Workshop on Review and Assessment of European Air Pollution Policies

Göteborg 25-27 October 2004

Workshop on Review and Assessment of European Air Pollution Policies

Göteborg 25-27 October 2004

Organised by
The Swedish ASTA programme and
The Nordic Council of Ministers

In collaboration with
The UN ECE Convention on Long Range Transboundary Air Pollution and
The European Commission Clean Air for Europe programme (CAFE)

1 Introduction

The development of European policies on air pollution prevention is currently in an intensive phase. The European Commission Clean Air for Europe (CAFE) programme is preparing an air pollution strategy and the Convention on Long-range Air Pollution may start a review of the Gothenburg Protocol during 2005. The purpose of this workshop was to review and assess the scientific basis and tools employed in this policy work and to provide guidance to the policy development. Future needs of scientific support in a longer perspective were also discussed. Workshop participants included experts and policymakers from the European states as well as from the US.

A large part of the workshop was focussed on the role of airborne particles. Human health effects caused by exposure to airborne particles have received increasing attention in recent years and concerns of health effects are today the main driving force for air pollution prevention and research. In addition to this, new concepts for describing effects of acidification and ozone are being introduced providing more accurate and relevant descriptions of ecosystem effects to changes in air pollution levels. The needs for considering air pollution on a hemispheric scale were also highlighted.

This workshop was arranged by the ASTA programme in co-operation with the Nordic Council of Ministers and the CAFE Programme. It is a follow-up of the workshop held in Saltsjöbaden, Sweden, in April 2000.

2 General conclusions and recommendations

2.1 General

Large reductions of emissions, transboundary transport and deposition of SOx, NOx, VOC have been achieved as a result of the Convention protocols, EU directives and national legislation. For ammonia, the situation is less positive and emissions have only been reduced to a limited extent.

Human health impacts of particulate matter (PM) have become the most important driver for development of air pollution abatement strategies within CLRTAP and CAFE.

The old problems of acidification and eutrophication of terrestrial and aquatic ecosystems, ozone damage to vegetation and human health still remain and will require further measures, although there are signs of significant improvement in some parts of Europe.

2.2 Particles

Recent research indicates that there is no threshold concentration for harmful effects of PM, which suggests that a general reduction of exposure is needed.

Different targets for strategies to reduce PM levels can be used. Both equity and efficiency need to be taken into account when developing strategies to reduce emissions and population exposure. Several specific policy options to reduce PM emissions are available such as limit values in the NEC directive and targeting urban low-level sources. Combinations of limit values and emission reductions would give favourable results in terms of reducing health impacts in the general population as well as in population groups in high exposure areas. Uncertainties in efficiency are similar for different policy options (NEC/limit value). The issue of efficiency and equity of different policy options could be further discussed, e.g. via a dedicated workshop organised by CAFE.

The scientific basis of source-receptor relationship of PM needs to be strengthened in several areas such as:

- emission inventories,
- formation and composition of secondary organic particles
- chemical composition and size distribution of PM from different source categories and how these parameters are affected by different abatement strategies
- the relationship between chemical composition, size distribution and toxicity

2.3 Hemispheric transport

The inclusion of hemispheric transport of pollutants within the framework of CLRTAP is scientifically motivated and policy relevant for European air quality. Future policy development in the air pollution area needs to take this into account.

Air pollution policies can benefit from exploring and exploiting commonalties with climate change policy.

A framework for providing scientific support on hemispheric transport of air pollutants to support policy development is needed. Main scientific issues include emission inventories, model development/assessment and measurements. Much of the basic science is available but needs to be compiled and evaluated with air pollution policies in mind.

It was suggested to form a Task force on hemispheric transport (TFHM) within the CLRTAP framework to take this issue further and develop mechanisms for inclusion of the hemispheric scale in air pollution strategies.

2.4 Nitrogen

There are large problems in solving the eutrophication problem in Europe due to its close relation to agriculture. A long-term solution would need changes in the European agricultural policies.

