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TNO innovation for life

Memorandum

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Subject
Potential benefits of Triple-A tyres in the EU

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Summary

In a previous study assigned by the Dutch Ministry of Infrastructure and Environment, TNO and M+P determined that large cost savings can be achieved in the Netherlands by a switch from currently-used tyres to high-performance tyres with A-labels on each parameter of the EU tyre label: energy efficiency, wet grip and noise. These AAA-labelled tyres are also referred to as ‘Triple-A’ tyres.

In this memo the same methodology and similar assumptions are used to determine an order-of-magnitude estimate for the potential benefits of Triple-A tyres in the EU.

As for the Netherlands, the results for the EU show that Triple-A tyres have a large impact on energy consumption, safety and vehicle noise. The use of Triple-A tyres in the EU would annually **save up to 17 billion litres of fuel** and **reduce CO_2 emissions by roughly 42 Mton**. This is equivalent to nearly 5% of the total CO_2 emissions from road transportation in the EU. Yearly, **2,567 less people would be killed in traffic accidents**, the number of **serious injuries would be reduced by 12,353** and **the number of slight injuries would be reduced by 19,631**. Due to the favourable noise characteristics of Triple-A tyres, the **number of annoyed and highly annoyed people by road traffic would be reduced by 8.3 and 13 million respectively**. The **number of sleep-disturbed and highly sleep-disturbed people would be reduced by 3.4 and 6.1 million respectively**. From a **societal perspective, the associated annual cost savings are estimated to amount to 34 billion Euros**. For the end-user, annual fuel cost savings would range from 90 € for passenger cars to 2000 € for long-haul vehicles.

Given the large potential benefits of high-quality tyres, an accelerated market uptake could help in making road transport more environmentally friendly, safer and quieter. An impact assessment can provide insights into the effectiveness of potential intervention measures.

1. Introduction

In a study commissioned by the Dutch Ministry of Infrastructure and the Environment (I&M), TNO and M+P evaluated the potential benefits of high-performance tyres for the Dutch society as well as for the end-user. TNO has been invited to present these study results at the 60th session of the Working Party on Noise (GRB), which took place on September, 1st - 3rd 2014. In order to put the corresponding results in a European perspective, the ministry of I&M requested TNO to extrapolate the Dutch results to the European frame of reference.

The previous study conducted for the Netherlands [TNO, 2014] shows that large cost savings can be achieved by switching to high-quality tyres, both for society as well as for the end-user. When taking into account the fuel cost savings and the associated reductions of CO_2 emissions, the reduced amount and severity of traffic accidents and the reduced amount of annoyed and sleep-disturbed people, the annual societal cost savings amount to nearly one billion Euros for the Netherlands alone. Based on the fact that Europe has 28 member states it is expected that these benefits will be roughly 28-fold for the EU-28 as a whole.

The aim and scope of this new study has been to calculate an order-of-magnitude estimate of the potential benefits of Triple-A tyres in the EU. This memo documents the methodology and the results of such estimations by taking into account similar assumptions and findings as determined in the Dutch tyre study [TNO, 2014].

In chapter 2, the methodology and assumptions are explained in more detail. The results for energy savings, safety improvements and noise reductions are discussed in chapter 3, followed by the summarised benefits for all three aspects of tyre labelling in chapter 0.

2. Methodology and assumptions

The core research question of this study is: what are potential benefits of Triple-A tyres if all consumers across the EU were to switch their currently-used tyres to Triple-A tyres, i.e. tyres labelled A for energy efficiency, A for wet grip and A for noise. The difference of this study compared to the previous study [TNO, 2014] is the frame of reference: EU vs. NL.

Labelled tyres differentiate performance in terms of energy efficiency, wet grip and noise. Potential benefits can therefore be categorized in the following manner:

- Energy savings potential: expressed in reduced amount of fuel consumption, costs and CO_2 emissions;
- Safety improvement potential: expressed in reduced numbers of traffic casualties and costs;
- Noise reduction potential: expressed in reduced numbers of annoyed and sleep-disturbed people and the associated health and sound isolation costs.

Though Triple-A tyres are currently not ready to market, large improvements in tyre technology over the last decades have been achieved, with the introduction of AAB-tyres, ABA-tyres and similar. As shown in the previous study [TNO, 2014], already large cost savings can be achieved when consumers switch to best-quality tyres that are currently available.

