Reducing the carbon footprint from road use

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Asphalt's Carbon Footprint, SCI, London

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Principal factors that influence carbon footprint from road use

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Principal factors that influence carbon footprint from vehicle use

- No of vehicles – globally set to treble by 2050
- Type of vehicle – weight, aerodynamic drag
- Type of engine – IC, hybrid, electric
- Type of fuel – hydrocarbon, biofuel, fuelcell
- Fuel Price – oil price, tax
- Vehicle materials/manufacturing methods/use of recyclate
- Fuel Economy – '50by50 Challenge' launched at Geneva Motor Show
- Legislation – Emission standards

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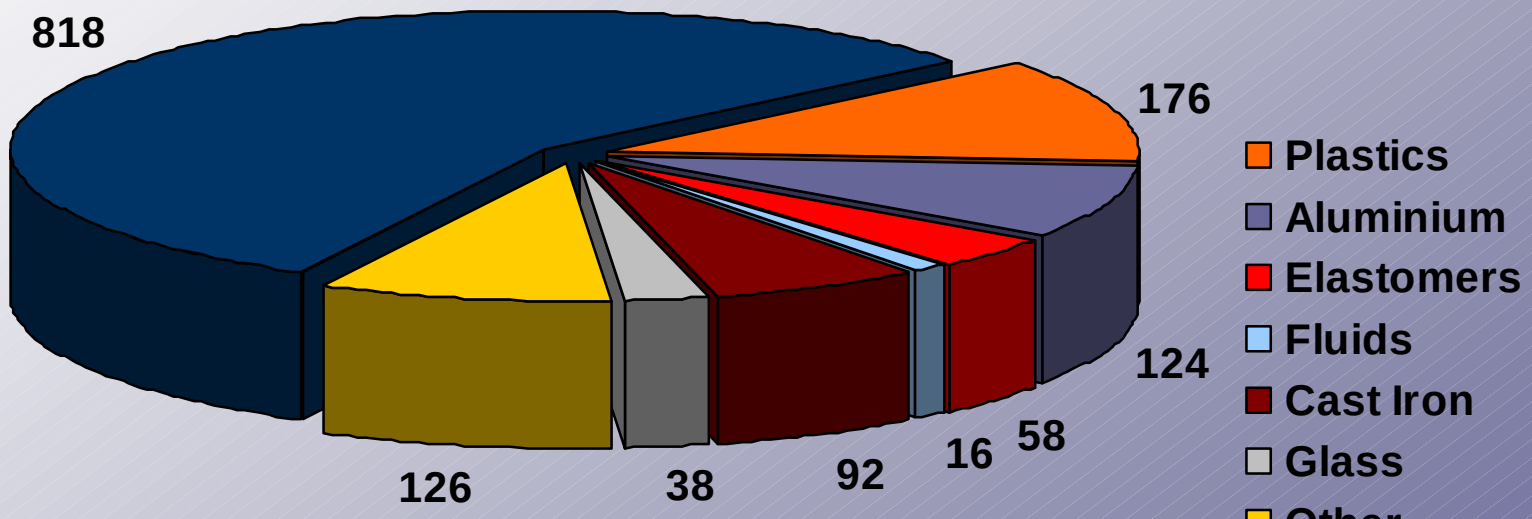
Composition of a vehicle: Ford Mondeo

Weight of components, kg



Total weight = 1449kg

Tyres account for about 40kg

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Environmental impact of tyres

- Use of renewable (or sustainable) materials
- Energy consumption over life cycle of rubber product è
  Depletion of fossil fuels
  CO_2 emission è climate change
  - Production of raw materials
  - Transportation of materials and products
  - Use
  - Lifetime
  - Disposal or recycling

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Renewable raw materials used in tyres

Recently:

Epoxidised Natural Rubber (ENR)

Vegetable oils (or derivatives)

