

3. VERT Workshop on UFP-Emissions from HD-Vehicles
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Benefit/Cost-Analysis when using Emission Control Devices for IC Engines

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In other words

are „Health Benefits“ and „Emission Control Devices“
like DPF and SCR different categories –
uncomparable

or can they be **linked by money** –
using their monetary value as overall denominator ?

Resulting Questions

- can we define a monetary benefit for measures – like DPF to mitigate health impacts ?
- are these benefits higher or lower than the cost ?
→ **Benefit / Cost -Ratio**
- how compare DPF/GPF/DOC/SCR/PFF
- who pays for cost and who receives benefits ?

**FOR THE OWNER, DPF/GPF
has no direct commercial advantage
*„nothing but a Cost Factor“***

- Purchase price
- Installation cost
- Some maintenance involved
- Backpressure reduces fuel economy
- Warranty for the engine may be refused
- Additional safety and dependability aspects ?

FOR PEOPLE in Street Canyons and drivers – exposed to exhaust gas DPF/GPF provides a Health Benefit

Switzerland, year 2000: Health Effects are very large:

- **Mortality** due to traffic related air pollutions **4'500**
- Mortality due to traffic accidents **600**
- Mortality due to smoking **8'000**
- **Hospitalization days** **15'700**
- **Asthma attacks** **41'100**
- **Bronchitis in children** **39'000**
- **Days with restricted activity** **1'773'800**

FOR GLOBAL SURVIVAL

**the contribution to limit global warming
might be the (a) decisive factor**

**If filters can contribute to lower global
warming by eliminating Black Carbon
Particles**

**→ what is the co-benefit for the global society and
how does this translate into a monetary value?**

THE REGULATOR:

WHO 1987/2012

Environmental Law in Switzerland,
EU: EURO-VI, USA: CAA 201 etc

- **Diesel Particle Emission is carcinogenic**
- **has no “no-effect” level**
- **Must therefore be minimized**
- **Best Available Technology BAT required**