This EU study follows the same methodology as used in the previous study for the Netherlands. The European vehicle usage is, however, different from vehicle usage in the Netherlands. Therefore, assumptions with respect to vehicle distribution over road networks, driving behaviour, road conditions and traffic safety, have been adapted. The scope of this study is to provide an order-of-magnitude estimate of the total associated cost savings in the EU. It is not a full-scale impact assessment but, rather, indicative and intended for use towards stakeholders (policy makers, representatives of industry and RTOs) as a point of reference and to give an indication of the potential benefits of using best-quality tyres on vehicles. This memorandum is limited to documenting the essential differences between the study for the Netherlands and the current study on a European scale. For the detailed results of the Dutch study, which are not discussed here, the reader is referred to [TNO, 2014].

Table 1 gives an overview of similar and adapted assumptions for the EU compared to the Netherlands. The most important assumption in this study is that the current tyre distribution in the EU is identical to the Netherlands. In this respect, the average consumer is expected to currently drive on tyres with the following labels:

- Energy: Fuel efficiency label between C and E (label D is not defined)
- Safety: Wet grip label C
- Noise: Noise “label B” (indicated by two black waves)

The following paragraphs further elaborate on the underlying assumptions.

Table 1: Overview of similar and adapted assumptions between the Netherlands and the current study for the EU.

	Same assumptions as in NL	Adapted assumptions to EU
General	• NL tyre distribution	-
Energy savings	• NL driving patterns • NL share of vehicle technologies • NL fuel consumption	• EU fleet in vehicle-kilometres
Safety improvement	• NL accident causation	• EU road network • EU weather conditions • Calculations for car occupants only (EU)
Noise reduction	• NL road surface characteristics • NL driving speeds	• EU number of annoyed and sleep-disturbed people

2.1. Assumptions for energy savings potential

The energy savings potential depends on the difference of the coefficients of rolling resistance and the driving pattern of a certain vehicle. The savings potential is copied from the previous study [TNO, 2014]. On average, it roughly varies between 3.8 and 5.4% for different vehicle segments, see Table 2.

Table 2: Assumed driving pattern and the resulting energy savings potential.

Tyre class	Vehicle segment	Driving Pattern	Energy savings potential (summer)	Energy savings potential (winter)	Energy savings potential (average)
		[%] urban / [%] highway	[%]	[%]	[%]
C1	Passenger cars (petrol)	43 / 57	4.80%	5.65%	5.23%
	Passenger cars (diesel)	43 / 57	4.80%	5.65%	5.23%
	Service/delivery (diesel)	32 / 68	4.92%	5.78%	5.35%
C2	Distribution (diesel)	20 / 80	3.55%	4.45%	4.00%
C3	Heavy duty (diesel)	20 / 80	4.05%	4.05%	4.05%
	Bus (diesel)	73 / 27	3.84%	3.84%	3.84%

Estimates of the annual mileage in Europe is determined for different vehicle groups based on TREMOVE [TML, 2010], see Table 3. The forecasted mileage of 2015 is used in the calculations and the average fuel consumption is taken from the previous study [TNO, 2014].

Table 3: Estimates for annual cumulative mileage of vehicles in Europe and assumed fuel consumption.

Tyre class	Vehicle group	Annual mileage	Fuel consumption
		[Mkm]	[l/100 km]
C1	Passenger cars (petrol)	1,430,366	6.4
	Passenger cars (diesel)	2,135,171	5.5
	Service/delivery (diesel)	233,568	6.5
C2	Distribution (diesel)	75,926	13.2
C3	Heavy duty (diesel)	290,407	32.1
	Bus (diesel)	55,612	31.1

Recent studies on real-world driving emissions show that the average fuel consumption for passenger cars in the Netherlands are up to 10% higher than the fuel consumption according to Type Approval. However, for reasons of consistency, the fuel consumption of the previous study has been used. The effective energy savings potential shown in section 3.1 is therefore a conservative estimate.

Fuel costs savings are calculated from a societal and end-user perspective. The societal cost is related to the fuel cost excluding taxes, while the end-user costs are including taxes. Since end-user (fuel) costs are different across Europe and varies with time, average fuel prices are determined as a function of the Brent crude oil price. The relation between oil price and fuel price is based on [AEA, 2012]. At current oil prices of roughly 100 $/barrel, the fuel prices are calculated (see Table 4).

Table 4: Average European fuel prices from a societal and end-user perspective [AEA, 2012].

	Fuel price, end-user perspective (incl. excise duty, incl. VAT)	**Fuel price, societal perspective (excl. excise duty, excl. VAT)**
	[€/l]	**[€/l]**
Petrol	1.33	0.75
Diesel	1.26	0.82

2.2. Assumptions for safety improvement potential

The study for safety improvement regarding the wet grip performance is based on the assumption that collision speed is reduced for tyres with better grip, and as a result injuries of victims will be less severe. The calculation scheme is depicted in Figure 1.

