New directions : cleaning the air : will the European Commission's clean air policy package of December 2013 deliver?

Harrison, Roy M.; Brunekreef, Bert; Keuken, Menno; Denier Van Der Gon, Hugo; Querol, Xavier

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New Directions: Cleaning the Air: Will the European Commission's Clean Air Policy Package of December 2013 Deliver?

The European Commission has published its plans for development of air quality policy over the forthcoming decades (EU, 2013). These merit close examination:

- *Emission and air quality standards have different roles*

There are many aspects to a successful policy to improve air quality, but those which are most important are emissions standards, which place an upper limit on the emissions from a particular process or device, and ambient air quality standards which set the benchmark for acceptable air quality. Whilst enforcing tighter emissions standards will inevitably lead to some direct improvement in air quality, air quality standards work in an indirect way by generating the pressure for air quality improvement in order to achieve compliance. In its latest review of air quality policy (EU, 2013), the European Commission argues that since there are currently many breaches of air quality Limit and Target Values (which are effectively air quality standards, often with some exceedences permitted), policy should be directed at reviewing specific emission standards and meeting the current air quality Limit and Target Values rather than adopting even tighter air quality objectives as required implicitly by the World Health Organisation's Review of Evidence on Health Aspects of Air Pollution (REVIHAAP) process (WHO, 2013). Emission and air quality standards have different roles. For example, more stringent EURO emission standards have in theory reduced the emission levels of NO_x and Particulate Matter (PM) from traffic in the last decade. However, the dieselisation of the vehicle fleet and the increase of vehicles have counterbalanced much of the benefit of the tougher emission standards. It is only the pressure to attain the air quality Limit and Target Values that has given rise to additional action plans that have contributed to better air quality. Furthermore, in the case of PM, non-exhaust emissions (wear and resuspension) are not influenced by emission standards (Denier van der Gon et al., 2013), and these contribute to a large proportion of PM exceedences in urban areas. Thus, both emission and air quality standards need to be simultaneously adjusted with time to improve air quality.

- *Are current air quality Limit Values protective of public health?*

The need for lowering the air quality Limit Values for especially PM_{10} and $PM_{2.5}$ has been underscored by recently published findings from the EU funded largest ever investigation in Europe of the adverse health effects of air pollution, the European Study of Cohorts for Air Pollution Effects (ESCAPE), see Beelen et al. (2014) and Raaschou-Nielsen et al. (2013) as examples. These studies documented that adverse health effects of PM are observed at concentrations well below the current Limit Values. The Commission proposes to achieve air quality improvements through measures targeted on a number of specific sources which are currently poorly controlled, and overall limits on emissions applying to individual member states. Measures already in the pipeline include better control of NO_x from light-duty diesels, and newly proposed measures relate to medium combustion plants (i.e. combustion installations of a thermal capacity between 1-50 MW), abatement of ammonia emissions from agriculture and further control of emissions from shipping. These specific measures are accompanied by a proposed extension of the National Emissions Ceilings Directive (NECD). This Directive currently sets limits on emissions from individual countries for SO_2, NO_x, non-methane VOCs and NH_3 to be achieved by 2020. Notably, the emission reductions proposed use, somewhat mysteriously, the year 2005 emissions as baseline. As reported by EEA (2013a), emissions of all relevant components had already been reduced considerably by 2011, see Table 1.

Table 1: Emissions reductions proposed for 2020 and those already achieved by 2011, both as a percentage of 2005 emissions

	SO_2	NO_x	(NM)VOC	NH_3	$PM_{2.5}$
Proposal reductions in % of 2005 emissions for 2020	59	42	28	6	22
Already achieved by 2011	42	24	20	5	13

This makes the proposals rather un-ambitious relative to what has already been achieved in the past 6 years or so. Disconcertingly, another EEA report shows that over that same time period, reductions in ambient $PM_{2.5}$ concentrations in Europe were minimal (EEA, 2013b). The Commission proposes substantially tougher limits to be achieved by 2030 and the addition of limits on emissions of methane and primary $PM_{2.5}$.

The Commission claims that the new air policy objectives for 2020 and then 2030 relative to 2005 will achieve a reduction in premature mortality due to particulate matter and ozone of 52%. It is not clear exactly how this number is estimated as the impact assessment shows reductions of premature deaths due to $PM_{2.5}$ exposure of 50%, and those due to acute ozone exposure of 33% relative to 2005. Such numbers represent a very substantial benefit for public health, but are they achievable and do they address all of the public health impacts of poor air quality?

- *Are the inventories an adequate tool?*

$PM_{2.5}$ has both primary and secondary components (although around 70% of ambient $PM_{2.5}$ is comprised of secondary components) (Putaud et al., 2010) and the proposed target for 2030 for primary $PM_{2.5}$ to be implemented through the NECD is a reduction of 51% from 2005 emissions. There must be serious questions over whether this can be achieved. For example, at present around 50% of the emissions of $PM_{2.5}$ from road traffic arise from non-exhaust sources (abrasion of brakes, tyres and the road surface) (AGEQ, 2012) and currently there are no measures proposed to control such a source. There are other $PM_{2.5}$ sources within the inventory which provide huge difficulties of quantification. One example is that of domestic wood combustion. There are major problems in quantifying the level of activity since much of the wood is acquired through unregulated mechanisms, and emissions factors (the mass of particles emitted per mass of wood burned) are hugely variable dependent upon combustion conditions (Harrison et al., 2012; EMEP/EEA, 2013) and in many countries knowledge of the combustion appliances used is very poor. There are even greater problems associated with emissions of $PM_{2.5}$ from cooking, which is increasingly being seen as a significant source of primary particles within urban areas (Allan et al., 2010). This currently is not included in national emissions inventories. The overall implication is that controls on regulated sources will need to be tightened by far more than the 51% required by the proposal for the NECD to allow for those sources which are not subject to regulation, and even if emissions included in national inventories are reduced by 51%, the reduction in primary $PM_{2.5}$ emissions will be significantly smaller due to the sources that are not included.

