Legislation towards risk based ambient air quality standards

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Focal Points

1. Ambient air PM regulation in Switzerland
2. What are the appropriate metrics for healthier ambient air?
3. Approach for additional ambient air limit

1. Ambient air PM Regulation in Switzerland and EC

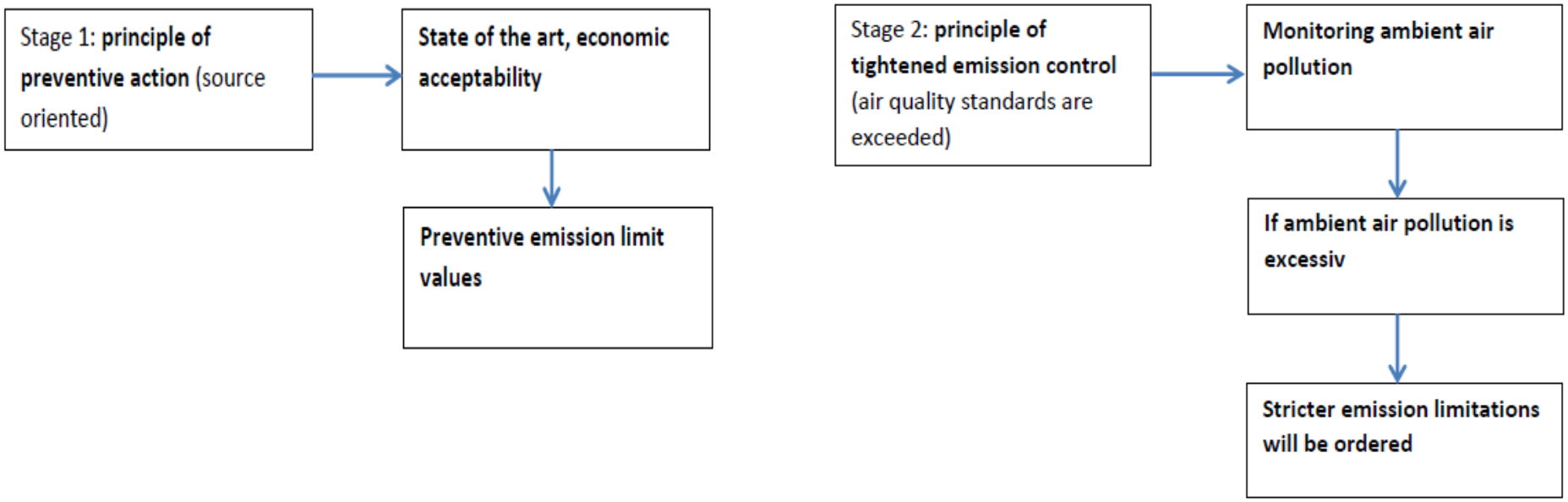
- 1986 Total suspended particulates: Annual mean = 70 ug/m^3
- 1998 PM10: Annual mean = 20 ug/m^3 and 24-hour mean = 50 ug/m^3 including limit values for the metals lead and cadmium
- 2003 EC: PAHs (BaP = 1 ng/m3 and As, Hg, Ni)

Federal Commission for Air Hygiene (FCAH) 2014:

- Suggests PM 2.5 annual mean 10 ug/m^3
- Based on a report on the analysis and evaluation of particulate matter in Switzerland (2014)

Are these standards sufficient for measures to attain healthier ambient air? Does this air quality policy points in the right direction?

