Extended abstract for 17th ETH Conference on Combustion-generated Nanoparticles

Ultrafine particles: some views on preferred metrics

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The European Federation of Clean Air and Environmental Protection Associations (EFCA) was founded by European associations in the 90-ies in reaction to the decision to harmonise environmental policies in Europe. EFCA stimulates scientific and professional activity in Europe and, during the last ten years, developed a strategy with priority topics, in line with its mission to connect science and policy [1]. In this paper we report on two interrelated priority topics on which we advised the European Commission:

- "One atmosphere": the need for integrated policies on clean air and climate
- "Particulate matter": the deficiencies in the PM-regulation

EFCA's approach

With 15 Member associations in Europe EFCA is in a position to sponsor a continuous programme of conferences and conference series on atmospheric topics and have specific topics selected. Apart from proceedings also conference reports for policymakers are published. When conferences generate new insights which seem relevant for policy EFCA may take a *Policy Initiative* in which progress is reviewed, deficiencies in European policies are identified and recommendations for improvement are given. Through Forum discussions at its website possible remaining questions may be addressed in order to improve the quality of the advice before it is sent to the European Commission.

One atmosphere

The Earth has only one atmosphere which provides an impressive number of eco-services, functions essential for life. However, our atmosphere is facing two causally related problems with high impacts for men and ecosystems: air pollution and climate change.
In 2008 EFCA's French Member APPA, in cooperation with IUAPPA, organised a first conference on this topic [2]. Its conclusions were subsequently tested at a workshop on 'Intermediate policies for climate and clean air', organised at the initiative of the Swedish presidency of the EU in 2009; these formed the basis of a Policy Initiative [3].
An integrated policy approach may generate co-benefits and also help to avoid trade-offs which result from present separate policies and increase overall cost-effectiveness of policies. EFCA's assessment of then existing EU legislation revealed that the Climate and Energy package of 2008 [4] generates considerable reductions of the emissions of major air pollutants. Also in vehicle regulations it is attempted to balance limit values for exhaust emissions with fuel-efficiency requirements.
In 2010 the existing legislation which is relevant for air quality, however, did not refer to the climate problem. The *Environmental Impact Assessment Directive* has ample scope to include energy-efficiency as a requirement for consideration in new activities. In the recent revision [5] energy-efficiency is referred to, though not as a requirement. In the *Industrial Emissions Directive* [6] energy-efficiency is not either a criterion. Here the Bref's, reference documents on Best Available Technology, provide an easy way to achieve co-benefits by selecting technologies requiring least energy. It is uncertain whether this road will be taken. For the *National Emissions Ceilings Directive* and the *Ambient Air Quality Directive* proposals for their revision, announced for this year, are being awaited.

Particulate matter

With respect to air pollution, particulate matter is presently regulated by the metrics PM_{10} and $PM_{2.5}$, in Europe and elsewhere. The legitimation for this is their correlation with a number of short term and long term health endpoints as recently confirmed by WHO Europe [7]. Such 'container metrics' ignore the complexity of the atmospheric mixture of particulate matter which varies with respect to source, size, shape, colour, chemical composition, atmospheric behaviour, interaction with gaseous pollutants and are inadequate, therefore, to reduce impacts on health, environment, climate and weather. The implementation of PM_{10}/$PM_{2.5}$ regulation will not necessarily result in measures with maximal health protection.

In 2007 EFCA's German Member GUS, in cooperation with the Karlsruhe Institute of Technology and EFCA, started a bi-annual series of symposia on ultrafine particles. At UFP-3 in 2011 a group of scientists proposed Black Carbon Particles (BCP) as additional metric to improve health protection, next to PM_{10}/$PM_{2.5}$. It had already been recognised as a valuable instrument for air quality management at local scale [8] and a scientific assessment in support of the proposal was published in 2012 by WHO [9]. Because questions on other aspects remained EFCA organised a Forum discussion at its website (2011/2012) at which the alternative metric of particle numbers (PN) was well addressed. The outcome was the basis for an EFCA Policy Initiative in 2012 in which the position of present and possible metrics was assessed with respect to their usefulness in air quality policy and in climate policy, and in which EFCA concluded to support the proposal of BCP as additional metric [10]. What were our reasons?

In the political discussion cost/benefits analysis of policy options plays an important role. Integrated assessment modelling, primarily a combination of an air quality model with an economic module, is the basis for such analysis; in Europe IIASA's GAINS model is being used to assess present health risks in monetised terms and to compare benefits of reduced excess mortality with the costs of the required policy measures.

Table 1. Comparison of the infrastructure for integrated assessment estimates for three metrics of particulate matter

	PM2.5	BCP	PN
Dose-effect relation (short term effects)	+	+	+/-
Dose-effect relation (long term effects)	+	+/-	-
Emission inventory	+	+/-	(+/-)
Monitoring data (network-based)	+	+/-	-
Source specificity	-	+	-
Co-benefits with climate objectives	?	+[1)]	?

+ available/positive; +/- incomplete; (+/-) scarce data only; - data absent/negative

[1)] BC is one of the Short-Lived Climate Pollutants (SLCPs; other are Ozone and Methane [11]); BC is the second largest climate forcer [12] and held responsible for 0.5-1.1°C warming in NH; contrary to long-lived climate forcers (CO_2, F-gases), emission reductions of BC have an immediate negative effect on global warming

In table 1 the availability of input data for three metrics, $PM_{2.5}$, BCP and PN is compared; these include:

- Dose-response relations from epidemiological studies, in particular for long term excess mortality
- EU-wide emission inventory
- Validated model: emissions vs. monitoring data

To these we added two additional criteria because of their relevance upon implementation of regulation: source specificity and co-benefits with climate objectives.

Not surprisingly, the modelling database is complete for $PM_{2.5}$, in contrast with those for BCP and PN. When comparing the latter two, however, the situation is much better for BCP than for PN because completing the emission inventory and further roll-out of operational monitoring capacity for BCP in Europe seems feasible within a few years. For PN our estimate is that this could take 5 to 10 years.

For neither of the metrics a dose-effect relation for long-term health effects, (excess mortality) is available. For BCP the outcome of studies is inconclusive; for PN such studies have not been reported yet.
Short-term effects have been reported for both metrics and provide conclusive evidence for BCP with higher RR values than those for $PM_{2.5}$ [9]; for PN there are strong indications for a correlation [13].
The differences with respect to infrastructure for assessment modelling plead for BCP as additional metric when compared with PN. Its source-specificity and its potential for creating co-benefits with climate objectives would enable Member States and local authorities to select more cost-effective measures to reach compliance with air quality requirements while contributing to climate targets and makes it the preferred additional metric.

EU-Vehicles regulation

The preference for BCP may seem at odds with the existing regulation for emissions limit values for PN in the type approval phase of new vehicles [14, 15]. The risk for inconsistencies is small, however, because combustion-generated nanoparticles are likely to be black for a major part. Nevertheless, it is presently impossible to make an estimate of the impact of the regulation on excess mortality, other health end-points or its co-benefits for climate objectives. Establishing robust relations between BC- and PN-emissions for specific sources could close this knowledge gap.

Conclusions

1. An integrated policy approach on air quality, climate and transport in the EU could further cost-effectiveness and requires urgent attention
2. Specific regulation on BCP and/or PN are no-regret options
3. BCP regulation is the preferred additional metric
4. Knowledge gaps for sound AQ policies on particulate matter include:
    - Dose-response relations for long-term health effects of BCP and for short-term and long-term health effects of PN
    - Databases of emissions and monitoring data of BCP and PN
    - Robust relations between BC-emissions and PN-emissions from vehicles

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