JADE UNIVERSITY
OF APPLIED SCIENCES
Wilhelmshaven Oldenburg Elsfleth

2nd Int Env. Noise Conf. Tallinn, 2010

Effect of the reduction of environmental noise on health due to established noise barriers

Analyzing of practical examples from Germany and results of researches about different methods for noise level reduction, compared with German rules of noise protection and their influence on health

by Jan Middelberg
Dr.-Ing., Dipl.-Phys., Prof. of Building Physics and Mathematics
Dept. of Civil Engineering and Geoinformation, Jade Hochschule
University of Applied Sciences,
Ofener Str. 16/19, D-26121 Oldenburg

Contents

Sound is objective measurable quantity

Noise is consciously and unconsciously disturbing sound

It effects:

Physical	Spontaneous damage of ear hearing system (pulse)
	Noise deafness
	Risk of cardio vascular diseases
	Disturbed sleep
Psychological	Nervousness and decrease in performance
	Disturbed well-being
	Decrease of concentration and learn ability
Social	Interference of speech distinction
	Interference of communication
	Change of dwelling situation
	Change of social structure
	Impairment of social behavior
Economic	Expenses for sedatives and treatment of deafness
	Decrease of dwelling quality and value of estates
	Costs due to errors caused by noise nervousness

Questions:
-How many human lives can be saved?
-For how many people live quality can be improved noticeable?
-Which economical costs can be saved by noise protection?
-What is the individual improvement for anybody?

This presentation can not give an accurate answer to these questions, particularly since these are statistic informations, but tries to introduce to estimate calculations.

1.2 Introduction

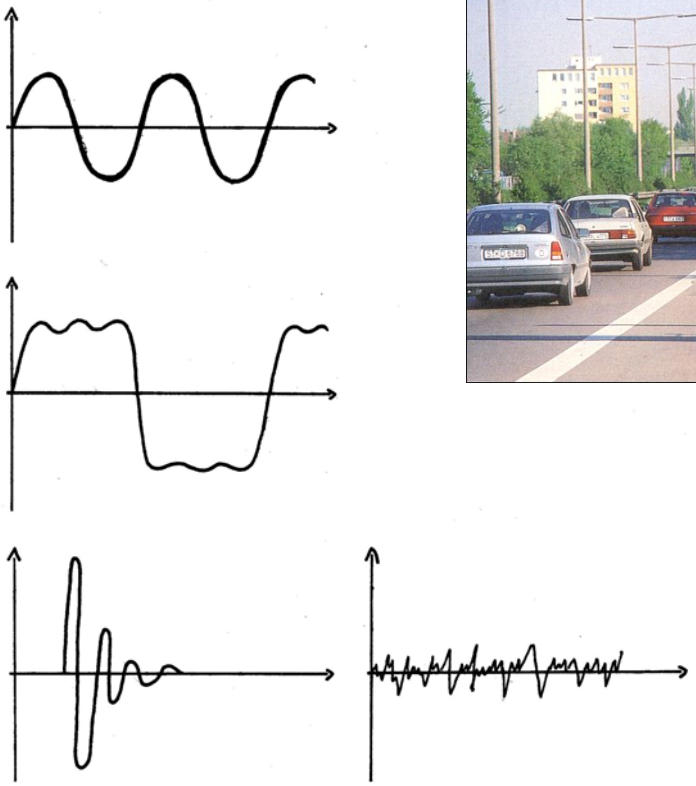
2009	year of foundation
6	faculties
3	campuses
6200	total number of students
30	Bachelor-courses
8	Master- courses
600	number of employees
188	number of professors
90	partnerships in 30 countries

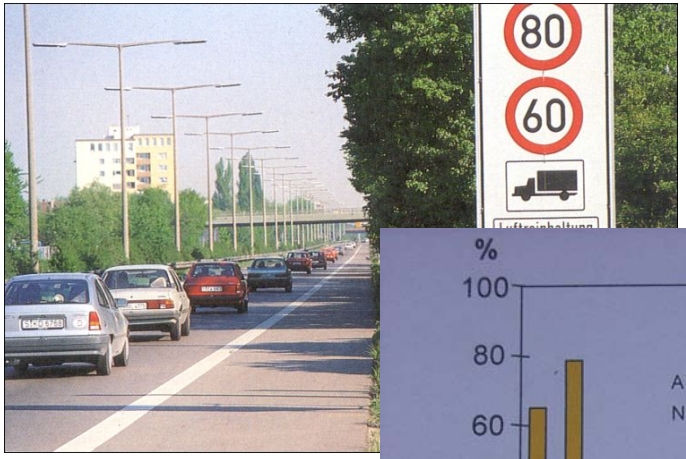
Campus Wilhelmshaven: Mechanical Engineering and Buisiness Administration,
Campus Elsfleth: Maritime Studies
Campus Oldenburg **Departements: Architecture,**
Civil Engineering and Geoinformation

Physics laboratory,
Fields of research: energy saving construction
heat protection and passive-house technology
climate protection, sustainable construction and certification
aeration and air quality
solar technology and water treatment
sound technology, acoustic improvement
immission protection, noise, vibrations and air pollution

Jan Middelberg, middelberg@fh-oldenburg.de, www.jade-hs.de
since 1997 Full Professor at Jade Hochschule, Oldenburg (resp. FH Oldenburg; FH-OOW)
since 1995 Consulting Engineer (member of Chamber of Engineers, Niedersachsen)
1994 to 1997 Assistant Professor at Hochschule Bremen (Int. Cours of Env. Techn.)
1990 to 1994 Scientific manager at Microgravity Laboratory "Fallturm Bremen"
1987 to 1990 Project management of construction and setup of "Fallturm Bremen"
1995 Doctor in Mechanical Engineering
1987 Diploma in Applied Physiks
1980 Gesellenbrief in Car Mechanics
1978 Abitur (Gymnasium)

2.1 Physical Background





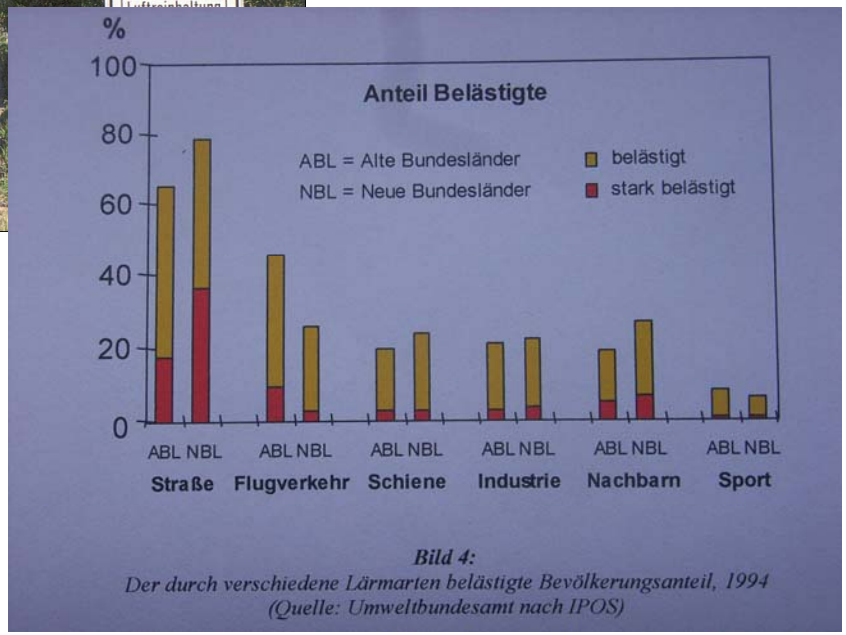


Bild 4:
Der durch verschiedene Lärmarten belästigte Bevölkerungsanteil, 1994
(Quelle: Umweltbundesamt nach IPOS)

Injurious environmental noise is generated mainly by traffic (street and railway) as well as by industry, in opposite to noise inside of buildings, which here will not be considered

2.2 Physical Background

E_{ac} = Acoustic Energy

P_{ac} = Acoustic Power

$$P_{ac} = E_{ac} \cdot t$$

I = Intensity

$$I = P_{ac}/A = p^2/(\rho \cdot c)$$

Power Level:

$$L_w = 10 \lg(P/P_0)$$

Sound Level:

$$L = 10 \lg(I/I_0) = 20 \lg(p/p_0)$$

Equivalent Intensity

$$I_{eq}(\Delta t) = \Sigma(E_i \cdot \Delta t_i) / A$$

$P_0 = 10^{-12}$ W = Reference Power

$I_0 = 10^{-12}$ W/m² = Reference Intensity

ρ= Density, c = Sonic Speed

Equivalent Sound Level:

