Triple A Tyres for Cost-effective Noise Reduction in Europe

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Summary
Tyre-road noise is still a major and growing issue in Europe. A recent study performed in The Netherlands for the Dutch Ministry of Infrastructure and Environment examined the benefits of widescale introduction of high quality labeled tyres, with 'Triple A' rating for rolling resistance, wet grip and noise. Two scenarios were investigated, one with the current mix of tyre types in use, the second in which all current tyres are replaced by high quality tyres. In this paper the socio-economic benefits due to traffic noise reduction are highlighted in terms of reduced numbers of highly annoyed and sleep disturbed people and the societal monetary benefits. The results of the study show that major benefits are achievable at negligible costs. Besides noise reductions, substantial benefits are also obtained by fuel savings, CO_2 reduction and reduced numbers of road casualties, making this initiative a viable policy option for the near future. Required future steps are tighter limits for tyre noise and incentives for choosing tyres with the best label.

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1. Introduction

Road traffic noise is still an ongoing and growing issue in Europe. Numbers of annoyed and sleep disturbed people due to road traffic run into the tens of millions in the EU [1,2], resulting in reduced quality of life and stress-related illnesses including heart disease.

Vehicle noise emission is regulated by the EU with limits for vehicle pass-by noise [3] and tyre noise [4]. In 2009 a European tyre label was introduced [5], obligatory for new tyres since 2012, that informs customers on the tyre performance in terms of rolling resistance, wet grip and noise emission. Rolling resistance is closely related to fuel consumption and CO2 emissions. Wet grip is related to safety. Tyre noise is relevant both for the environment and for passenger comfort.

In a recent study performed in the Netherlands for the Dutch Ministry of Infrastructure and Environment [6], the benefits of widescale introduction of high quality (AAA) tyres were examined, with the best rating for fuel consumption, CO2 emissions, safety and noise respectively. Benefits for the EU were also estimated [7] based on data from the Netherlands.

In this paper the tyre label is briefly explained and the overall benefits of widescale use of AAA-tyres by fuel savings, CO2 reduction, reduced numbers of road casualties and noise reduction are presented. The socio-economic benefits due to traffic noise reduction are derived in terms of reduced numbers of disturbed people and the societal monetary benefits based on noise valuation and savings in health costs. It is finally discussed how this initiative is a viable policy option for the near future.

2. Tyre label and availability of AAA-tyres

The label currently found on all new tyres is shown in Figure 1 for an average tyre for the Netherlands and a 'Triple A' tyre. Rolling resistance, which affects fuel consumption and CO_2 emission is on the left of the label. Wet grip, which affects safety and accident fatalities, is in the second column. Noise emission, underneath, is indicated by the noise level and a volume symbol. Although a third letter for noise is not included on

the label, best performance tyres are indicated here with 'AAA'. A-performance for noise corresponds to lowest levels within a range of around 6 dB depending on the tyre type (e.g. 66-72 dB(A) for C1 tyres).

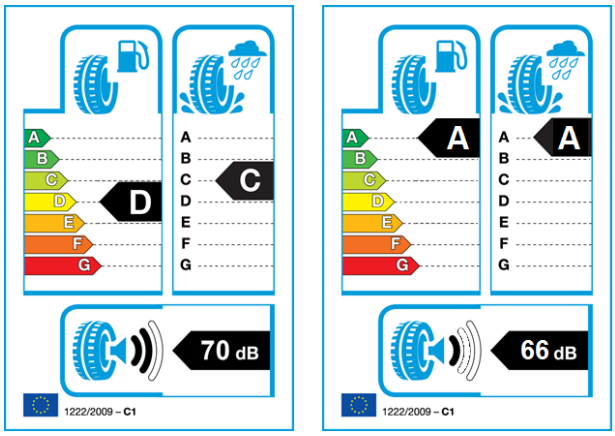
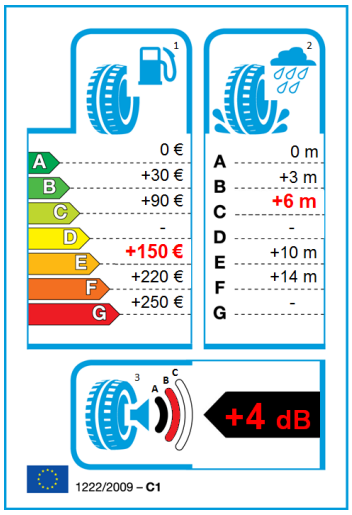


Figure 1. Example of tyre label according to EC1222, 2009, on a tyre with average performance for the Netherlands (left) and a 'Triple A' tyre (right).



