MONITORING PROCEDURE IN THE VEHICLE NOISE REGULATION

ECE R 51 monitoring
Cost/benefit analysis

Informal document **GRB-53-19** (agenda item 3(b))
Presented by Louis-Ferdinand PARDO

Steps

The cost-benefit analysis involves the following steps:

1) Determination of the effects of the different scenarios on the noise emission of different vehicle categories.
2) Implementation of these new emission stages into the TRANECAM model, calculation of the effects on Lden and transformation of noise reduction levels into monetary benefits.
3) Industry consultation and estimation of costs per vehicle.
4) Implementation of these new emission stages into the cost model and transformation of noise reduction levels into monetary costs.
5) Impact assessment results.

Step 1

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Scenarios for CB analysis

- Cost-effectiveness of noise reduction is estimated on 5 scenarios compared to a “do nothing” scenario.
- Noise reductions for each stage, as shown on table 1, are chosen to offer a complete estimation of costs and benefits.

	Noise reduction for each stage		
	Stage 1	**Stage 2**	**Stage 3**
Scenario 0	*Current equivalent limits values (CEL)*		
Scenario 1	-1 dB (201x+2)		
Scenario 2	-2 dB (201x+2)	-	-
Scenario 3	-2 dB (201x+2)	-2 dB (201x+10/12) (2)	-
Scenario 4	-2 dB (201x+2)	-2 dB (201x+5/7) (1)	-1 dB (201x+10/12) (2)
Scenario 5	-2 dB (201x+2)	-2 dB (201x+5/7) (1)	-2 dB (201x+10/12) (2)

(1) *5 years for M1/N1/M2-A and 7 years for M2-B,/M3/N2,/N3*

(2) *10 years for M1/N1/M2-A and 12 years for M2-B,/M3/N2,/N3*

Table 1

Effects of the different scenarios

- For this first step, it is assumed that **production above the limit are remain to limit line.**

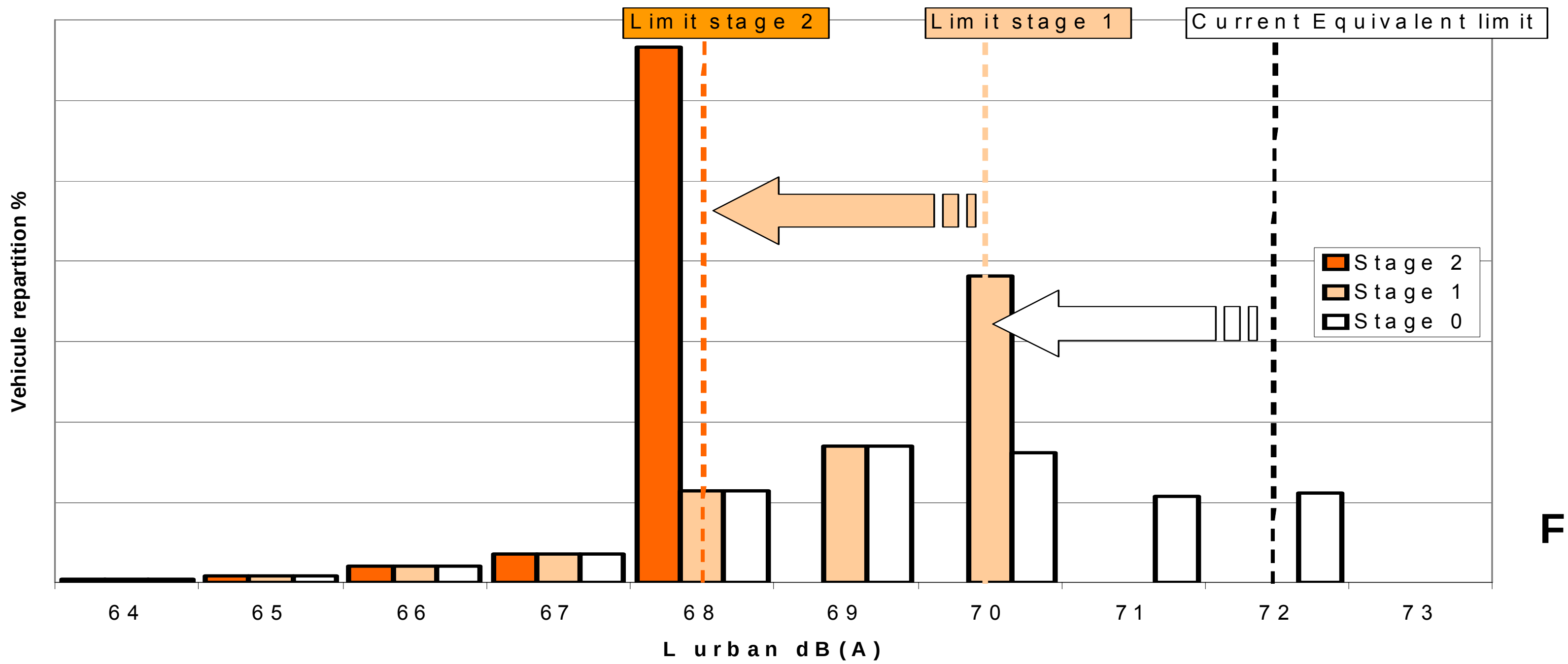

Figure 1

- The calculation of the effective noise reduction for vehicle categories is based on the L_{urban} frequency distributions in the monitoring dbase and the distribution of vehicle product into sub-categories.

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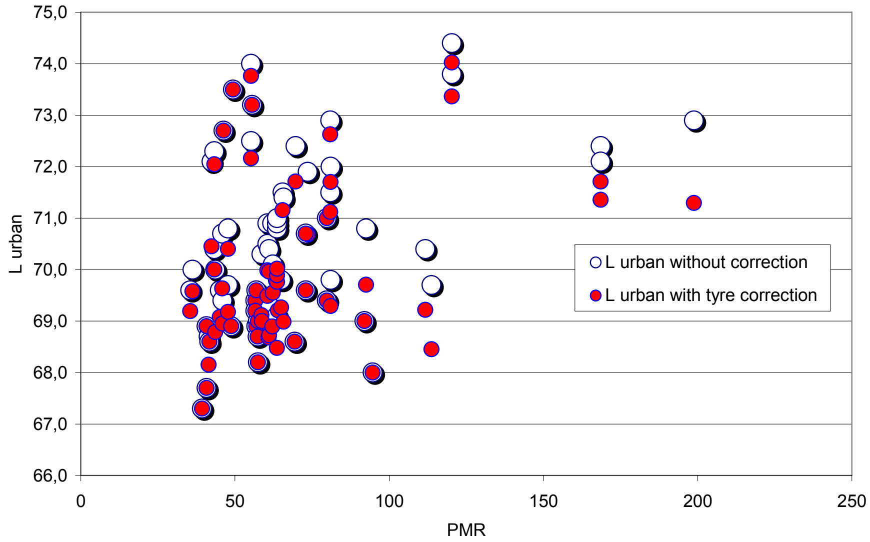
Effects tyre noise regulation (EC)No 661/2009

- M1/N1 is considered to benefit from the lower noise limits of new tyre regulation. For calculation, noise distributions of M1, N1 and M2-A was weighted to take into account the impact of Regulation (EC) No 661/2009.