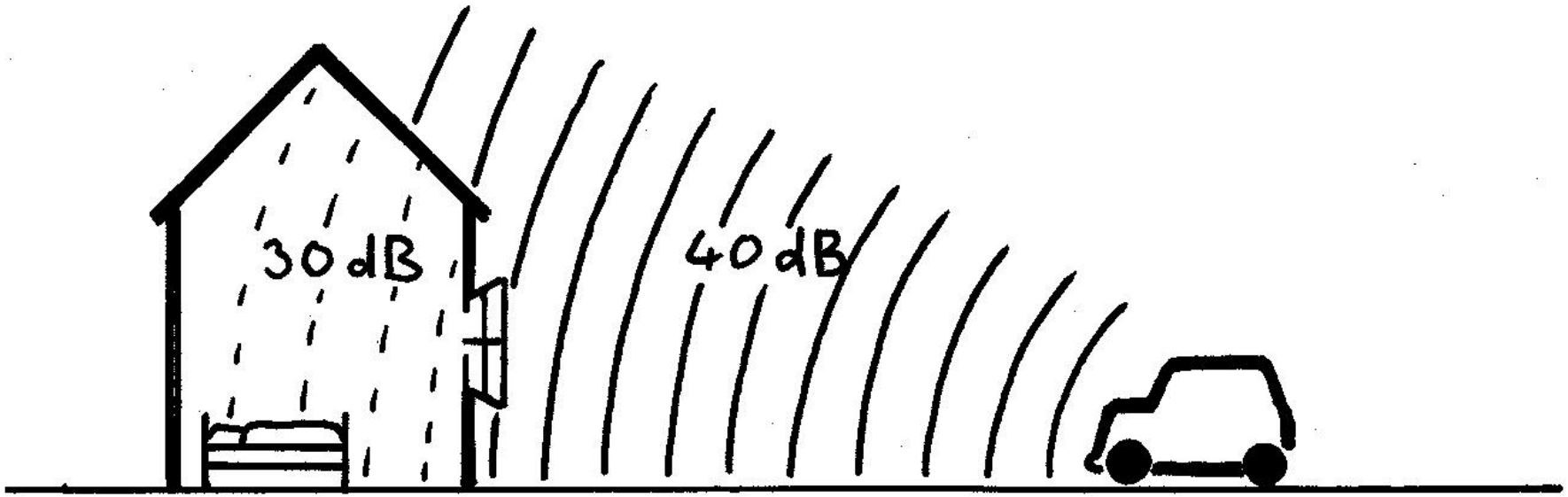
$$L_{eq} = 10 \lg(I_{eq}/I_0)$$

The negative effect of noise can be easily quantified by measurement of the average noise level (confidential level L_r)

3.1 Injurious Effects of Noise

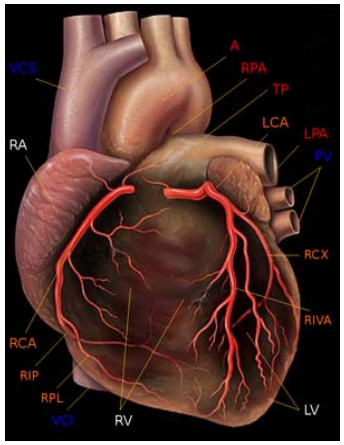
Intensity	Pressure		Level		Limit for...	Danger of...	Reason, e.g.:
I/(W/m²)	p/Pa		L/dB				
10^{3}			150		consciousness	deafness	explosion
	200						
							jet fighter, shot
10^{0}	20		120		pain, distinction	partial deafness	
							accident, forging
	2						
10^{-3}			90		ear protection	hearing defect	machines, workshop
	0,2						
							lecture, shop, city
10^{-6}	0,02		60		concentration, rest	cardio vascular disease	
							office, urban background
	0,002						
10^{-9}			30		nocturnal relaxation	sleeplessness	rural background
	0,0002						
							calm breathing
10^{-12}	0,00002		0		auditory perception		

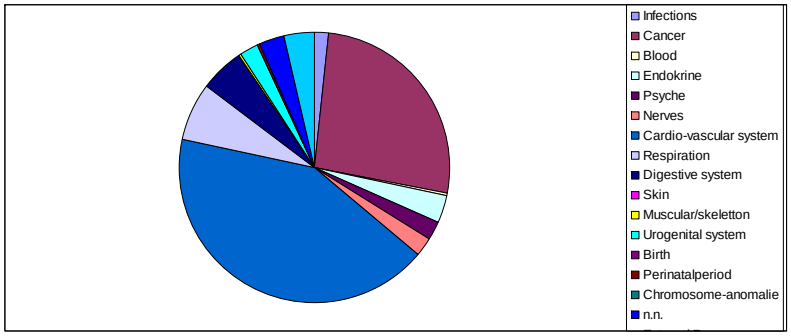
A damage of health occures by specific mechanisms due to exceed of specified noise limits (sound level scale).

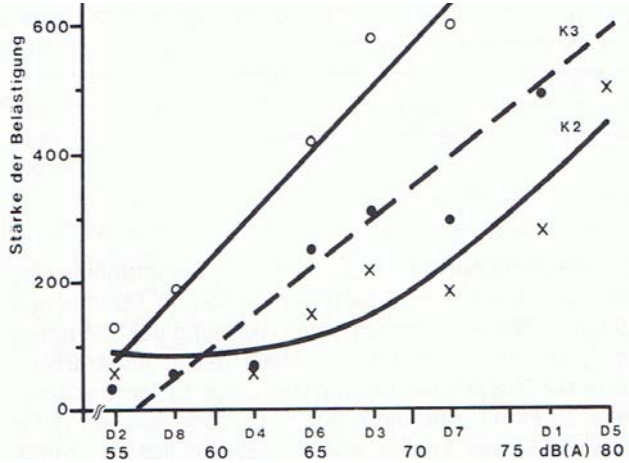


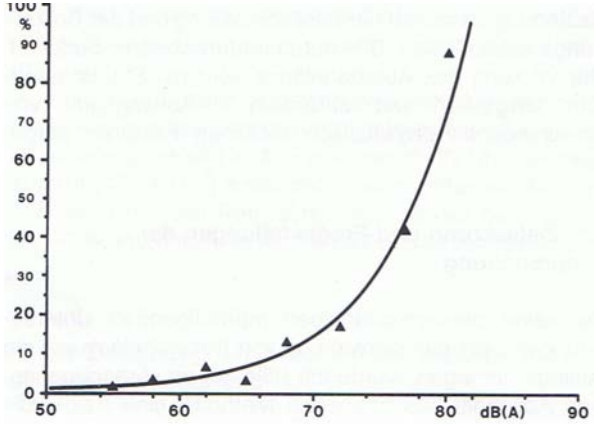
Decrease in nocturnal relaxation and in live quality occures with a level of 30 dB in bedrooms, this results in a limit level L_r of 40 dB in residential areas

3.3 Injurious Effects of Noise









As the rise of the blood pressure due to noise level is not a sharp function (it depends on age, fitness, gender, weight etc.), the effect can only be evaluated statistically. Several scientific studies and investigations proof, that stress with the consequences high blood pressure (hypertension) and damages of cardio-vascular system is the result of continous levels above 60 dB. So this can be determined as a treshold level.