Concept of Swiss Air Pollution Control



Concept applied to PM

Stage 1: Emission limit values

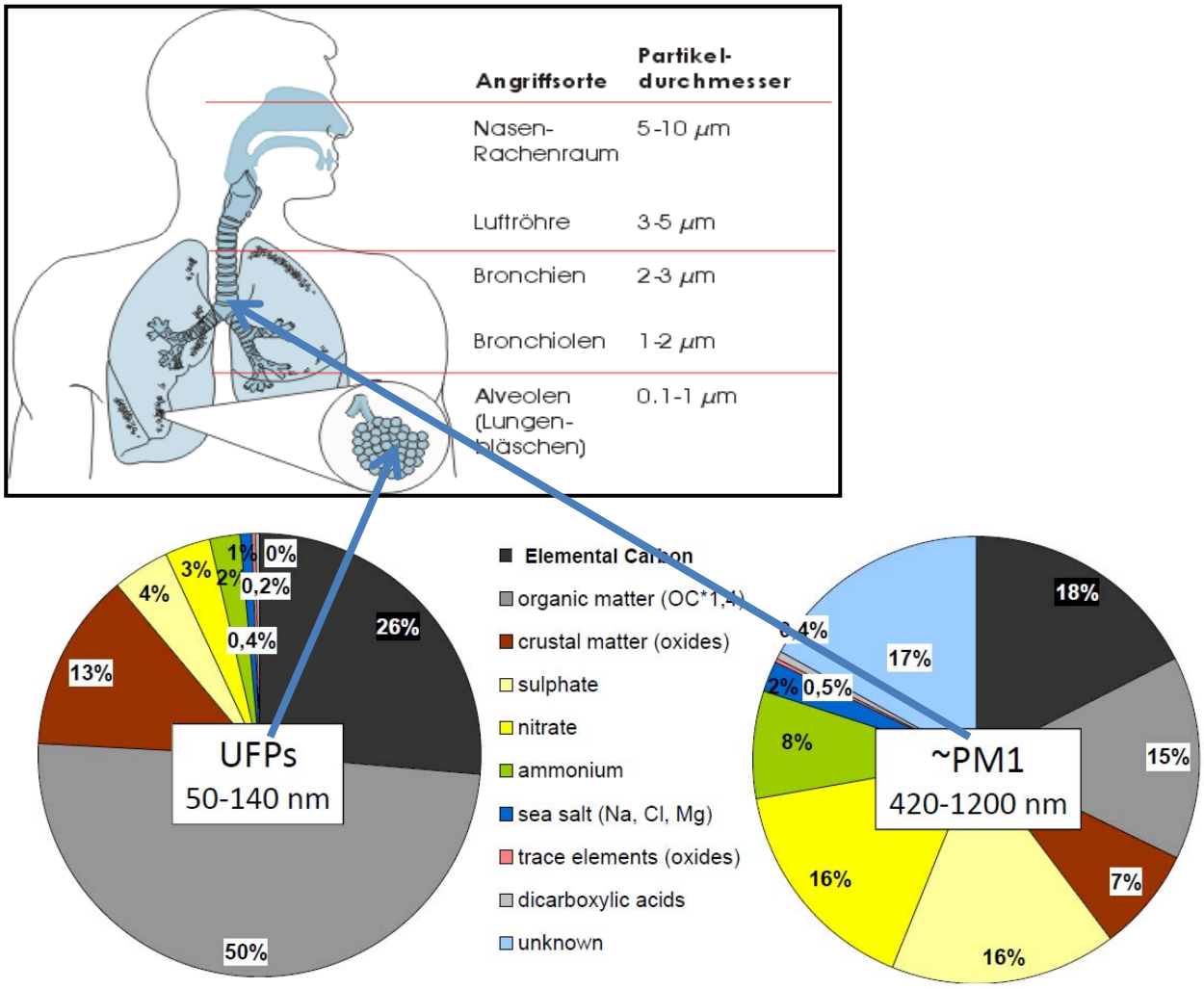
- Diesel soot = Carcinogen, class 3 substance (WHO diesel exhaust is class 1)
  Emission limit value = 5 mg/m^3 at a mass flow of 25 g/h or more
- Particle-number based emission limit value for:
  - construction machinery (off road) 1 x 10^{12} /kWh
  - EURO -6: Light duty vehicles 6.0 x 10^{11}/km
  - EURO-VI: Heavy duty vehicles 8.0 x 10^{11}/kWh

Stage 2: Stricter emission limits in case of excessive air pollution

- Ambient air limit values for 12 air pollutants (incl. PM10)
- Monitoring ambient air PM10 → Excessive ambient PM 10 → stricter emission limits for wood-fired installations, shorter deadlines

These principles have been successful to reduce NO_2 and PM10 and EC in ambient air. For particle number based emission limit values however there is not yet a corresponding ambient air limit value and therefore not a legal requirement for tightening emission limits and corresponding measures.