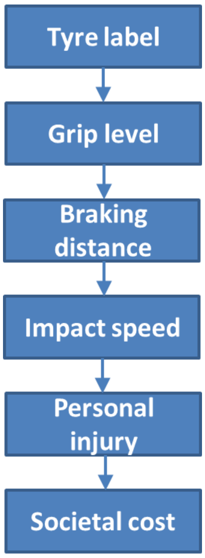

Figure 1: Calculation scheme for safety improvement potential calculation.

Only accidents on wet road are considered, and the type of accidents is related to the road type infrastructure and typical driving speed. Furthermore improvements were assessed for different road user groups (i.e. car, truck, cyclists and pedestrians) in the Netherlands. In the previous study the methodology has been developed for a detailed assessment, however to assess the potential on a European level some simplifications have been made due to the limited availability of consistent information.

For the estimation of the safety improvement potential on a European level the following assumptions are made for EU member states.

A. Occurrence of accident types is similar for each member state when separated for road types;
B. The distribution of vehicles on road types is proportional to the road length;
C. The potential improvement for each accident type is similar for each member state;
D. The ratio of injury type (i.e. fatal / severe / slight) is similar for each member state.

The distribution of tyre labels for vehicles on the road will be different between EU member states, but that is not considered here. Note that assumption D is actually supported by accident statistics. Furthermore the calculations are made only for car occupants due to limited available data, and the calculation results in an underestimation of the potential benefits as not all road users that may be involved in the accidents are considered. The amount of vulnerable road users will vary significantly between EU member states, and will appear differently in accident statistics due to the specific road infrastructure, traffic regulation and other important factors in the member states.

2.3. Assumptions for noise reduction potential

As the method for computation of noise benefits is based on the European VENOLIVA computation method for numbers of (highly) annoyed and sleep-disturbed people [VENO, 2011], the assumptions and reference data for this study were taken from VENOLIVA.

This method distinguishes 8 road type / traffic combinations. For the EU reference scenario, i.e. the current situation with the current tyre distribution, the VENOLIVA reference is used. Per road type / traffic combination the reductions of (highly) annoyed and sleep disturbed people are extrapolated using the EU reference numbers multiplied by the reduction factors, as determined in the previous study [TNO, 2014]. The EU reduced numbers of (highly) annoyed and sleep disturbed people are obtained by summation of reductions per road type / traffic combination.

An essential assumption is that the EU average reduction factors of annoyed and sleep-disturbed people are assumed to be equal to the reduction factors for the Netherlands. Assessment of the monetary benefits on a European scale is therefore done by linear extrapolation of the Dutch results.

3. Results

This chapter discusses the results for the EU for the independent categories energy, safety and noise. The overall benefits of Triple-A tyres are summarized in chapter 0.

3.1. Energy savings potential in Europe

Table 5 shows the energy savings potential of Triple-A tyres in Europe. A considerable reduction of fuel, fuel costs and CO_2 can be achieved amounting to roughly 17 billion litres of fuel, 13 billion Euros and 42 Mton of CO_2 in total. Overall cost savings are the highest for passenger cars (3.6 billion Euros for vehicles on petrol and 5 billion Euros for vehicles on diesel). Cost savings for heavy-duty vehicles and busses account for cost savings of roughly 3 and 0.5 billion Euros.

Table 5: Societal perspective: Annual fuel, fuel cost and CO_2 reduction in case of changing to A-labelled tyres for energy.

Tyre class	Vehicle group	Energy savings potential (average)	Annual fuel savings	Annual cost savings	Annual CO_2 reduction
	[]	[%]	[Ml]	[M€]	[MtCO_2]
C1	Passenger cars (petrol)	5.23%	4,775	3,581	11.29
	Passenger cars (diesel)	5.23%	6,090	4,994	15.89
	Service/delivery (diesel)	5.35%	810	664	2.11
C2	Distribution (diesel)	4.00%	400	328	1.04
C3	Heavy duty (diesel)	4.05%	3,781	3,101	9.87
	Bus (diesel)	3.84%	663	543	1.73
		TOTAL	16,519	13,211	42

Calculating the potential fuel cost savings in terms of the EU energy consumption of the transport sector yields similar findings. The consumption of petrol and diesel are shown in Table 6 [EU, 2013]: in 2013, roughly 117 billion litres of petrol and 245 billion litres of diesel was used in the EU. This is equivalent to societal costs of about 288 billion Euros in total. At an energy savings potential between 3.8 and 5.4%, the effective cost savings amount to 10,957 M€ and 15,571 M€ respectively. The annual cost savings potential of 13,211 M€ , as calculated above, therefore seems to be a good order-of-magnitude estimate.