3.3 Injurious Effects of Noise

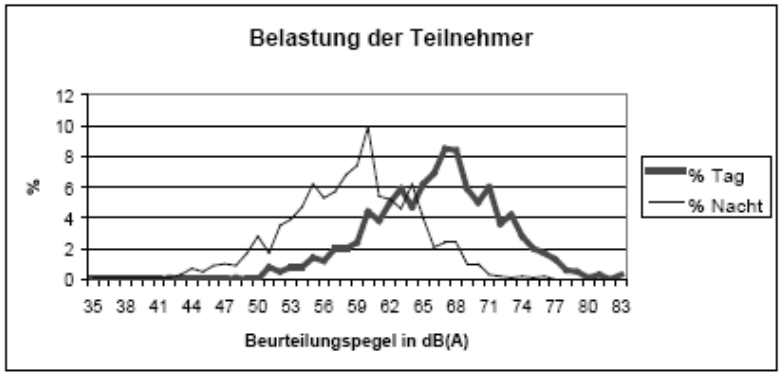


Abbildung 1: Belastung der Teilnehmer am Tage und in der Nacht

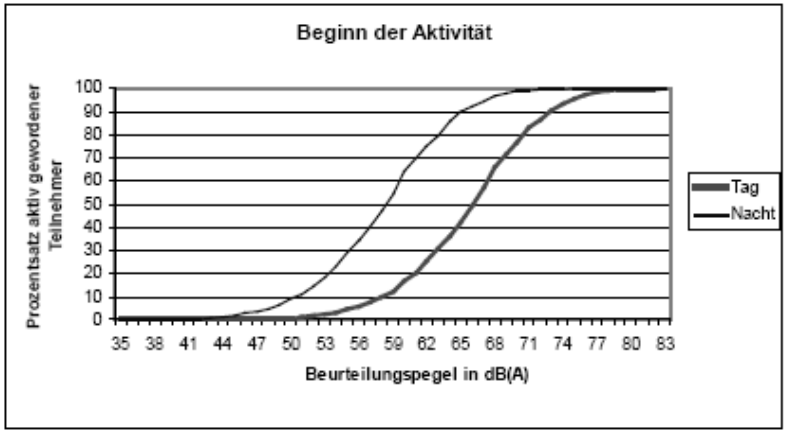
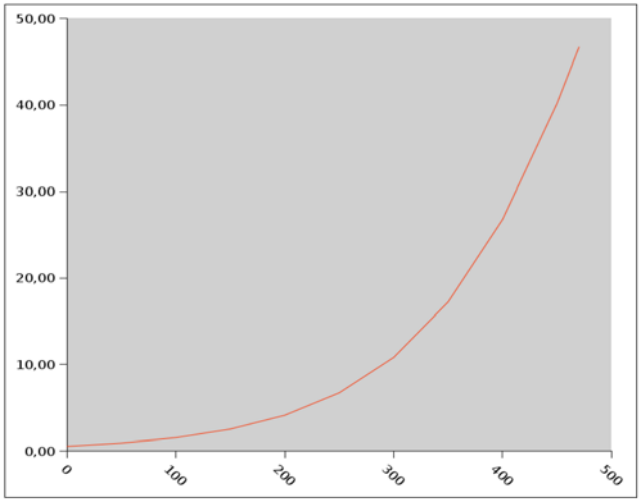
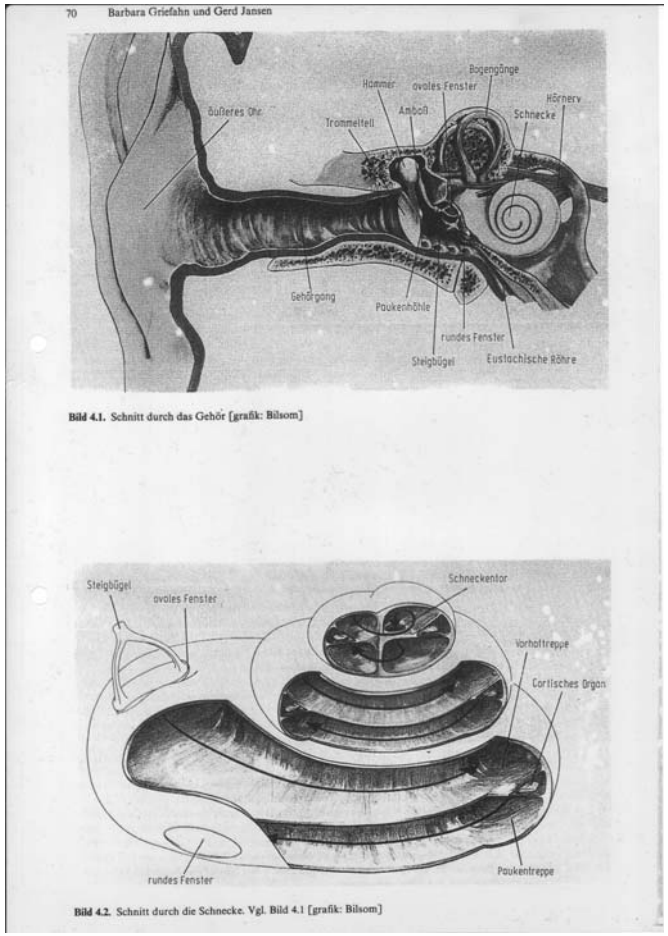


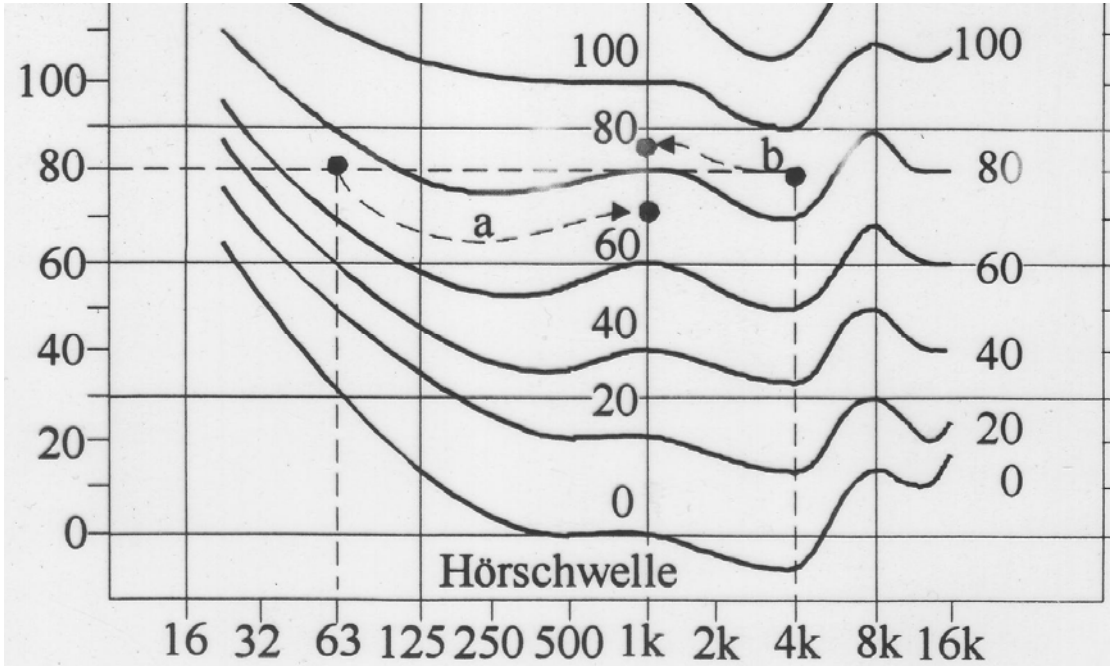
Abbildung 2: Summenkurve in Prozent der aktiv gewordenen Teilnehmer



Estimated propability of death or non-fatal myocardial-infarction over one year corresponding ti selectet values of the individual scores. Ordinate: individual score, abscissa: Propability of death or non-fatal myocardial infarction in 1 year (in %)

3.4 Injurious Effects of Noise





Environmental noise louder than 90 dB is rare, but causes auditory damages directly