Analysis made on 2004 ACEA database gives reduction of L urban from 0 to 2,4 dBA (0.5 dB on average) due to tyre regulation.

Figure 2

- Other categories than M1/N1 do not benefit from the lower noise limits from (EC) No 661/2009.

Effects of the different scenarios

Resulting noise reduction per vehicle category :

veh_cat	scenario	Delta_Leq in dB(A)	0 dB(A)	-1 dB(A)	-2 dB(A)	-3 dB(A)	-4 dB(A)	-5 dB(A)	-6 dB(A)
	Scenario 1	-0.13	85.17%	14.83%	0.00%	0.00%	0.00%	0.00%	0.00%
M1	Scenario 2	-0.38	71.16%	14.01%	14.83%	0.00%	0.00%	0.00%	0.00%
	Scenario 3	-1.49	25.86%	22.14%	23.16%	14.01%	14.83%	0.00%	0.00%
	Scenario 4	-2.34	9.24%	16.62%	22.14%	23.16%	14.01%	14.83%	0.00%
	Scenario 5	-3.27	3.65%	5.59%	16.62%	22.14%	23.16%	14.01%	14.83%
	Scenario 1	-0.07	92.42%	7.58%	0.00%	0.00%	0.00%	0.00%	0.00%
N1	Scenario 2	-0.24	79.75%	12.67%	7.58%	0.00%	0.00%	0.00%	0.00%
	Scenario 3	-1.43	20.00%	30.00%	29.75%	12.67%	7.58%	0.00%	0.00%
	Scenario 4	-2.26	6.25%	20.00%	23.75%	29.75%	12.67%	7.58%	0.00%
	Scenario 5	-3.23	2.00%	8.25%	9.75%	30.00%	29.75%	12.67%	7.58%
	Scenario 1	-0.21	77.39%	22.61%	0.00%	0.00%	0.00%	0.00%	0.00%
rigid truck	Scenario 2	-0.58	57.26%	20.13%	22.61%	0.00%	0.00%	0.00%	0.00%
	Scenario 3	-1.85	19.57%	17.50%	20.19%	20.13%	22.61%	0.00%	0.00%
	Scenario 4	-2.65	11.78%	7.79%	17.50%	20.19%	20.13%	22.61%	0.00%
	Scenario 5	-3.61	2.22%	9.56%	7.79%	17.50%	20.19%	20.13%	22.61%
	Scenario 1	-0.24	74.01%	25.99%	0.00%	0.00%	0.00%	0.00%	0.00%
trailer truck	Scenario 2	-0.77	41.21%	32.81%	25.99%	0.00%	0.00%	0.00%	0.00%
	Scenario 3	-2.45	7.61%	7.71%	25.89%	32.81%	25.99%	0.00%	0.00%
	Scenario 4	-3.39	3.26%	4.35%	7.71%	25.89%	32.81%	25.99%	0.00%
	Scenario 5	-4.39	0.00%	3.26%	4.35%	7.71%	25.89%	32.81%	25.99%

Table 2

Step 2

The cost-benefit analysis involves the following steps:

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Implementation into the TRANECAM model

Determination of the effects of the reduction is measured on the noise emission behavior under real world driving conditions :

- For all scenarios the noise reduction was calculated for road categories, traffic volumes and compositions as shown in table 3.
- For rigid trucks and trailer trucks was assumed that the reduction is related to propulsion noise only. This was also the case for M1 and N1 for scenario 2. For the scenarios 3 to 5 was assumed that the rolling noise needs to be reduced also for M1 and N1 vehicles.
- Stone mastic asphalt 0/11 was chosen as road surface, since this surface has become a representative surface in many European regions in the meantime.

Road category and traffic load scenario

Road category	no of lanes	ADT	percent LDV	percent HDV
residential streets, speed limit 30 km/h	2	250	3.3%	1.0%
residential streets, speed limit 50 km/h	2	500	3.3%	1.0%
urban, main streets, speed limit 50 km/h, right of way	2	2000	4.6%	3.0%
urban, city centre	2	20000	4.4%	4.0%
urban, main streets, speed limit 50 km/h, traffic lights	4	40000	4.5%	5.0%
urban, main streets, speed limit 60/70 km/h	4	40000	4.4%	5.0%
rural, speed limit 70 km/h	2	15000	4.3%	8.0%
rural, speed limit 80/90 km/h	2	15000	4.2%	8.0%
rural, speed limit 100 km/h	2	15000	4.0%	10.0%
motorway, speed limit 80 km/h	4	40000	4.2%	20.0%
motorway, speed limit 100 km/h	4	40000	4.2%	20.0%
motorway, speed limit 120 km/h	4	40000	4.2%	20.0%
motorway, without speed limit	4	40000	4.2%	20.0%

Table 3

Aggregation and averaging of results

- For the further calculation the results were aggregated to urban, rural and motorway by averaging the reductions achieved within these classes.
- It was assumed that 10% of the people affected by Lden values above 55 dB(A) live near motorways, 20% near rural roads and 70% in urban areas.
- The results are shown in table 5 :

	Delta-Lden in dB(A)			
road category	**scenario 2**	**scenario 3**	**scenario 4**	**scenario 5**
urban	-0.2	-1.5	-2.3	-3.1
rural	-0.1	-1.2	-1.8	-2.5
motorway	-0.1	-0.9	-1.2	-1.6
overall	-0.2	-1.4	-2.1	-2.8

Table 5

Calculation of phase in periods

- The previous table contains information about the noise reduction, when all vehicles in the fleet have to comply with the new limit values. In order to get an assessment of the time needed to reach this condition, the TRANECAM model was modified in that way that the phase in timeframe could be determined.
- The calculation was based on registration rates for new vehicles and on assumptions about the percentages of new vehicles that have to comply with the new limit values.
- Figure 3 shows the reduction in Lden as functions of the reference year. A time span up to 2034 is needed to reach the full noise reduction in real traffic.

