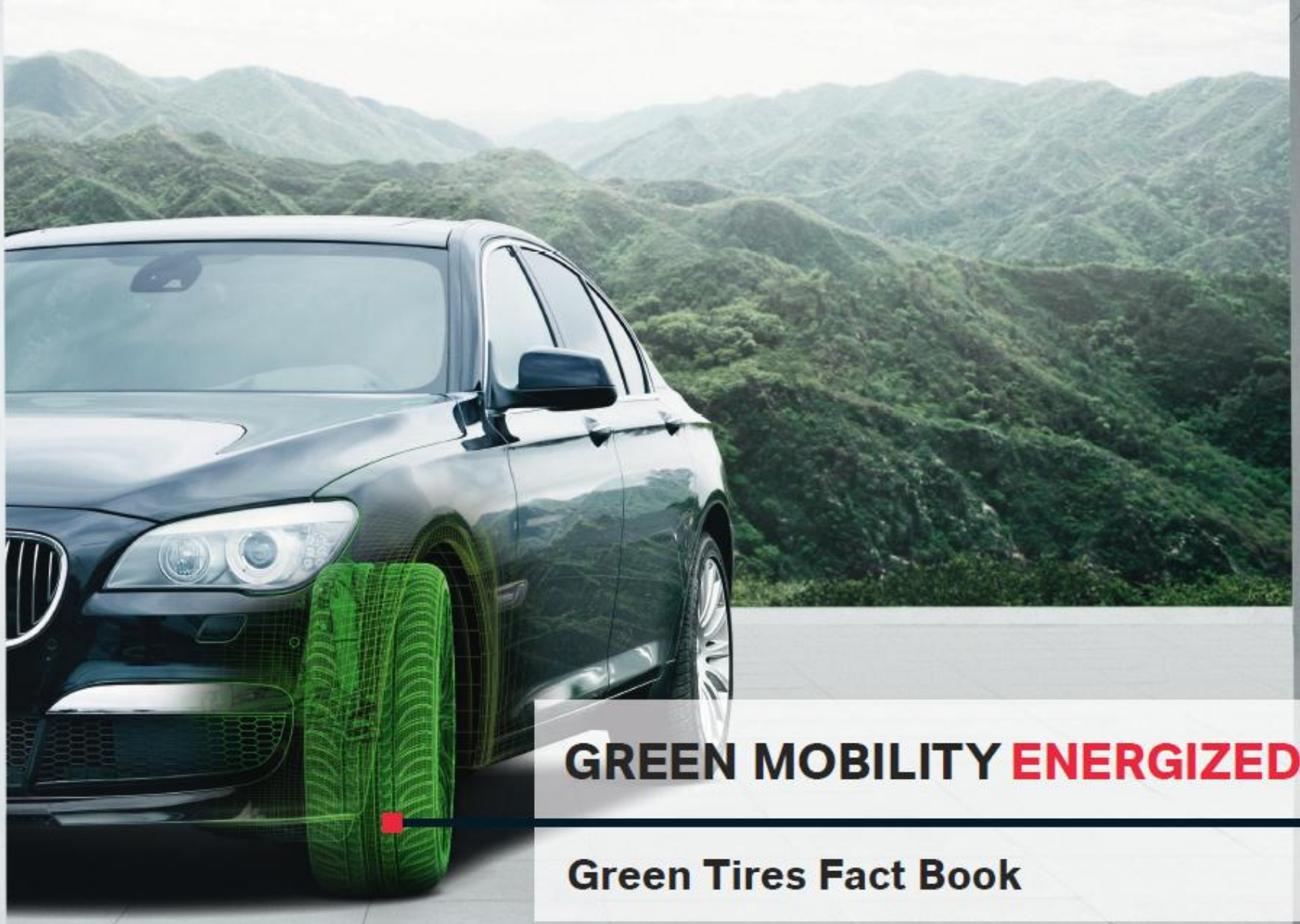

# GREEN MOBILITY ENERGIZED BY

LANXESS
Energizing Chemistry

## Green Tires Fact Book

# Agenda

1. **LANXESS – committed to global megatrends**
2. The need for $CO_2$ emission reduction – EU leading the way
3. Tire basics and the role of rubber
4. The environmental benefits of “Green Tires”
5. “Green Tires” meeting consumer expectations
6. An emerging global market for “Green Tires”
7. LANXESS – a key enabler of “Green Tires”

# LANXESS – a global player in the specialty chemicals industry

LANXESS
Energizing Chemistry

**Specialty chemical company**

- Spun-off from Bayer in 2004, listed in the DAX* since 2012
- Focus on: plastics, synthetic rubber, specialty chemicals, intermediates

**Global success story**

- Roughly 17,100 employees in 31 countries
- 49 production sites worldwide
- 2011 sales of EUR 8.8 billion


**Strategy of targeted innovation**

- Vital role in LANXESS' growth
- Focus on process and product innovation

* German stock market index



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# LANXESS is Energizing Chemistry

## Premium quality

- Premium specialty chemicals company
- More than 5,000 products for a diverse range of applications
- High quality solutions enabling customers to successfully meet current and future challenges

## Technical expertise

- State-of-the-art materials, services and solutions that meet the most exacting standards
- Creating significant value for our customers, the environment and our company

## LANXESS – global mission

## Sustainability

- Commitment to sustainable development
- Creation of green solutions to meet the challenges of global megatrends
- Development of environmentally-friendly technologies, resource-efficient processes and next-generation products

## Innovation

- Targeted innovation designed to meet customer needs
- Pragmatic corporate culture drives product, process and outside-the-box innovation
- Highly effective innovation network, combining global reach with local expertise



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# LANXESS capitalizing on global megatrends

## Mobility


## Agriculture

## Urbanization

## Water



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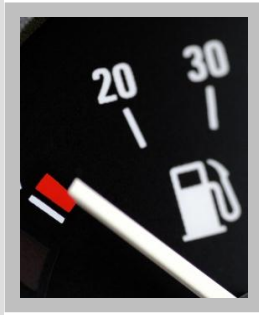
# Future challenges drive the need for sustainable mobility

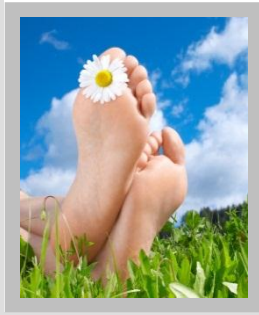
## Environment

- Climate protection
- Impact of climate change is significant




## Economics

- Shortage of resources
- Rising prices for fossil fuels



## Consumer

- Trend toward a sustainable lifestyle
- Societal demand for environmental stewardship

## Growing mobility

- Among the growing middle class in emerging economies

## Urbanization

- Almost 60% of the world's population will live in cities by 2030
- Greater traffic density leads to increased noise emissions

## Politics

- More stringent legislation
  - to protect the environment
  - to reduce emissions and fossil fuel dependency


Source: United Nations, Department of Economic and Social Affairs



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# LANXESS solutions help people and goods travel quickly, cleanly and safely

Examples

| | | |
|---|---|---|
| **Lightweight construction** | ▪ LANXESS high-tech plastics make vehicles lighter, safer and more comfortable |  |
| **“Green Tires”** | ▪ LANXESS synthetic rubber blends and additives are key ingredients that allow modern tires to improve performance, save fuel, enhance safety and last longer |  |
| **Bio-based raw materials** | ▪ With innovative products such as Keltan Eco – the first form of bio-based EPDM rubber in the world – LANXESS supports the development of bio-based alternatives to petroleum based materials | SUSTAINABILITY BY LANXESS BIOSOURCE |



LANXESS

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# Meeting the global climate challenge

**Worldwide efforts to reduce $CO_2$ emissions**

**Focused country initiatives to reduce energy consumption in key sectors**

| Construction | Manufacturing | Energy conversion | Mobility |
|---|---|---|---|
|  |  |  |  |

**Adoption of regulations and establishment of minimum energy efficiency standards**



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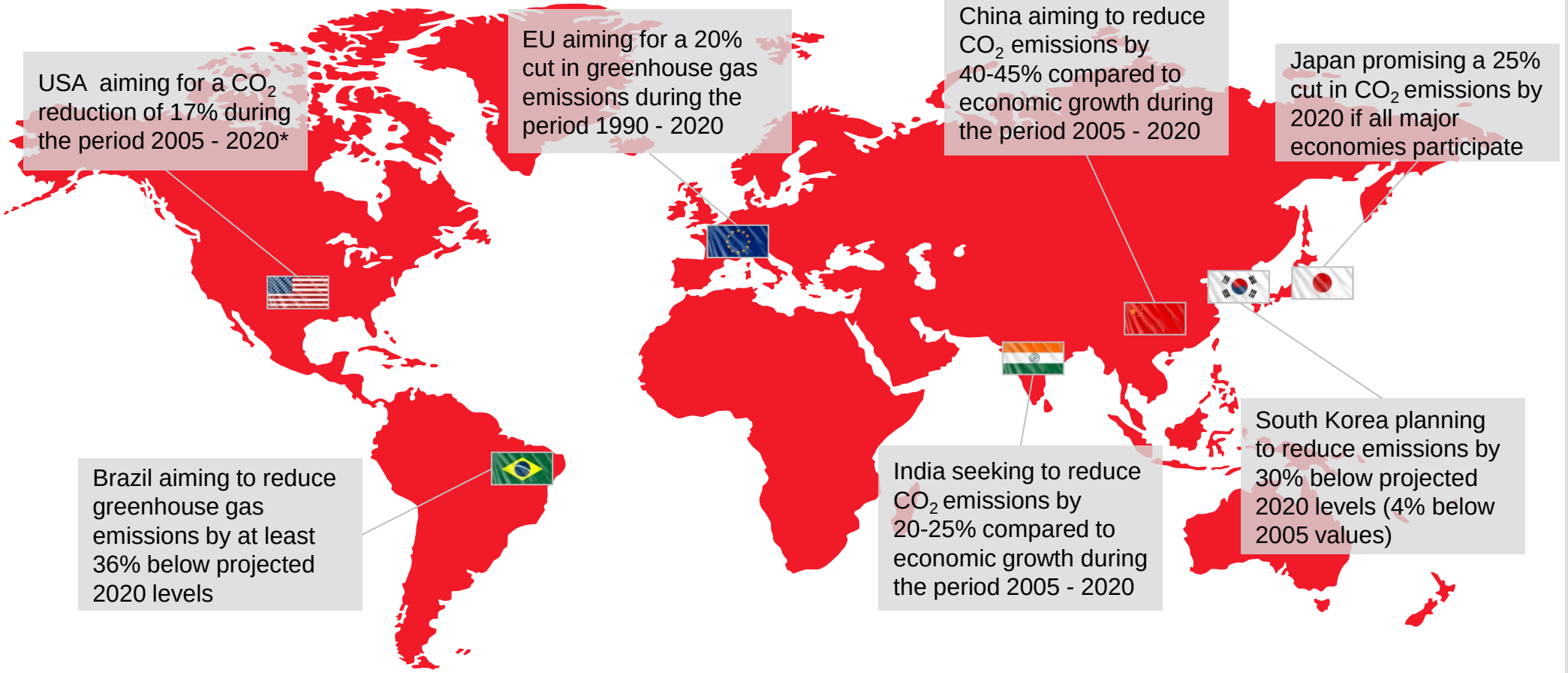
# Worldwide initiatives for the reduction of $CO_2$ emissions




Source: United Nations Framework Convention on Climate Change (UNFCCC) * Provided that the awaited law on climate control comes into effect as scheduled



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# EU – a clear commitment to increased energy efficiency

**EU Energy Efficiency Plan**

- Increasing energy efficiency to boost sustainable growth and competitiveness
- EU strategy focused on
  - enforcement of existing legislation
  - development of innovative solutions

**Key objectives for 2020** (compared to 1990)

- Cutting energy consumption by 20%
- Reducing annual greenhouse gas emissions by 740 million tons
- Cutting energy costs by EUR 100 billion per year

Sources: EU Energy Efficiency Plan 2011, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0109:FIN:EN:PDF
Directive of the European Parliament and of the Council on energy efficiency, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0370:FIN:EN:PDF



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# Traffic forms a substantial part of the EU Efficiency Plan

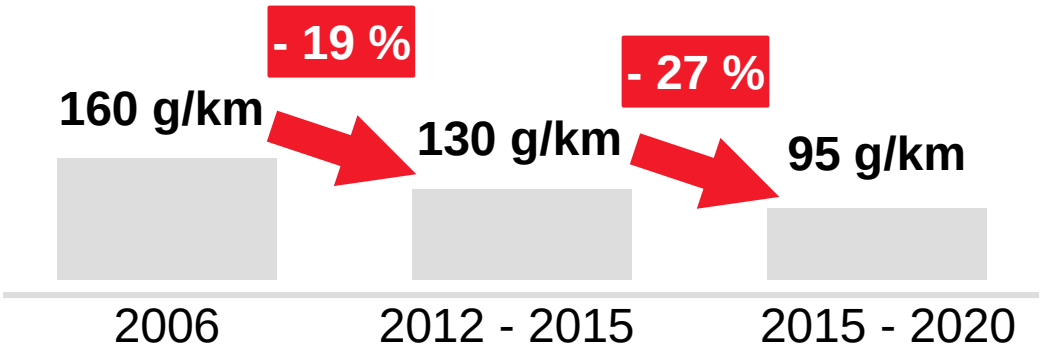
**Key Facts**

- 18% of global $CO_2$ emissions are related to traffic
- In the EU, transport is the only economic sector which $CO_2$ emissions are constantly increasing, especially in those segments involved in vehicular transportation

**EU Objective by 2012** (compared to 2006)

- Lowering average $CO_2$ emissions for newly-registered vehicles from 160 g/km to 130 g/km by 2015 and to 95 g/km by 2020
- Of that, 10 g/km is to be achieved through measures not directly linked to fuel combustion (e.g. tires)

**EU objective to lower $CO_2$ emissions for new vehicles**




Source: Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009 setting emission performance standards for new passenger cars, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0001:0015:EN:PDF



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# Modern tires improve energy efficiency in traffic

**Key Facts**

- 20-30% of a vehicle's fuel consumption is related to tires
- 24% of a vehicle's $CO_2$ emissions are related to tires

**New EU regulations aim to**

- Improve energy efficiency and safety standards of future tires
- Enable consumers to make informed purchasing decisions

Sources: BMW, Der Reifen im Spannungsfeld zwischen hohen technischen Anforderungen und immer schärfer werdenden gesetzlichen Auflagen, 2008
Michelin, $CO_2$ Reduzierung – Ein Beitrag der Reifenindustrie, 2008



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# EU type approval – improving standards for future tires

## Regulation 661/2009/EG

- Establishes uniform requirements for the type approval of new tires (categories C1 – C3*) across the EU with regard to
  - safety (wet grip)
  - rolling resistance
  - rolling noise
- Introduction of new limit values for type approval of tires in November 2012
- As of November 2014 all new vehicles must be equipped with type approved tires and only these can be sold on the replacement market

**Limit values for the safety aspect of wet grip**

| Usage category | Limit value (G) |
|---|---|
| M+S tires with a maximum permissible speed of 160 km/h | 0.9 |
| M+S tires with a permissible speed above 160 km/h | 1.0 |
| Normal tires | 1.1 |

**Limit values for rolling resistance**

| | Phase 1 (as of 2012) | Phase 2 (as of 2016) |
|---|---|---|
| Tire category | Limit value (kg/t) | Limit value (kg/t) |
| C1 | 12 | 10.5 |
| C2 | 10.5 | 9.0 |
| C3 | 8.0 | 6.5 |