2. What are the appropriate metrics for healthier air?



Quelle: Dr. Konrad Müller, Abteilung Chemie, IfT Leipzig

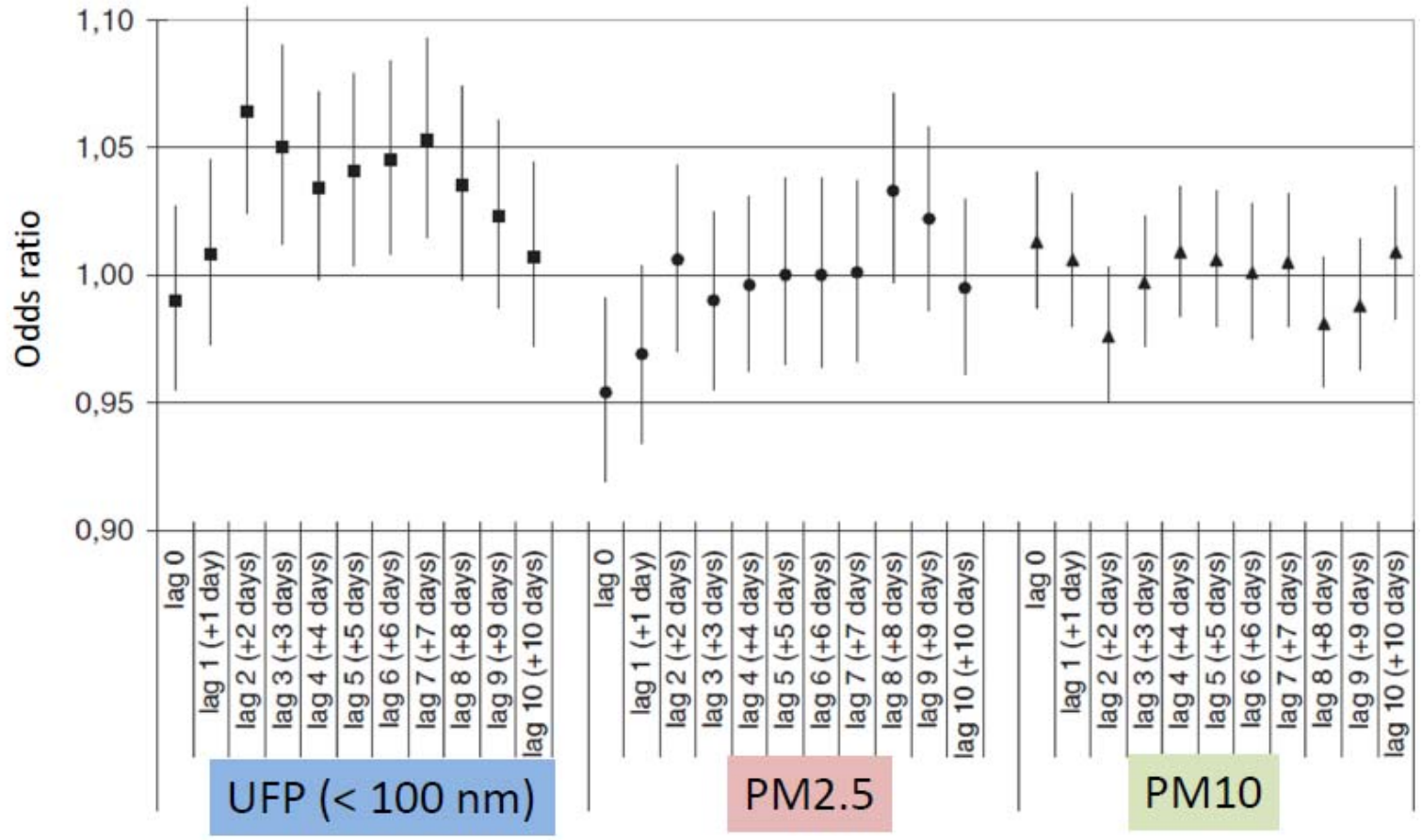
Health effect of main fractions (risk): HEQ-Concept (Kasper et al 2007)