Table 6: Energy consumption of petrol and diesel in the EU [EU, 2013], in terms of quantity, CO_2 content and societal costs.

	Fuel quantity [Ml]	CO_2 content [Mt]	Societal Costs [M€]
Petrol	117,098	277	87,824
Diesel	244,550	638	200,531
TOTAL	**361,648**	**915**	**288,354**

3.2. Safety improvement potential in Europe

The study for the Netherlands indicates that 40% of accidents on wet roads are less severe when tyres with better grip are used. The European CADAS database [CADaS, 2014] was accessed to obtain accident statistical data for EU member states. From this database it is found that 5,125 fatalities are recorded for accidents on a wet road, which accounts for 19 EU member states. An extrapolation has been made towards the total for 28 EU member states in the assumption that average ratio of dry and wet accidents of the 19 EU member states is representative for the remaining 9 EU member states [EU, 2012]. This results in an estimated total of 6,355 fatalities in the total 28 EU member states. Table 7 shows the casualties considered in the different countries.

Table 7: Overview of accident injuries on wet roads for light-duty vehicles.

Countries	Fatalities	Severely injured	Slight injured
Netherlands (2009)	89	627	2,773
EU-19 (2010)	5,125	29,562	141,350
EU-28 (2010)	6,355	36,657	175,274

A further separation is made for different road types as the typical driving speed and road infrastructure is a main factor in the accident scenarios. The potential improvement is therefore depending on the type of roads present in the EU member states. Figure 2 shows the distribution of road types for the member states that are included in the EU-28 group.

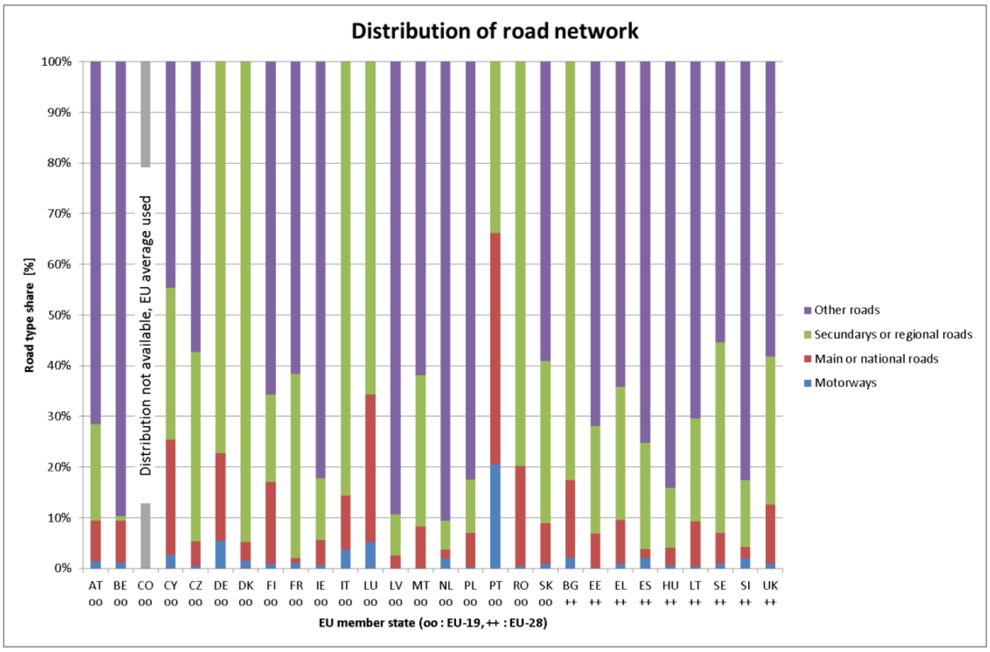

Figure 2: Road type distribution for EU-28 countries [EU, 2012].

For conversion towards the monetary benefits, Table 8 lists the conversion amounts used and the calculation results.

Table 8: Benefits of introducing tyres with A-label wet-grip performance.