But the law requires also

THE LAW requires in addition that the measures chosen must be

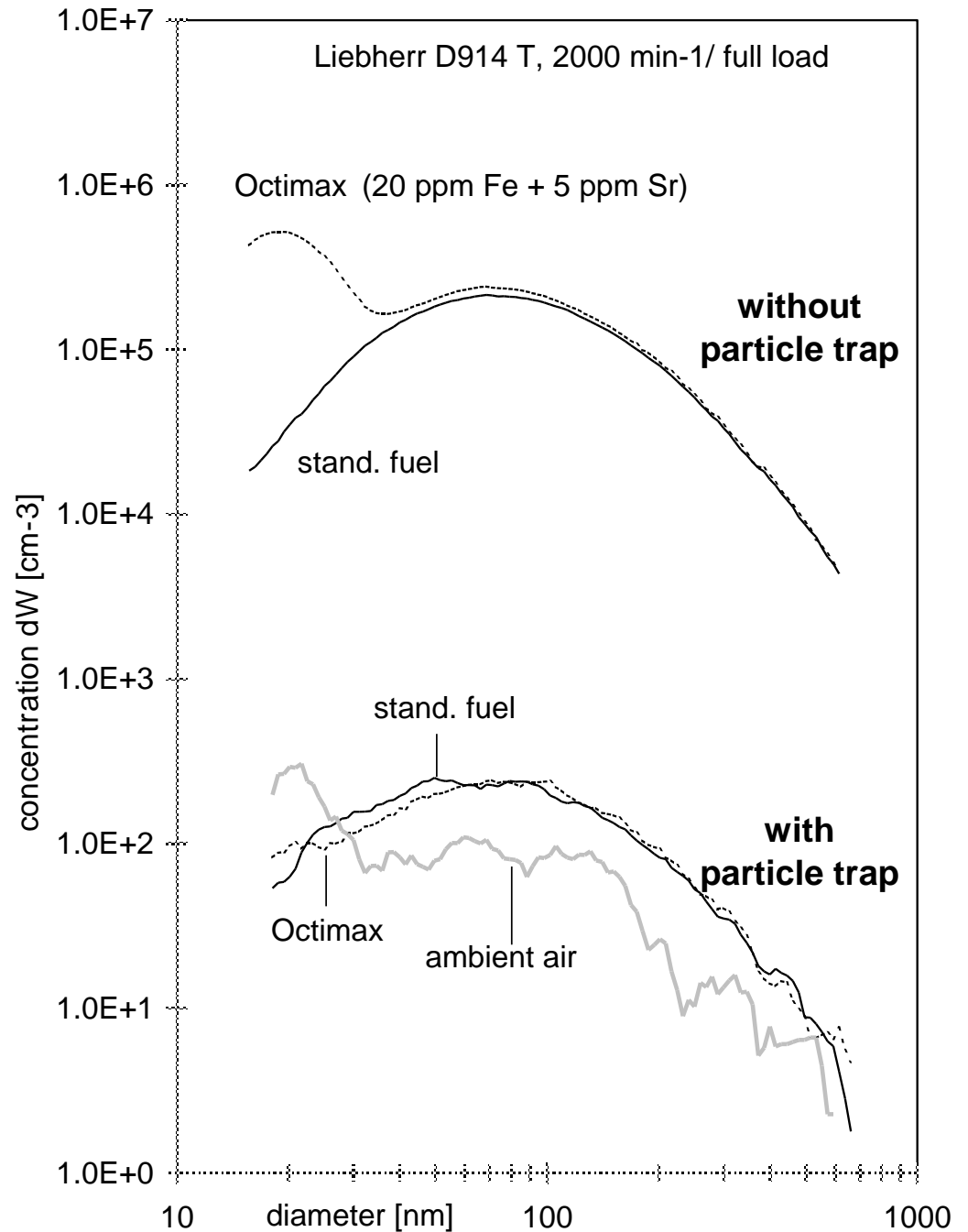
- **technically feasible** (technisch möglich)
- **operationally reliable** (betrieblich möglich)
- **cost must be in a reasonable relationship to benefit** (wirtschaftlich tragbar)

This is, what we intent to investigate here:

Extruded Cordierit and Silikonkarbid typical ceramics for honeycomb filters



Particle Elimination with CORNING-Filter and FBC



Cost-Effectiveness € / kg Soot

| | | |
|----------------------------------|---------------------------|--|
| | HDV+FFF | |
| PM-Emission EURO III/3 | 0.1 g/kWh | |
| Mileage | 1000 hrs/y | |
| Average Performance [kW] | 100 | |
| PM Emission [kg/year] | 10 | |
| Overall vehicle life [year] | 15 | |
| Emission [kg/vehicle life] | 150 | |
| Filter type | wall flow | |
| Filter efficiency [%] | 99.9 (P=0.1) | |
| Filter Cost [€] | 8'000 | |
| Total prevented soot [kg/life] | 150 | |
| Cost-Effectiveness [EUR/kg soot] | 53.3 ¹⁾ | |

1) USA-EPA: 40-50 \$/kg for offroad applications

2) UBA Wien (2009): Offroad 50-90 €/kg; LKW 90 €/kg; PKW offene Filter 200-643 €/kg

Benefit / Cost

For the Society Benefits must be quantified in **Monetary Terms** and compared to **Cost** in order to decide whether a Measure is economic and therefore justified or not

Benefit / Cost – Factor

[€] / [€]

a dimensionless factor → comparing apples to apples¹²

How to convert Public Health Effects into Monetary Terms ?

WHO and many National Health Institutions have investigated the multitude of so-called “external cost elements” like hospital cost, medication, lost working time, lateral cost, tax loss etc. in function of ambient air pollution and established dose-effect relationships.

They have statistically linked these cost to ambient air pollution to individual pollution parameters like Ozon, CO or PM10 and evaluated the integrated monetary effects on population living in megacities, cities or countryside.