Natural fibres

Starch

- **Goodyear GT3, BioTred (2001)**
  Part-replacement of silica and black, improved performance

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Renewable raw materials used in tyres

Recently:

Epoxidised Natural Rubber (ENR)

Vegetable oils (or derivatives)

Natural fibres

Starch

➢ **Kumho (2007)**
Lyocell a fibre from wood pulp cellulose

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Renewable raw materials used in tyres

Recently:

Epoxidised Natural Rubber (ENR)

Vegetable oils (or derivatives)

Natural fibres

Starch

➢ **Nokian Hakkapeliitta 4 (2003)**
Used rape-seed oil,
improved performance

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Renewable/sustainable raw materials used in tyres

Recently:

NR + Epoxidised Natural Rubber ➤ **Sumitomo ENASAVE 97 (2008)**

Vegetable oils (or derivatives)

Natural fibres

Silica (sustainable ?)

Non-petroleum materials content up from 44% to 97%

- **ENR-silica treads**
- **ENR/NR sidewalls**
- **ENR inner liner**
- **Improved rolling resistance**
- **Better wet grip**

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Sustainable raw materials?

A Definition:

A sustainable system or process must be based on resources that will not be exhausted over a reasonable period (sometimes expressed as the 'long term').

Thus, silica may be regarded as a sustainable resource.

This is important for ENR in the context of sustainability.

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Natural rubber - sustainability

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Natural rubber - sustainability

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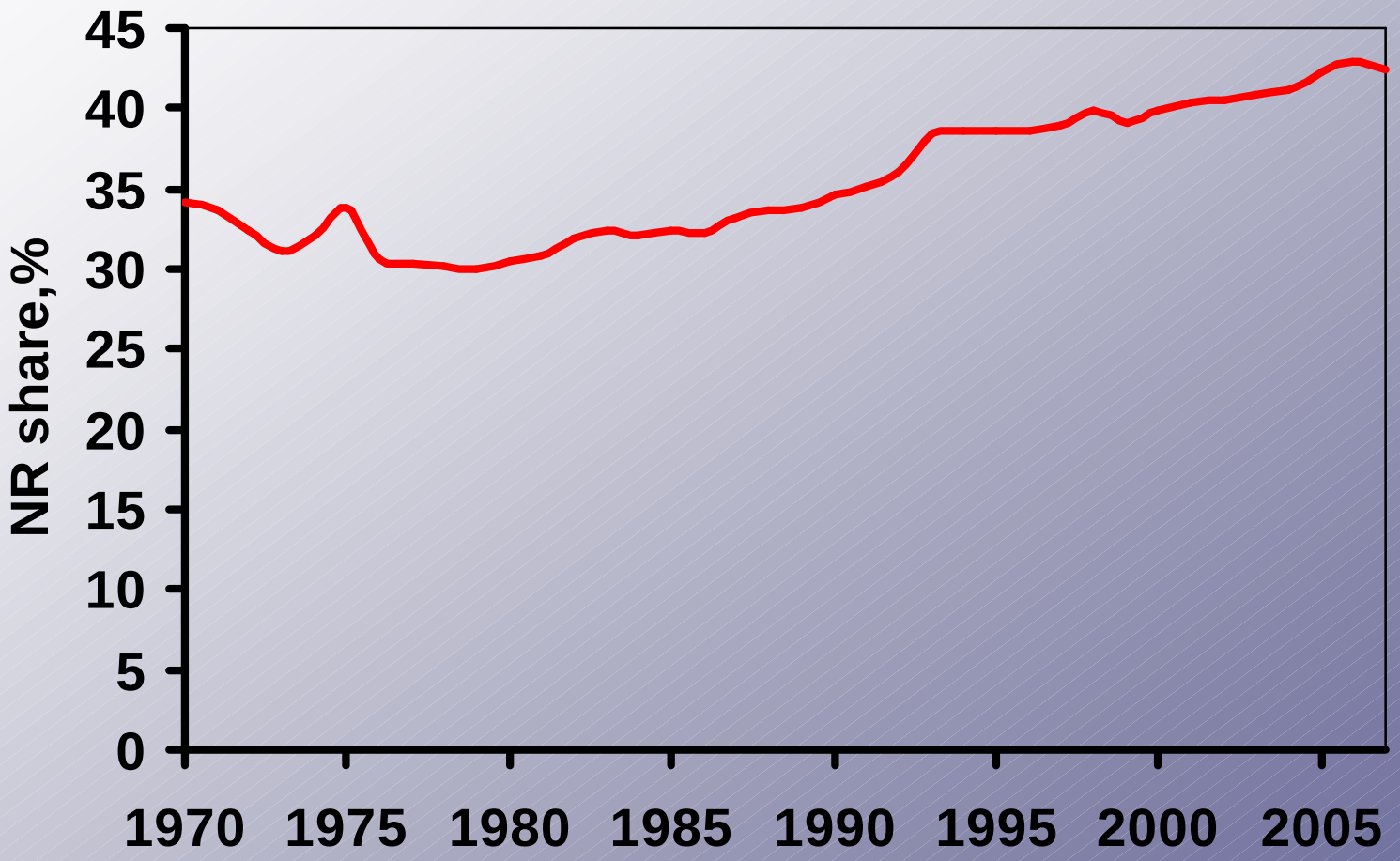
Natural rubber share in consumption