* C1: tires according to ECE R 30 (cars)
C2: tires according to ECE R 54 (light trucks)
C3: tires according to ECE R 54 (heavy duty vehicles)

Source: Regulation (EC) No 661/2009 of the European Parliament and of the Council of 13 July 2009 concerning type approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefor: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:200:0001:0024:EN:PDF



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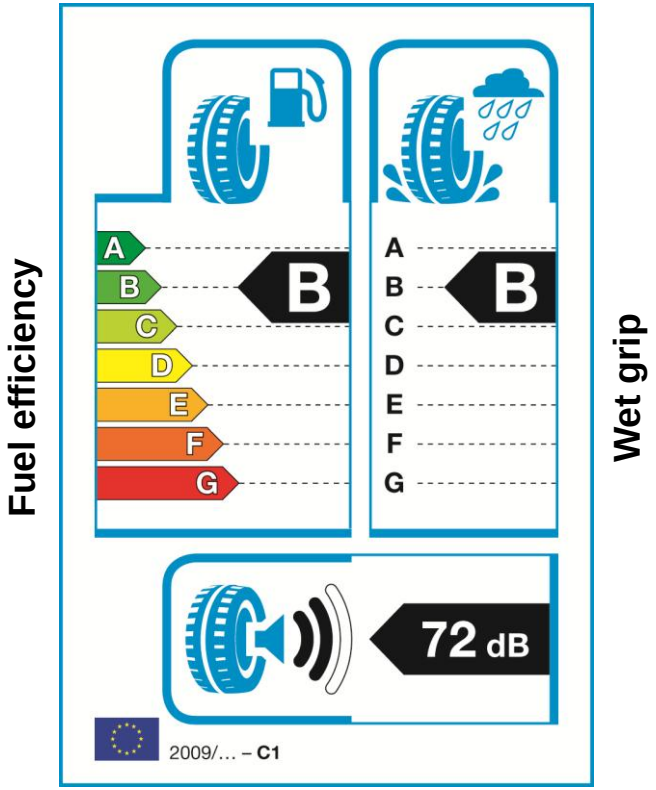
# EU tire labeling – enables consumers to make informed purchasing decisions

## Regulation 1222/2009/EG

- Tire labeling aims to improve safety, ecological and economical efficiency of road traffic
- The label informs consumers about key tire performance parameters
  - impact on fuel efficiency associated with rolling resistance
  - impact on safety associated with wet grip
  - external noise level
- Tire labeling becomes mandatory from November 2012, meaning that all tires* produced as of July 2012 must have the label

**Indicating three key parameters of tires**




Source: Regulation (EC) No 1222/2009 of the European Parliament and of the Council of 25 November 2009 on the labeling of tires with respect to fuel efficiency and other essential parameters: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:342:0046:0058:EN:PDF

* Passenger car, light truck and heavy duty vehicle tires



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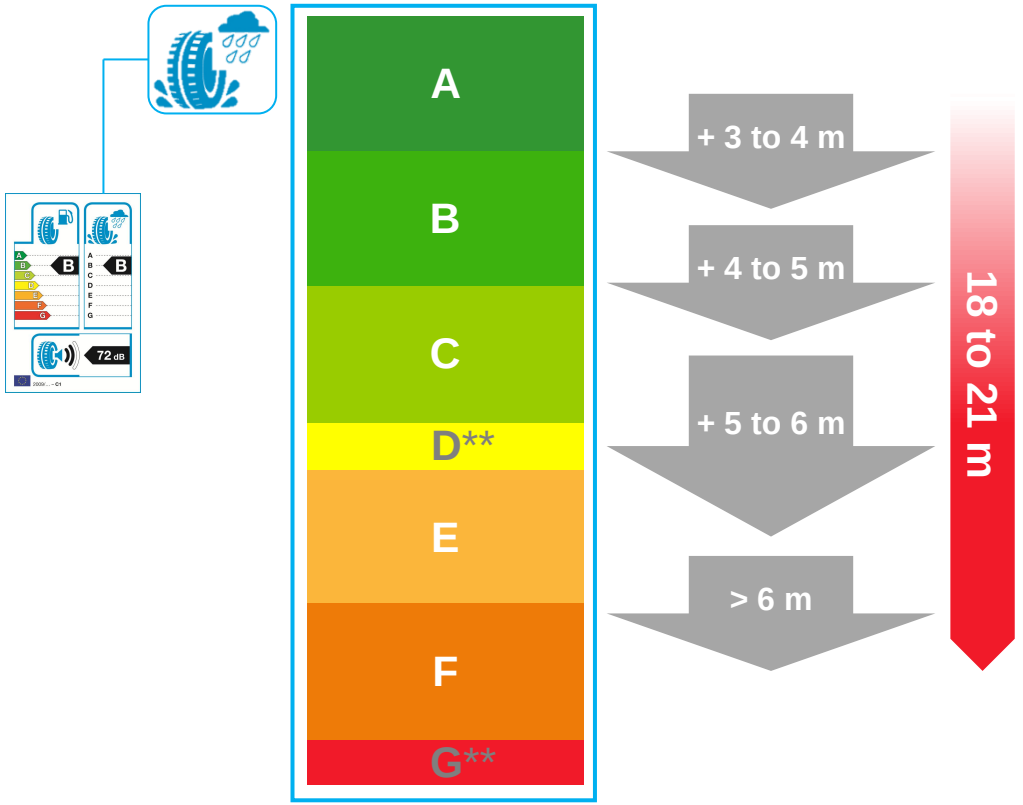
# EU tire labeling and its impact – wet grip

- Wet grip is one of the most important safety characteristics of a tire
- Tires with excellent wet grip have a shorter braking distance in rainy weather
- “A”-rated tires provide the most wet grip, while “F”-rated tires provide the least
- For example: an “F”-rated tire needs an additional 18 to 21 meters to come to a standstill from a speed of 80 km/h compared to an “A”-rated tire*

**Difference in wet braking distance by rating class (80 km/h to 0 km/h)**




Source: Continental

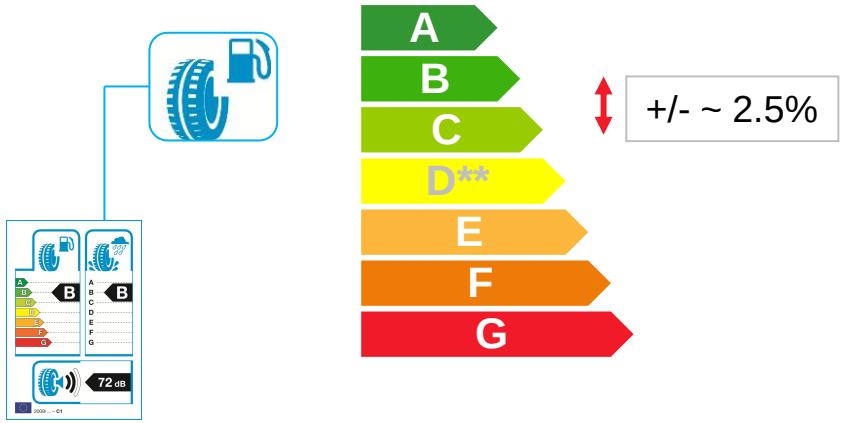
* Actual braking distance may vary according to road surface and vehicle

** Class D and G are not defined

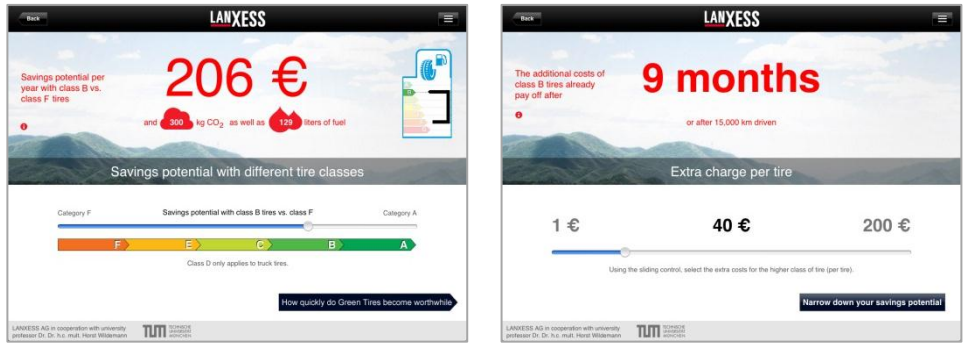
# EU tire labeling and its impact – fuel efficiency

- A vehicle's fuel consumption is affected by the rolling resistance* of its tires
- By reducing rolling resistance, a tire can improve fuel efficiency of a car
- For example, the difference between a "C"- and a "B"-rated car tire translates into a change in fuel consumption of ~2.5%

**Difference in fuel efficiency per rating class**




**With the Fuel-Saving-App*** you can calculate how much fuel you save with "Green Tires"**



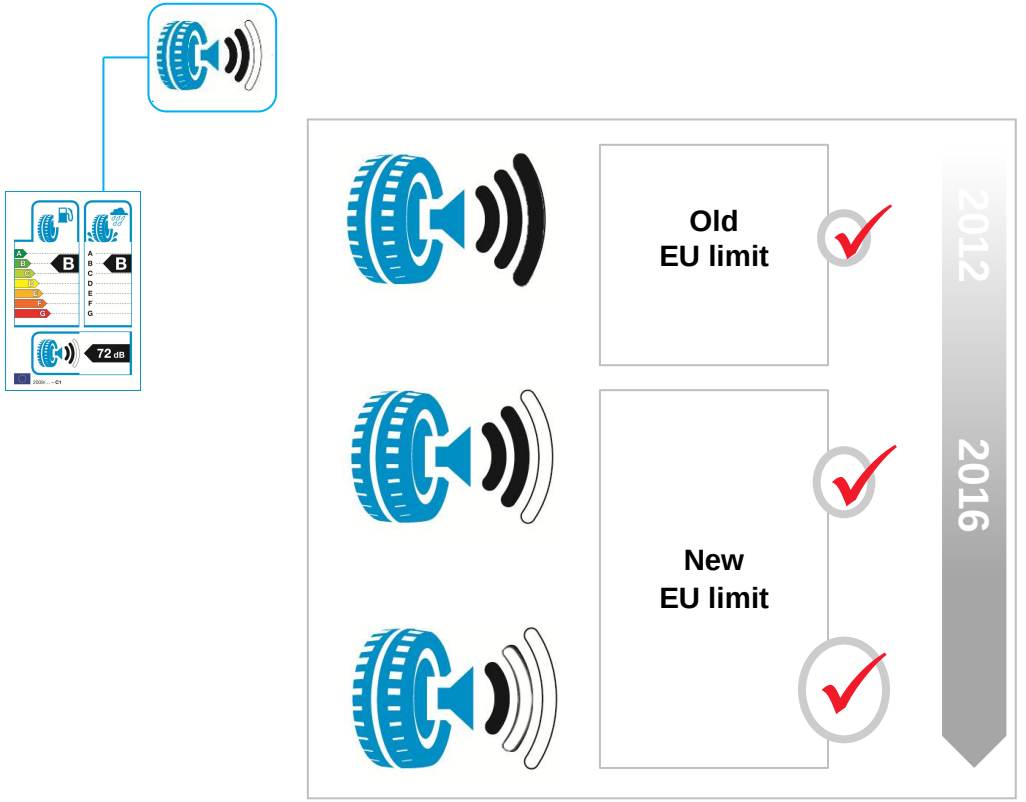

Source: Continental

* The impact of rolling resistance on engine performance is explained in detail on page 40 ** Class D only applies to truck tires
*** For more information and to download the app, visit http://save-fuel.lanxess.com

# EU tire labeling and its impact – noise emissions

- The label describes the level of external noise generated by the tire (not the internal noise heard by the car's occupants)
- External noise level is expressed in decibels (dB), and indicated by one, two or three sound waves
- For example: one black wave indicates optimal noise level performance (3 dB below the new EU limit*), while three black waves indicate the highest noise level (tire is in compliance with old EU limit)

**Difference in noise level per rating class**




Source: Continental

* The new European tire external noise levels will be introduced by 2016



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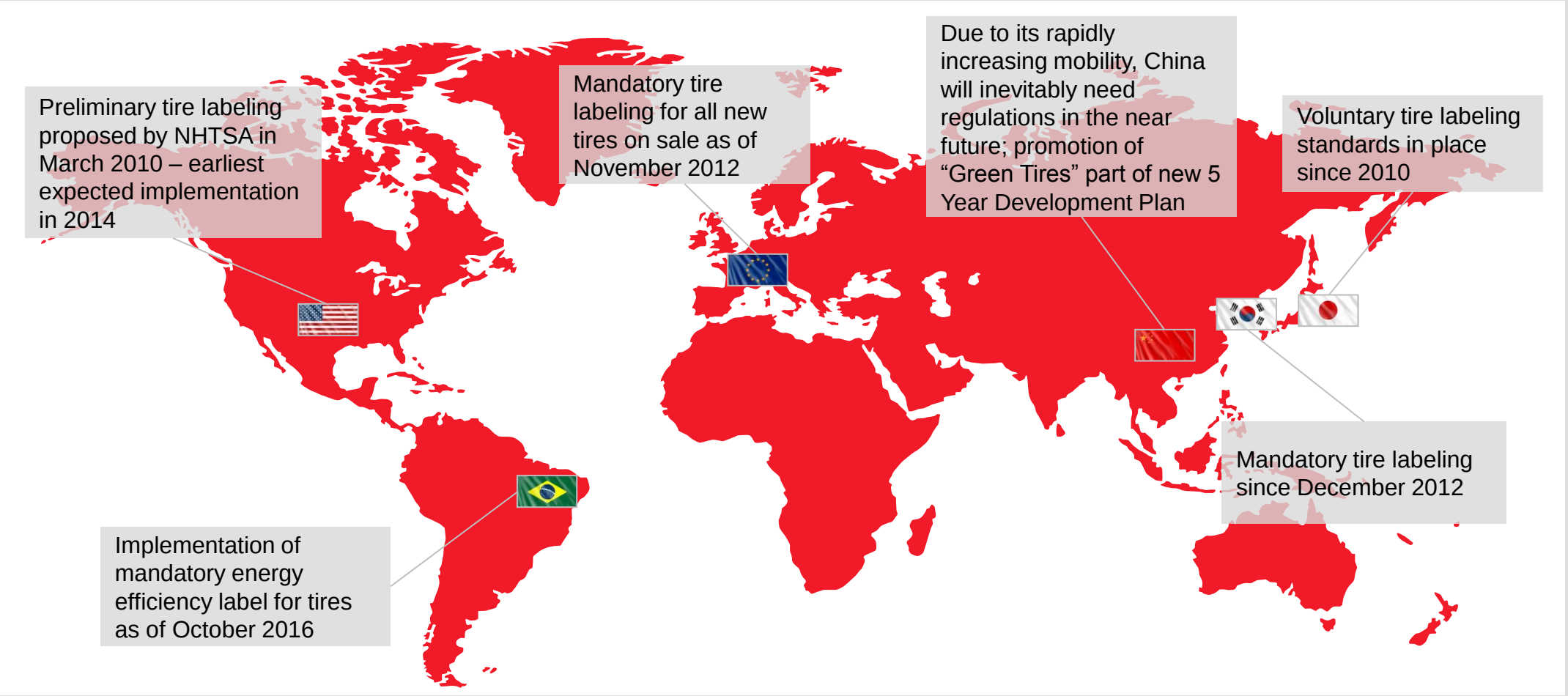
# Emergence of worldwide adoption of tire regulations and implementation of tire labeling



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# Tires are an essential part of each vehicle