Noise reduction vs reference year

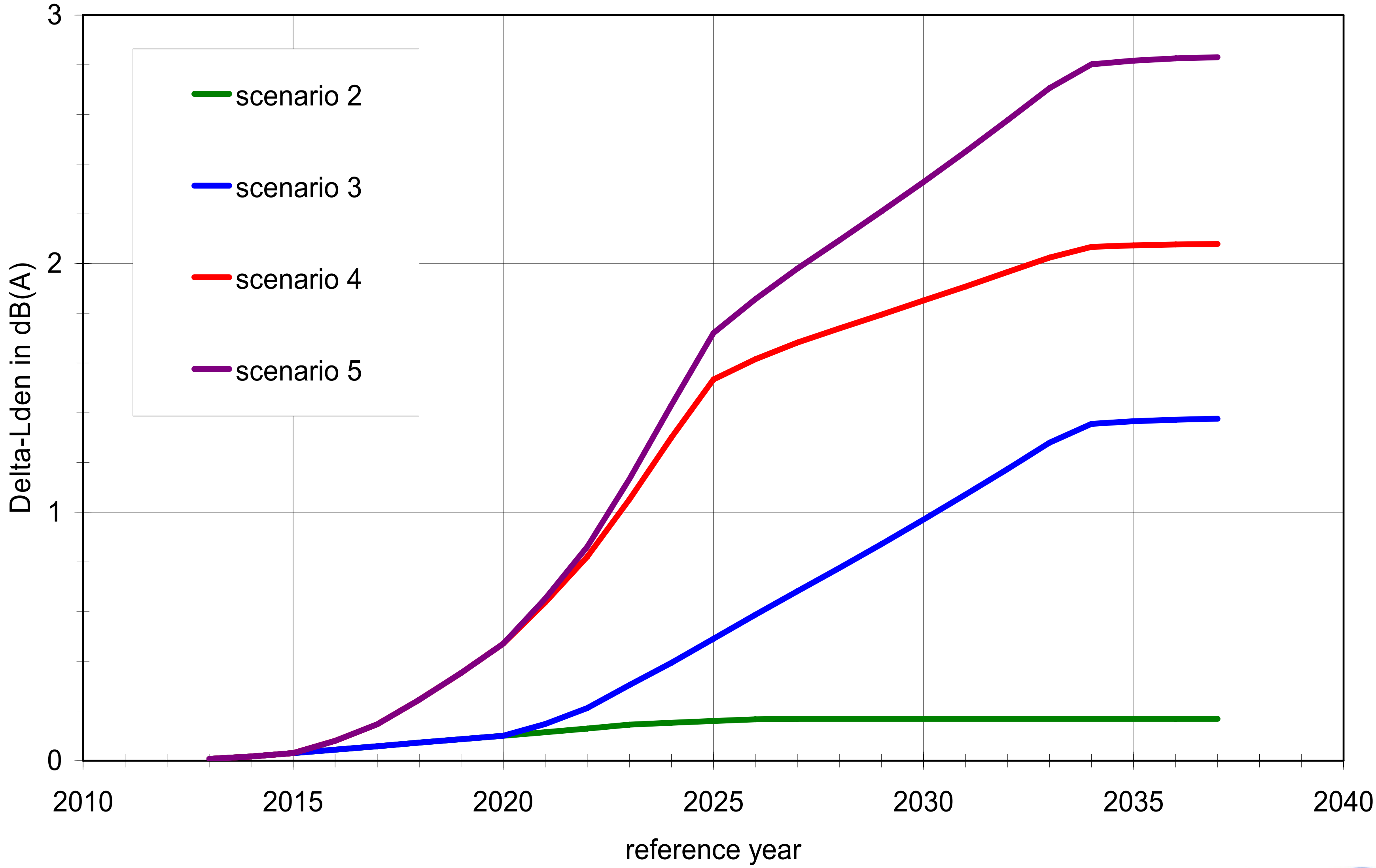

Figure 3

Calculation of monetary benefit

- In order to assess the cost efficiency of noise reductions measures, the costs need to be compared to the benefits, expressed in monetary values. The benefit calculation is based on the well known and established monetary willingness to pay value of **25 € for 1 dB noise reduction per household per year**, which is applicable to households that are affected by Lden above 55 dB(A).
- For the EU 27 an average number of 2,5 persons per household was assumed which results in a monetary value of 10,0 € per person per dB per year.
- The resulting cumulative benefit in € per person per year is shown in Figure 4.