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Natural rubber

The natural rubber tree, *Hevea Brasiliensis*, efficiently sequesters carbon*:

Photosynthetic rate of mature *Hevea* leaf	**11 µmol/m^2/s**
Other tree species	**5-13 µmol/m^2/s**

Over a 30 year life, C sequestration per hectare:	**272 tonnes #**
Rain forest	**234 tonnes**
Secondary rain forest	**150 tonnes**

Yields have increased from about 250 kg/Ha to as high as 3500 kg/Ha

Hevea is also a valuable source of timber

* Jones, K.P. (2000) *Kautsch. Gummi Kunstst.* **53**, 735

\# Chung, C.-M., Wang, R.-S. and Jiang, J.-S. (2007) *J. Env. Sci.* **19**, 348

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Natural rubber

Energy inputs for NR production (MJ/kg)*

Fertilisers & other chemicals	5
Primary processing	3
Transport	5-8
Total	15-16

Synthetic rubber: ~100 MJ/kg ° 3 kg CO_2/kg

Biodiversity high in rubber plantations compared with other monocultures

* Jones, K.P. (1994) *Rubb. Dev.* **47**, 37

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Vehicle Lifecycle energy consumption

- ~ 90% of the total lifecycle energy consumption of a vehicle occurs during its lifetime on the road
  - Average of 79GJ* associated with passenger vehicle manufacture, disposal/recycling vehicle at end of life
  - Estimated 25000 litres of fuel consumed by a passenger vehicle during lifetime
  - Energy consumption of 880GJ during vehicle lifetime
- Fuel economy is the key factor in vehicle lifecycle energy consumption

*Dust to Dust – The Energy cost of new vehicles from concept to Disposal. CNW Marketing Research Inc.

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Environmental impact of tyres

- Use of renewable (or sustainable) materials
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  - Production of raw materials
  - Transportation of materials and products
  - Use
  - Lifetime
  - Disposal or recycling
- **Tyres:**
  - **Most of impact on energy consumption is during use**
    Due to rolling resistance è fuel economy
  - **For passenger tyres -**
    86% of environmental impact during use (Michelin)

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Principle factors that influence tyre rolling resistance

- Tyre pressure
- Temperature
- Tyre Tread
  - Tread Pattern, tread depth
  - Polymer — NR, BR, eSBR, sSBR, ENR
  - Filler — Silica
    Carbon Black
    Carbon silicon dual phase fillers
    New ‘nanostructure’ carbon blacks
    Biofillers
- Road surface – concrete, asphalt, ‘chip and seal blacktop’,
  – increased porousity, better in wet conditions
  – affects fuel economy by up to 10%

