

PN as Toxic Air Contaminant is by far underestimated while NO₂ is overestimated – what about Toxicity Equivalent TEQ?

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Attention:

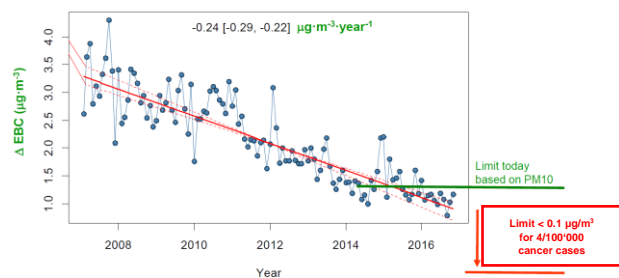
this is not a statement of a professional toxicologist. It is an outcry of a very concerned engineer, who is perfectly able to clean the combustion engines exhaust gas from all toxic emissions; however, he is in needs of valid information on priorities from the health community and of a responsible statement of the governments on the price the society is willing to pay.

Up to now both seem unable to deliver and so we remain far from implementing best available technology.

EC Particles are carcinogenic and the Miners Study 2011 found 180 lung cancer mortality cases within 16000 workers observed in 8 US metal mines. Based on this finding WHO in 2012 moved Diesel soot from class 3 to class 1 like Asbestos. Using the usual number of max. 4 death within a population of 100'000 as acceptable guideline for a carcinogen in ambient air leads to a limit value of < 0.1 µg/m³ for EC as the NL-official OCR study concluded on 26.Oct.2017. Actually, we have not even a limit value for EC in ambient air! And at the working place in Switzerland, where EC is used to characterize Diesel particle emissions, the actually valid limit value is 0.1 mg/m³ – 1000 times too high? This is unacceptable and the fact that worldwide no single government has adjusted their limit values for PM after the clear statement of WHO in 2012 is not acceptable either. Adapting limit values for emission and ambient air would permit to enforce particle elimination strategies for the whole vehicle fleet as well as other sources and to implement them within a short period. A reduction of 200'000 mortalities in Europe would probably be possible within 5 years.

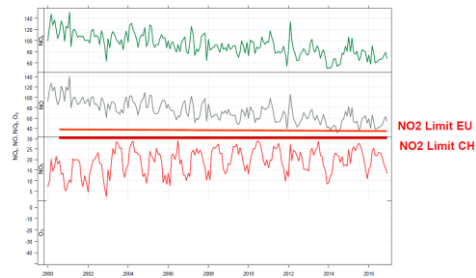
NO₂ is also toxic and an irritating gas when inhaled by disabled persons and asthmatics. However it is not a carcinogen and according to US-EPA and many occupational health studies it is not confirmed by any toxicity studies that it could be responsible for mortality at concentrations below 400 µg/m³. Most epidemiological studies are misleading since they principally cannot separate between the health effects of PN and NO₂. Speculations about indirect effects though secondary particle formation in the atmosphere are to be rejected since there is no evidence at all available. Today's legal limit values are on the safe side – which is good from a point of view of ambient air hygiene - and the implemented emission reduction technologies as they are now required by European and US-Law will bring NO₂ concentration easily below the legally requested level. Retrofitting the existing HD-fleet in cities with SDPF (deNO_x+Filter) would accelerate this process. But is this measure cost effective and affordable?

Solid ultrafine particle concentration at a busy Swiss motorway cross



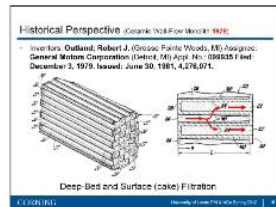
EC (or PN) Ambient Air Quality is constantly improving due to the application of particle filters in all new LDV + HDV according EU-legislation and large retrofit activities in the existing HDV and NRMM fleet in Switzerland. We have reached the legislated limit values of PM10 which may be reflected by an estimated 1.5 µg/m³ but an EC(PN)- level to cope with an acceptable cancer risk limit is still far out of reach.

NO_x, NO and NO₂ concentration at the same location by Hüglin



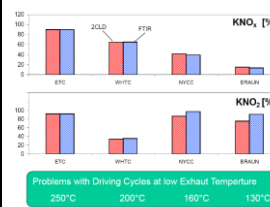
NO_x is also nicely coming down which reflects the emission improvement of all vehicles. NO₂ does not follow yet this downward trend, but we believe it will with more SCR being installed in HDV and LDV. The legislated limits, in Switzerland lower than EU are clearly reached. This might not be the case yet in all city street canyons but with the fleet turnaround it will if controls will work

Technical Solution for elimination of ultrafine particles is DPF and GPF



available on the market since 1982 by Corning. Filtrations for solid ultrafine particles > 99% is proven in all vehicle applications; Now implemented in all new Diesel HDV and LDV in Europe and in Switzerland even in locomotives, ships, construction and industry and In EU-DI petrol cars since 2017 mandated

Technical Solution to reduce NO_x are SCR, LNT, EGR



98% conversion is possible at $t > 230^{\circ}\text{C}$ but city driving at light load can be very challenging and might require cost intensive temperature management → engine industry tried to avoid this cost by criminal defeat devices in 2014 ff. This is now under control.

Benefit/Cost: excellent data available. For this revolutionary emission elimination technology B/C is > 30:1 even for EU III HDV retrofit, for first fit > 50:1 → society is gaining money

Benefit/Cost: data base for health cost are still under discussion With health+environment benefit 12.7 €/kg acc. to NEEDS/EU2008 a EE III HDV retrofit B/C may reach B/C = 1.5-2 → borderline

Limit values for EC particle exposition [µg/m³]

- No-effect level does not exist with carcinogens
- 0.01 lifelong creates a 4/100'000 cancer mortality risk
- 1 creates a 400/100'000 cancer mortality risk
- 100 for Swiss tunneling (SUVA MAK)
- 50 for TRGS Germany from 2018 (MAK)
- 2 estimated from PM10-limit in Switzerland

Even the Swiss limit exceeds the cancer mortality risk by factor 200

Limit values for NO₂-exposition [µg/m³]

- 3000 no symptoms found (Kraus RWTH 2017)
- 3000 first symptoms at working place EU 2016
- 6000 Swiss working place 15 min (SUVA+NIOSH) 1995
- 950 New limit proposed by EU 2018
- 400 first symptoms with asthmatics – EPA 2016
- 100 general limit value EPA 2016 annual mean
- 40 general limit value EU (30 CH) annual mean

Reaching 80 (München) still is 5x below EPA symptom limit

TOXICITY EQUIVALENT TEQ of PN (EC) is two orders of magnitude higher than TEQ of NO₂ ?

→ Conclusion of an Engineer: Reduce NO₂ wherever reasonable but eliminate PN