Monetary benefit per person vs reference year

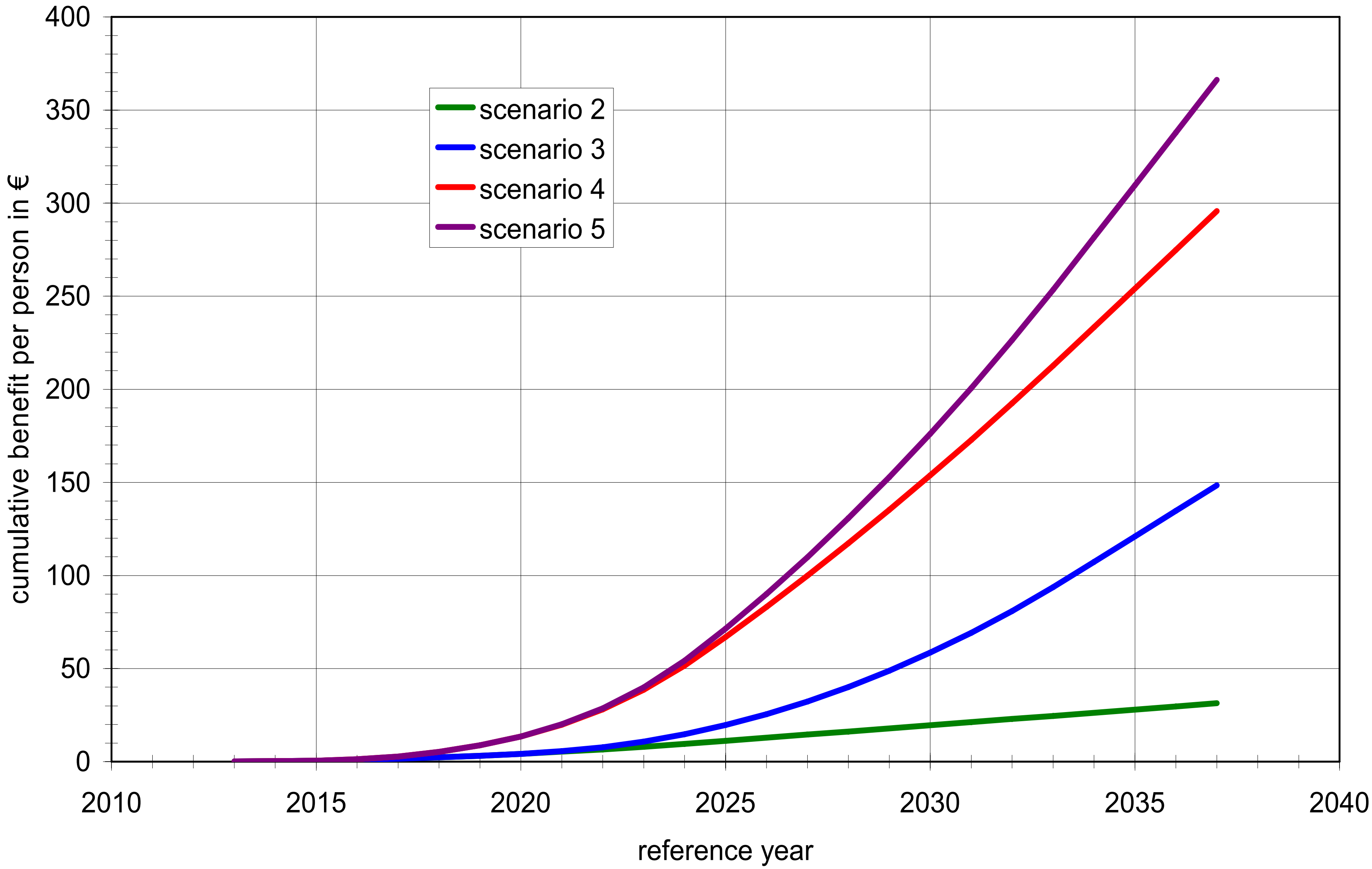

Figure 4

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Calculation of monetary benefit

- For the calculation of the total benefit was assumed that 41% of the EU population is affected by Lden values above 55 dB(A). This assumption is based on the results of the noise mapping within the framework of the EU environmental noise directive (END). This amounts in 204,5 Mio people and results in total monetary benefit curves as shown in figure 5.
- Till 2034 the benefit sums up to
  - For scenario 2 5 billion €,
  - For scenario 3 22 billion €,
  - For scenario 4 48 billion €,
  - For scenario 5 58 billion €.

Total monetary benefit vs reference year

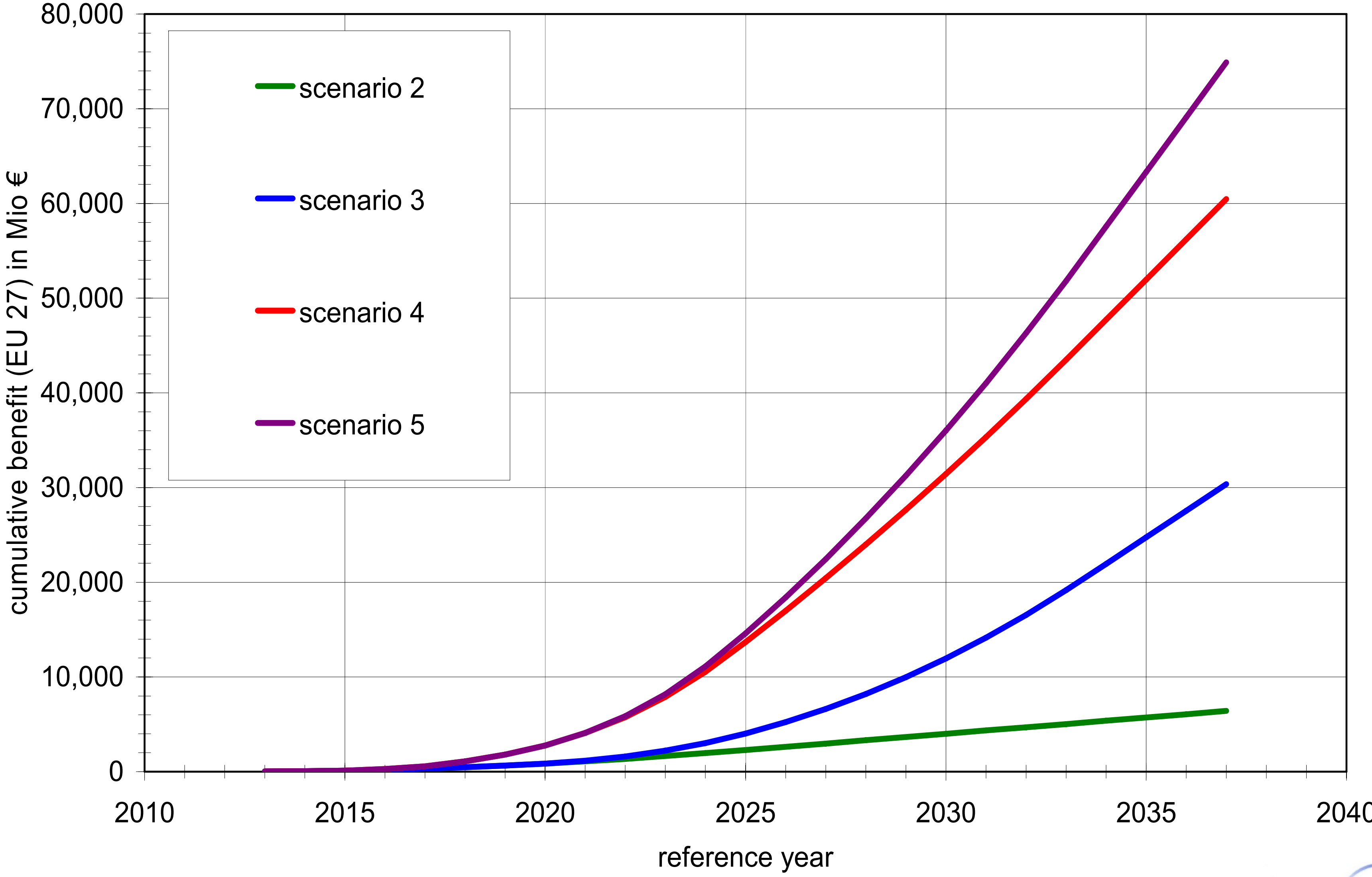

Figure 5

Step 3

The cost-benefit analysis involves the following steps:

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Industry consultation

- For evaluation of industrial impacts and costs, major representatives' stakeholder were consulted :

  - ✓ Manufacturers (PC, LDV, HDV and coachs/busses),
  - ✓ Suppliers (tyre industry, insulation, exhaust, …),
  - ✓ Automotive project managers,
  - ✓ R&D consultants.

- **Noise reduction concerns were enlarged to all vehicle categories and services (environment, safety, competitiveness, …)**

Industry concerns

- The leading requirement for exterior noise is the regulation.
- Nowadays, to improve vehicle noise, manufacturers work on components to find solutions which have very low impact on other services.

  Stringent requirements will modify the impact of exterior noise on vehicle architectures : **Technical solutions for noise reduction will have to be balanced with the other specifications (interior noise, pollution, emissions, safety, thermal, volume, weight, competitiveness, etc.).**
- The timeframe and reduction required have to take into account development phase process and design. In all cases, investments are needed because technologies are not already available for more than 1 or 2 dB reduction.

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Review of technical solutions and costs

- Technical solutions and their costs and efficiency are based on consultation and on state-of-art.
- Solutions range from simple modifications of components to major modifications of systems.
- Evaluation of costs is based on the life-time of a new vehicle type divided into development period (investment costs) and selling period (production costs).
- Regressions of individual solutions give 3rd order polynomials cost curves functions. Cost curves shown on figure 6 and 7 represents the cumulative cost for a noise levels reduction considering initial Lurban levels.