based on the normalization of physical, chemical and biological properties

PM-Components	Carbon			Inorganics			Metals					Minerals
	EC (fine/coarse)	**OM / OC** (overlap with PAH)	**pPAH**	**Ammonium** NH_4^+	**Nitrate** NO_3^-	**Sulfate** SO_4^{2-}	**Transition metals** (Fe, Ni, V, Zn)	**FeO**	**MgO**	**CaO**	**Noble Metals** (Pt, Pd, Rh)	**Mineral dust** (Silicates, incl. Al, Mg)
Typical particle size [nm]												
MAK	0.02[1]	–	1[2]	0.00066[3]	–	0.00066[4]	–	0.00066[5]	0.00066[5]	0.001[6]	1[7]	0.00066[8]
Solubility	1	1	1[12]	0.0027[9]	0.0017[10]	0.5025[11]	–	1[12]	1[12]	0.6[13]	–	–
Hygroscopic	–	–	–	1[14]	–	1	–	–	–	1	–	1
Lipophilic[15]	1	1	1	0.001	0.001	0.001	–	0.001	0.001	0.001	–	–
Radical generating capacity[16]	1[17,18]	1[17,18]	1[18]	–	–	–	1[18]	–	–	–	–	–
DNA-reactivity	1[17,18]	1[17,18]	1[17,18]	–	–	–	1[17,18]	–	–	–	–	–
Mutagenic potential	1[18]	1[18]	1[18]	–	–	–	1[18]	–	–	–	–	–
Carcinogenic potential	1[17]	1[17]	1[17]	–	–	–	1[17]	–	–	–	–	–
Toxicity	1[17,18]	1[17,18]	1	0.001[19]	0.001[19]	0.001[19]	–	0.001[19]	0.001[19]	0.001[19]	–	–
TEQ product												

Short-term effects: Admission to hospital due to hypertension

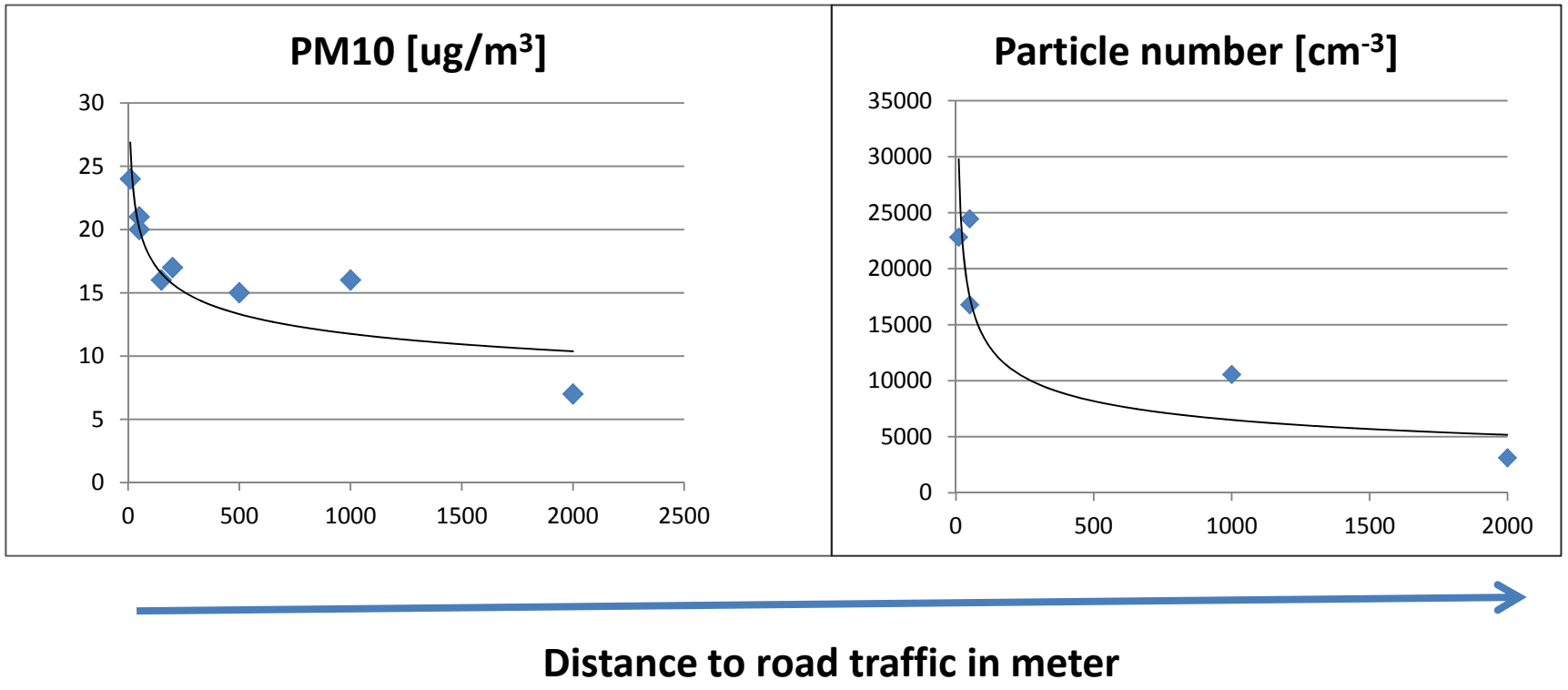
(Wolfram Birmili, Leipzig 2011)