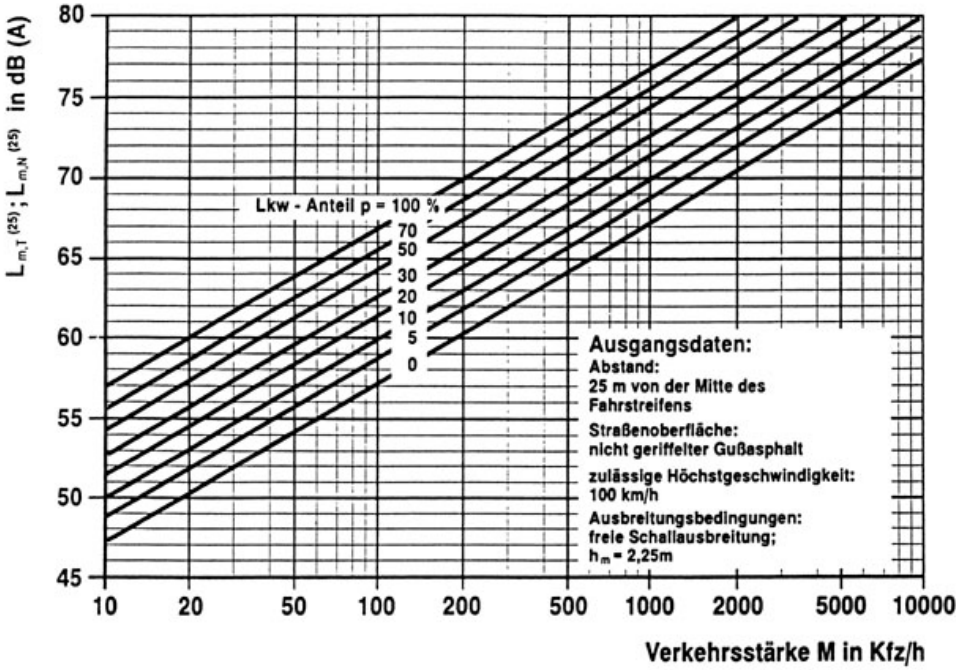
4.1 Legal Regulations

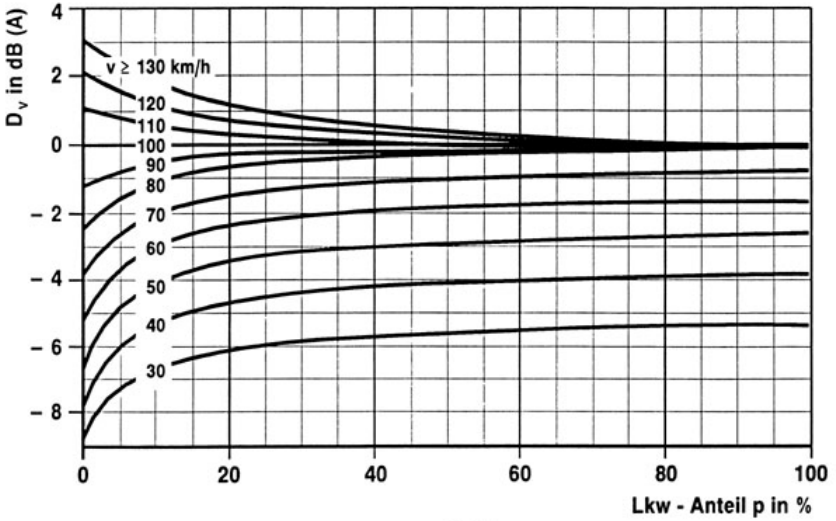
The recommended immision values for Germany are given by the TA-Lärm, the immission limits for traffic noise by the 16. BimSchV, which are both committed by the german immission protection law (BImSchG)

To protect the neighbourhood against injurious environmental effects of traffic, in case of construction and relevant change, the recommended level may not exceed the following immission limit values:

	Day	Night
1. at hospitals, schools, receation homes and senior residences	57 Dezibel (A)	47 Dezibel (A)
2. in pure and common residual areas and villages	59 Dezibel (A)	49 Dezibel (A)
3. in core areas, rural and mixed areas	64 Dezibel (A)	54 Dezibel (A)
4. in working areas	69 Dezibel (A)	59 Dezibel (A)

$$L_{r,N} = L_{m,N^{(25)}} + D_v + D_{StrO} + D_{Stg} + D_{S\perp} + D_{BM} + D_B + K$$





$$D_v = L_{Pkw} - 37{,}3 + 10 \cdot \lg \left[\frac{100 + (10^{0{,}1 \cdot D} - 1) \cdot p}{100 + 8{,}23 \cdot p} \right] \quad \text{dB(A)}$$

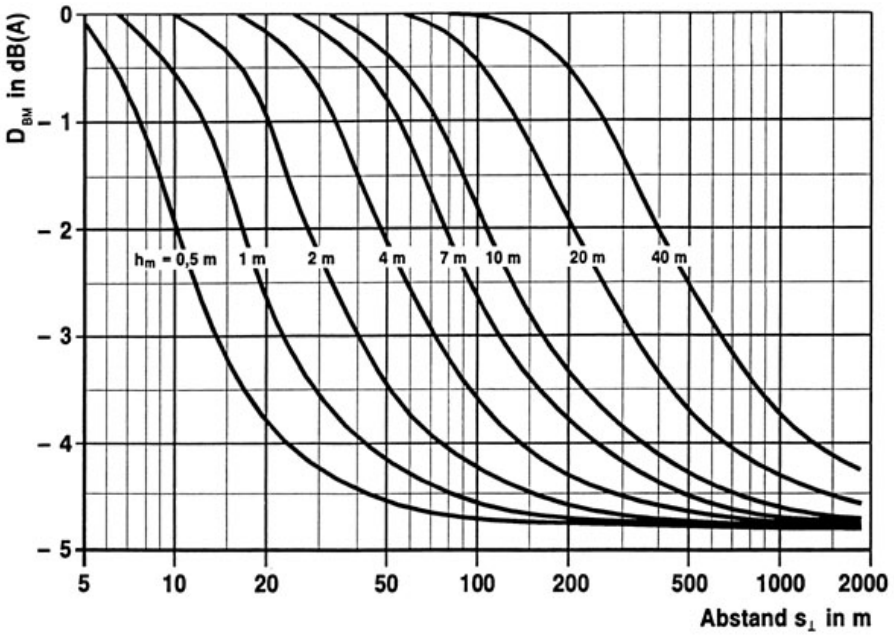
$$L_{Pkw} = 27{,}7 + 10 \cdot \lg \left[1 + (0{,}02 \cdot v_{Pkw})^3 \right]$$

$$L_{Lkw} = 23{,}1 + 12{,}5 \cdot \lg (v_{Lkw})$$

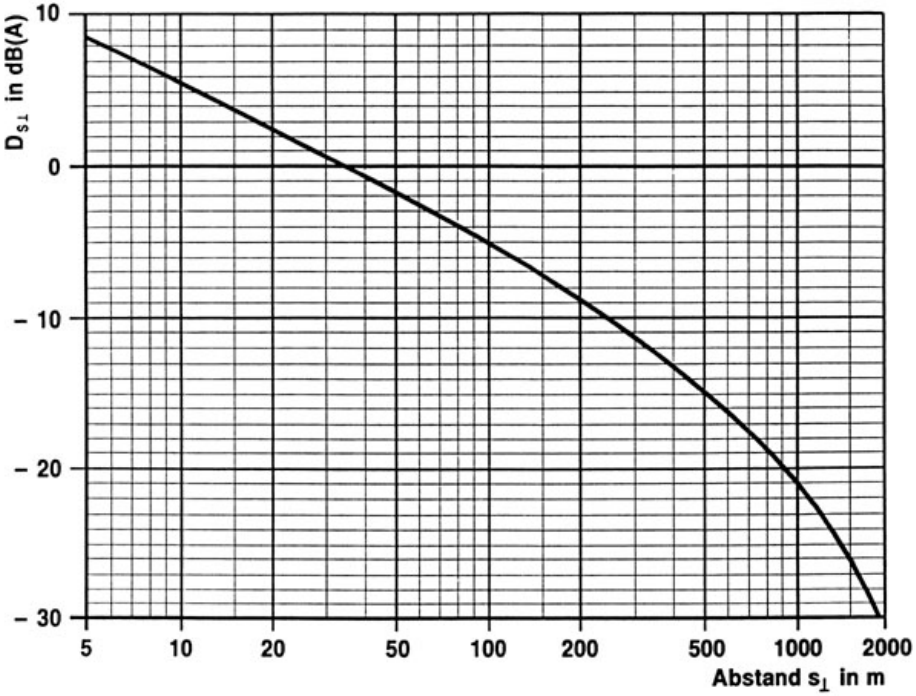
$$D = L_{Lkw} - L_{Pkw}$$

$$L_{m,T}^{(25)} \text{ bzw. } L_{m,N}^{(25)} = 37{,}3 + 10 \cdot \lg \left[M (1 + 0{,}082 \cdot p) \right] \text{ dB (A)}$$

$$L_{r,N} = L_{m,N^{(25)}} + D_v + D_{StrO} + D_{Stg} + D_{S\perp} + D_{BM} + D_B + K$$



$$D_{BM} = -\ 4{,}8 \cdot \exp\left[-\left(\frac{h_m}{s_\perp} \cdot \left(8{,}5 + \frac{100}{s_\perp}\right)\right)^{1{,}3}\right] \quad \text{dB(A)}$$



$$D_{S\perp} = 15{,}8 - 10 \cdot \lg(s_\perp) - 0{,}0142 \cdot (s_\perp)^{0{,}9} \quad \text{dB(A)}$$

Three possibilities of noise protection:

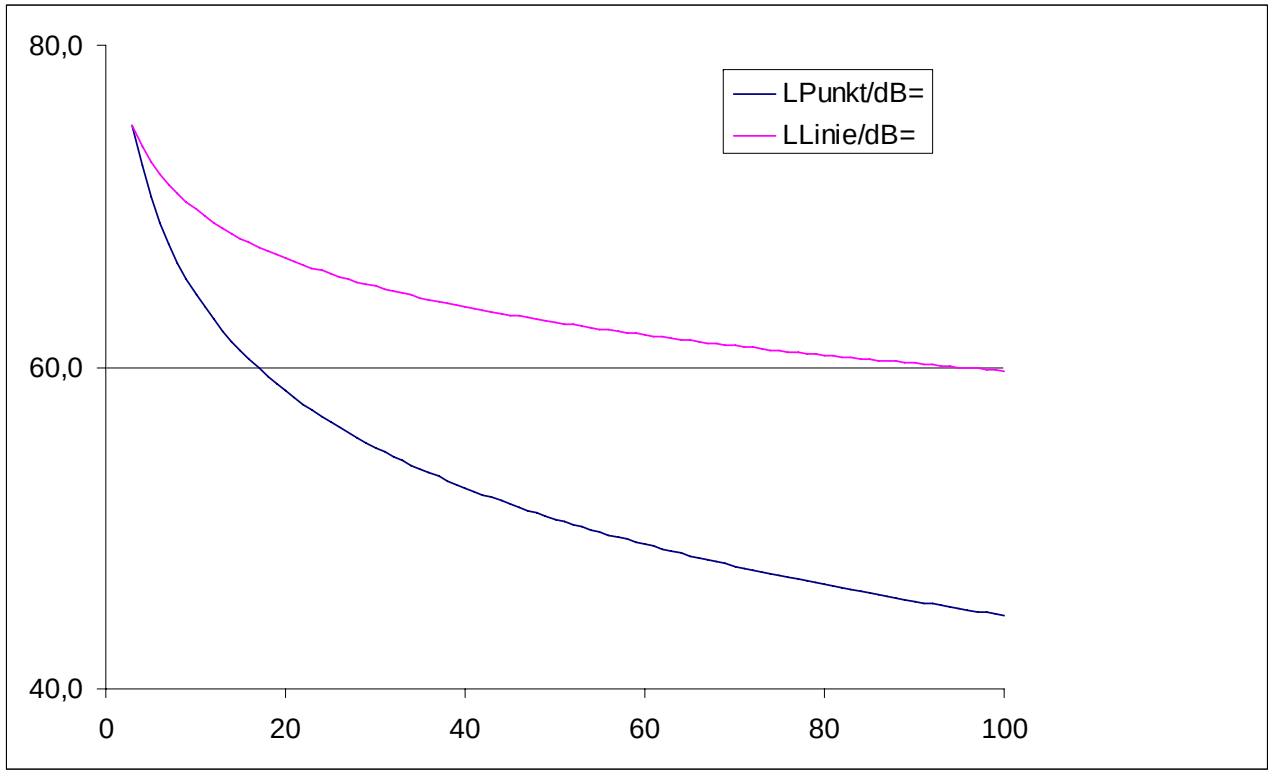
> at the source

> on the way

>

directly before reception

5.1 Reduction Possibilities



Traffic noise:

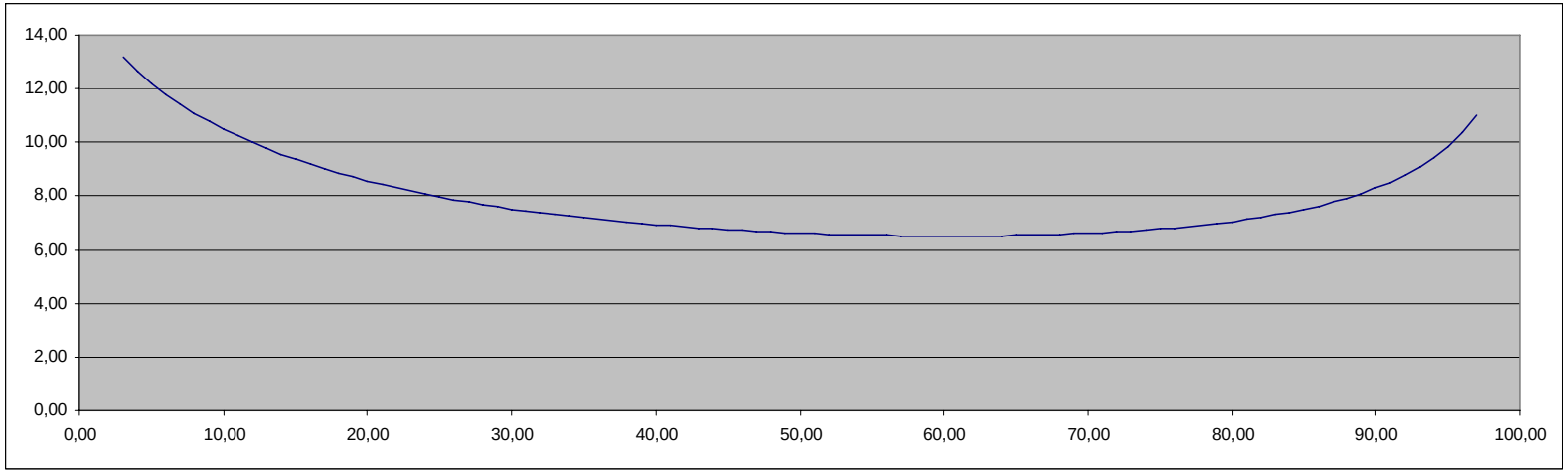
$L_L\,(r_0) = L(r_0)\text{-}10\,\lg(r/r_0)$

Industrial noise:

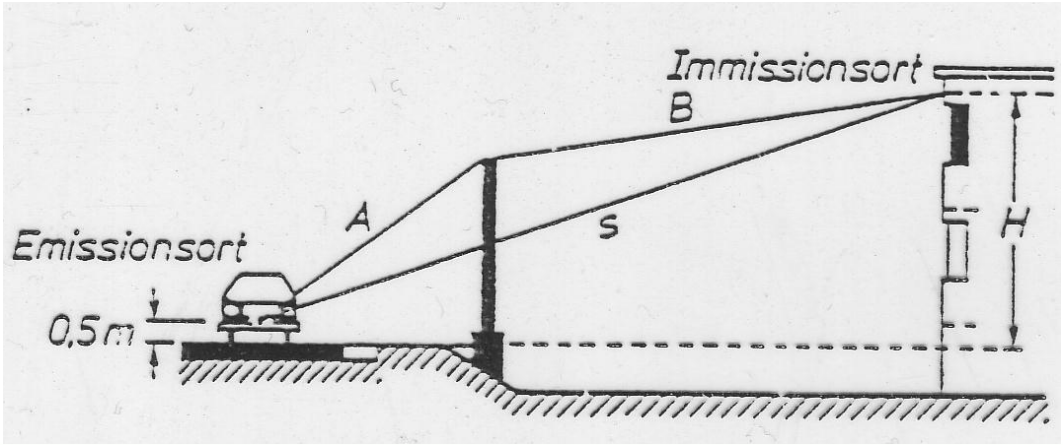
$L_P\,(r_0) = L(r_0)\text{-}20\,\lg(r/r_0)$

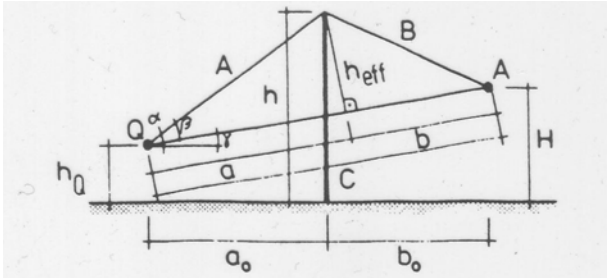
Noise abatement by distance is very effective for industrial noise (point source) with -6 dB by doubling, while for traffic noise (line source) only a reduction of 3 dB occures by doubling distance

5.2 Reduction Possibilities



Additional noise barriers must be established either close to the source or close to the place, which shall be protected