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http://www.vejdirektoratet.dk/publikationer/VInot23/index.htm

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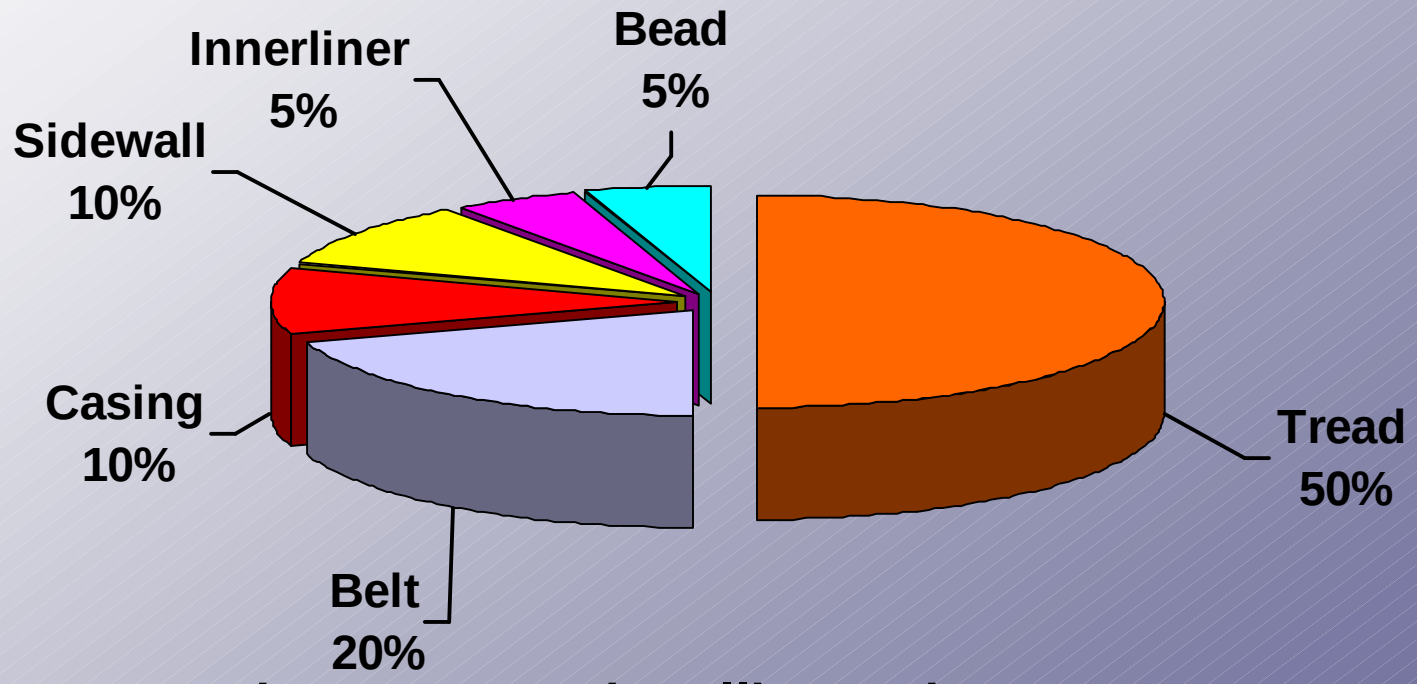
Influence of tyre components on rolling resistance – passenger tyre

Rolling resistance:

- 8 – 18% of fuel consumption, up to 60% at constant speed
- 50% lower than 1980s levels – mainly through radials



- A 10% improvement in rolling resistance can yield a saving in fuel of 0.5 – 1.5%