- A tire fulfills multiple important functions
  - supporting the weight of the vehicle
  - absorbing shocks from the road
  - transmitting the power to accelerate, brake and steer on the road
  - maintaining and changing direction
- A tire should meet certain criteria
  - safety (dry/wet conditions, high speeds, braking)
  - comfort (shock absorption, noise)
  - fuel economy
  - durability

**Basic function of key tire parts**

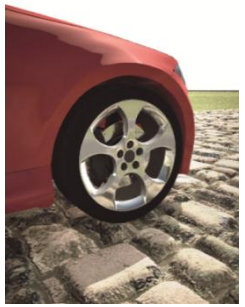
**Carcass**
Carrying the weight of the car

**Tread**
Directing and transferring all forces generated by the vehicle

**This and other criteria are constantly tested by associations and trade magazines***

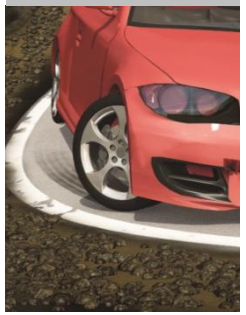
Safety

Comfort



Fuel economy

Durability



Source: Michelin; Hankook; Allgemeiner Deutscher Automobil-Club e.V. (ADAC)

* Test representatives include ADAC, Austrian Auto Motor and Touring Club (ÖAMTC), Touring Club Switzerland (TCS), AutoBild, Auto Motor und Sport, and others



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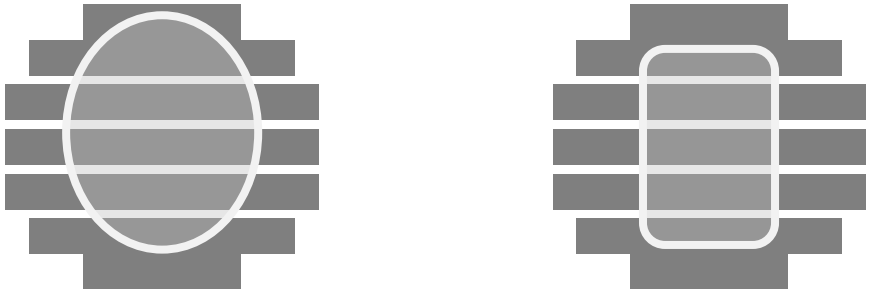
# Where tire and road surface meet

- Tires are the only part of the vehicle in contact with the road
- Each tire's contact patch*, or footprint, is only about the size of a postcard
- The distribution of pressure across a tire's footprint differs depending on rolling speed
- With increasing speed, the shape of the footprint changes from a circle to a square
- At moderate speed, energy loss (in the form of heat) occurs primarily in the tire tread
- At highway speed, energy loss occurs primarily in the sidewalls and inner liner

**Tire structure is key to the even distribution of vehicle load across the tire footprint**

**Contact patch with road is about the size of a postcard**

**Tire footprint at different speed levels**



Moderate speed

Highway speed

Source: Automobilwoche

* Area of tread in contact with the road surface



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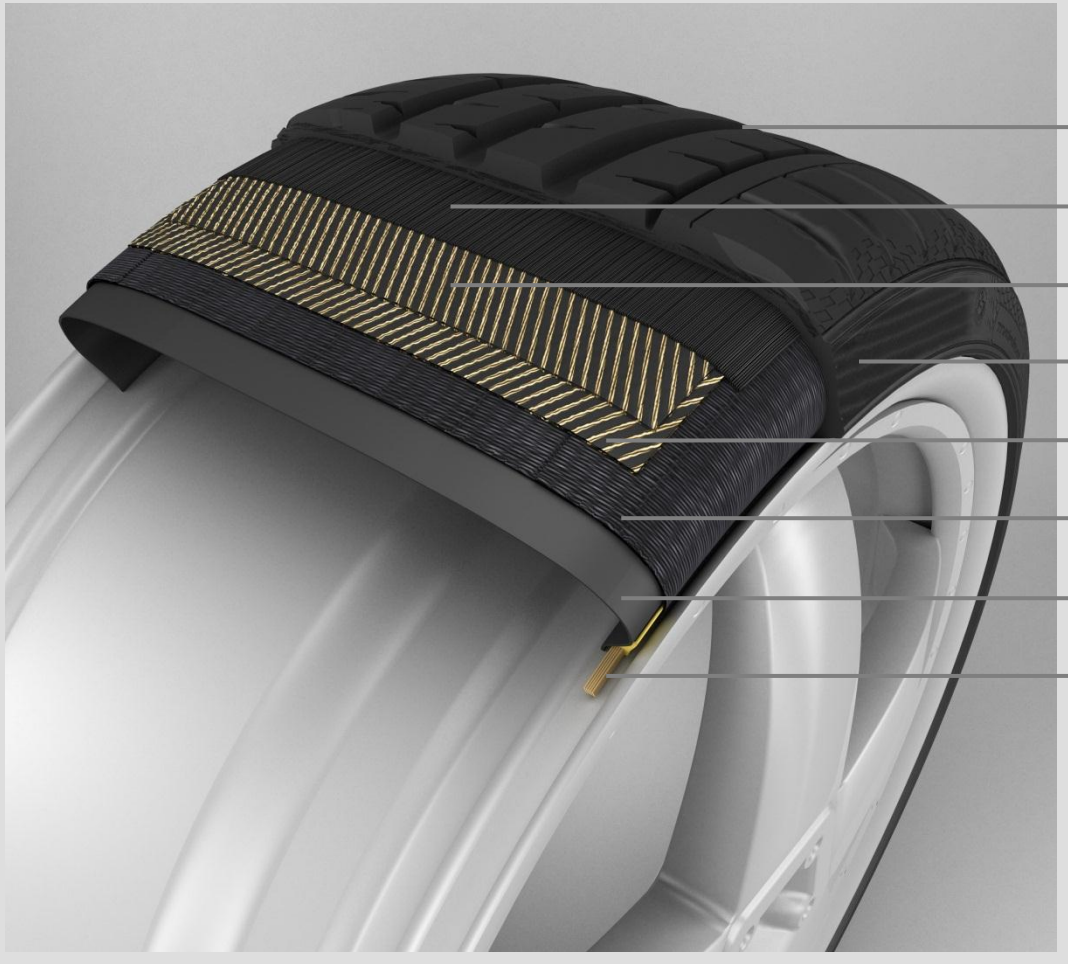
# A tire consists of eight different layers



| | |
|---|---|
| **Tread** | → ***Influences grip, fuel economy and noise*** |
| **Undertread** | → ***Joins the tread to steel belt and carcass*** |
| **Upper steel belt** | → ***Influences driving features and shape*** |
| **Sidewall** | → ***Protects carcass and influences fuel economy*** |
| **Lower steel belt** | → ***Influences driving features and shape*** |
| **Carcass** | → ***Gives support and shape*** |
| **Innerliner** | → ***Replaces the tube*** |
| **Steel wires** | → ***Keeps the tire safely attached to wheel rim*** |



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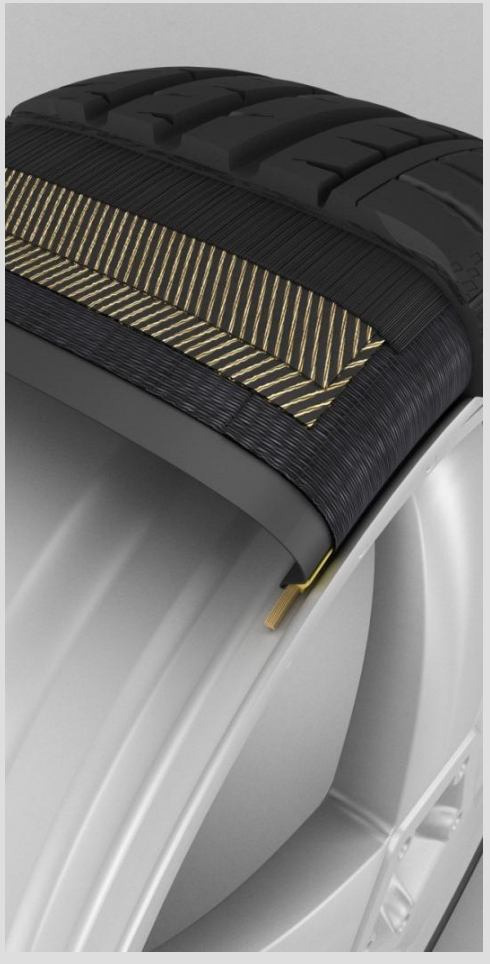
# All layers must meet certain requirements

| | |
|---|---|
| **Tread** | ▪ High energy and low energy losses for traction and rolling resistance<br>▪ High abrasion resistance |
| **Undertread** | ▪ High stiffness<br>▪ Low rolling resistance |
| **Upper steel belt/ Lower steel belt** | ▪ Must be dent-resistant while simultaneously allowing the tire to remain flexible |
| **Sidewall** | ▪ Must be able to easily change shape<br>▪ High resistance to flex cracking and fatigue as well as low heat build-up required |
| **Carcass** | ▪ High strength and fatigue resistance<br>▪ Compound needs to stick well to carcass cords |
| **Innerliner** | ▪ Must be particularly impermeable to air |
| **Steel wires** | ▪ Must provide good steer response made possible by high strain modulus, maintaining footprint at higher speeds<br>▪ High stiffness, low RRC* and good adhesion to steel cord surface |



Source: Michelin Fact Book 2003
U.S. Department of Transportation

* Rolling resistance coefficient



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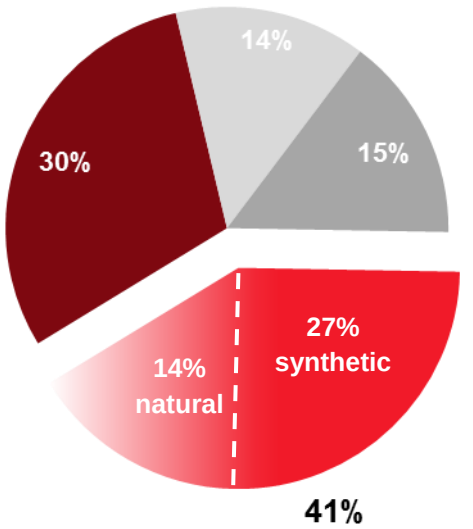
# Rubber is the main ingredient in tires

- While more than 200 individual ingredients can go into a modern passenger car tire, most of them fall within one of three main categories that affect a tire's performance profile
  - rubber (natural, synthetic)
  - fillers* (carbon black, silica, etc.)
  - additives** (vulcanizing agents, vulcanizing accelerators, antioxidants, softeners, waxes for light protection, etc.)
- Today, the mix of natural (14%) and synthetic rubber (27%) accounts for roughly 40% of a modern passenger car tire's total components

**Nearly 1/3 of a passenger car tire consists of synthetic rubber**

**A passenger car tire is made up of various component groups**




- Natural rubber
- Synthetic rubber
- Reinforcing fillers
- Additives
- Reinforcing materials (steel, polyester, rayon, nylon)

Source: Washington State Department of Ecology/Rubber Manufacturers Association; Continental

* These reinforce rubber compounds; they include active fillers (strengthening the rubber) and inactive fillers (making the rubber go further)
** Processing aids, which affect the final properties of the end product



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# Natural rubber and synthetic rubber

## Natural rubber

- Derived from latex, a milky white fluid collected from rubber trees in tropical plantations
- One of the most elastic types of rubber
- Resistant to wear and fatigue
- Only moderate resistance to damage from exposure to heat and light
- Global production increased by 7%, from 9,690,000 tons in 2009 to 10,399,000 tons in 2010

## Synthetic rubber

- Oil is the most common raw material for synthetic rubber production
- Mechanical production based on chemical processes
- Highly resistant to abrasion and oxidation
- Superior resistance to heat
- Contamination-proof
- Global production increased by 14%, from 12,385,000 tons in 2009 to 14,082,000 tons in 2010

Source: Trelleborg
International Rubber Study Group (IRSG)



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# Different types of synthetic rubber and their role in tires*

| Rubber | Characteristics | Tire industry applications |
|---|---|---|
| **Polybutadiene (BR)** | ▪ Reduced heat build up<br>▪ High abrasion resistance<br>▪ Improved fatigue properties | ▪ Tread<br>▪ Sidewall<br>▪ Carcass |
| **e.g. neodymium polybutadiene rubber (Nd-PBR)** | ▪ Outstanding abrasion resistance<br>▪ Excellent strength<br>▪ High crack resistance | |
| **Styrene-butadiene rubber (SSBR)** | ▪ Moderate abrasion resistance<br>▪ Good mechanical properties | ▪ Tread |
| **Butyl rubber (IIR)** | ▪ Good resistance to acids, hot water, etc.<br>▪ Excellent impermeability | ▪ Inner tubes for tires<br>▪ Bladders for tire manufacture |

* See benefits on pages 69 et seq.



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# The production of synthetic rubber

## Production of synthetic rubber

### 1 Extraction from raw material feedstocks

- In a refinery, monomers* are extracted from oil
- Liquid monomers are generally made from ethyl benzene
- Gas monomers are usually obtained by using heat to break up the molecules in the presence of a catalyst

**Monomers**

Gas

Liquid

### 2 Polymerization

- Monomer molecules are brought together through a chemical reaction to form polymer chains

**Polymers**

Synthetic rubber

### 3 Separation

- The polymer is isolated from the solution medium in the form of crumbs

### 4 Compression

- Crumbs are washed, dried and pressed into bales

**Synthetic rubber bales**

The raw rubber in plastic form is shipped to tire manufacturers

Source: International Rubber Study Group (IRSG)

* A molecule that forms the basic unit for polymers



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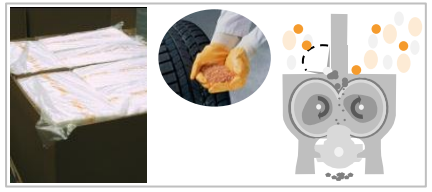
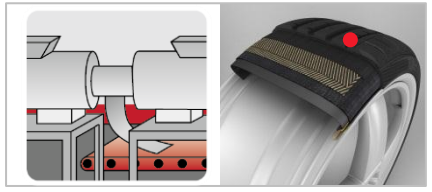
# The production of tires

## Semi-finished products are manufactured

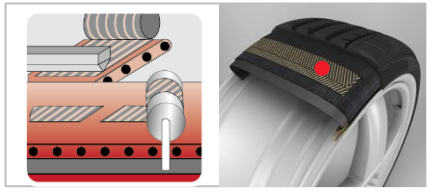
**1** Up to 12 different **rubber** compounds are blended together in a kneader



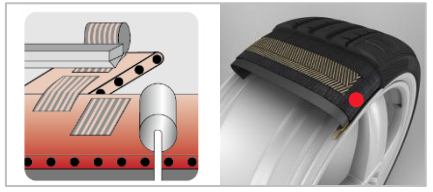
**2** The blended rubber material is shaped into an endless **tread strip** by means of an extruder



**3** Rubberized **steel cord fabric** is cut and assembled into a single, continuous strip

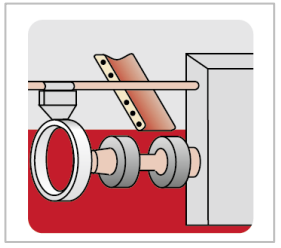


**4** For the **textile layer**, a sheet of fabric is embedded within a layer of rubber and cut into varying widths and angles

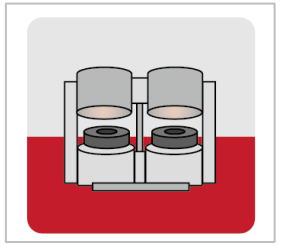


## Building and vulcanization*

**5** The individual semi-finished products are assembled into a **tire blank**



**6** “Baked” in a heating press, the plastic, raw rubber is **vulcanized** into elastic rubber, thus combining the different components of the tire into its final shape



