# Ultrafine Particles and its fractions

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# Content of presentation

- EFCA – Mission and Activities
- Priority topics
- Particulate matter: Fraction-by-Fraction
- Health risks by fraction
- Feasibility of Fraction-by-Fraction Approach
- Conclusions and Roadmap for progress

# What is EFCA?

**European Federation of National Associations**

## Objectives

- Furthering professional activity in Europe
- Connecting science and policy

## Mission

To help to achieve policies and measures that will protect the environment, climate and human health in Europe against the effects of pollution while fostering sustainable development

# Priority topics

Present drivers

- **Concern on the limitations of the policy approach on particles**: $PM_{10}/PM_{2.5}$ are „container metrics“
- **One atmosphere: need for integration of clean air and climate in science and policy**

Professional activities

- **Conference series on Non-$CO_2$ Greenhouse Gases**
  - VVM, Netherlands; since 1993; NCGG-7 in 2014
- **Conference series on Ultrafine particles**
  - GUS, Germany; since 2007; UFP-5 in 2015
- **Conferences on “One Atmosphere”**
  - APPA, France; 2008, 2011; Vancouver, 2010

# Policy Activities

- ***Response at EU Public Consultations***
- ***Policy Initiative*** „Linking air pollution and climate change“ (PI-2, 2010)
- ***Policy Initiative*** on Black Carbon Particles as extra metric, <u>additional</u> to $PM_{10}$/$PM_{2.5}$ (PI-3, 2012)
- ***Publicity actions***
  - *Special sessions and presentations* at conferences (Lille, 2006 on PM; Vancouver 2010 on ‚One atmosphere‘; Istanbul 2012 on ‚Transboundary transport in the Mediterranean‘; Zurich, Sibenik, Capetown and Belgrade, 2013 on Black Carbon/PM)
  - *Publications* (Proceedings, Journals and EFCA‘s Newsletters and website)

# Black Carbon Particles

Focus on Black Carbon:

- Better correlation with short-term health endpoints than $PM_{10}$/$PM_{2.5}$
- BC-sources are well known; emissions in ultrafine mode
- BC-policy is coherent with policies to reduce emissions of particle numbers from combustion sources
- Climate forcer: AQ-policies for BC result in less warming
- Potential co-benefits of integrated policy furthers implementation of AQ legislation in MS

However, PM is more than just Black Carbon

# Composition of $PM_{10}/PM_{2.5}$

***Primary***

- Black Carbon
- Organic Carbon
  - ✓ Primary Organic Aerosol (POA)
- Metals
- Abrasion particles
- Natural
  - ➢ Sea salt
  - ➢ Pollen
  - ➢ Saharan dust

***Secondary***

- Organic Carbon
  - ✓ Secondary Organic Aerosol (SOA)
- Inorganic aerosol
  - ➢ sulphates
  - ➢ nitrates
- Natural (natural haze)
- Resuspended aerosol

# Ultrafine particles

## specific health risks

***Primary***

- **Black Carbon**
- Primary Organic Aerosol (**POA**)
- Metals (combustion, metallurgical processes)
- Abrasion particles (traffic)
- Natural (Sea salt, Saharan dust)

***Secondary***

- Secondary Organic Aerosol (**SOA**)
- Inorganic aerosol
  - Sulphates (ultrafine?)
  - Nitrates (ultrafine?)
- Natural (Natural haze)
- Resuspended aerosol: ultrafine?

# Fraction-by-Fraction policy

**size - chemical composition**

- Evidence that size (ultrafine fraction, 30-170 nm) is a crucial factor for cardiovascular and olfactory induced effects

***$PM_{10}$/$PM_{2.5}$ -policy may be effective for respiratory effects, but not necessarily for cardiovascular and olfactory effects***

- Black Carbon: meta-analysis of published studies (Janssen et al, 2011; WHO, 2012)
- POA: semi-volatile PolyCyclic Aromatics (PCAs) are co-emitted with BC, and subsequently are deposited at particle surfaces (POA); several PCA's are carcinogenic
- SOA: under summersmog conditions POA are oxidised in part and converted into ‚*reactive oxidative species*'; body of knowledge limited