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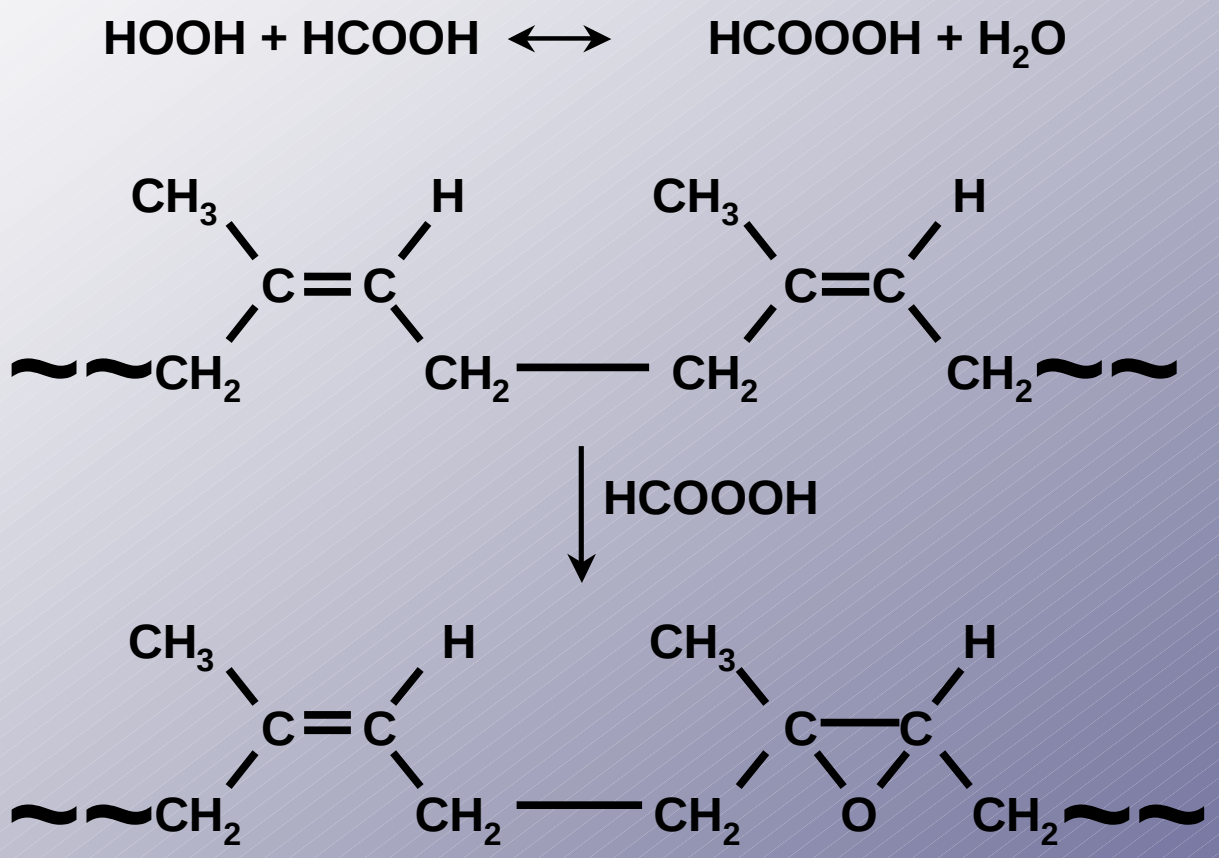
Epoxidised natural rubber – ENR - Ekoprena™

Reaction of NR latex with performic acid



25mol% epoxidation for tyre tread applications

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Use of ENR-25 in passenger tyres

- **ENR-25 interacts strongly with silica filler – no coupling agent required**
  - **Reduced rolling resistance**
  - **Interaction moderated by water – improved wet grip**
  - **Improved microdispersion of silica – improved wear?**