**7** After visual inspection and uniformity checks, the tire is ready for shipment

Source: Continental

* Vulcanization takes place at 140-200°C in a process determined by time, temperature and pressure



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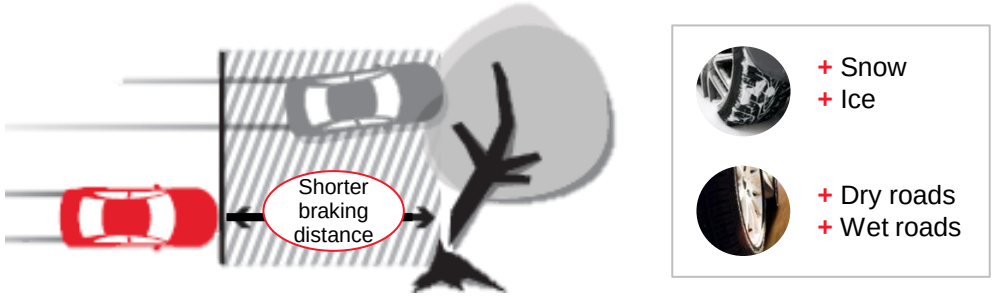
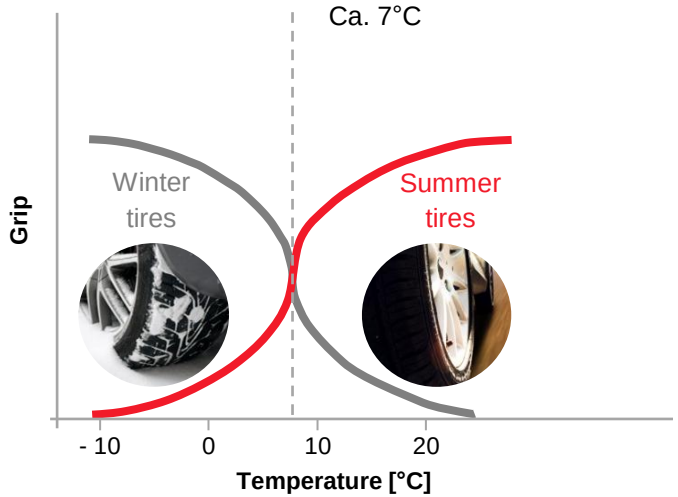
# Consumers can prevent tire failure – by making the right tire choices

**The right tire type can help to avoid accidents**




**The influence of temperature on tire grip**




- Optimal road holding in wet, slippery or winter conditions can be assured by different tire types
- Summer tires perform best in warm weather
- Winter tires perform best in severe winter conditions
- Due to the cold temperatures, winter tires are comprised of more flexible rubber compounds
- In snow, a vehicle with summer tires needs almost twice as much distance to come to a full stop
- All-season tires provide reliable performance in warm and moderate winter conditions
- Mud and snow (M&S) tires have higher void ratios to channel away rain, mud and snow

**Matching tires to prevailing weather conditions is essential for safety**



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# Consumers can prevent tire failure – by checking the DOT code on their tires to determine their age

**The DOT code – an illustrated example**


**The DOT code explained**

| DOT | 2X | 13 | CJ H | 10 | 09 |
|---|---|---|---|---|---|
| | Plant code | Size | Brand code* | Week | Year |

- The DOT code is an alphanumeric sequence that is printed on the side of a tire to show its age, size, brand and origin
- The first two characters indicate the plant code
- The third and fourth characters represent the tire size
- The last four numbers represent the week and year the tire was built
- The technical properties of a tire deteriorate over time
- When buying a car, a tire should be not older than three years

**The DOT code provides technical information on the tire**

Source: Allgemeiner Deutscher Automobil-Club e.V. (ADAC)

* Identification of brand as well as other characteristics important to manufacturers; number of characters between tire size and the final four characters may vary



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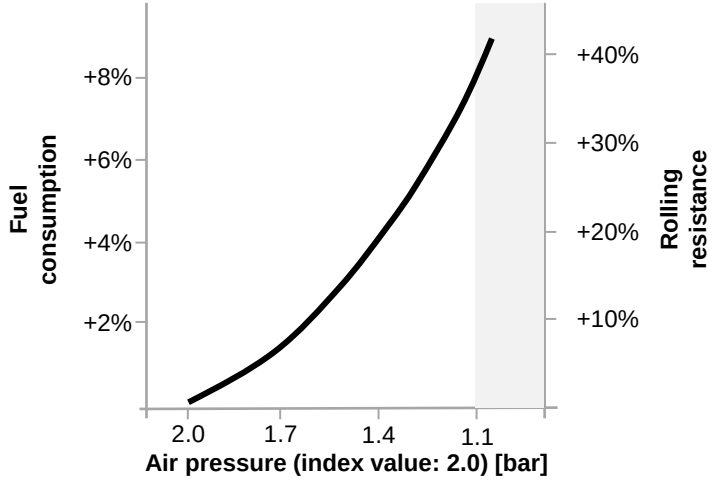
# Consumers can prevent tire failure – by regularly checking their air pressure and adjusting it accordingly

**Tire pressure gauge**

**Impact of air pressure on rolling resistance and fuel consumption**




- Improper air pressure contributes to tire failure (e.g. tread separation, blowouts, flat tires)
- It also negatively influences rolling resistance*
- For example, a tire with air pressure of roughly 1 bar below recommended levels results in a more than 30% increase in rolling resistance
- Additionally, this deficiency causes a car to burn an extra 0.5 liters of fuel per 100 km
- Therefore, not only does improper air pressure increase safety risks but also fuel consumption and $CO_2$ emissions

**Proper air pressure helps save fuel**

Source: Continental

* Rolling resistance is the energy that is lost when the tire is rolling; the main reason for the loss of energy is the constant deformation of the tire



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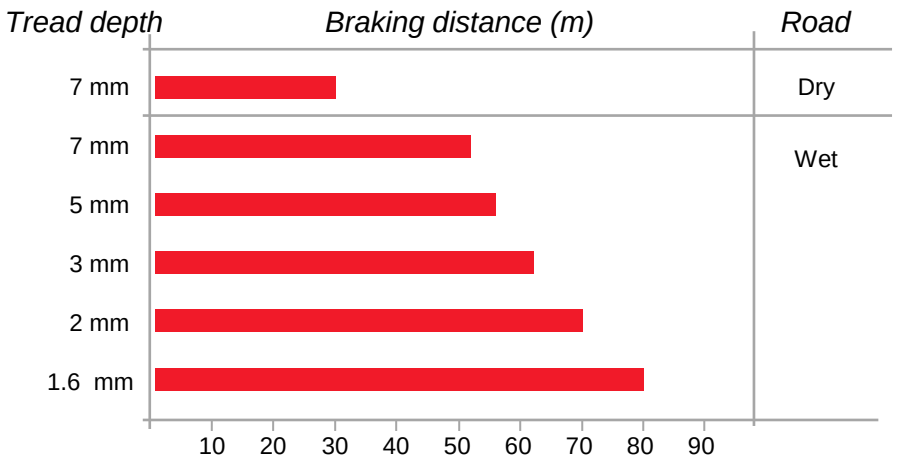
# Consumers can prevent tire failure – by measuring tire tread depth

**Measuring tire tread depth with a €1 coin**

**Impact of decreasing tread depth on tire safety***




- Sufficient tread depth is vital, even at low speeds
- Decreased tread depth reduces comfort, grip, traction and braking
- Legal minimum tread depth standard is 1.6 mm**
- Recommended minimum tread depth is 3 mm***
- Tread depth measurements can be taken with €1 coin (yellow rim should entirely fit into the tread grooves)
- Grooves are a key feature of the tread pattern; over decades, they have been continuously optimized
- Today, innovative tires that feature asymmetrical tread designs also assist in noise reduction

**Regularly checking tread depth is key to safety**

Source: Continental

* Summer tire, braking from 100 km/h to 60 km/h ** Adopted as a regulation by many of the world's national transportation authorities
*** Recommended by major European car manufacturers



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# The history of tires – the long journey to the modern tire

- **1844:** Charles Goodyear invents vulcanized rubber, which later becomes a key ingredient for tires
- **1888:** John Dunlop invents the air-filled or pneumatic* tire for bicycles
- **1895:** Michelin introduces the first pneumatic automobile tire
- **1904:** Grip-Tread pattern for pneumatic tires is introduced
- **1909:** Synthetic rubber is invented by chemist Fritz Hofmann of Elberfelder Farbenfabriken, one of the antecedents of LANXESS
- **1910:** Carbon black** is added to white rubber
- **1946:** Michelin introduces the radial tire***, which is still in use
- **1972:** DuPont invents a polyamide fiber called Kevlar – a replacement for steel in racing tires
- **1977:** Goodyear introduces year-round, all-weather tires
- **1992:** Michelin incorporates silica into tire rubber compounds

1909

1946

1992

* Filled with (compressed) air ** Reinforcing filler that blackens rubber and gives it strength
*** Featuring body ply cords that are laid radially from bead to bead, nominally at 90º to the centerline of the tread. Two or more belts are laid diagonally in the tread region to add strength and stability



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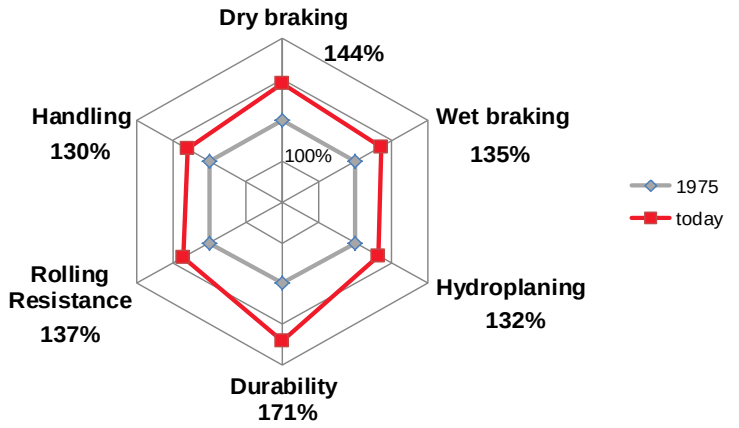
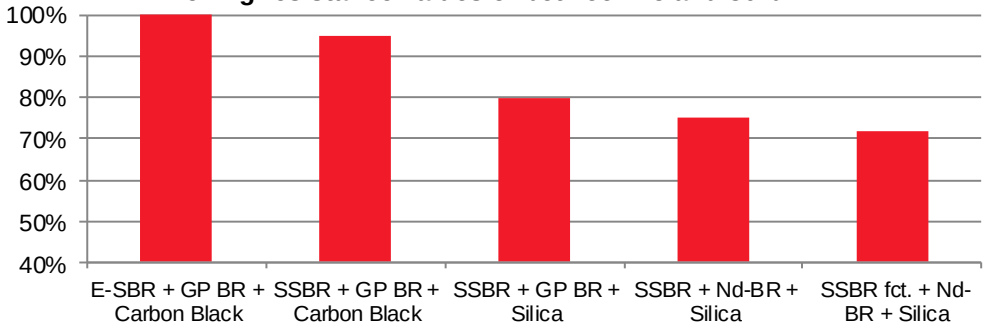
# Until today, overall tire performance improved significantly

- As a result of the continuous development of innovative technologies and materials, modern high-quality tires offer exceptional performance in all areas of measurement
- Since 1975, tire manufacturers have managed to optimize all key tire parameters by at least 25%, e.g.
  - rolling resistance
  - handling
  - dry traction
  - wet traction
  - hydroplaning
  - durability

**Continuous innovation and concurrent improvement of overall tire performance**




**Over the past two decades, improved materials led to a reduction of rolling resistance values of between 25 and 30%**




Source: Continental AG



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1. LANXESS – committed to global megatrends
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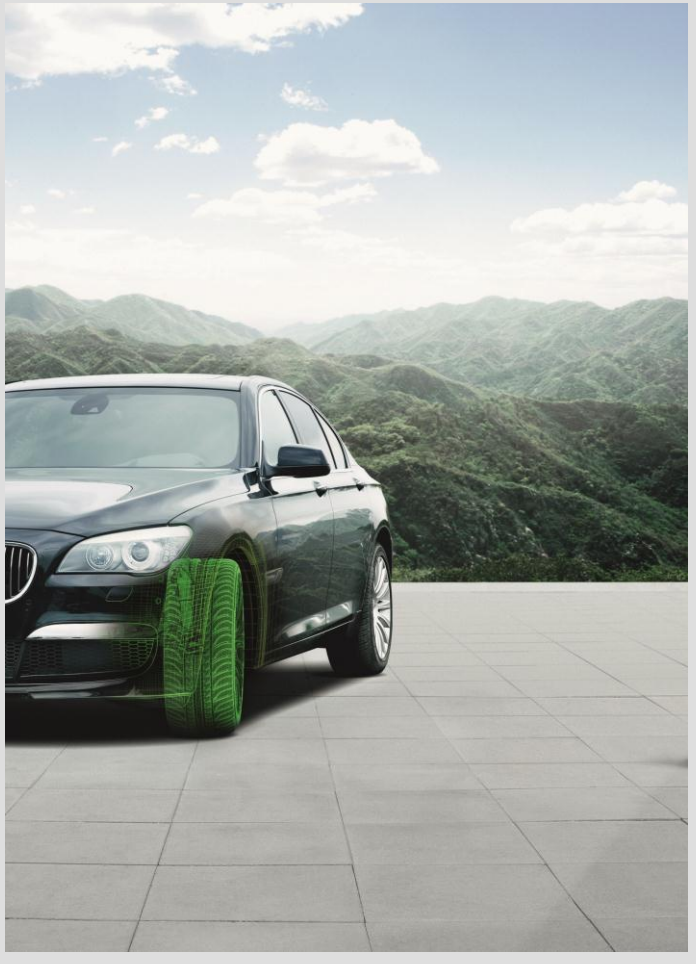
7. LANXESS – a key enabler of “Green Tires”

“Green Tires” contribute to sustainable mobility by increasing fuel efficiency and reducing greenhouse gas emissions in road traffic. Simultaneously, “Green Tires” offer excellent safety and driving features.