Table 1 Air pollution cost factors in EUR/ton of pollutant (€₂₀₀₈ values)

| Pollutant | PM _{2.5} (exhaust) | | | PM ₁₀ (non-exhaust) | | | NO _x | NMVOC | SO ₂ |
|----------------|-----------------------------|-----------------|-----------|--------------------------------|-----------------|-----------------|-----------------|-------|-----------------|
| | Metropolitan | Urban | Non-urban | Metropolitan | Urban | Non-urban | | | |
| Source | HEATCO | *UBA/ HEATCO | HEATCO | *UBA/ HEATCO | *UBA/ HEATCO | *UBA/ HEATCO | NEEDS | NEEDS | NEEDS |
| Country | | | | | | | | | |
| Austria | 482,200 | 155,900 | 80,700 | 192,900 | 62,400 | 32,300 | 13'600 | 1'600 | 10'000 |
| Belgium | 483,400 | 156,000 | 104,400 | 193,400 | 62,400 | 41,700 | 8'700 | 2'600 | 10'900 |
| Bulgaria | 70,500 | 22,700 | 18,100 | 28,200 | 9,100 | 7,200 | 7'100 | 400 | 6'200 |
| Czech Republic | 355,400 | 114,500 | 88,200 | 142,200 | 45,800 | 35,300 | 10'600 | 1'100 | 9'500 |
| Denmark | 436,400 | 140,700 | 51,300 | 174,500 | 56,300 | 20,500 | 5'300 | 1'200 | 5'700 |
| Estonia | 261,700 | 85,000 | 44,200 | | | | | 600 | 4'500 |
| Finland | 432,600 | 139,400 | 36,100 | | | | | 600 | 3'500 |
| France | 438,600 | 141,200 | 87,700 | | | | | 1'400 | 9'900 |
| Germany | 430,300 | 138,800 | 83,900 | | | | | 1'400 | 10'900 |
| Greece | 338,600 | 109,100 | 47,700 | | | | | 600 | 5'800 |
| Hungary | 288,900 | 93,000 | 74,100 | | | | | 1'000 | 9'100 |
| Ireland | 537,200 | 173,400 | 56,200 | | | | | 1'100 | 5'400 |
| Italy | 397,400 | 128,400 | 72,300 | | | | | 1'100 | 8'700 |
| Latvia | 245,300 | 78,900 | 45,600 | | | | | 700 | 5'000 |
| Lithuania | 266,300 | 86,500 | 53,300 | | | | | 800 | 5'700 |
| Luxembourg | 877,100 | 282,400 | 125,000 | 350,800 | 112,900 | 50,000 | 12'700 | 2'400 | 10'300 |

Switzerland
500 €/kg PM2.5
2'000 €/kg soot

| | | | |
|-------------|---------|---------|--------|
| Switzerland | 498,700 | 160,500 | 82,400 |
| Poland | 248,900 | 79,900 | 74,700 |

Health Benefit for DPF on a Euro III HDV

| | | | |
|-----------------------------------|----------------|-----|--------------|
| | HDV+FFF | | |
| PM-Emission (Euro III / 3) | 0.1 g/kWh | | |
| Mileage | 1000 hrs/yr | | |
| Average Performance [kW] | 100 | | |
| PM Emission [kg/year] | 10 | | |
| Overall vehicle life [year] | 15 | | |
| Emission [kg/vehicle life] | 150 | | |
| Filter type | wall flow | | |
| Filter efficiency [%] | 99.9 | | |
| Health Cost [€/kg] | PM2.5 | 500 | Soot 2'000 |
| Total prevented soot [kg/life] | 150 | | |
| Health Benefit [€] | 75'000 | | Soot 300'000 |

Health Benefit / Cost

- Health Benefit: 75'000.- €
- Filter Investment: 6'000.- €
- Filter Maintenance: 1'500.- €

$$B/C = 10$$

Summary

Overall Monetary Assessment of PM-Emission-Reduction by BAT Particle Filters has a double benefit for the Society reducing health risk and global warming.

*Benefit for the Society is **> 10 x higher** than actual Filter Cost*

Conclusion

Swiss Council 2002:

„Introduction of Particle Filters is a large benefit for public health and an economic requirement“