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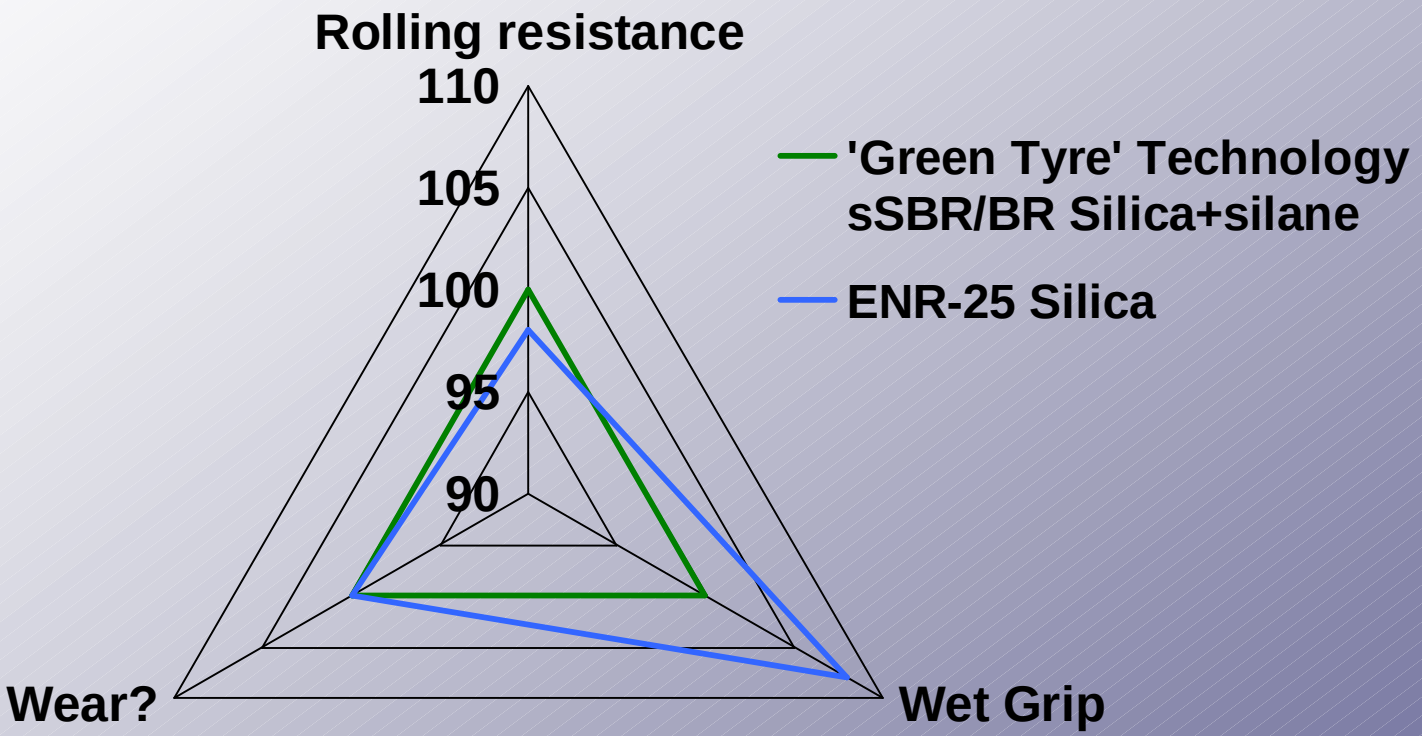
Improved performance from ENR-25 in passenger tyres



Silica filled ENR-25 uses 20 – 30% less energy to mix

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Conclusions

- Fuel economy far outweighs other factors in vehicle lifecycle energy analysis
- Tyre rolling resistance has a significant effect on vehicle fuel economy
- Road surface can contribute strongly to tyre rolling resistance [Also to wet grip and noise – all legislative issues for tyres]
- Use of sustainable resources is increasingly important in tyres
- Use of ENR in tyres can help to reduce the Carbon Footprint of tyres and improve wet grip

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