- Reduced fuel consumption by 5% to 7%
- Reduced $CO_2$-emissions by 1.2 kg/100 km*
- Shorter braking distance at 80km/h by up to 21 meters compared to normal tires
- Extra costs amortized within one to two years**

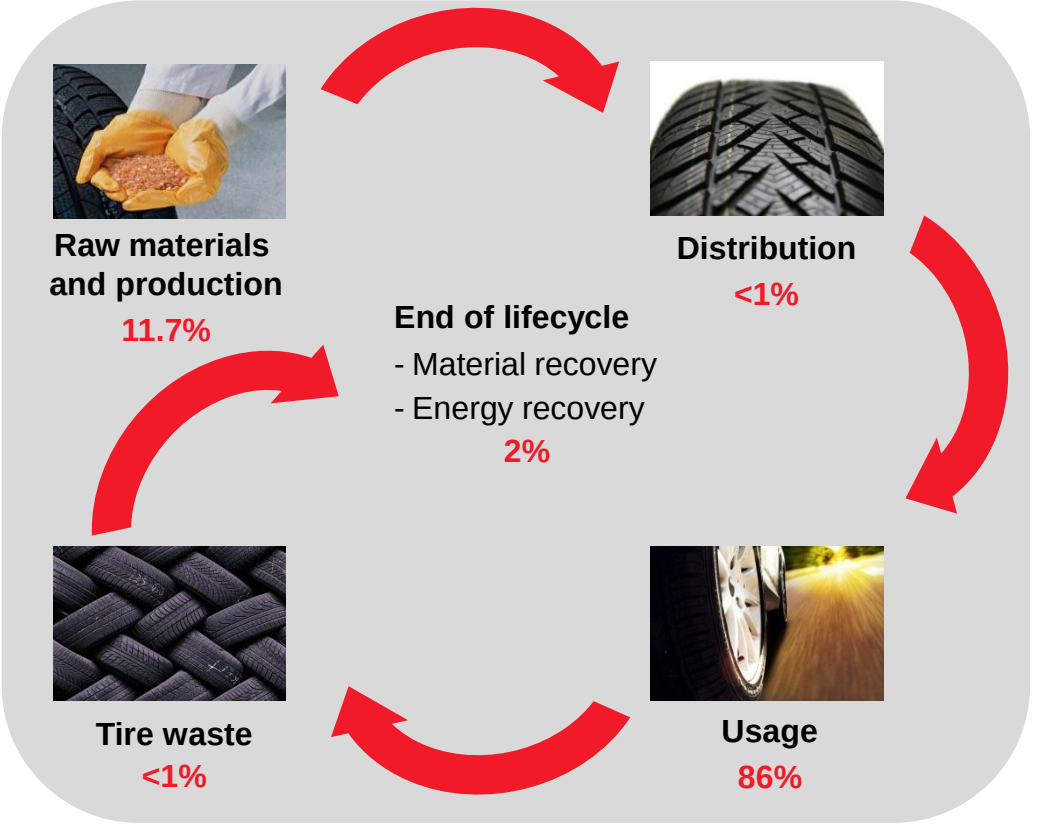


* Calculation based on a car with a gasoline engine and an average fuel consumption of 10 L/100 km
** Depending on distance driven

# Tires have the highest environmental impact when they are in use on the road

- The biggest share of environmental pollution related to tires is created during road use, in total 86%
  - tire wear/particulate matter from abrasion accounts for roughly 10%
  - 76% of the adverse environmental impact of tires can be traced back to fuel consumption (and the associated emissions) during usage

**Contribution of the different stages of tire life cycle to the global impact on the environment**




Source: Michelin Fact Book 2003



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# Environmental impact of “Green Tires”

## “Green Tires” are vital for sustainable future mobility

(Calculation based on a car with a gasoline engine and an average fuel consumption of 10 L/100 km)

| | |
|---|---|
| **Reduced rolling resistance** | -30 % |
| **Reduced fuel consumption** | -0.5 l/100 km |
| **Reduced $CO_2$ emissions** | -1.2 kg/100 km |

**Improved environmental impact**

Source: www.auto-motor-und-sport.de/eco/verbrauchsreduzierung-rollwiderstandsoptimierte-reifen-alles-ueber-den-reifen-rollwiderstand-1899808.html



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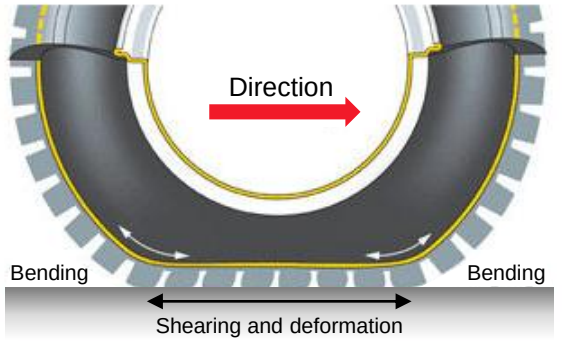
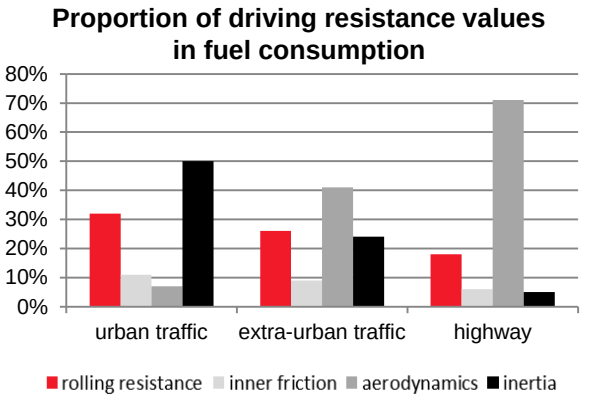
# Impact of rolling resistance on engine performance

**Fuel consumption** | **$CO_2$ emissions** | **Noise emissions**

- During travel, the tire deforms to absorb road surface irregularities – it is because it can change shape that it provides grip and comfort
- As the rubber compounds are deformed, they heat up and dissipate part of the energy transmitted by the engine – a phenomenon known as rolling resistance
- On average, 20-30% of fuel consumption is used to overcome rolling resistance, while the rest of the fuel consumed serves to counter air resistance, inertia and inner friction (e.g. in the engine or transmission)

**"Green Tires" with lower rolling resistance help to reduce fuel consumption**




Sources: BMW, Der Reifen im Spannungsfeld zwischen hohen technischen Anforderungen und immer schärfer werdenden gesetzlichen Auflagen, 2008
Michelin Fact Book 2003
ADAC, www.adac.de/infotestrat/reifen/rollwiderstand.aspx



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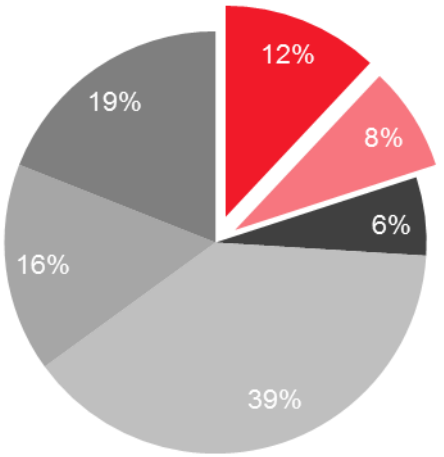
# The relationship between $CO_2$ emissions and tires

| Fuel consumption | $CO_2$ emissions | Noise emissions |
|---|---|---|

- Passenger cars are responsible for
  - roughly 12% of total $CO_2$ emissions in the EU
  - roughly 5% of man-made $CO_2$ emissions globally – this is on the rise
- A reduction of road traffic emissions – especially in developed countries – would have a significant effect on the overall $CO_2$ balance
- Rolling resistance and fuel consumption have an immediate impact on $CO_2$ emission

**Fuel-efficient "Green Tires" help to reduce road-traffic-related $CO_2$ emissions**

**Road transport accounts for about one fifth of the EU's total $CO_2$ emissions**




- Passenger cars
- Other road traffic
- Other transport
- Generation & conversion of energy
- Industry
- Households

Sources: ec.europa.eu/clima/policies/transport/vehicles/cars_en.htm
www.acea.be/index.php/news/news_detail/sources_of_co2_emissions_in_the_eu



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# Road traffic and noise pollution

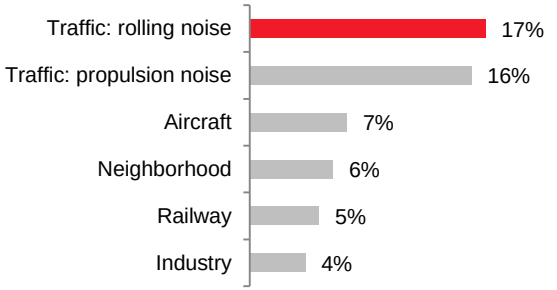
| Fuel consumption | $CO_2$ emissions |
|---|---|

- Traffic noise is by far the biggest source of noise pollution
- An overall increase in traffic has offset continuous reductions in noise pollution across the automotive sector
- Road traffic noise consists primarily of propulsion noise (engine, exhaust systems etc.) and rolling noise (tire-road interaction)
- The vast array of preventive and remedial measures includes tire and engine technologies, road surfacing and traffic management strategies

**Quiet tires with innovative tread patterns and optimized rubber composites help to reduce rolling noise emissions**

## Noise emissions

**At 33%, traffic noise represents the biggest source of noise pollution in Germany**




Sources: www.nynas.com/templates/Page____9037.aspx?epslanguage=EN
www.iproplan.de/cms/images/stories/pdf/10_03.pdf



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6. An emerging global market for “Green Tires”
7. LANXESS – a key enabler of “Green Tires”

# “Green Tires” meet diverse consumer demands

**High safety standards**

**Reduced environmental impact**

**Greater durability**



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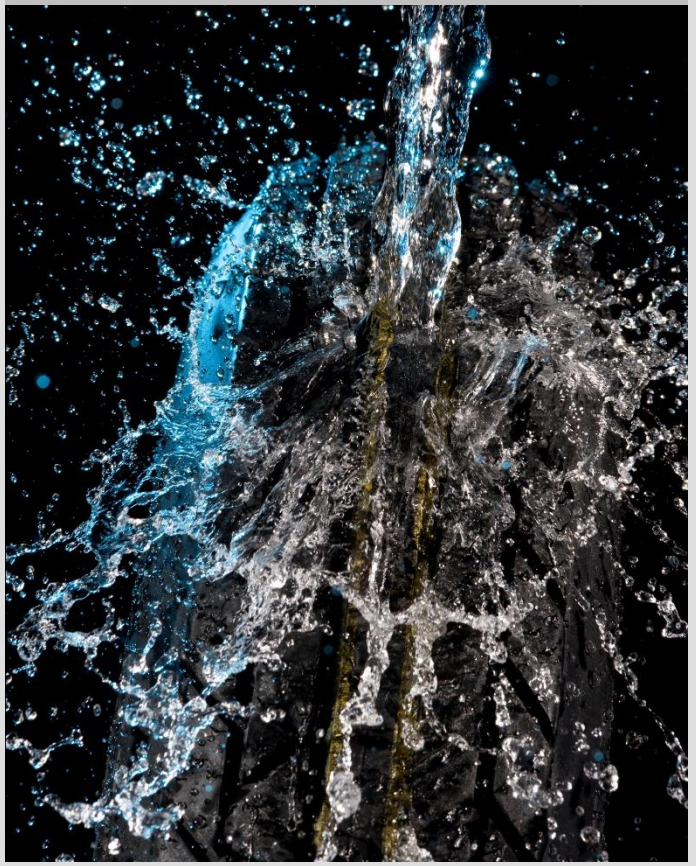
# “Green Tires” – improving safety standards

**Safety** | **Sustainability** | **Durability**

## Safety comes first

- Safety ranks as the most important parameter for drivers
- “Green Tires” offer excellent performance in traction, handling and wet grip
- Wet grip of tires is a key factor for safety
  - “Green Tires” guarantee a better wet road grip and thus a shorter braking distance than regular tires
  - new EU tire labeling informs customers of the important safety aspect of wet grip performance and helps set the right priorities in the purchasing process





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# “Green Tires” – providing better environmental protection

| Safety | **Sustainability** | Durability |
|---|---|---|

**Growing societal demand for environmental stewardship**

- High consumer demand for sustainable mobility driven by
  - increased traffic volume
  - the high price of fossil fuels
  - increased environmental awareness
- “Green Tires” allow every driver to make a personal contribution to improving the energy efficiency of automobiles and to protect the environment
- Fitting all vehicles worldwide with “Green Tires” could result in annual savings of around 20 billion liters of fuel and nearly 50 million metric tons of $CO_2$ emissions

Source: Michelin



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# “Green Tires” – increasing mileage and service life

| Safety | Sustainability | Durability |
|---|---|---|

**Enhancing ride quality and mileage**

- Raising consumer demand for driving comfort and tire durability due to
  - increasing personal mobility
  - longer travel distances and higher mileage
  - growing cost sensitivity
- “Green Tires” provide enhanced mileage and longer service life, resulting in
  - better price-performance ratio
  - conservation of environmental resources
  - reduced particulate matter from tire abrasion
  - less tire waste



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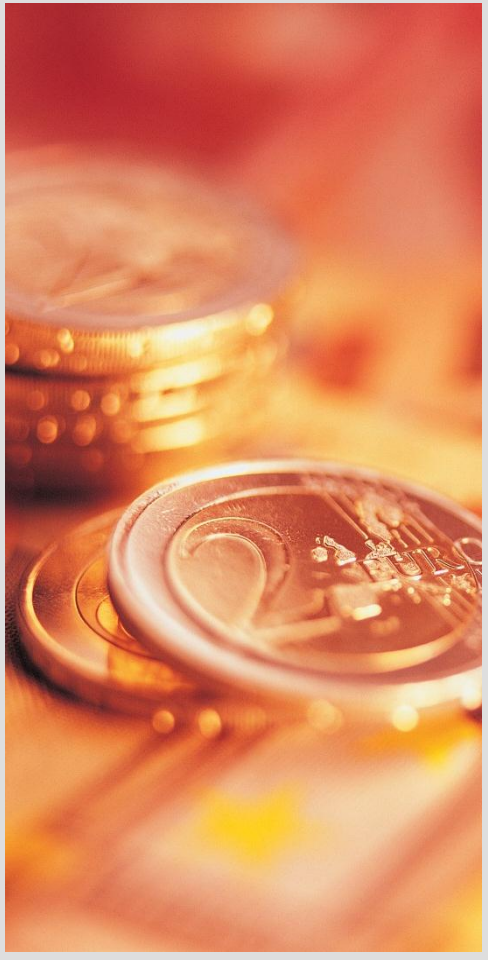
# “Green Tires” – a worthwhile investment

**“Green Tires” offer savings potential**

- While “Green Tires” may cost a little more up front, they reduce fuel consumption by 5% to 7%
- Consumers will benefit in the long run from better fuel economy, translating into savings at the gas pump
- ***Example:*** A person traveling 12,500 km per year could easily save up to 100 EUR of fuel each year. The additional investment of 20 to 50 EUR per tire is amortized within two years





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# “Green Tires” that combine efficiency and safety are already a reality

Examples

| Pirelli | Bridgestone | Continental | Goodyear | Michelin | Hankook |
|---|---|---|---|---|---|
| **Cinturato P1** | **Ecopia EP 150** | **Ecocontact 5** | **EfficientGrip** | **Energy Saver** | **Kinergy Eco** |
| ▪ Reduced rolling resistance **25%*** | ▪ Reduced rolling resistance **15%*** | ▪ Reduced rolling resistance **20%*** | ▪ Reduced rolling resistance **15%***** | ▪ Reduced rolling resistance **20%*** | ▪ Reduced rolling resistance **12%*** |
| ▪ Reduced wet braking distance **3%*** | ▪ Reduced wet braking distance **5%*** | ▪ Reduced wet braking distance **10%*** | ▪ Reduced wet braking distance **3%***** | ▪ Shorter wet braking distance **3m** (from 80 to 10 km/h)* | ▪ Reduced wet braking distance **8%*** |
| ▪ Improved mileage **30%**** | ▪ Improved mileage **15%*** | ▪ Improved mileage **12%*** | ▪ Improved mileage **3%***** | ▪ Improved mileage **40%***** | ▪ Improved mileage **no data** |

Sources: Pirelli; Bridgestone; Continental; Goodyear; Michelin; Hankook

* Compared to their predecessors
** Compared to ordinary tires
*** Compared to the average performance of leading competitors’ tires