- *Non-linear relationships between the emissions and secondary atmospheric pollutants*

The secondary component of $PM_{2.5}$ represents probably an even larger challenge. This has three main components: sulphate (mainly ammonium sulphate), nitrate (ammonium and sodium nitrates) and secondary organic matter. Both atmospheric measurement studies and numerical modelling show huge non-linearities in the relationship between precursor emissions and ambient concentrations of secondary PM and ozone. For example, a reduction of X% in sulphur dioxide emissions is accompanied by a much smaller percentage decline in sulphate concentrations (Jones and Harrison, 2011). Nitrate concentrations are even less responsive to reductions in NO_x emissions, and reductions in sulphur dioxide can lead to increases in nitrate concentrations (Harrison et al., 2013). One model (Harrison et al., 2013) predicts that combined reductions in sulphur dioxide of 36%, NO_x of 25% and ammonia of 4% lead to a reduction of only 8.2% in secondary inorganic particles. The fact that the decline in NH_3 emissions is slow (see also Table 1) will cause difficulty in abating particulate ammonium nitrate levels which have a large influence on $PM_{2.5}$ concentrations. Prediction of the impact of even larger reductions in emissions as proposed to be required by the NECD is fraught with problems as some of the parameterisations used in numerical models are inevitably tuned with real-world data, and moving so far from current conditions may greatly weaken the predictive capability of the models. This is well recognized in the air quality modelling community. Secondary organic matter creates an even larger problem, as recent work has shown much of this to arise from biogenic precursors (Heal et al., 2011) which will be unaffected by cuts in VOC emissions required by the NECD. It has already been noted in an earlier article in this column (Harrison et al., 2008) that despite large reductions in emissions estimates for SO_2, NO_x and primary PM, urban PM_{10} concentrations in much of western Europe showed no obvious reduction from 2000 to 2006, which serves to emphasize the poor linkage between emissions inventories and ambient concentrations. The focus on $PM_{2.5}$ ignores coarse particles, which are increasingly being associated with adverse health outcomes (e.g. Brunekreef and Forsberg, 2005, Pérez et al., 2009, WHO, 2013), and have major anthropogenic as well as natural sources (Karanasiou et al., 2012).

- *Control of ozone*

Currently the target values for ozone (a secondary pollutant) for the protection of health and vegetation are exceeded in the majority of the European territory (EEA, 2013). WHO (2013) reported that health outcomes are evident at concentrations below these targets. At first sight it might be expected that the large cuts in emissions of NO_x and VOC precursors would lead to a reduction of ozone concentrations. However, past reductions in emissions have led to a reduction in peak ozone concentrations while average concentrations have been static or even increased (especially in urban areas EEA, 2013). Due to the complex atmospheric chemistry of ozone, concentrations in urban areas where most public exposure occurs are generally lower than those in the surrounding countryside, but reductions in NO_x emissions leading to a convergence between urban and rural concentrations, with urban concentrations rising towards those in surrounding rural areas. There is therefore a very significant risk that abatement of NO_x from ground-level sources may be beneficial for urban nitrogen dioxide but counter-productive in terms of ozone concentrations.

Clearly, the proposals from the Commission have been underpinned by numerical modelling of both air quality and health impacts, as well as cost-benefit analysis. However, the voluminous documentation produced by the Commission does not provide sufficient detail for independent assessment of the air quality modelling and there must be a strong suspicion that the conclusions drawn by the Commission on the basis of models are grossly over-optimistic. We suggest that downward revisions of some of the Limit Values, as implied by the advice of REVIHAAP (WHO, 2013) specifically in relation to $PM_{2.5}$, PM_{10}, NO_2 and long-term exposure to O_3, might provide a valuable complementary driver towards air quality improvement alongside more ambitious emissions limits, especially in the medium term to 2020.

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* Roy M. Harrison
Division of Environmental Health & Risk Management, School of Geography Earth and Environmental Sciences, University of Birmingham, B15 2TT, United Kingdom
Also at: Department of Environmental Sciences / Center of Excellence in Environmental Studies, King Abdulaziz University, PO Box 80203, Jeddah, 21589, Saudi Arabia

Bert Brunekreef
Institute for Risk Assessment Sciences, Universiteit Utrecht, PO Box 80178, 3508 TD, Utrecht, Netherlands, and Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht

Menno Keuken
TNO, Princetonlaan 6, 3584 CB, Utrecht, Netherlands

Hugo Denier van der Gon
TNO, Princetonlaan 6, 3584 CB Utrecht, The Netherlands

Xavier Querol
IDAEA-CSIC, C/ Jordi Girona 18-26, 08034 Barcelona, Spain

* Corresponding author.
Email address: r.m.harrison@bham.ac.uk (Roy M. Harrison)