[1] Extra yearly fuel costs for average mileage (17000 km/year)

[2] Extra braking distance on wet road at 80 km/h (Distance for A about 27 m)

[3] Noise*
- A: about twice as quiet
- B: average
- C: about twice as noisy

** Doubling is 3 dB*

Figure 2. Indication of yearly fuel savings, extra braking distance and differences in noise levels for a change to A label tyre, for a mileage of 17000 km/year and fuel economy of 7.5 l/100 km. Differences for an average Dutch tyre are in red.

Analysis [8] of the current Dutch market shows that A-rated tyres are no more expensive than other tyres. Statistically there is even a small tendency for lower prices at better rating. The distribution of tyre labels in the current market is illustrated in Figure 3 for noise.

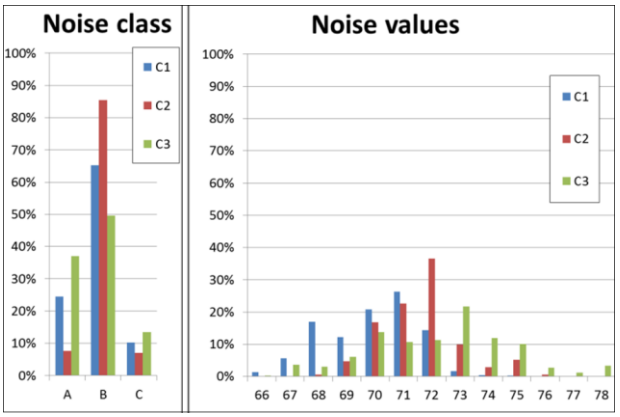


Figure 3. Distribution of tyre label data in the investigated control group. This control group is based on the 7 tyre brands and 7 tyre sizes with the largest market share in the Netherlands.

3. Multiple benefits

Replacing the currently-used tyres by A-rated tyres would have a large impact on energy consumption, safety and vehicle noise. In the Netherlands it would save nearly 506 million litres of fuel and reduce CO_2 emissions by around 1.3 Mton annually. Each year, 43 less people would be killed in traffic accidents, 260 less serious injuries and 364 less slight injuries would occur. 216000 less people would be highly annoyed by road traffic noise and 204000 less people would be highly sleep disturbed. These benefits are set out in Table I for the Netherlands and for the EU, which has far greater potential benefits.

Table I. Potential savings on energy, safety and noise for triple A tyres, in the Netherlands and in the EU.

Benefits NL/EU	Energy		Safety		Noise		TOTAL	
	NL	EU	NL	EU	NL	EU	NL	EU
Annual fuel savings [billion litres]	0.5	17	-		-		0.5	17
Annual CO2-reduction [million tons]	1.3	42	-		-		1.3	42
Reduced number of fatalities	-	-	43	2567	-		43	2567
Reduced number of serious injuries	-	-	260	12353	-		260	12353
Reduced number of slight injuries	-	-	364	19631	-		364	19631
Reduced number of highly annoyed people [millions]	-	-	-		0.22	8.2	0.22	8.2
Reduced number of annoyed people [millions]	-	-	-		0.36	13	0.36	13
Reduced number of highly sleep disturbed people [millions]	-	-	-		0.2	3.4	0.2	3.4
Reduced number of sleep disturbed people [millions]	-	-	-		0.31	6.1	0.31	6.1
Annual cost savings [Billion €]	0.4	13	0.2	10	0.4	11	1	34

Assuming the characteristics of A-rated tyres could be combined into one AAA tyre, this would lead to the sum of all of the above benefits. From a societal perspective, the associated annual cost savings would then amount to nearly one billion Euros in the Netherlands and 34 billion Euros in the EU. For the end-user, annual cost savings would range from €117 for passenger cars to €2418 for long-haul vehicles. Further background to these figures is given in the TNO report [6] and memorandum [7]. In this paper the main focus is on the factor noise.