Cost curves

for M1, N1 and M2-1

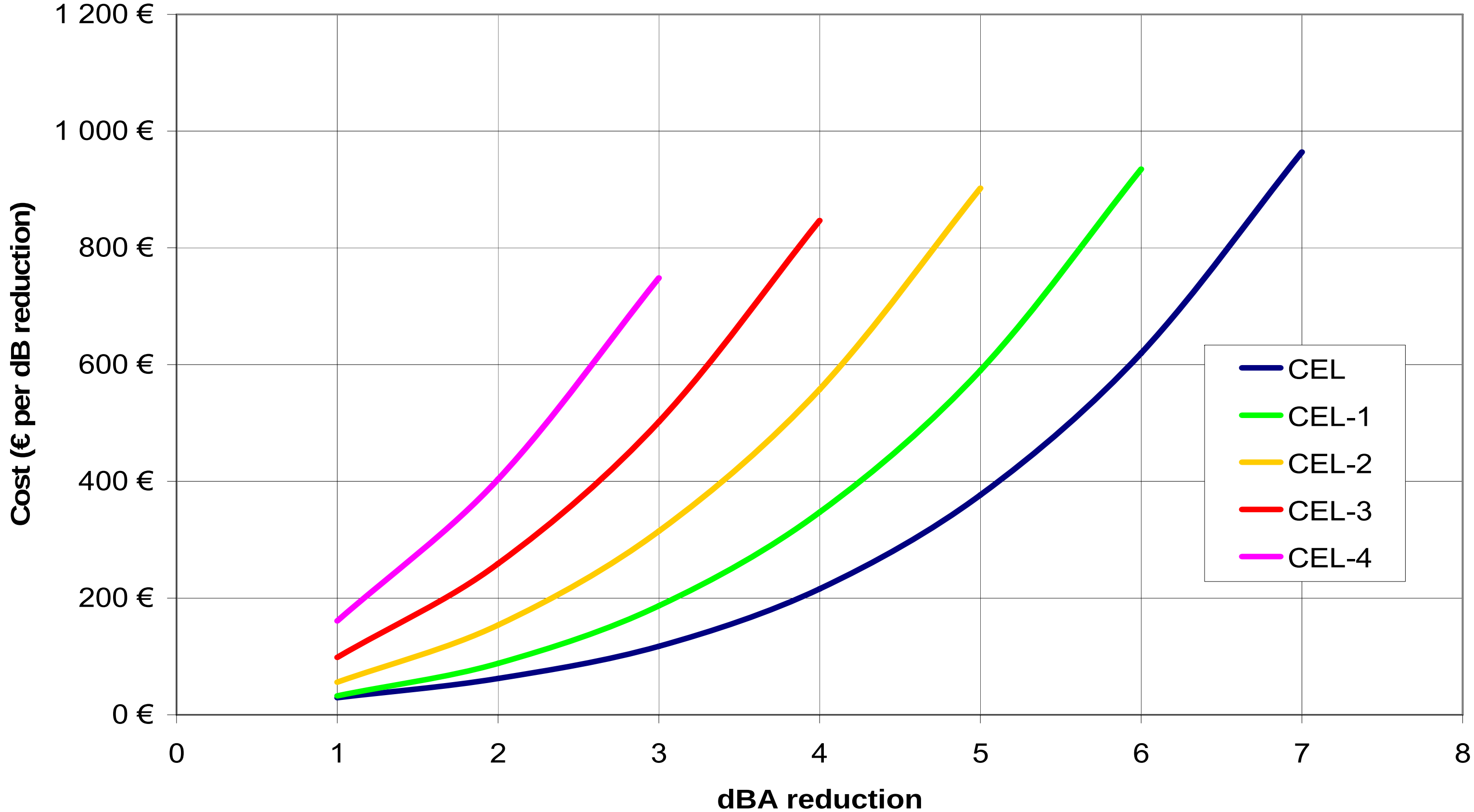

Figure 6

CEL is the equivalent limit level for method B

Cost curves

for M2-2, M3, N2 and N3

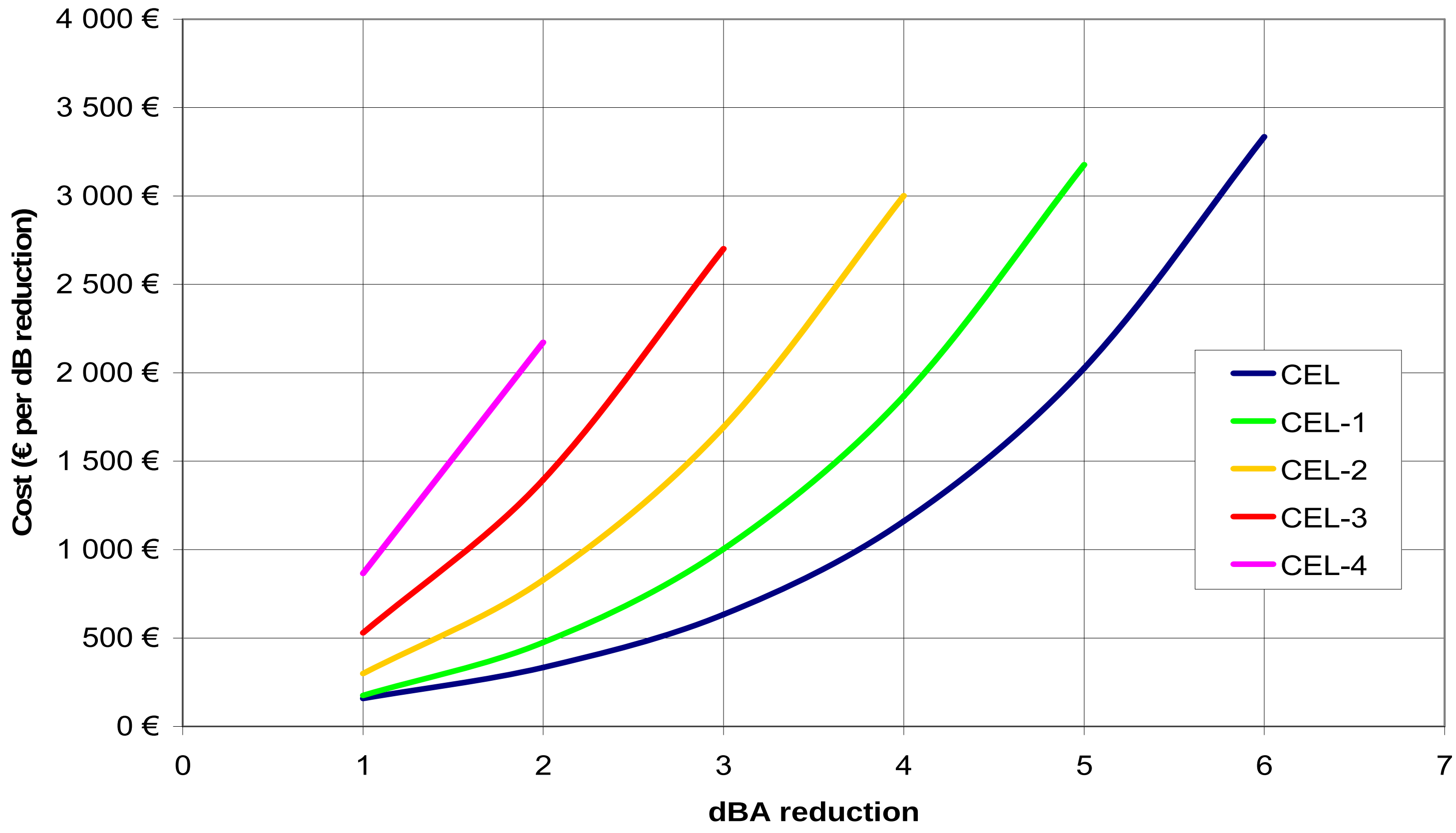

Figure 7

CEL is the equivalent limit level for method B

Cost curves - Example

For M1-1 : CEL = 72 dBA - Example for a limit equal to 69 dBA

Cost curves :

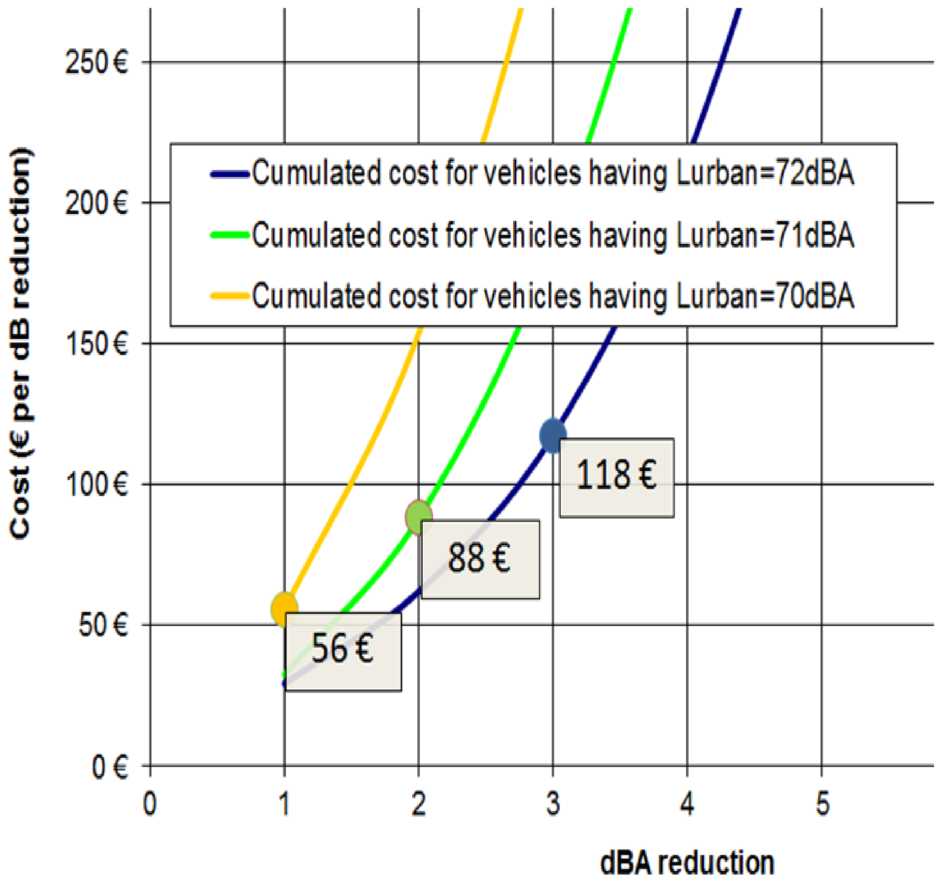

Figure 8

Effect :

L urban	Reduction required	Costs per vehicle
= 72 dBA	3 dB	118 €
= 71 dBA	2 dB	88 €
= 70 dBA	1 dB	56 €
≤ 69 dBA	0 dB	0 €

Table 5

Evolutions of costs curves

- Costs curves have to be weighted to consider timeframe of limit stages (increase/decrease of costs for limit stages shorter/longer than those chosen for calculation).
- Cost is maintain but reduce over the years and over model's renewing (cost of solutions previously design will be reduced by 30% at each complete redesign without new reduction requirement).
- Costs is estimated only for exterior noise requirement improvement. Futures effect on noise due to requirements such like emission and safety regulations are not taken into account.

Step 4

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Calculation of monetary costs

- Increase of vehicle price come from production costs (during selling period) and investments costs (during development period).
- All cost are considered to be completely transmit to customers.
- For customers, increase of vehicle price for manufacturer is equal to overall costs distributed on all selling vehicles.

The increase in vehicle price is equal to the increase in price for manufacturers multiplied by 1.7, with account taken of the purchase channel (transport, sellers, etc.) and the taxes.

- For manufacturers, investments made before the selling period will be getting back. But, advance money runs until around 6 years after the last limit stage.

Calculation of monetary cost

- For the calculation of the total costs was assumed that only customers were affected by noise level reduced vehicles. This amounts in less than 17,6 Mio customers and results in total monetary cost curves as shown in figure 9.

- Till 2034 the costs sums up to
  - For scenario 2 3 billion €,
  - For scenario 3 22 billion €,
  - For scenario 4 63 billion €,
  - For scenario 5 112 billion €.