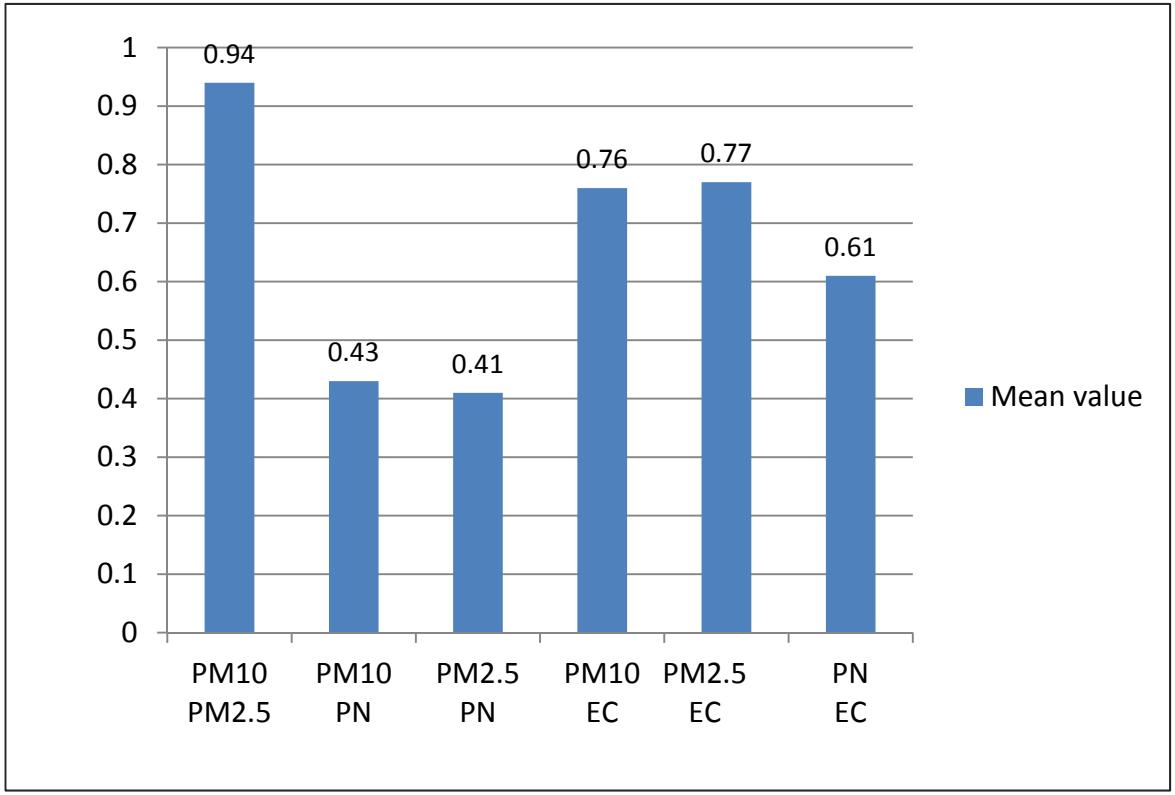
Franck et al. (2011) The effect of particle size on cardiovascular disorders, Sci. Tot. Environ., 409, 4217–4221.