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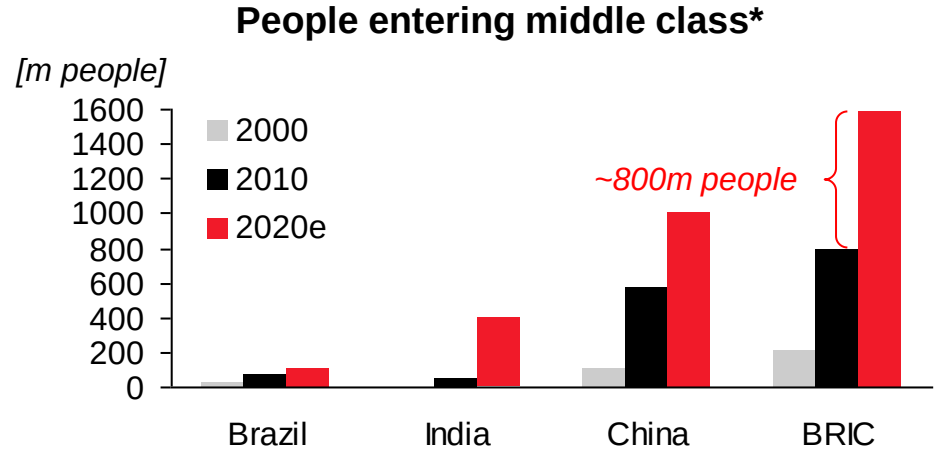
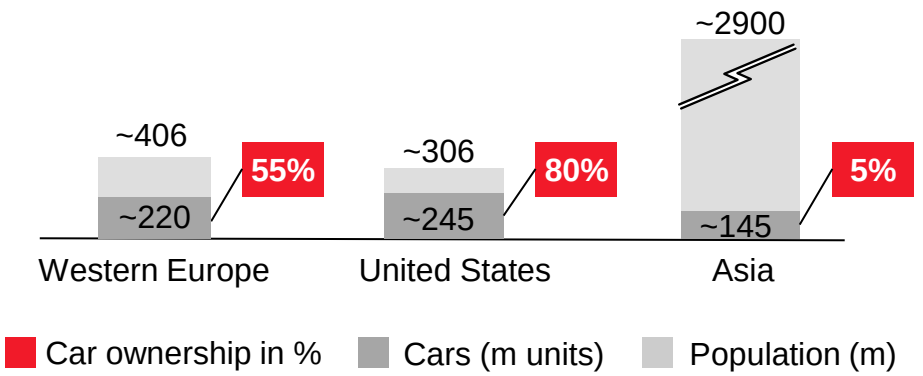
# Increasing worldwide demand for mobility

- Rising worldwide prosperity, particularly in China and India
- Enables an increasing number of new middle-class families to achieve personal mobility
- Millions of trade-ups to be realized soon
  - bicycles for mopeds
  - mopeds for cars
- Leading to increased car ownership, especially in Asia

**Future mobility demand driven by emerging Asian middle class**




Sources: Goldman Sachs Global Economics Group. "Is this the BRICs decade?", 2010
Michelin estimates

* Population with income >$6,000 and <$30,000/capita in BRIC countries



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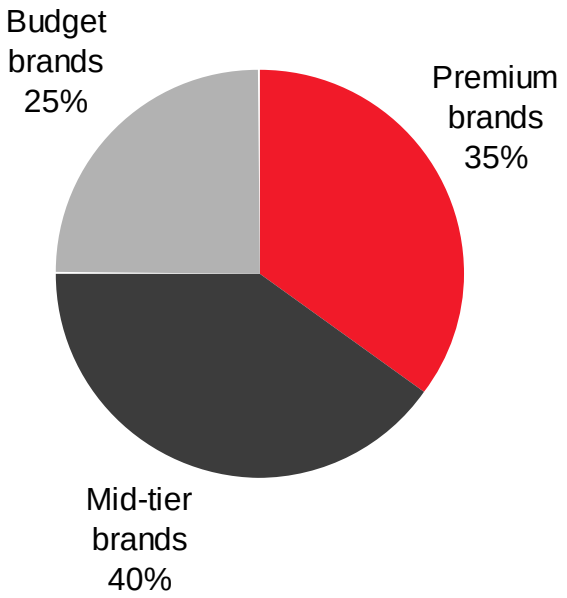
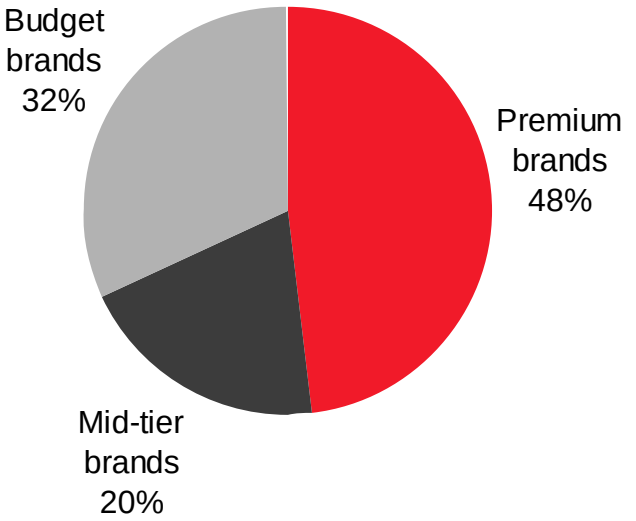
# New tire regulations will lead to a polarized tire market

## Tire market by segment, pre-regulation*




## Tire market by segment, post-regulation




**Growing demand for high-performance premium brands**

Source: Exane BNP Paribas estimates

* Global tire related regulations (EU, Japan, South Korea, etc.)



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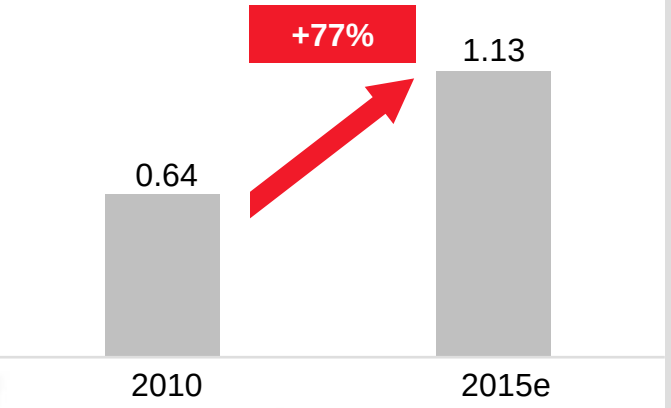
# Increasing demand for tires

**Demand for high-performance tires is growing**

- By 2015, the high-performance tire segment will have increased by 77%
- Rolling-resistance-optimized tires are expected to replace regular tires and become the standard in Europe
- The implementation of new EU regulations will challenge the global rubber, tire and automotive industries to adapt their products and processes to the $CO_2$ emission requirements

**Increasing tire demand**

Global production of (high-)performance tires [bn units]




**LANXESS offers the right products for “Green Tires”**



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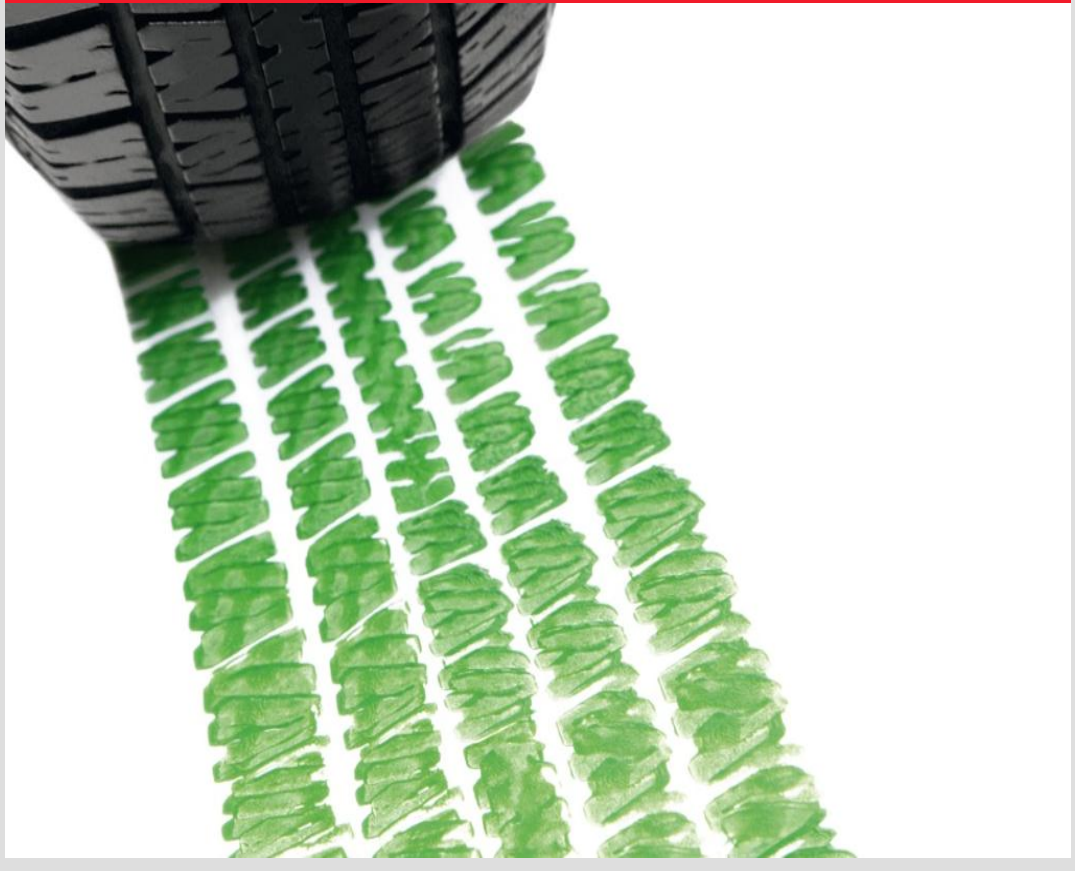
7. **LANXESS – a key enabler of “Green Tires”**

# Expertise and innovation are key elements for sustainable development

## Driving sustainable mobility…

- LANXESS has more than 100 years of experience in the development and production of synthetic rubber and rubber chemicals
- LANXESS sets the pace in the field of performance rubbers by constantly developing new innovative products
- Half of LANXESS' sales to the rubber industry are to tire manufacturers
- LANXESS is clearly focused on products for "Green Tires"

## …through continuous development





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# LANXESS is committed to products for tires

| | | |
|---|---|---|
| **R&D** | ▪ Focusing on product innovations that enable our customers to create safe, durable, and fuel-saving tires that meet the challenges of growing mobility worldwide |  |
| **Production facilities** | ▪ Expanding rubber production capacities to serve growing demand<br>▪ Construction of the world's largest Nd-PBR plant in Singapore by 2015 |  |
| **Technical support** | ▪ Technical experts in the rubber business units support our most exacting customers with state-of-the-art services and solutions that bring significant value to their business |  |



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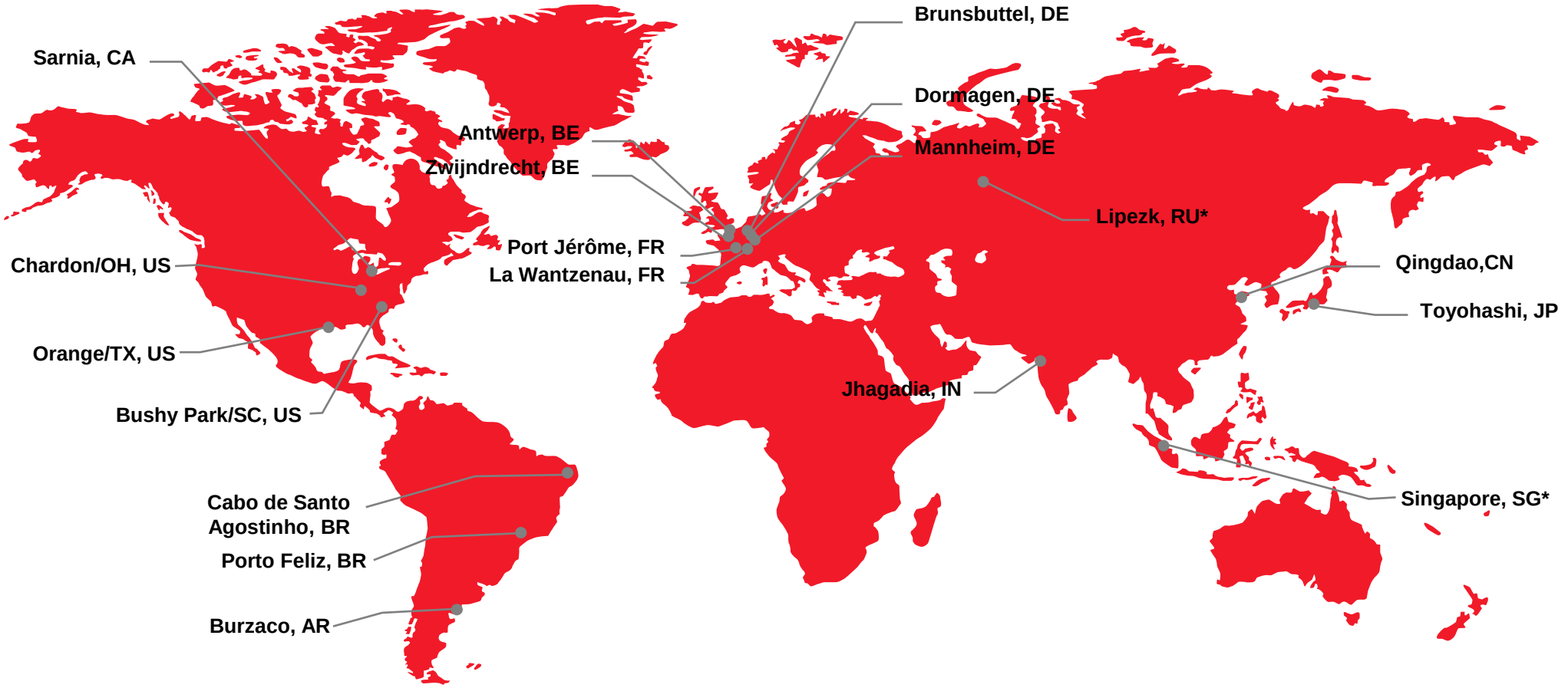
# LANXESS sites worldwide providing products for “Green Tires”




* Under construction



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# LANXESS offers the broadest portfolio of synthetic rubbers and additives in the industry (1/2)

| Supplier | Tire | | | Technical Rubber Products | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SBR | BR | IIR | EPDM | CR | NBR | HNBR | AEM | ACM | EVM | CSM | FKM | ECO |
| LANXESS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | | ✓ | |
| POLIMERI EUROPA | ✓ | ✓ | | ✓ | | ✓ | | | | | | | |
| DUPONT | | | | | ✓ | | | ✓ | | | | ✓ | |
| DOW | ✓ | ✓ | | ✓ | | | | | | | | | |
| Exxon | | | ✓ | ✓ | | | | | | | | | |
| JSR | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | | | | |
| ZEON CHEMICALS | ✓ | ✓ | | | | ✓ | ✓ | | ✓ | | | | ✓ |



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# LANXESS offers the broadest portfolio of synthetic rubbers and additives in the industry (2/2)

| Supplier | Accelerators | | | | | Antidegradants | | | | | Special Chemicals | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CBS | TBBS | DCBS | MBS | MBT | 6PPD | IPPD | 77PD | DTPD | TMQ | DBD | BDTCH | BCI-MX | Silica Add.* | Vulka-link** |
| LANXESS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| FLEXSYS | | | | | | ✓ | | ✓ | | | | | | | |
| SINORGCHEM | | | | | | ✓ | ✓ | | | | | | | | |
| China Sunsine Chemical Holdings Ltd. | ✓ | ✓ | ✓ | | ✓ | | | | | ✓ | | | | | |
| Kemai | ✓ | ✓ | ✓ | | | | | | | ✓ | | | | | |
| KUMHO PETROCHEMICAL | | | | | | ✓ | | | | | | | | | |
| GENERAL QUÍMICA | ✓ | ✓ | | | ✓ | | | | | ✓ | | | | | |
| ISTROCHEM DUSLO | ✓ | ✓ | | | | ✓ | ✓ | | | | | | | | |
| 武汉经河化工有限公司 WUHAN JINGHE CHEMICAL CO.,LTD | | | | | | | | | | | ✓ | | ✓ | | |