Total monetary cost vs reference year

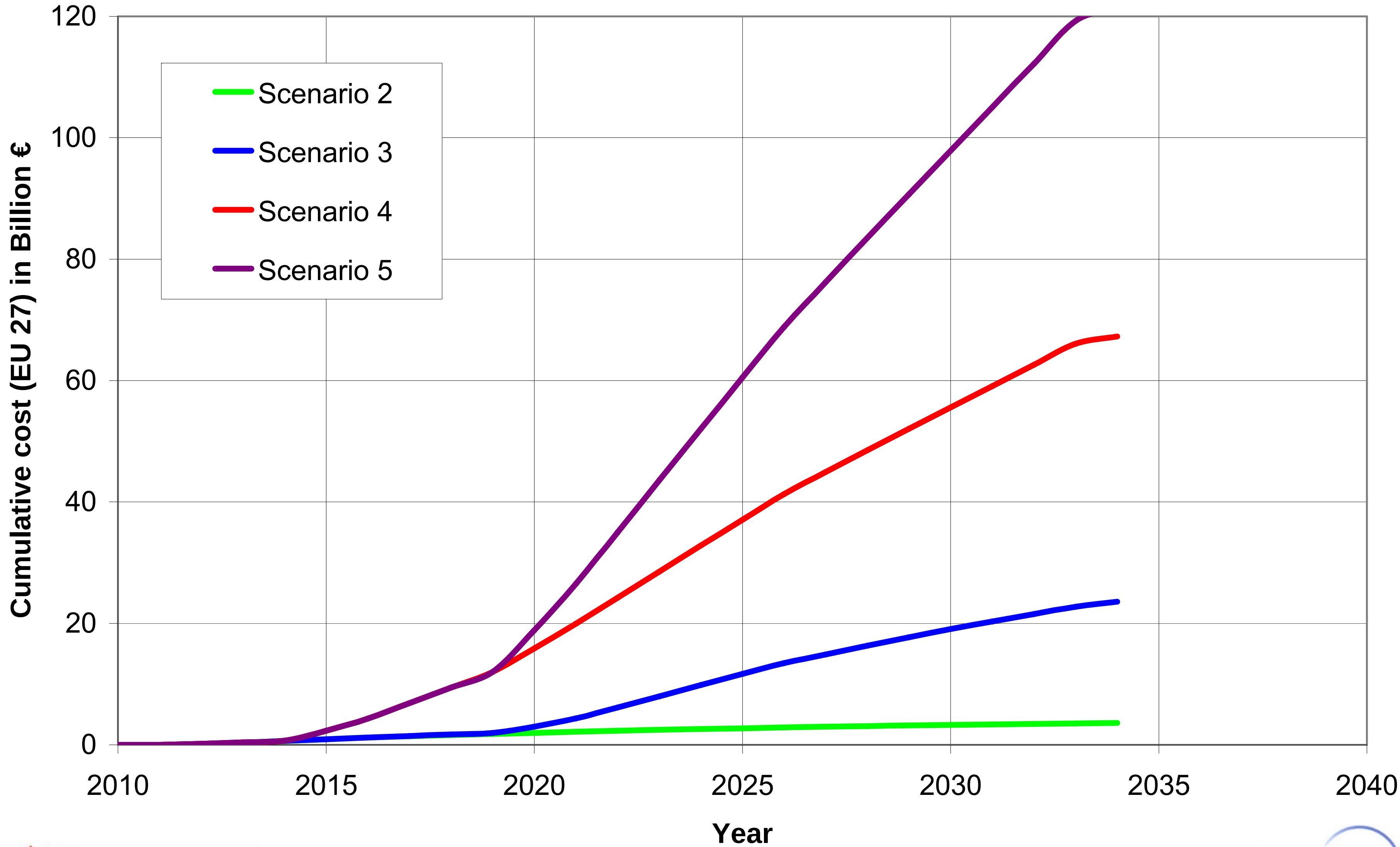

Figure 9

Step 5

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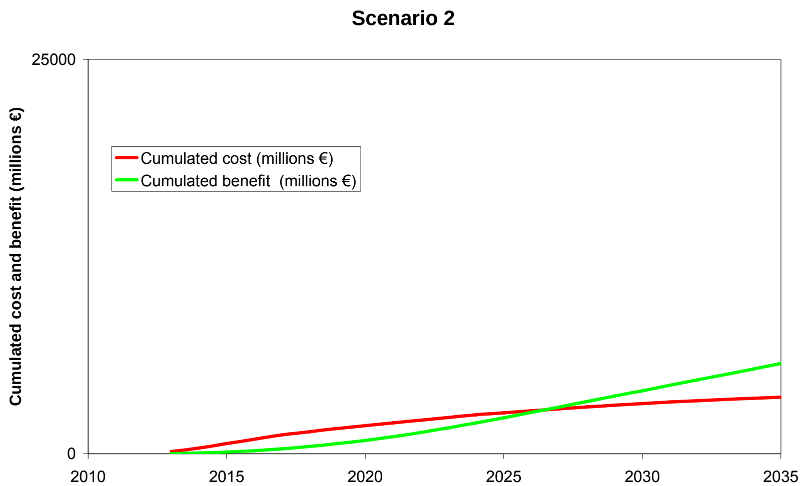
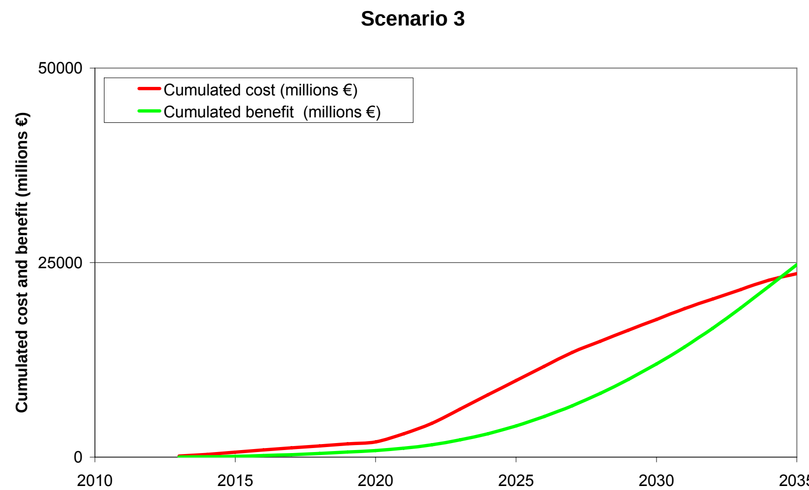
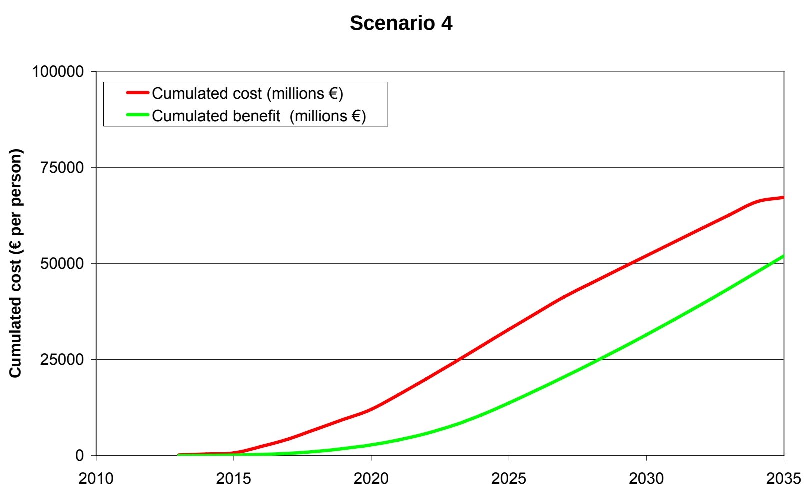
Cost and benefit comparison