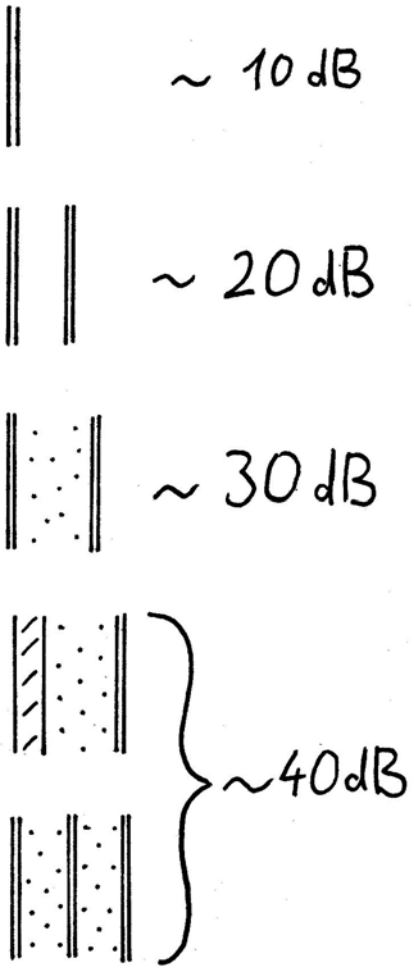
$$z = (A + B) - C$$

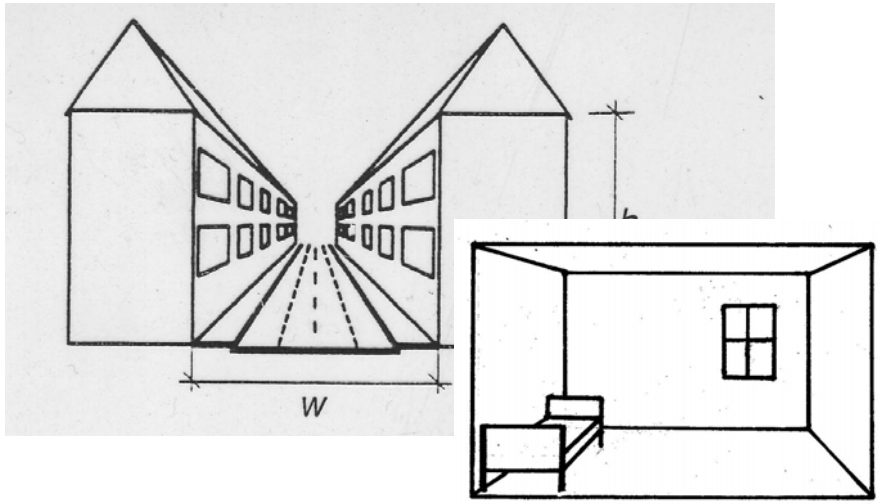
Näherungsweise gilt: [230)]

$$z = \frac{h_{eff}^2}{2} \cdot \left(\frac{1}{a} + \frac{1}{b}\right)$$

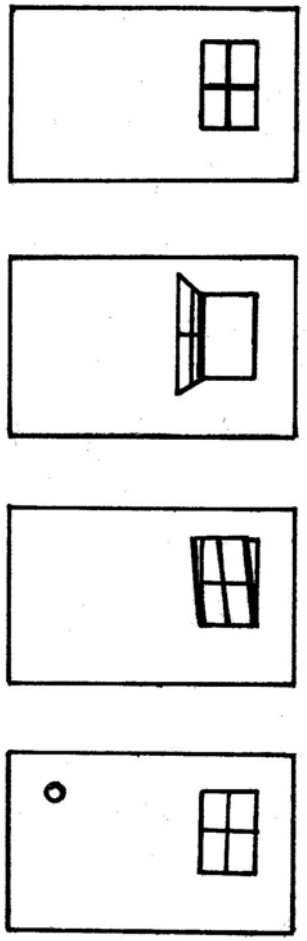
Für $h_{eff} < 0$ gilt: $z = 0$

5.3 Reduction Possibilities

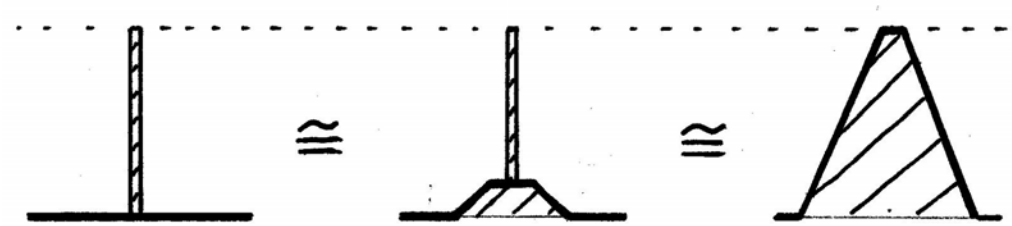




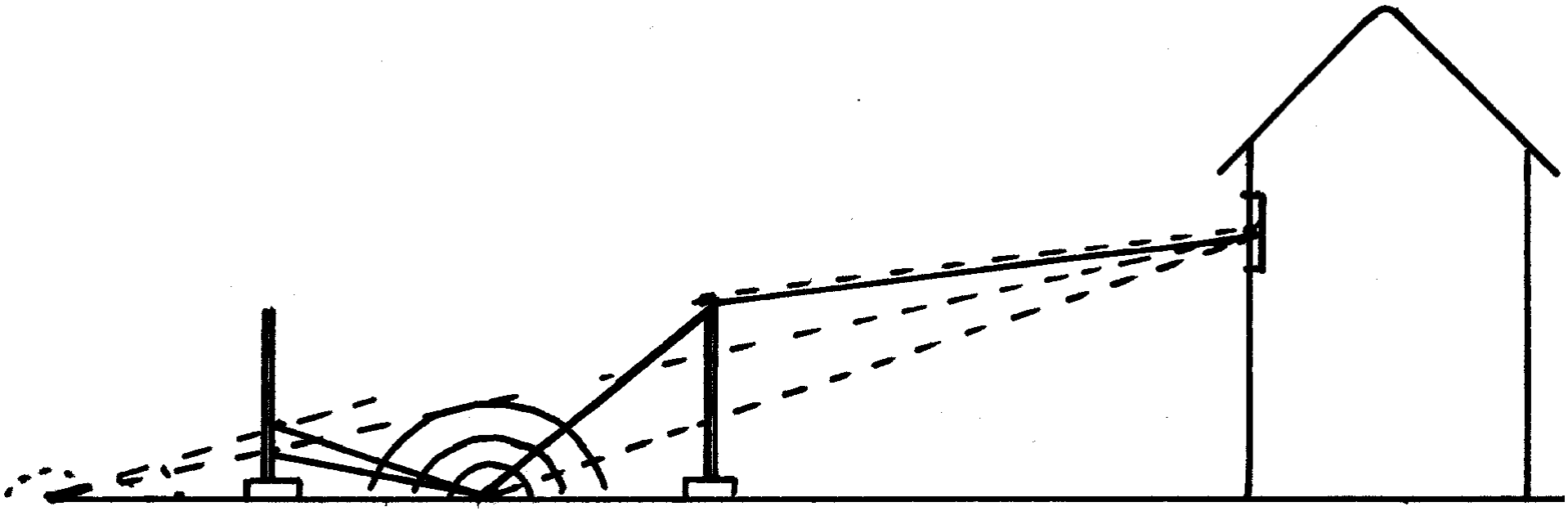
Improvement of about 10 dB are gained by noise protection windows with special glazing, under suitable conditions, compared to normal double glazing



