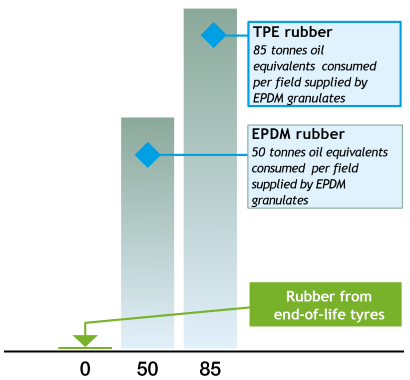
The majority of the country’s artificial turf pitches are council owned. Sweden’s councils have the capacity and ability to manage artificial turf pitches themselves or in collaboration with local football clubs. However, it is important that the responsibility for the pitches is clarified and that there are clear instructions for installation, use, operation, maintenance and recycling. Artificial turf is considered to be able to fulfill the criterion in an exemplary manner.

8 ”Is the material carefully controlled and certified?”

Certification is currently underway for SBR granulates for artificial turf. This means that the criteria for responsible recovery and delivery of the material are met. The conclusion is that recycled SBR granulates meet the Swedish Tyre Recycling Associations requirements for material recycling. They also require that measures are taken to minimise spillage and that responsibility for the pitch during and after the life span is regulated.

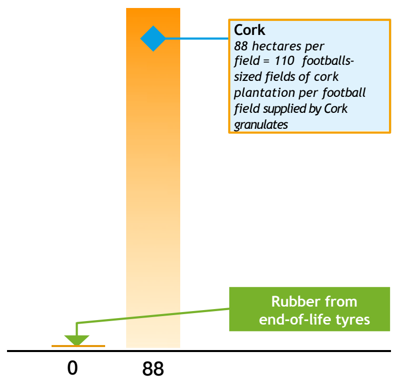
Resource consumption

Tonnes of fossil fuel consumed for the infill football field



Land use

Hectares affected



[1] *ECHA – European Chemicals Agency*

[2] *ETRMA – European Tyre and Rubber Manufacturers Association*

[3] *GROT – Logging residue: Branches and treetops*

The Swedish Tyre Industry Association's support for research and development

The below list is research supported by the Swedish Tyre Industy Associaion to advance knowledge and analysis. If you woud like to read any of these reports they can be found at www.sdab.se.

- Water purification in ground beds with tyre shreds (2018)
- Life cycle Assessment (LCA) for artificial turf and rubber asphalt (2018)
- Rubber asphalt-technical and commercial conditions (2018)
- FoBIG-European study on possible health issues/artificial turf pitches using recycled rubber tyres (2018/19)
- Kalmar-state-of-the-art artificial turf pitch with minimisation of spill (2019)
- The development of the CERUB Certification system (2019)
- Examination of the impact of puncture fluids on the environment (2019)
- ETRMA study on Microplastics from artificial turf (2019)
- VTI project on microplastics from tyre and road wear (2020)

What's next?

EU label for worn and retreaded tyres?

The EU Energy label is currently only valid for new tyres. By making demands on a tyre for performance and safety, even when worn, the development for *use down to regulated tread depth level* can be supported. Extending the life of tyres will reduce the need for new resource extraction.

Public procurement can increase demand level

In the context of public procurement, the market can move towards higher tyre performance, (increased safety and reduced rolling resistance), which is why it is important that governments and local councils could use the EU Energy label as a tool for setting and maintaining higher demands.

Principles are important but so is pragmatism

In a utopian world, anything raising the slightest concern for the planet would be banned. With today's challenges, we need to be more pragmatic and use all the available means (which can be dealt with without risk in the short or long term) to succeed in taking us away from today's unsustainable trajectory.

The tyre industry's difficulties in reaching its recycling ambitions are a clear example of the lack of a public authority responsible for a systems perspective on sustainability issues such as:

- Waste vs Product
- Content vs Risk
- Public procurement
- Responsibility for systems perspective

Logistics and recycling

Distribution routes are changing as more tyres are sold via car dealers, internet based sales are increasing and recycling is becoming customised. New logistical concepts are also being developed based on the sorting of tyres. New technology is reducing the investment cost of equipment. Devulcanisation is being refined and manufacturers are becoming more involved in the entire value chain.