Exposition data for PM10 and particle number

in function of the distance to road traffic (own calculations on the basis of NABEL-data 2012)



Correlation coefficient (r) for selected air pollutants at selected sampling sites for daily mean values (FCAH 2014)



Summary: Risk relevance table (qualitative risk assessment)

Risk = harmful effect x occurrence

Harmful effects: Exposition Variation, HEQ-Index, Epidemiological evidence, Results from cell experiments, existing emission limits

Occurrence: Ambient concentration

Harmful effect Parameter	Exposition Variation	HEQ-Index	Epidemiology Cell cultures	Emission standards	Ambient concentration	Result (Risk)
PM2.5	-	+	+	-	+	Recommended (WHO)
Particle Number	+	+	?	+	+	relevant
EC	+	+	+	+	+	relevant
OM/OC	+	+	+	-	+	relevant
PAH	+	+	+	+	-	Low occurrence
Transition metals	?	+	?	-	?	More investi-gations needed

3. Approaches to quantify additional ambient air limits

Elemental Carbon EC

Approach 1: Emission limit and ambient air limit differ by a dilution-factor 10'000 (e.g. SO_2, NO_2 = 8'333)

- Emission-Standard EURO V Heavy duty vehicle = 0.025 g/kWh
- Conversion from kWh to m^3 exhaust gas (1 kWh ≡ 6 m^3)

→ 25'000 ug/kWh div 6 m^3/kWh = 4'000 ug/m^3 (Emission concentration)

→ Ambient air with a concentration reduced by a factor of 10'000:
4'000 : 10'000 = 0.4 ug/m^3

This procedure suggests a recommended value of 0.4 ug/m^3 EC

Approach 2: Protection goal is a lifetime risk of not more than one cancer case per million inhabitants

→ population weighed EC-concentration = 0.1 ug/m^3

→ locations with a high traffic = 0.3 ug/m^3

This procedure suggests a recommended value of not more than 0.3 ug/m^3 EC

Approach for ambient air limit value for particle number

Approach :

Based on emission standard and dilution by a factor of 10'000

Particle Number concentration in the exhaust gas of EURO V Heavy duty vehicule
= 10^7-10^8 P/cm^3

→ Ambient air concentration should not exceed a factor of 10'000 less:
10^8 P/cm^3 : 10'000 = 10^4 P/cm^3

This procedure suggests a recommended value of not more than 10'000 P/cm^3

→ This approach is coupled with the technical feasibility to reduce the emissions. Though there is no epidemiological basis for the recommended value, it is a step in the direction of health risk reduction.

Summary

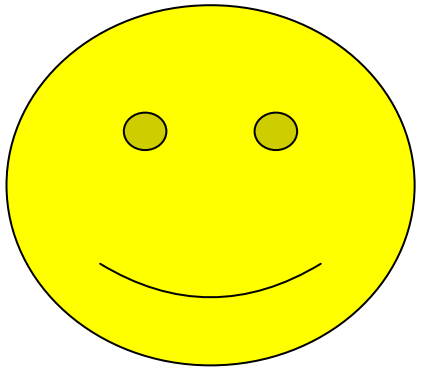
- The impact of DPF on PN, EC on the emission side should be observable in ambient air with PN and EC data. For the improvement of the effectivness of the filter technology we need corresponding ambient air limits (as a legal push according to stage 2).

- Additional PM ambient air limits should consider chemical composition, sensitivity to exposition, health equivalent index of main fractions of PM.

- To reduce the risk of UFP in the ambient air, we need an additional limit value in order to justify further and specific measures.

- Has to be discussed

Index



Contents