6.1 Technicel Realisation

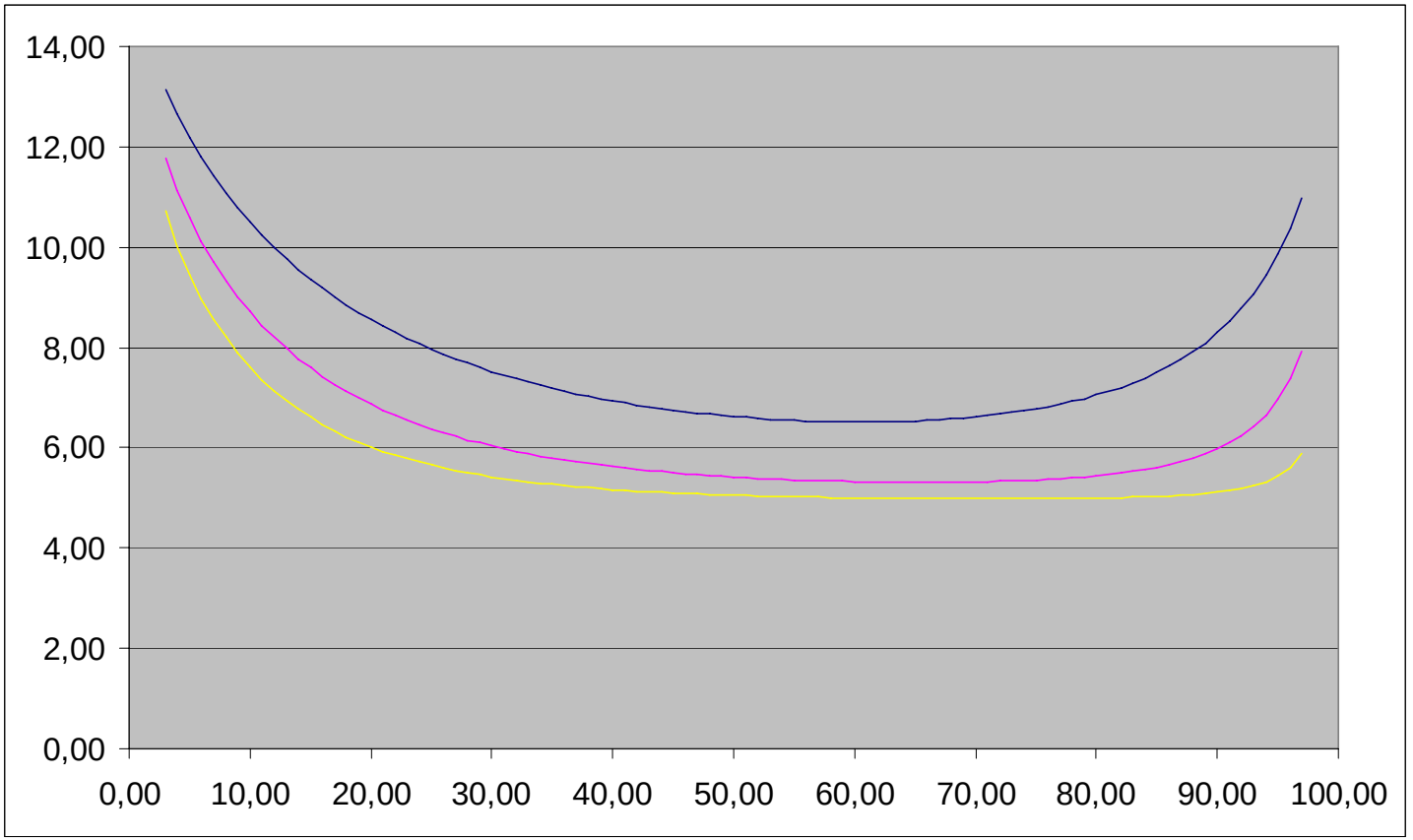


Constructed barriers like walls and ramparts are good for reduction up to 15 dB.
An important condition is, that the transmittede sound energy is significantly less than that, bended on the edge: $R > D_Z + 10$ dB.
Thus massice barriers with more than 25 dB need a minimum strength of d = 0.1 m (compare: $R = 28 \log(d \cdot r /(kg/m^2)) – 20$ dB)



In many cases it is necessary to construct walls as noise barriers at least one-sided with high absorption (α > 90%) to prevent an increase of noise level on the opposite side

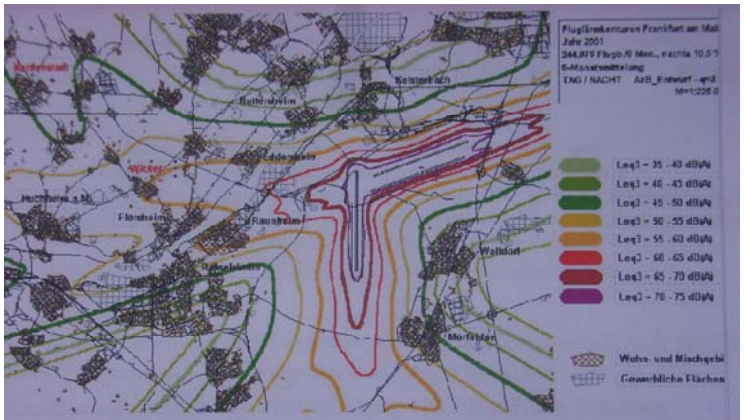
7.1 Calculation of Effects



s_L/m=	100
h_s/m=	0
hw/m=	2
h_e/m=	0,5
h_{LSW}/m=	4
C/m=	100,01

Required noise forecasts are drown up due to TA-Lärm and 16.BimSchV, occasionally RLS 90 resp. Schall 03 in conjunction with different standards (DIN 4109, DIN 18005, VDI 2058 etc.)

7.2 Calculation of Effects



.2-1: Ausschnitt aus der Fluglärmkonturenkarte für die Gebiete westlich des F
fens (Quelle: Hessisches Landesamt für Umwelt und Geologie – HLUG)

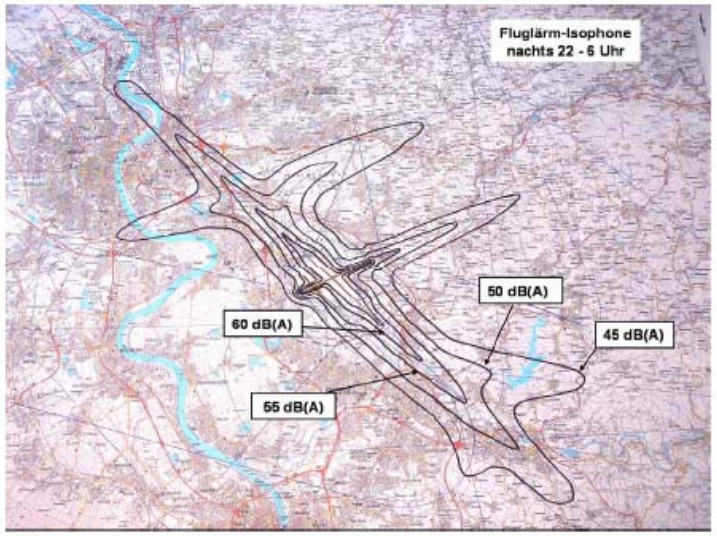


Abbildung 5. Fluglärmbelastung während der Nachtzeit (22.00 bis 6.00 Uhr) im Be
reich des Flughafens Köln/Bonn

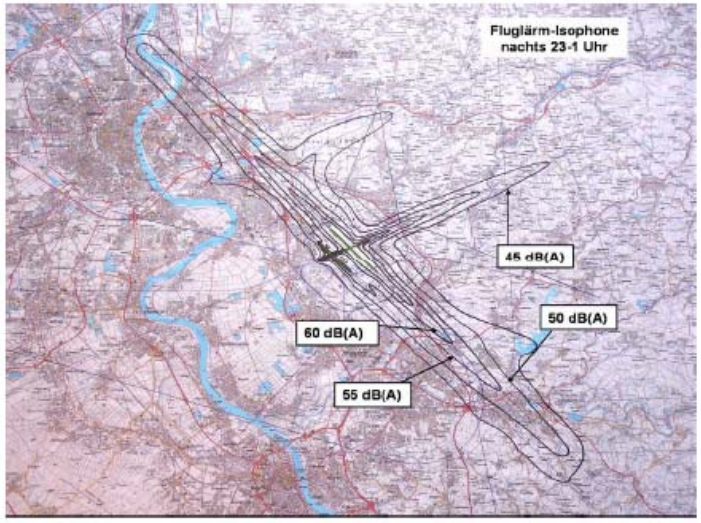


Abbildung 6. Fluglärmbelastung während der Nachtstunden von 23.00 bis 1.00 Uhr
im Bereich des Flughafens Köln/Bonn

Noise maps allow to find out the demand of additional noise protection and the respective economical effort

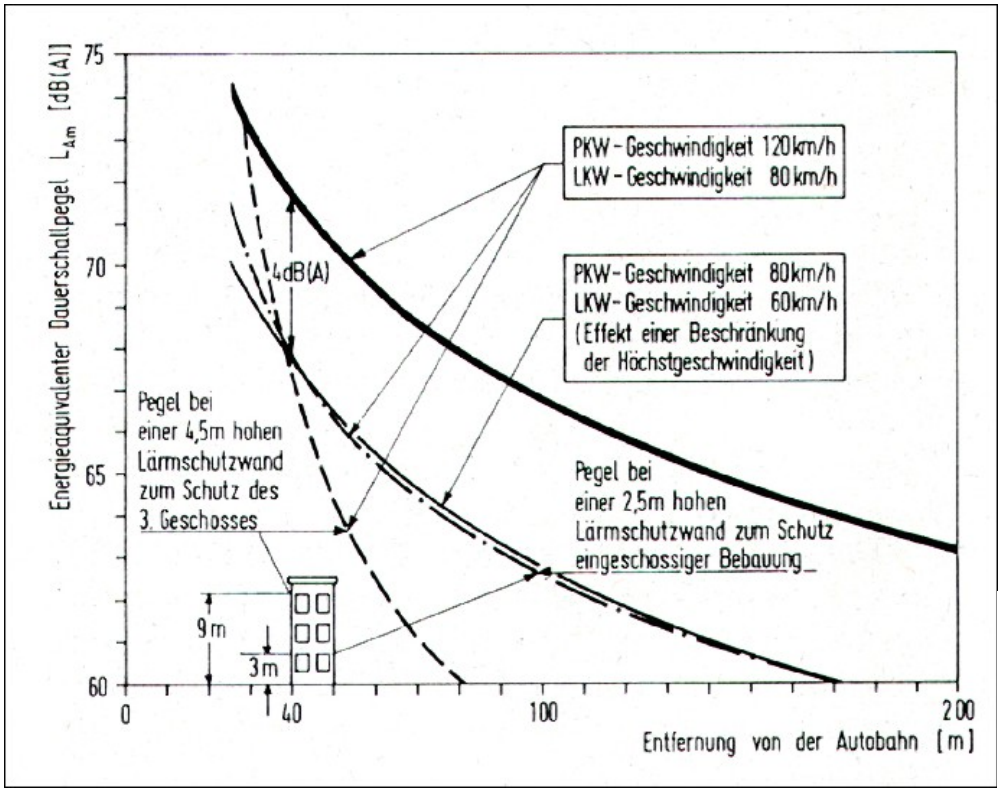
Beeinträchtigung durch Fluglärm: Arzneimittelverbrauch a Indikator für gesundheitliche Beeinträchtigungen