With good systems of communication and data collection, tyre manufacturers get more feedback on performance from the recycling actors, which in turn will drive decision making in the future.

Sweden's legislation can learn from the EU

The current Swedish legislation and framework is focused on the chemical content of tyres, rather than identifying and managing actual potential risks. Sweden, in many cases, goes beyond the EU in its regulations on products as well as its waste.

From a wider perspective, this can lead organisations to focus on identifying possible problems and to quickly disqualify different recycled materials and their solutions. This is despite the fact that some materials can help relieve the planet from the over-extraction of raw materials. The consequences of doing so have been described in this white paper. The European average is 95% material value lost after the first use cycle.

The Swedish % is even worse. Achieving the EU level could be the first step for Sweden.

It is also necessary to change views on the Swedish interpretation of the term 'hazardous' and to move to a new perspective on risk-handling opportunities.

Products

Tyres are becoming more developed and advanced. Electronics, sensors, new materials, technologies for puncture repair and prevention, noise reduction, continued optimisation based on raw materials, rolling resistance and recycling are now shaping the future.

Recycled materials need the same rights as raw materials

Separate legislations and responsibilities create unfair competition for products made from raw materials compared to products from recycled materials, even when the contents are identical. A 'new' product is normally covered by, amongst other things, a free trade and voluntary declaration of harmlessness in use. Whilst a 'commodity' of waste-classed recycled material, may require permits for transport, cannot be traded across borders, may require authorisation for each individual use and may have higher requirements regarding content.

The Swedish Tyre Industry Association

The Swedish Tyre Industry Association (Däckbranschen Sverige) has members in many areas from manufacturing and distribution to the use of material from recycled tyres.

The leading suppliers of Tyre, Rim and Equipment within the Swedish market are members of the Swedish Tyre, Rim and Equipment Suppliers' Organisation. Tyres are no longer manufactured in Sweden and are now produced internationally according to EU regulation, additionally, production is regulated by organisations such as the UN organisation UNECE[1].

Sustainability efforts on every continent

The eleven largest global tyre manufacturers have created the Tyre Industry Project (TIP), with support from universities across the globe, to address sustainability issues. This project covers a wide range of issues from research of wear particles through to the study of end-of-life tyres.

European tyre manufacturers are members of The European Tyre and Rubber Manufacturers Association (ETRMA) and have a section which covers tyre recycling. National EPR organisations collaborate with regular progress reports and joint projects related to health and environment.

The Swedish National Association of Tyre Specialists is an organisation for the distributors of tyres and tyre fitters, whose activities are regulated by national legislation. They also provide support and guidance for local sustainability work.

The Swedish Tyre Recycling Association is a non-profit EPR (Extended Producer Responsibility) organisation, equalling the legal responsibility of tyre producers.

This white paper

This white paper summarises the Swedish Tyre Industry Association's view on sustainability across the sector, and focuses on the areas where the possibilities of making an impact on a national level are the greatest. It highlights opportunities to make a real difference which are, primarily, in recycling and distribution. The production is covered from a general perspective, however, the tyre's design and development is given greater attention due to its relevance throughout the lifecycle of the tyre and its components.

The members of The Swedish Tyre Industry Association, associated partners, organisations and companies mentioned in this document are not bound by its contents, nor are the tyre producers or distributors.

Däckbranschen Sverige

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[1] *UNECE: United Nations Economic Commission for Europe*

Our commitment to the future

"The Swedish Tyre Industry Association is committed to working according to the principles outlined in this document. This means working to influence the industry's own players throughout the value cycle and to seek support for change among legislators, authorities, customers and its members."

Fredrik Ardefors

CEO The Swedish Tyre Industry Association

"Imagine a society in harmony with nature.
A society that makes the best possible use of the resources it has already acquired.
A society where the benefits of this type of care reaches far beyond the divisions between industry, society and the natural world.
This is a world that The Swedish Tyre Industry Association wants to help create."

Jonas Roupé, MSc

Circular Economy Expert
Board member of Swedish Tyre Recycling Association, SDAB

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