Emission reduction strategies for nitrogen compounds (NOx, NH_3) need to be improved. Nitrogen emissions continues to contribute to ozone and particle formation, eutrophication and acidification and it should be kept in mind that only limited progress in acidification recovery can be made with further reductions of SOx.

There are significant gaps in our understanding of nitrogen biogeochemistry. Especially the fate of nitrate and ammonia deposited in terrestrial ecosystems is poorly understood, since ecosystem impacts will be highly dependent on the rate of nitrogen transformations and uptake by organisms.

Nitrogen is an environmental issue on local, regional and global scales. Thus, abatement strategies need to be flexible and take into account these different scales.

2.5 “New” sources

Off-road vehicles and machinery are uncontrolled in many countries, and further control measures could be considered for these source categories. A directive exists for new vehicles but older vehicles account for considerable emissions of NOx and VOC.

Shipping has become a more important emission source of SOx and NOx in Europe as emissions from other sources have decreased and shipping emissions have increased. Measures to control these emissions are likely to be cost effective. Emissions from aviation are also increasing and may be of importance, in particular for problems associated with hemispheric scale problems.

Long term policies need to be developed and may be based on measures such as assignment of shipping and aviation emissions to countries (improved inventories), charging and/or incentives to both modes to cut emissions, and for ships, providing land-based power supply while in port. EU and international policies for shipping emissions are being developed in three main contexts: the 2002 EU ship emissions strategy and marine fuel sulphur proposal, the 2005 Clean Air For Europe programme, and forthcoming revisions to the International Maritime Organisation's air pollution convention, MARPOL Annex VI.

Interactions between climate change and air pollution issues need to be identified and dealt with in policy and science. This includes synergies in policies as well as transport and effects of air pollutants.

2.6 Developments in science and policy tools

A continuous development of the scientific understanding of air pollutant emissions, transport and impacts has been crucial for the development of new modelling tools and air pollution strategies. Also results from existing European monitoring networks of air pollutants, water quality and effects within EMEP and other CLRTAP bodies have played an important role in this development. Some of the more recent developments include:

- Dynamic models for acidification and ozone uptake/flux models for vegetation effects have been introduced in the integrated assessment work within CLRTAP and CAFE leading to more detailed and accurate descriptions of ecosystem damage and recovery.
- New results from epidemiological research have further strengthened the importance of PM health effects.
- The EU funded research project MERLIN presented preliminary results of an Integrated Assessment of European air pollution. It is important that alternative and complementary research and assessments are undertaken in order to increase reliability and legitimacy of the CAFE strategy.
- The methodology of Cost Benefit Analysis for air pollutants has been improved and is currently being applied in the CAFE programme.
- The unified EMEP model has proven to be of better quality and more flexible than previous regional air pollution models. This development and the introduction of 50x50 km grid system has led to more accurate source-receptor determinations as well as more detailed and accurate descriptions of ecosystem effects.
- Considerable efforts have been made to improve the RAINS modelling system including the development of baseline scenarios for individual countries and coupling of measures to reduce climate gases and pollutants.
- Non-linearities in atmospheric transport and deposition of pollutants have been identified and described.

To be able to meet needs and requirements for future air pollution policy development, a number of research and monitoring needs can be identified:

- Sources, formation, composition and human health impacts of particles.
- Nitrogen biogeochemistry and links to carbon cycling. Dynamic models that can be used for control strategies.
- The implementation of the EMEP monitoring strategy and other measurement and data collection activities in order to support the more advanced models and policy needs identified by recent and ongoing scientific research.
- Realistic scenarios for post-Kyoto emission reduction strategies need to be identified.

- Synergies between air pollution policies and policies to reduce climate gas emissions including the influence of climate change on emissions, transport and impacts of air pollutants.
- The role of hemispheric and global transport of air pollutants and toxic substances.