Forschungsprojekt im Auftrag d
Umweltbundesamtes
FuE-Vorhaben
Förderkennzeichen 205 51 100

November 2006

Eberhard Greiser
Katrin Janhsen
Claudia Greiser

7.3 Calculation of Effects



Change of the noise level due to speed limits resp. noise barriers (highway, distance 40 m, M= 2400 cars/h, 15% fright cars (by: Krell)

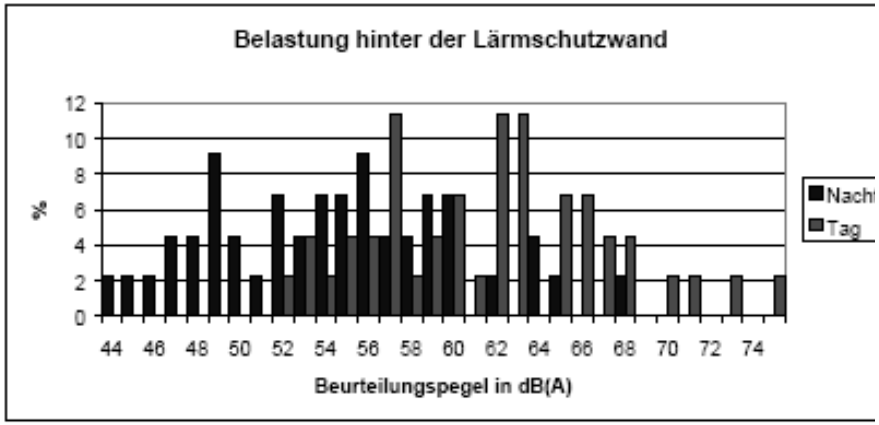


Abb. 3: Lärm hinter der Lärmschutzwand

7.3 Calculation of Effects

Abb. 1 > Effizienz-Effektivitäts-Diagramm nach SRU Nr. 301.

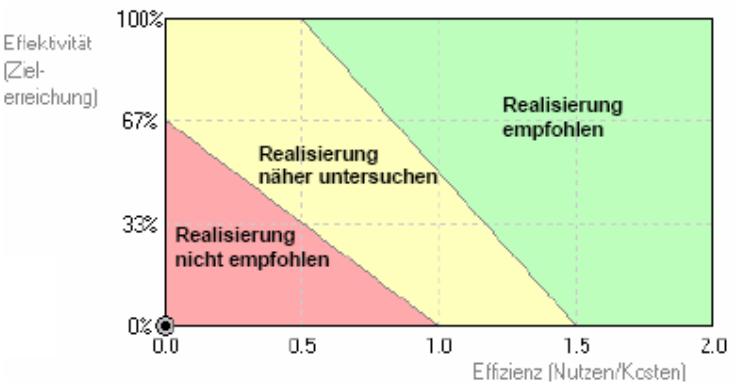
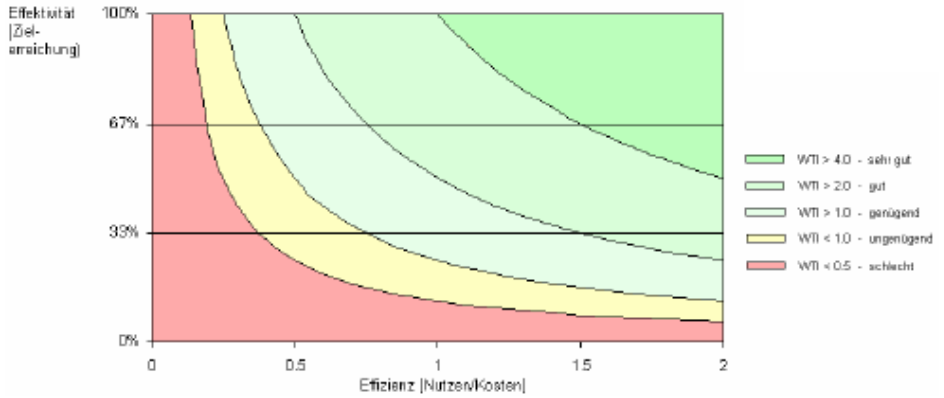


Abb. 2 > Vorschlag neues Effizienz-Effektivitäts-Diagramm.

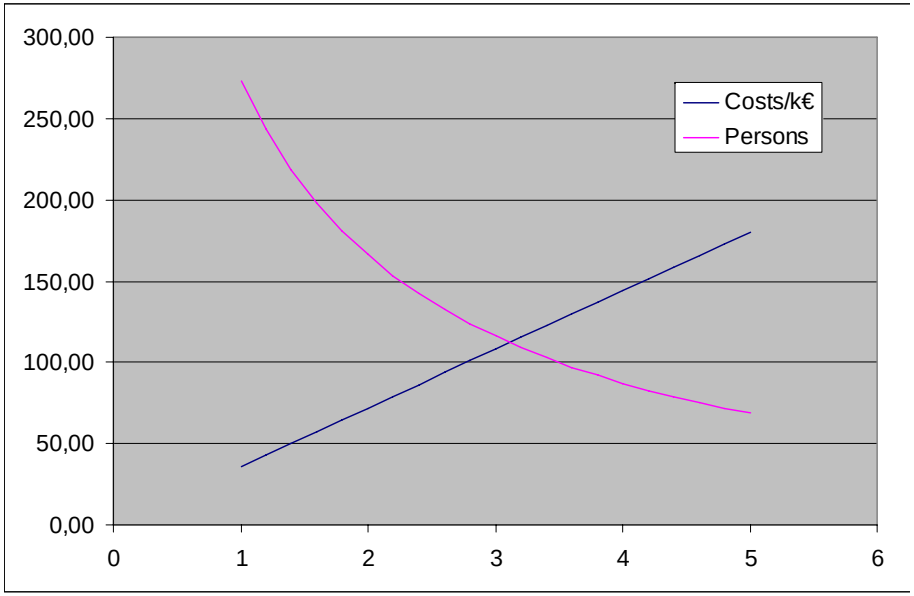


WTI = 4 * Effektivität/% * Effizienz

Bundesamt für Umwelt BAFU, Bern 2006
Wirtschaftliche Tragbarkeit und Verhältnismäßigkeit von Lärmschutzmaßnahmen

Noise protection walls		1200,--	/m²
Surface redevelopment (effect -3 dB)	30,--		/m²
Surface redevelopment (effect -5 dB)	35,--		/m²
Water drain adaption *		120,--	/m²
Additional winter service *	10,--		/m²·a
Monitoring (time span 12.5 a) *	1440,--		/m²·a
Monitoring (time span 25 a) *		1160,--	/m²·a
Complete covering	5000,--		/m²

* = min. effect -5 dB



8.1 Conclusions

To achieve an optimal improvement of the environmental situation with limited ressources, not a maximum level reduction at single points, but the observance of the appropriate limits for all places should be aimed.

The treshold value for these limits can be set as 40 dB in the night and max. 60 dB for living ares.

One of the most effective possibilities are (low) noise barriers, when the dwelling concentration is high and the hights of immission points are low.

In other cases technical solutions like noise absorbing street surfaces and noise protektion windows must be applied additionally.

Noise barriers, established under these conditions, can contribute to save billions of Euros by prevention of noise induced diseases, to save the live of thousends and to improve the live quality of ten-thousends of people.

Abstract

- To reduce unhealthy environmental noise effectively, a carefull planning is needed, using knowledge of physical origine, propagation conditions and physiological consequences of sound.

- For this purpose, measurement priciples, physics of spread and damping, as well as organic mechanisms are applied to define noise limits and recommended immision values.

-From these tresholds the neccessarity and dimensions of noise barriers can be derived.

Thank you for listening!