4. Potential noise reduction benefits in the Netherlands and the EU

The potential benefits for noise reduction due to full transition from the 2013 mix in tyre types to triple A tyres have been calculated using an approach similar to that applied in the VENOLIVA study [1] in 2011. In that study, the EC data base of type approval test results was used to assess the expected noise emission reduction during the acceleration and the constant speed tests caused by noise reducing measures, either to the power train or to the tyres or to both. The noise reduction in normal traffic was estimated for accelerating and free flowing traffic, based on adjusted type test results. The procedure to derive the benefits related to noise is outlined in the following steps.

Step 1. The average reductions of the tyre rolling noise were determined for each of the main tyre classes C1/C2/C3, as shown in Table II. Tyre statistics were based on the Dutch VACO database (Dutch branch association of tyre and rim suppliers). Average rolling noise reductions of 3-4 dB are achievable for C1/C2 tyres, and upto 6 dB for C3 (truck/lorry) tyres.

Step 2. The resulting effective reductions of in-traffic vehicle noise emissions, were then computed as a function of the following road and traffic characteristics:

- Vehicle category: Light, medium weight and heavy vehicles (instead of the five types used for VENOLIVA, to be consistent with the Dutch statutory noise calculation method [9]);
- Driving speeds: 30, 40, 50, 80, 100, 120 km/h;
- Operating condition: Accelerating or free flowing (= constant speed);
- Road types: Residential, urban main, arterial, urban and rural motorways and rural main roads;
- 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)

The results show that the average noise emission per vehicle will be reduced by:

- 1.2 – 2.6 dB(A) for light vehicles,
- 0.6 – 2.6 dB(A) for medium weight vehicles,
- 0.6 – 3.4 dB(A) for heavy vehicles,

depending on the type of road, road surface and traffic conditions.

Table II. Weighted average reductions of tyre rolling noise per tyre class and sub-category – derived from label values in the VACO database.

Tyre class	Summer/ Winter	Section width	Limit value in Reg (EC) 661/2009	Average rolling noise emission of sub-category	Best performing low noise sample of subcategory	Estimated reduction of rolling noise emission
C1	Summer	< 185	70	69.4	66	-3.4
C1	Summer	195-245	71	70.2	66	-4.2
C1/XL	Summer	< 185	71	69.8	68	-1.8
C1/XL	Summer	195-245	72	70.6	67	-3.6
C1	Winter	< 185	71	69.2	66	-3.2
C1	Winter	195-245	72	69.8	66	-3.8
C1/XL	Winter	< 185	71	69.2	67	-2.2
C1/XL	Winter	195-245	72	69.6	66	-3.6
Weighted average / sum			**71.2**	**69.9**	**66.2**	**-3.7**
C2	Summer	0	72	71.3	69	-2.3
C2	Winter	0	74	72.2	68	-4.2
Weighted average / sum			**72.7**	**71.6**	**68.6**	**-3.0**
C3	Traction	0	75	73.3	66	-7.3
C3	Steering	0	73	71.2	66	-5.2
C3	Trailer	0	73	70.2	67	-3.2
Weighted average / sum			**73.8**	**71.9**	**66.1**	**-5.8**

Step 3. The characteristic noise reception levels of a traffic flow and their potential reductions were calculated for 8 different road/traffic combinations listed in Table III. Average traffic intensity and distance from the source are important parameters. The vehicle noise emission values from the Dutch statutory noise calculation method were used [9], reduced by the relevant noise reduction figures from step 2. The calculated reference and reduced levels per road type are listed in Table IV. The effect of these reductions per vehicle for the total noise impact of the traffic flow leads to an average reduction of L_{DEN} and L_{night} levels by 2.0 dB(A), ranging from 1.0 to 2.7 dB(A) for the various road types and traffic conditions.

Table III. Road / traffic combinations used for computation of traffic flow noise levels, for the Netherlands.