# Health risks - Black Carbon

- BCP is associated with health effects, that are not captured quantitatively in the same way by PM mass concentration
- For cohort studies, pooled estimates for all cause mortality per 1 µg/$m^3$ 5 to 14 times higher for BCP than for $PM_{10}$
  - Simulation: 50% less urban traffic emissions would then save 3-4 months of lost life expectancy when referred to BCP; this is just 21 days in terms of $PM_{2.5}$ (1 µg/$m^3$ $PM_{2.5}$ ~ 0.6 µg/$m^3$ BCP)
- BCP represents one of the more health relevant components of PM, especially for cardiovascular effects

(Janssen, 2011)

# Health risks – Organic Aerosols

- Semi-volatile Polycyclic Aromatics (PCAs) are co-emitted with BC from combustion sources, primarily as gases; their deposition at ambient temperatures on particles results in Primary Organic Aerosols (POA); various sources, wood stoves for heating is a risk in winter
- Under summer smog conditions PCAs at the POA surface are partly oxidised; chemical assay shows that the resulting '*aged smog*' or SOA has a higher oxidative capacity (metric for '*reactive oxidative species*') than POA; bioassay shows it is more reactive in genotoxic tests (Sioutas, 2011; Riskovski, 2013; Delfino 2014)
- Concern on Biofuels: simulation experiments in smog chambers show that their diluted exhaust gases produce much more '*reactive oxidative species*' than those from common diesel or petrol (Stevanovic, 2013)

In summary: much concern, but quantitative data are scarce.

# Health risks – (Heavy) Metals

- (Heavy) metals in PM samples has a long history of monitoring and study;
- Policies throughout Europe target health risks in areas around specific industrial sources; the Heavy Metals Protocol under the CLRTAP and EU's Industrial Emissions Directive further a harmonised control in Europe
- Likely to benefit from generic PM-emissions reductions
- Considering them separately within a fraction-by-fraction PM policy may not have priority

# Particle Numbers and Health Risks

- Consensus that the nano/ultrafine (30-170 nm) fractions constitute specific cardiovascular and olfactory risks; no certainty, however, that such risks are independent from chemical composition
- A PNC-approach is a perfect step in source-oriented policies; monitoring PNC is relevant, therefore
- However, PNC is a *„container metric“*, like $PM_{10}$/$PM_{2.5}$; less suitable in quality-oriented policy
- Fraction-by-Fraction (FbF) approach, addressing both, particle size and chemical composition, is required to assess the effectiveness of PM policy

# FbF - Gaps in knowledge

Assessment modelling input

- **Sources**: FbF approach requires an emission inventory for each primary aerosol fraction and parameters for conversion into secondary fractions
- **Air quality**: FbF approach requires standardized measuring methods per fraction for reliable monitoring data
- **Health risks**: Long-term epidemiology (mortality) data; this requires time series of monitoring data on FbF basis

# Feasibility of FbF approach
## (educated guess)

| | BC | POA | SOA | HM |
|---|---|---|---|---|
| **Standardized Monitoring method** | 2015 (EC + OC) | available | 2020? | available |
| **Applied in national monitoring networks** | 2017 | partly available | 2025? | available |
| **Epidemiological data** | 2025 - 2035 | ? | ~2035 | available |

# Conclusions

1. PM policy requires a Fraction-by-Fraction approach for adequate monitoring of its effectiveness and so furthering its cost-effectiveness; updating present policy tools is urgent
2. Controlling the PM problem probably requires addressing sources of primary PM-fractions as well as sources of precursors for photochemical oxidants (NOx, VOC)
3. More research and thorough assessment of the impacts of biofuels for transport on human health is required

# Roadmap for progress

- CEN-standards for measuring BC, PNC, POA and SOA in ambient air
- Legislation which stepwise requires their monitoring in networks (AQ Directive)
- Encouragement of health effect research based on standardised monitoring data of PM-fractions
- Advanced DPF-technology, targeting POA, in addition to PN/BC emissions, should also be made available for petrol-vehicles and for other combustion sources as far as technically/economically feasible

# Thank you!

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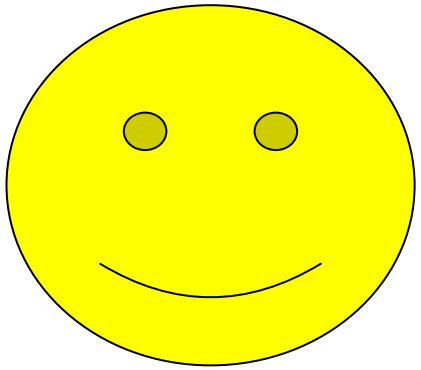

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