* General abbreviation does not exist yet

** Product under development



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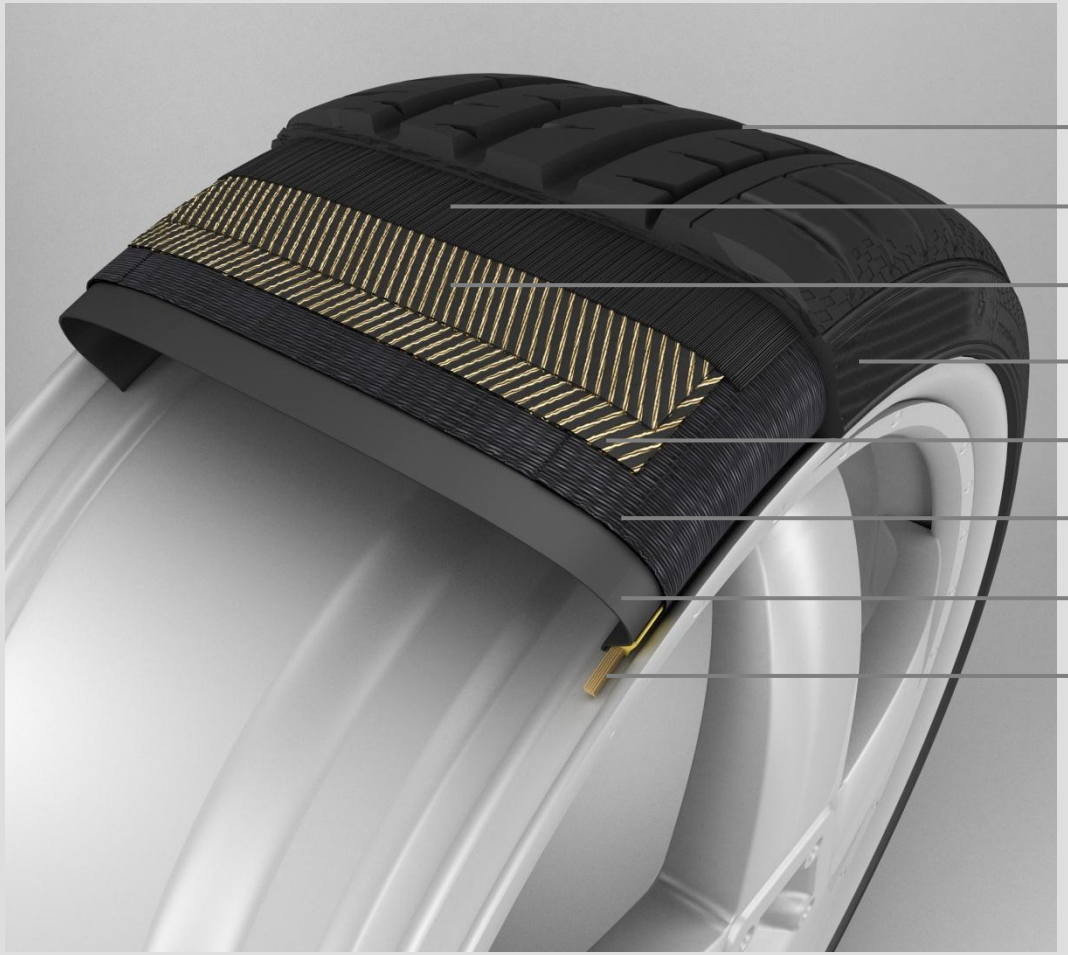
# “Green Tires” energized by LANXESS



| | |
|---|---|
| Tread | → *Influences grip, fuel economy and noise* |
| Undertread | → *Joins the tread to steel belt and carcass* |
| Upper steel belt | → *Influences driving features and shape* |
| Sidewall | → *Protects carcass and influences fuel consumption* |
| Lower steel belt | → *Influences the driving features and shape* |
| Carcass | → *Gives support and shape* |
| Innerliner | → *Replaces the tube* |
| Steel wires | → *Keeps the tire safely attached to wheel rim* |

**Energized by LANXESS rubber and additives**



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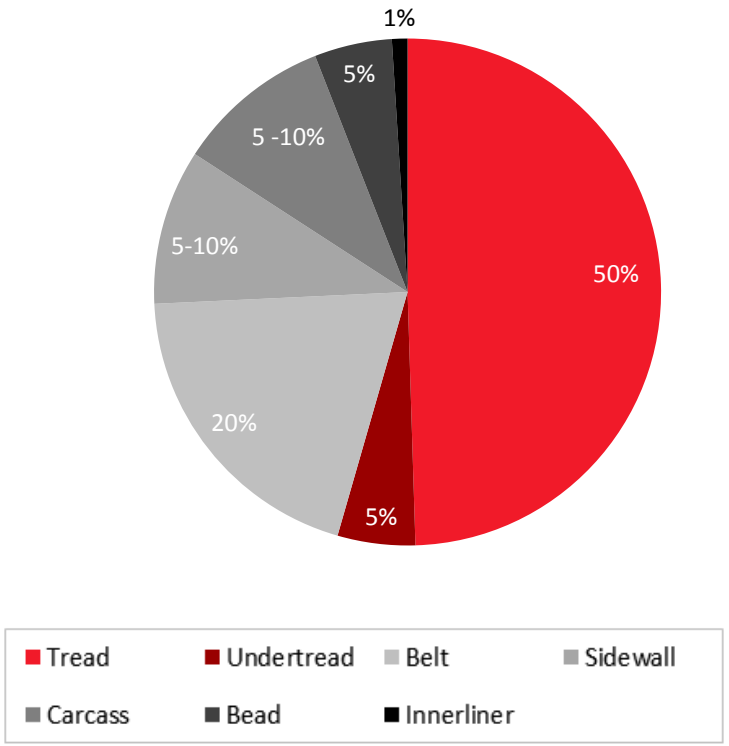
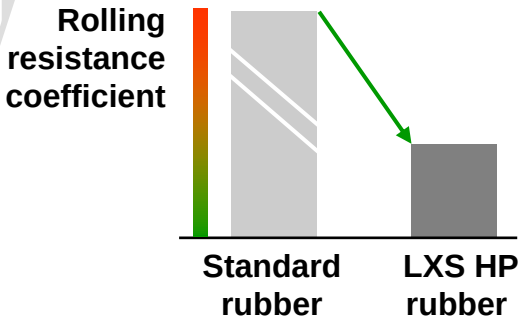
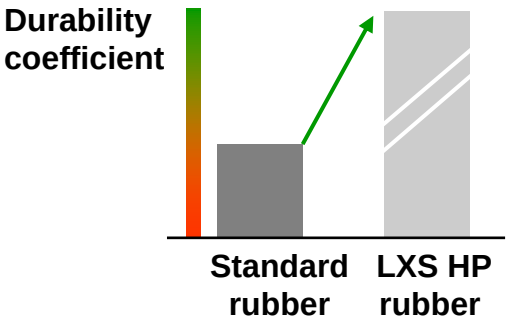
# High-end rubbers needed to improve tire efficiency

## Proportion of tire components in rolling resistance

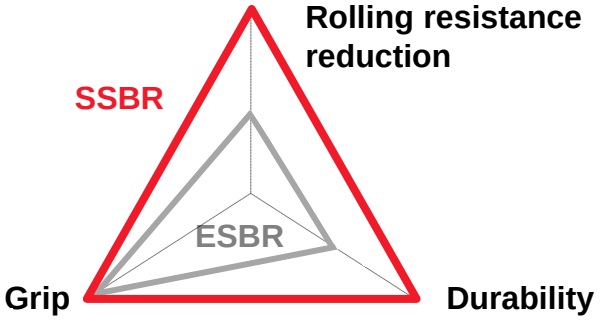



## LANXESS solutions to increase tire performance




### Effect of LANXESS high-end rubbers in treads




Source: BMW, Der Reifen im Spannungsfeld zwischen hohen technischen Anforderungen und immer schärfer werdenden gesetzlichen Auflagen, 2008



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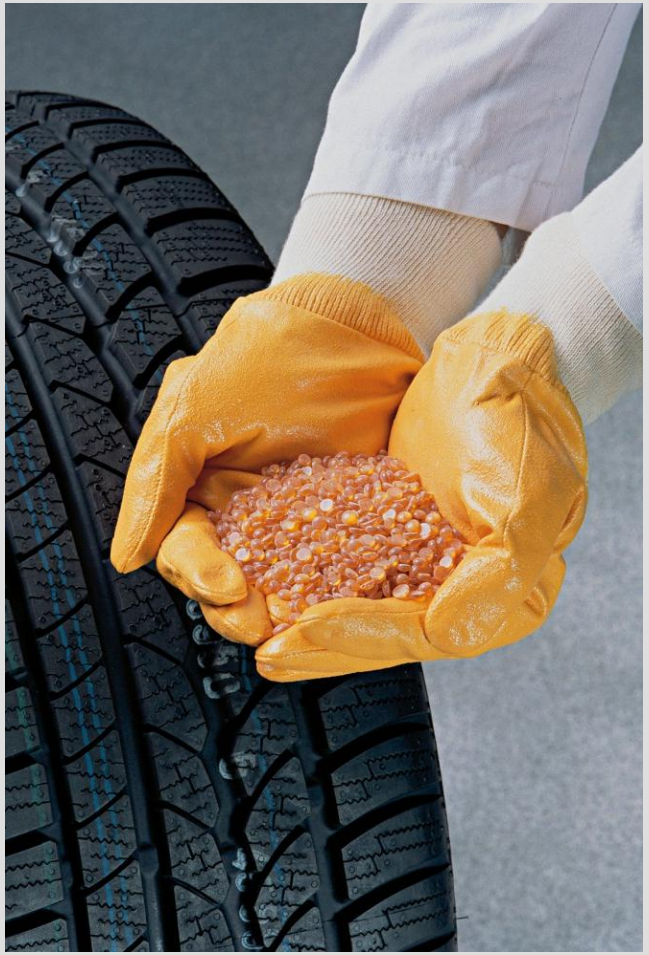
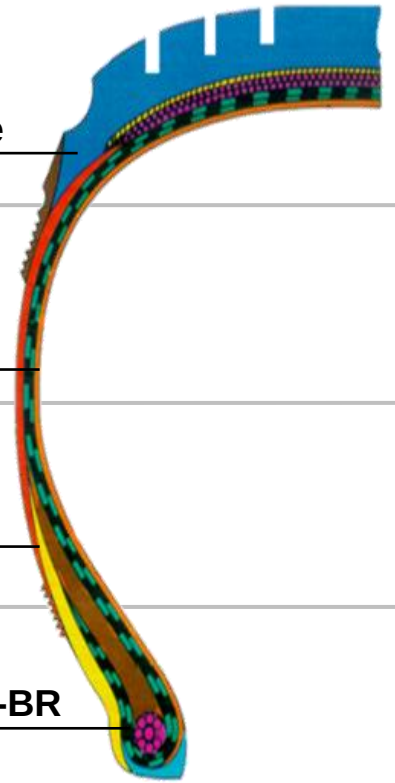
# Synthetic rubbers – more than just increased efficiency



| Characteristics of “Green Tires”: LANXESS products | |
|---|---|
| Optimized microstructure and filler interaction<br>→ **Fuel economy** | **S-SBR**<br>**Nd-PBR**<br>**Nanoprene** |
| Long chains (physical network)<br>→ **Crack resistance** | **Nd-PBR** |
| Flexible chains<br>→ **Elasticity** | **Nd-PBR**<br>**Co-BR** |
| High hardness<br>→ **Wear resistance** | **coupled Li-BR** |





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# LANXESS premium products for “Green Tires” – Solution-styrene-polybutadiene rubber (S-SBR)

**Characteristics**

- High density of anchor points that stick particularly well to the hard filler particles → excellent bonding to silica
- Covering of the silica particles with a thick, friction-reducing rubber skin → reduction of the internal friction of the reinforcing silica particles


**Benefits**

- Optimized rolling resistance → increase in fuel efficiency and reduction of $CO_2$ emissions
- Outstanding road grip → enhanced safety
- Very long service life → improved mileage

**Main brand**

Buna® VSL



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# LANXESS premium products for “Green Tires” – Neodymium polybutadiene rubber (Nd-PBR)

| | | |
|---|---|---|
| **Characteristics** | ▪ Highest stereoregularity, narrowest molecular weight distribution and least branching within group of high cis-BRs → manufacture of tires with outstanding physical data<br>▪ Very linear and unique macrostructure → lower heat build-up and higher flexibility than other tire elastomers<br>▪ Strain-induced crystallization → greater resistance |  |
| **Benefits** | ▪ Optimized rolling resistance → increased fuel efficiency and reduction of $CO_2$ emissions<br>▪ Excellent resistance to abrasion, flex cracking and fatigue → improved safety and durability |  |
| **Main brand** | Buna® CB | |



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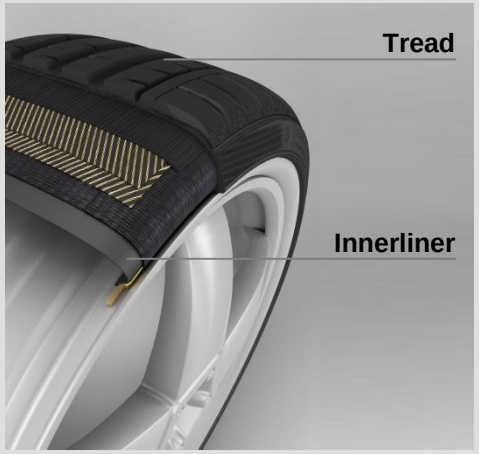
# LANXESS premium products for “Green Tires” – Butyl and halobutyl rubber

**Characteristics**

- Innerliners made of butyl rubber are highly impermeable to air → help prevent under-inflation
- Butyl rubber in tread compounds → softer tires and better grip and comfort




**Benefits**

- Optimized rolling resistance → increased fuel efficiency and reduction of $CO_2$ emissions
- Improved wet traction → greater safety

**Main brands**

Butyl® Chlorobutyl® Bromobutyl®



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# LANXESS premium products for “Green Tires” – Nanoprene

| | | |
|---|---|---|
| **Characteristics** | ▪ Consists of particles of only around 50 nanometers made from polymerized styrene and butadiene – i.e. “traditional” tire rubber raw materials → minimal size<br>▪ Nanoparticles with a swell-resistant, highly cross-linked core have special “anchor points” on their surface → Nanoprene particles can be perfectly linked with silica and silanes |  |
| **Benefits** | ▪ Enhanced road grip → greater safety<br>▪ Significant improvement in abrasion resistance → increased tire lifespan/mileage and reduced rubber particle emissions |  |
| **Main brand** | Nanoprene® | |