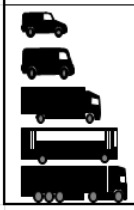
Road / traffic type	Residential street - Intermittent traffic	Residential street - Free flowing traffic	Main street - Intermittent traffic	Main street - Free flowing traffic	Arterial road	Urban motorway	Rural motorway	Rural main road	Total
Vehicle operating condition	accelerating	free flow	accelerating	free flow	free flow	free flow	free flow	free flow	
Speed range	V<50	V<50	V≈50	V≈50	60<V<80	V=100 / 80	V=120 / 80	60<V<80	
Total road length	15569	31610	7061	14336	3284	332	2185	32606	106982
Percentage of total road length	15%	30%	7%	13%	3%	0.3%	2%	30%	100%
Selected road length (km)	12455	25288	6355	12902	2627	265	1529	16303	77725
Percentage of selected road length	16%	33%	8%	17%	3%	0.3%	2%	21%	100%
Traffic intensity [vehicles / 24 h]	2000	2000	9470	9470	33700	48500	48500	16000	
Average number of exposed inhabitants/km	115	115	250	275	300	400	400	40	
Characteristic distance from road (m)	15	15	15	15	15	50	50	50	
Annoyance penalty, dB	0	0	3	0	0	0	0	0	
Noise sources									
	Powertrain + tyre/road	Tyre/road + powertrain	Powertrain + tyre/road	Tyre/road + powertrain	Tyre/road	Tyre/road	Tyre/road	Tyre/road	
	Powertrain	Powertrain + tyre/road	Powertrain	Powertrain + tyre/road	Powertrain + tyre/road	Powertrain + tyre/road	Powertrain + tyre/road	Powertrain + tyre/road	

Table IV. Characteristic L_{DEN} and L_{night} reception levels and reductions in dB, of 8 different road / traffic combinations for the Netherlands, for current tyre usage and for best performing tyres.

LDEN	Residential street - Intermittent traffic	Residential street - Free flowing traffic	Main street - Intermittent traffic	Main street - Free flowing traffic	Arterial road	Urban motorway	Rural motorway	Rural main road
Reference 2013	61.3	59.2	67.2	65.0	72.1	66.6	69.3	63.5
Best performing low noise tyres	60.2	57.1	66.2	62.8	69.7	64.1	66.7	61.4
ΔLDEN	1.1	2.1	1.0	2.2	2.3	2.4	2.7	2.1
LNIGHT								
Reference 2013	52.8	50.6	60.1	57.8	67.3	64.3	65.8	55.9
Best performing low noise tyres	51.7	48.4	59.1	55.6	64.9	61.8	63.2	53.7
ΔLNIGHT	1.0	2.2	1.0	2.2	2.4	2.5	2.7	2.2

Table V. Numbers of (highly) annoyed and (highly) sleep disturbed people for the Netherlands, for current tyre usage and for best performing tyres. MHA=millions of highly annoyed, MA= millions of annoyed, MHSD=millions of highly sleep disturbed, MSD= millions of sleep disturbed.

NL	Millions	Millions	Differences	Differences	Relative Differences	Relative Differences
Annoyance	MHA	MA	ΔMHA	ΔMA	%MHA	%MA
Reference 2013	1.456	3.308	-	-	-	-
Triple A - quietest tyres	1.240	2.947	-0.216	-0.361	-14.8%	-10.9%
Sleep Disturbance	MHSD	MSD	ΔMHSD	ΔMSD	%MHSD	%MSD
Reference 2013	1.588	3.043	-	-	-	-
Triple A - quietest tyres	1.384	2.734	-0.204	-0.310	-12.8%	-10.2%

Table VI. Numbers of (highly) annoyed and (highly) sleep disturbed people for the EU27, for current tyre usage and for best performing tyres.

EU	Millions	Millions	Differences	Differences	Relative Differences	Relative Differences
Annoyance	MHA	MA	ΔMHA	ΔMA	%MHA	%MA
Reference 2013	54.9	118.9	-	-	-	-
Triple A - quietest tyres	46.6	105.9	-8.2	-13	-15.0%	-10.9%
Sleep Disturbance	MHSD	MSD	ΔMHSD	ΔMSD	%MHSD	%MSD
Reference 2013	26.6	59.8	-	-	-	-
Triple A - quietest tyres	23.2	53.7	-3.4	-6.1	-12.9%	-10.2%

Step 4. Numbers of (highly) annoyed and (highly) sleep disturbed people were determined for each road type and traffic condition, L_{DEN} and L_{night} levels, population density and inhabited road lengths (see Table III) using the established dose-effect relationships recommended by the EU [10]. These numbers are set out in Table V for the Netherlands and in Table VI for the EU27. The EU estimate is based on the reference values from the VENOLIVA study [1] assuming that the EU reduction factors are similar to those of the Netherlands, regardless of differences in road surfaces, vehicle fleets and driving behavior. The EU27 population is set at 500 million, the Netherlands population is 16,7 million. The reductions in (highly) annoyed and sleep disturbed people vary from 10 to 15%.