Injury level	Reduction of casualties [n]	Conversion amount (k€/n)	Financial benefit (M€)
Fatalities	2,567	2,500	6,418
Severe injury	12,353	280	3,459
Slight injury	19,631	9	177
Total	**-**	**-**	**10,054**

3.3. Noise reduction potential in Europe

In two computational steps, the average reduction of the tyre rolling noise as well as the effective in-traffic reductions of vehicle noise emissions was determined. These average reductions were taken from the previous study [TNO, 2014]. The average reductions of the tyre rolling noise are determined for each tyre class at a transition from the current tyre mix to the best-performing low-noise tyre. The effective reductions of in-traffic vehicle noise emissions are computed as a function of the following road and traffic characteristics:

- Vehicle category: Light Vehicles (LV), Medium Vehicles (MV) and Heavy Vehicles (HV)
- Operating condition: Accelerating or Free flowing (= constant speed)
- Driving speed: 30, 40, 50, 80, 100 and 120 km/h
- Type of road surface:

- Dense Asphalt Concrete (DAC),
- Porous Asphalt Concrete (PAC),
- 2-layer PAC,
- 2-layer PAC with fine grading of the top layer (2/4 mm)
- Thin noise-reducing surface layer (porous or semi-porous)

In the third step, the reduction of the characteristic noise impact of a traffic flow is calculated for 8 different road / traffic combinations and is based on the vehicle noise emission values from the Dutch statutory noise impact calculation method [RMV, 2012]. The reduction of the numbers of (highly) annoyed and (highly) sleep-disturbed people are determined from the changes of the traffic flow noise impact. These computations are carried out using the dose-effect relationships for road traffic noise as recommended in the position paper published by the EC [Annoy, 2002]. The results in terms of the changes of the numbers and percentages are given in Table 9.

Table 9: Reductions of numbers of (highly) annoyed and (highly) sleep-disturbed people in the EU, resulting from a shift from an average tyre mix to the best-performing low-noise tyres.

Annoyance	**Millions Highly Annoyed [MHA]**	**Millions Annoyed [MA]**	**Differ-ences MHA**	**Differ-ences MA**	**Relative Differ-ences MHA**	**Relative Differ-ences MA**
Reference 2013	54.9	118.9	0,0	0,0	0%	0%
Most quiet tyres	46.6	105.9	-8.2	-13.0	-15.0%	-10.9%
Sleep disturbance	**Millions Highly Sleep Disturbed [MHSD]**	**Millions Sleep Disturbed [MSD]**	**Differ-ences MHSD**	**Differ-ences MSD**	**Relative Differ-ences MHSD**	**Relative Differ-ences MSD**
Reference 2013	26.6	59.8	0.0	0.0	0%	0%
Most quiet tyres	23.2	53.7	-3.4	-6.1	-12.9%	-10.2%

For the assessment of monetary benefits due to the widespread introduction of low-noise tyres a methodology is used similar to that applied in the VENOLIVA study [VENO, 2011], but with an updated approach for health benefits.

Table 10: Hedonic Pricing (= property valuation), health and total benefits in millions of Euros for the full introduction of low-noise tyres in the European Union, expressed as a maximum annual value, as an annual average and as accumulated benefits over the appraisal period 2015-2025.

	Hedonic Pricing benefits (M€)	**Health benefits (M€)**	**Total benefits (M€)**
Annual benefit for immediate implementation	7,105	3,863	10,968
Annual average	5,690	2,977	8,667
Accumulated 2015 - 2025	56,896	29,773	86,669

Overall benefits for Triple A tyres
The potential benefit of Triple-A tyres is determined as the sum of all societal benefits of energy, safety and noise as discussed in the previous chapter. The results are shown in Table 11. The benefits are shown separately for A-label performance of each aspect. The savings potential of AAA-rated tyres is calculated as the sum of the savings potential of respective A-rated tyres.

Table 11: Potential benefits of A-rated tyres in the EU (societal perspective).

Potential benefits	**Energy**	**Safety**	**Noise**	**TOTAL**
Annual fuel savings [in billion l]	17	-	-	17
Annual CO_2 reduction [in $MtCO_2$]	42	-	-	42
Reduced number of fatalities	-	2567	-	2567
Reduced number of serious injuries	-	12353	-	12353
Reduced number of slight injuries	-	19631	-	19631
Reduced number of highly annoyed people [in millions]	-	-	8.2	8.2
Reduced number of annoyed people [in millions]	-	-	13.0	13.0
Reduced number of highly sleep disturbed people [in millions]	-	-	3.4	3.4
Reduced number of sleep disturbed people [in millions]	-	-	6.1	6.1
Annual cost savings [in billion Euro]	13	10	11	34

It is noted that the estimated energy and safety benefits are quite conservative. On the one hand, low average fuel consumptions have been assumed in the calculation of the energy benefits. On the other hand, safety benefits are assessed for car occupants only, leaving out other road users that may be involved in accidents on wet roads.

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