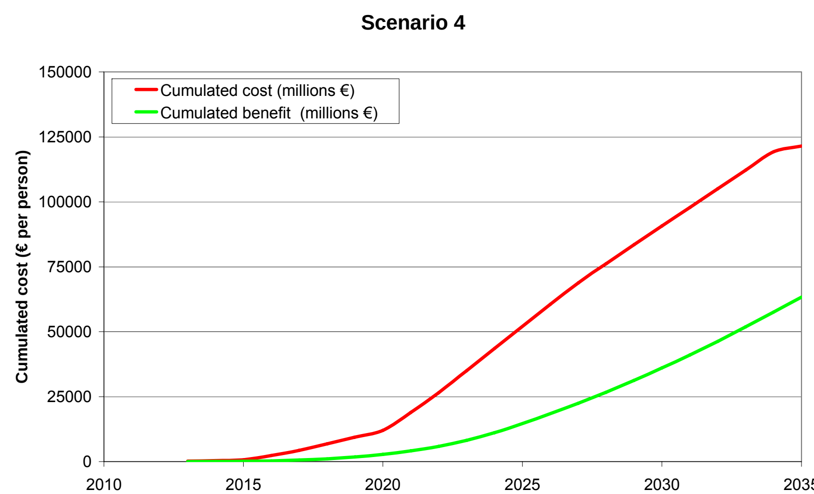


Figure 10

Total monetary ratio vs reference year

Cumulated cost benefit ratio (Cost divide by Benefit) :

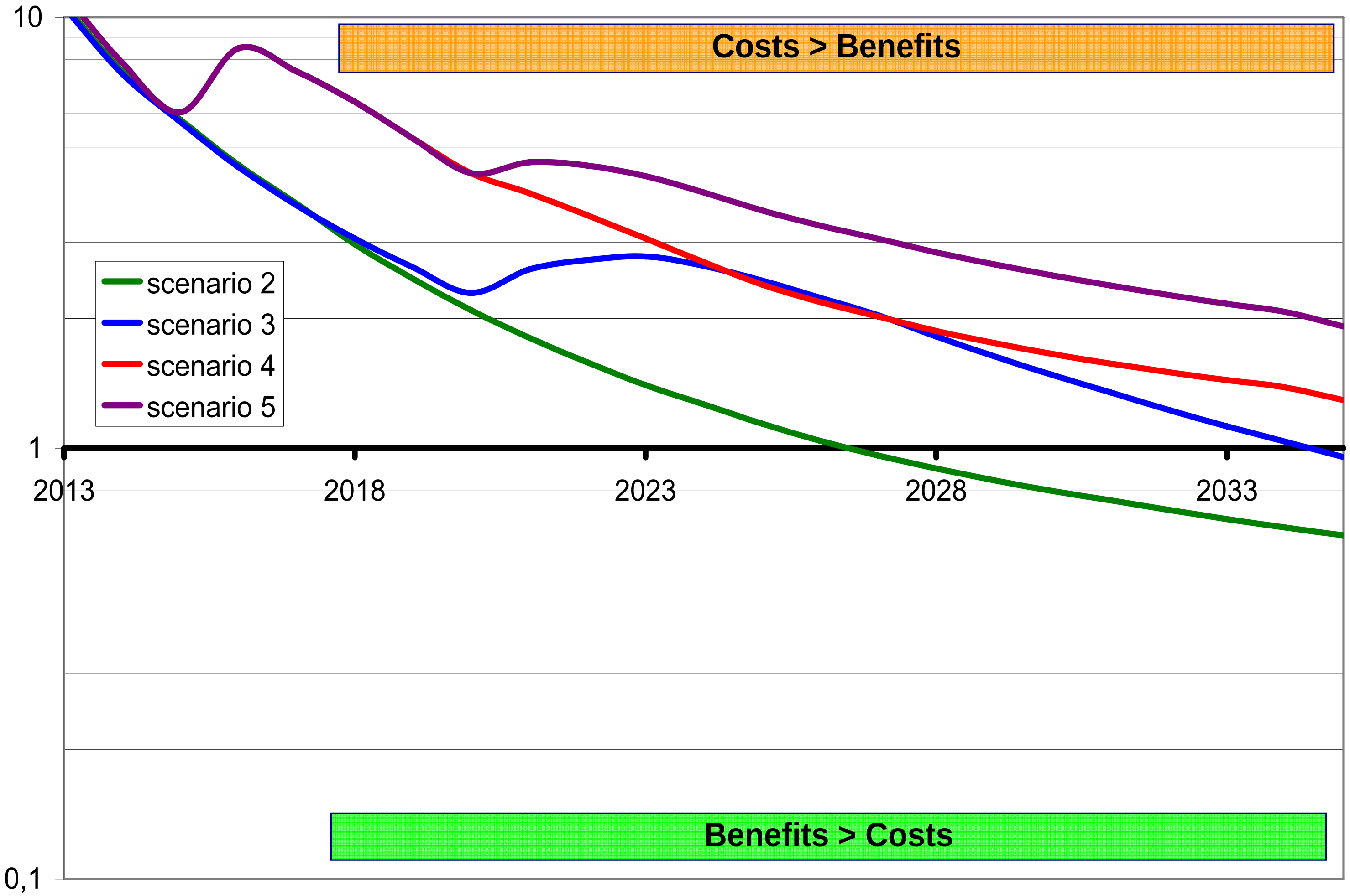


Figure 11

Conclusions

- The results of **Cost-effectiveness of legal vehicle noise limit reductions,** related to calculation options, are summarized in the table 6 :

Scenario*	**2**	**3**	**4**	**5**
Legal vehicle noise limits reduction	2 dB	4 dB	5 dB	6 dB
Environmental noise exposure reduction	0,2 dB	1,4 dB	2,1 dB	2,8 dB
Proportion of vehicles impacted	18%	66%	85%	92%
Cost over 20 years in billions €	3	22	63	112
Benefit over 20 years in billions €	5	19	44	52
Cost benefit ratio (C/B)	0,7	1,1	1,4	2,2

Table 6

- CBA ratio range from 0.7 to 2.2. Monetary values for cost and benefit are similar.

Conclusions

- Methodologies developed for CBA by UTAC/TUEV and TNO present some different assumptions and treatments which may introduce large differences.

	Legal noise limits Reduction		Environmental noise exposure Reduction	Cost over 17 years in billions €	benefit over 17 years in billions €	cost benefit ratio C/B
	M1N1	NM23				
(D) UTAC/TUEV - Scenario 5	6	6	2,8	69	36	2,2
(F) TNO - Option 5	4	3	3,1	8	120	0,06

Table 7

- On such studies, outputs depends mainly to inputs and analysis chosen. UTAC/TUEV and TNO studies can't be compared considering only output. **Further analysis need to be made to have a robust and cleaver comparison.**

Thank you for your attention