Step 5. The monetised benefits are calculated for changes in property valuation and reduced health costs due to reduced environmental noise levels. The annual hedonic pricing or property valuation benefit BHP can be derived according to**:**

$$B_{HP} = V_{HP} * N_H * NR \quad (1)$$

where

V_{HP} = value of hedonic pricing in Euros per household per dB per annum

N_H = number of households (calculated per road type and length)

NR= noise reduction in dB (LDEN) for the current year.

A V_{HP} value of €25 per household per dB noise reduction for the year 2002 was used (following [11]), which corrected for inflation to 2015 amounts to €28,45. This is considered a very conservative estimate, as in some EU member states significantly higher values are reported.

The health benefits are based on reductions in costs due to severe heart disease only (Acute Myocardial Infarction), in a manner comparable to the UK IGCB approach [12]. The annual health benefit valuation B_{health} per household and per dB noise reduction can be calculated from:

$$B_{health} = V_{AMI} * N_H * NR \quad (2)$$

where

V_{AMI} = health benefit in € per household per dB noise reduction, related only to Acute Myocardial Infarction,

N_H = number of households

NR = dB noise reduction in L_{DEN} level

The average value over all road types for the health benefit V_{AMI} per household per annum is estimated at €16,75 in 2015.

Table VII. Estimated monetary benefits of noise reduction due to AAA tyres based on hedonic pricing and health benefits, for the Netherlands (top) and the EU (below).

NL	Hedonic Pricing benefits (M€)	Health benefits (M€)	Total benefit (M€)
Annual benefit for immediate implementation	252	137	389
Annual average	202	106	307
Accumulated 2015-2025	2018	1056	3074

EU	Hedonic Pricing benefits (M€)	Health benefits (M€)	Total benefits (M€)
Annual benefit for immediate implementation	7105	3863	10968
Annual average	5690	2977	8667
Accumulated 2015 - 2025	56896	29773	86669

The estimated benefits are listed in Table VII for the Netherlands and extrapolated for the EU, for immediate implementation and for gradual implementation including accumulated benefits over the period 2015-2025. These figures are considered conservative estimates. Extrapolation of monetary benefits to EU level was done by multiplying the Dutch monetary benefit with the ratio between the EU and the Netherlands for the reduction of numbers of annoyed and sleep disturbed people.

The annual benefits for immediate implementation of noise reduction are estimated at 389 million Euros for the Netherlands and 11 billion Euros for the EU. Total annual benefits in the EU including energy and safety amount to around 34 billion Euros [7].

5. Viable policy options to reduce tyre noise

The following policy options may help to accelerate the use of tyres with the best available label, thereby reducing traffic noise levels:

- At European level: Further reduction of EU limits for rolling resistance, wet grip and noise of tyres;
- At member state level: Public awareness campaigns on benefits and savings, and incentives for choosing tyres with the best available label;
- In the industry: increase availability of best performing tyres and resolve outstanding issues such as other performance parameters not covered by the tyre label.

6. Conclusions

Benefits of the full transition from the current mix of tyre types to best performance tyres have been presented and are shown to be significant. Average rolling noise reductions of 3-4 dB are achievable for C1/C2 tyres, and up to 6 dB for C3 (truck/lorry) tyres. Widescale introduction of best performing tyres is achievable in a relatively short timescale at no cost and will result in savings for consumers, lower energy consumption, increased road safety, lower traffic noise levels and thereby less noise annoyance, sleep disturbance and health effects. Total socio-economic benefits for noise reduction are estimated at an average of 389 million Euro in the Netherlands and 11 billion Euro in the whole EU. Total average annual benefits in the EU including energy and safety amount to around 34 billion Euros. Further reduction of EU tyre limits, national incentives and awareness campaigns are viable policy options to accelerate the widescale use of tyres with the best possible label.

Acknowledgement

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