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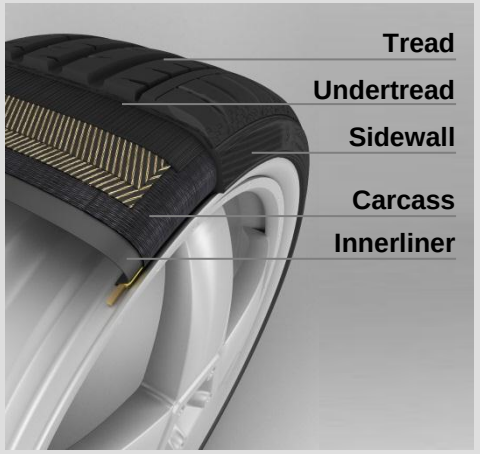
# LANXESS premium products for “Green Tires” – Sulfenamides for sulfur cross-linking

| | | |
|---|---|---|
| **Characteristics** | ▪ Highly effective accelerator of vulcanization<br>→ better kinetics and network establishment |  |
| **Benefits** | ▪ Outstanding scorch safety and fast vulcanization time<br>→ optimized safe and short tire curing |  |
| **Main brand** | **Vulkacit® CZ / NZ / DZ / MOZ** | |



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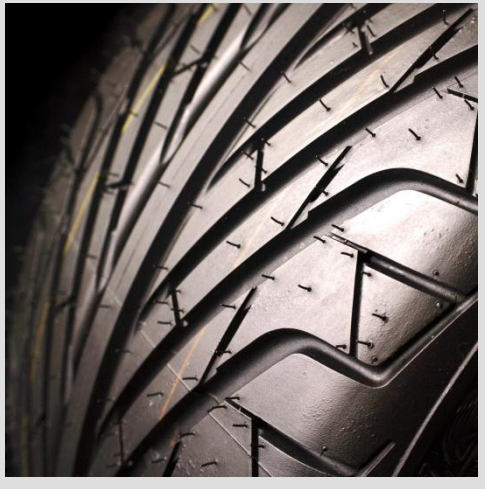
# LANXESS premium products for “Green Tires” – Phenylendiamines and quinoline as antidegradants

| | | |
|---|---|---|
| **Characteristics** | ▪ Protection of rubber goods against oxygen, ozone, fatigue cracking and rubber poison → manufacture of tires with good aging resistance<br>▪ Technologically and economically superior antidegradants for rubber particles → improved service life of tires |  |
| **Benefits** | ▪ Protection against fatigue and ozone, prevention of aging and improved service life of tires |  |
| **Main brand** | **Vulkanox® 4020 / 4010 NA / 4030 / 3100 / HS** | |



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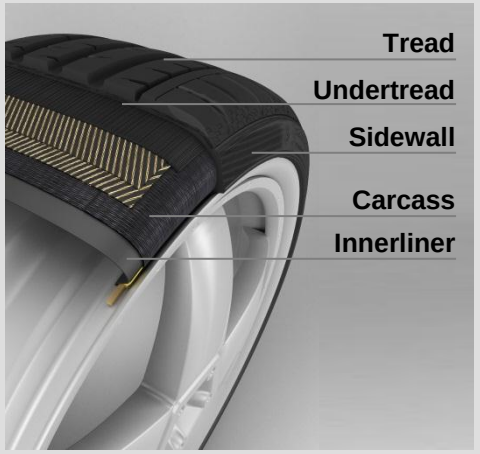
# LANXESS premium products for “Green Tires” – Peptizer for mastication of natural rubber

| | | |
|---|---|---|
| **Characteristics** | ▪ Reduction of molecular weight of natural rubber<br>→ improved processing and blending of mix |  |
| **Benefits** | ▪ Reduction of total mixing energy → lower energy required for processing of tires<br>▪ Shorter mixing time → higher output |  |
| **Main brand** | **Renacit® 10 / 11 / 9203** | |



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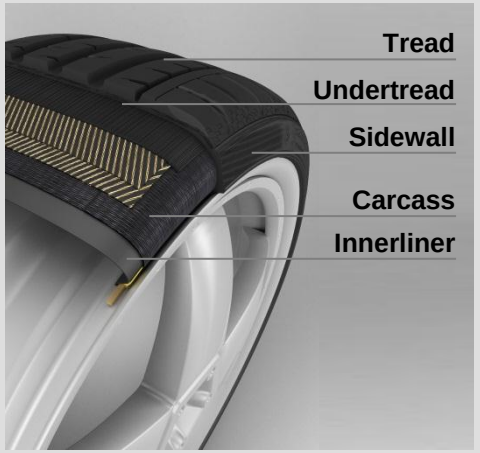
# LANXESS premium products for “Green Tires” – Antireversion agents

**Characteristics**

- Improved stability of network
  → maintaining physical tire characteristics
- Introduction of hybrid cross-links during vulcanization or repairing network during service life
  → improved service life of tires




**Benefits**

- Slower reversion of tread compound → more constant tire performance over the entire life of the tire
- Lower rolling resistance and DPG replacement possible → reduced fuel consumption and almost no aniline (carcinogenic) emission

**Main brands**

Vulcuren®  Perkalink® 900



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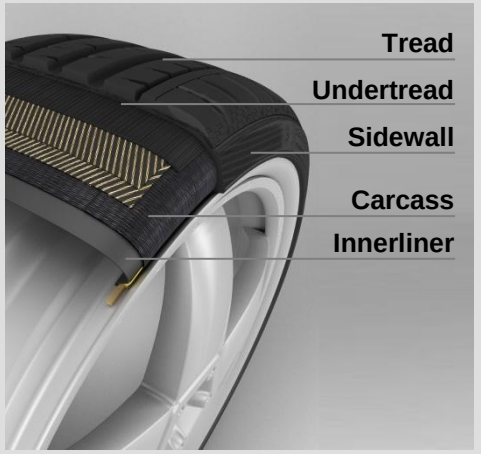
# LANXESS premium products for “Green Tires” – Processing additives for silica compounds

**Characteristics**

- Processing additives to reduce compound viscosity without reducing crosslinking density and hardness of the vulcanisate
- Often also the Rheometer behavior is improved (steeper curve with good scorch safety)




**Benefits**

- Avoidance of heavy metal zinc in manufacturing for tires → improved environmental friendliness

**Main brand**

**Silica Additive 9202**



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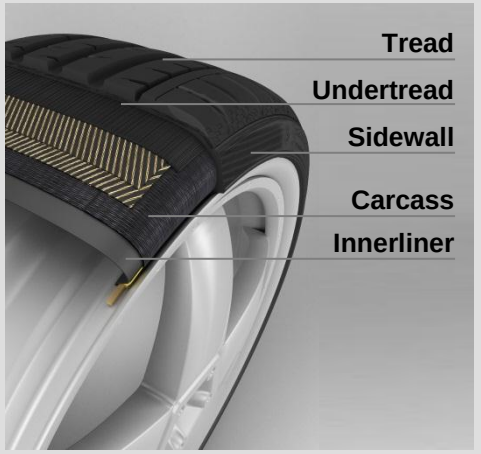
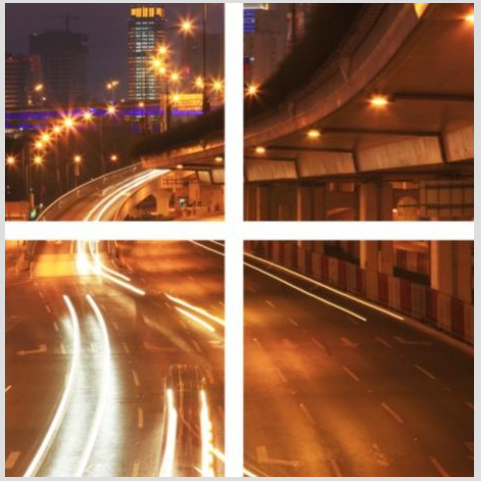
# LANXESS premium products for “Green Tires” – Functional additives

| | |
|---|---|
| **Characteristics** | ▪ Improved interaction between silica and polymer |
| **Benefits** | ▪ Optimized rolling resistance → increased fuel efficiency and reduction of $CO_2$ emissions |
| **Main brand** | **Vulkalink®** |





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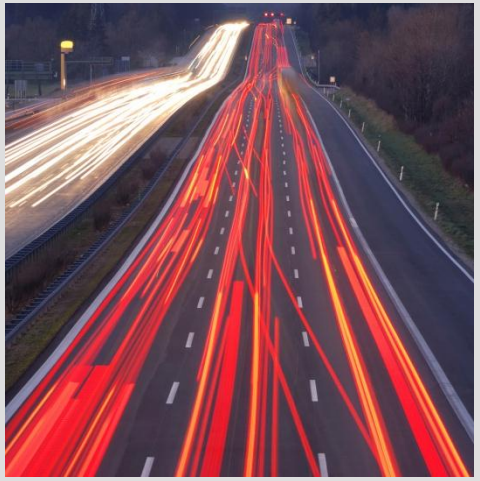
# LANXESS premium products for “Green Tires” – Processing agents

**Characteristics**

- Customized processing promoters available for all types of tire related compounds, e.g. processing agents specifically developed for use in silica treads


**Benefits**

- Improvement in processing properties → higher productivity, lower energy consumption
- No adverse effects on the tire’s physical properties → no compromise between savings in production and tire performance necessary



**Main brands**

**Aflux®** **Aktiplast®**



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# LANXESS premium products for “Green Tires” – Release agents

| | | |
|---|---|---|
| **Characteristics** | ▪ Typically adapted to the customer's specific setup → addresses all release problems of a production process in a tire plant<br>▪ Powder release agents for all grades of rubber, including soft and oily synthetic rubber compounds → easy interim storage of rubber sheets and further processing after relevant mixing stages |  |
| **Benefits** | ▪ Aqueous paints for the inside of tires & bladder coatings → problem-free vulcanization and lower scrap rates<br>▪ Semi-permanent bladder coating → longer service life |  |
| **Main brand** | **Rhenodiv®** | |



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# LANXESS premium products for “Green Tires” – Specialty accelerators

| | |
|---|---|
| **Characteristics** | ▪ Improves reversion properties in all kinds of rubber grades<br>▪ Enhance solubility of other accelerators such as benzothiazole sulfenamides or benzothiazoles (when combined) → higher crosslinking efficiency |
| **Benefits** | ▪ DPG replacement in silica formulations → no aniline (carcinogenic) emissions<br>▪ Exceptionally useful in difficult formulations based on mercaptosilanes → further optimized rolling resistance |
| **Main brand** | **Rhenocure®** |




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# LANXESS premium products for “Green Tires” – Bonding agents

**Characteristics**

- Ensures reliable bonding of rubber compounds with the textile and steel reinforcing layers of a tire


**Benefits**

- Stable RFL dip quality for fabric impregnation → less formaldehyde necessary
- Use in steel cord compounds → consistently high level of rubber to metal bonding in radial tires

**Main brands**

**Rhenosin®** **Rhenogran®**



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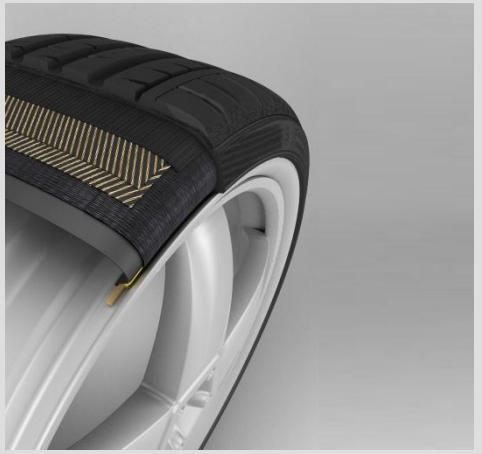
# LANXESS premium products for “Green Tires” – Zinc oxide and crosslinking resin

| | | |
|---|---|---|
| **Characteristics** | ▪ Provide an excellent solution to challenges involved in producing butyl bladder compounds |  |
| **Benefits** | ▪ Resin and ZnO already incorporated into butyl rubber → prevents clumps of resin forming on hot metal surfaces in the internal mixer<br>▪ Even dispersion of crosslinking chemicals → higher bladder durability |  |
| **Main brand** | **Rhenogran® PCZ-70/IIR** | |



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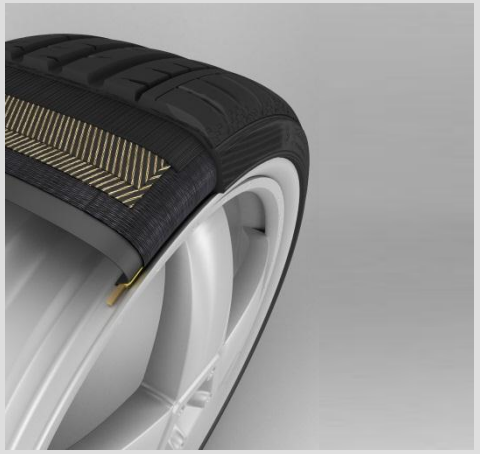
# LANXESS premium products for “Green Tires” – Rhenoshape® Curing Bladders

| | | |
|---|---|---|
| **Characteristics** | ▪ Ensure a smooth and efficient tire curing process |  |
| **Benefits** | ▪ Increased productivity → longer bladder life and shorter cure cycles with high conductive compound<br>▪ Better tire finish appearance → innovative bladder venting design and surface finish reduce tire scrap |  |
| **Main brand** | **Rhenoshape®** | |



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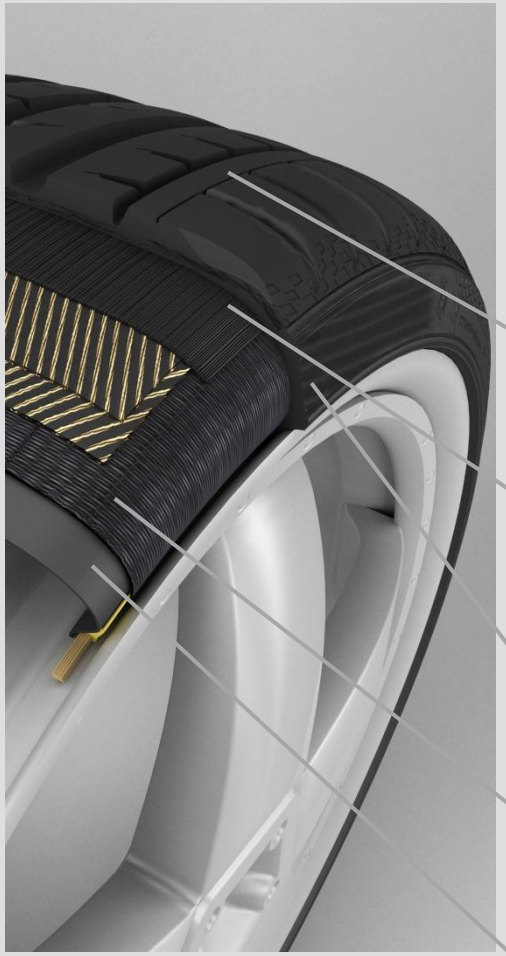
# LANXESS premium products for “Green Tires” – Overview



| LANXESS products / Tire components | Synthetic rubber | | | Additives | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Buna® VSL | Buna® CB | Butyl® Chlorobutyl® Bromobutyl® | Nanoprene® | Vulkacit® CZ , NZ, DZ, MOZ | Vulkanox® 4020, 4010, NA, 4030, 3100, HS | Renacit® 10, 11, 9203 | Vulcuren® Perkalink® | Silica Additive 9202 | Vulkalink® | Aflux® Aktiplast® | Rhenodiv® | Rhenocure® | Rhenosin® Rhenogran® |
| Tread | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Under-tread | | | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ |
| Side-wall | | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | |
| Carcass | | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ |
| Innerliner | | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |



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# LANXESS – for a sustainable future of mobility

- Performance rubbers are key to solving demanding tire requirements ✓
- LANXESS is the leading supplier of high performance rubbers and additives ✓
- LANXESS S-SBR and Nd-PBR for maximum performance ✓
- Vast expertise on how future tire generations can help achieve sustainable mobility goals ✓




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Energizing Chemistry

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