3 Working Group Reports

3.1 WG 1: Health and Environmental Effects: The Impact of Different Alternative Abatement Strategies

October 26-27, 2004 Gothenburg, Sweden

Johan Sliggers (Chair)
Kimber Scavo (Rapporteur)
Jes Fenger
Till Spranger
Francisco Ferreira
Tor Johannessen
Rob Folkert
Vladimir Kucera
Ellen Baum
Jean-Marie Brignon
Riccardo Marzuoli
Berit Kvaeven
Ulla Bertills
Lars Lundin
Harry Harmens
Annette Borowiak
Jaroslav Santroch
Jan Wilem Erisman
Jag Urbanus
Harald Sverdrup
Matti Johansson
Heinz Gregor
Brit Lisa Skjelkvåle

3.1.1 Introduction

The group was tasked to look at impact indicators related to health and environmental effects of alternative abatement strategies. The ICPs should be in the position in the next year to assess the scenarios to be used in negotiations with respect to effects.

The Group is asked to:

Look at scientific basis and look at policy options.

Recommendations & conclusions for European air pollution control strategies for short, medium, long-term.

Future developments & research needs (emissions inventories, critical loads, modeling).

3.1.2 Brainstorming Session

The Group conducted a brainstorming session. The following represents the ideas raised:

a) What does the effects community think of baseline scenario and no further controls and no revision of NEC guideline, what is result? Are we content with that?

b) What is the pay off to reduce pollution; how many life years have we gained? Link reductions directly with concrete effects (e.g., nitrogen deposition and biodiversity).

c) Address uncertainties on health.

d) Address the different chemical and physical characteristics of particulates.

e) Do we have new endpoints (indicators) on environmental and material effects? Can they be related to observed changes in the environment?

f) If we fulfil the Gothenburg Protocol, we still have additional goals to achieve. Goals must go further than the protocol. How do we go further? What is the strategy and how do we communicate the need to get more reductions? Keep old policy indicators and equity in mind when we revisit the Protocol. The pollution policies may be more effective if focus on speciation or ranking of sources/substances.

g) Focus policy more on exposure rather than ambient concentrations. There is a need for better estimation of population exposure.

h) Many directives and protocols affect the same sectors/activities. What are the trade offs and what is limiting? Establish link with non-air pollution indicators and policy (e.g., nitrate/ammonia and agriculture). There are also cross media policy issues. There is a need to integrate policies.

i) Linkages & co-benefits: e.g., the effect of ozone reduction on radiative forcing; acidification and heavy metals.

j) Eutrophication is a challenge of the future. We should have special focus on this problem. There are landscape management and air pollution links. Nitrogen is also a focus for acidification.

k) There are still problems associated with sulphur.

l) Stress multi-pollutant exposure and effects. Different regions of Europe have different air pollution problems (e.g., ozone effect in south, acidification in north). Real challenge is how to keep multi-pollutant focus to get reductions in all of Europe. So how do we set targets in a balanced way? It is multi-pollutants, but set targets in a different way for health and the environment.

m) Look at controls beyond conventional sources (ships, aviation, domestic wood burning/biomass). Quantify effects of certain emissions. Will need to link with other international organizations (e.g., IMO, ICAO).

n) Look at populations that are vulnerable.

o) How do we monitor the effectiveness of new strategies?

p) Need new European health study on regulated pollutants. If done carefully can work out life expectancy indicators. This would be a costly effort. PM2.5 studies are U.S. studies. Until then, we need to rely on data that is available.

q) List environmental indicators out of models and effects indicators. Look at specific (lives lost from specific pollutant) and general indicators (with many air pollutants/effects together).

r) What if air quality standards cannot be met because of hemispheric issue? What is the contribution? What is the marginal increase that will have an impact on the indicators and/or strategies? Better understand the extent to which other regions are impacting other regions in meeting air quality standards. Impact of different abatement strategies. What are the effects of European strategies and other measures on different scales?

s) How do we evaluate the impacts? Do we use monitoring, models and/or other assessment methods? Do we leave to the different assessment groups? Do we have the right structure in the EU and the Convention? Do we have the machinery to evaluate the impacts? Do we have the right infrastructure to evaluate the impacts? Doubts were raised about the deficiencies in the infrastructure from a health standpoint but the right infrastructure may exist and could be enhanced with more cooperation.

t) What about natural versus anthropogenic. Should address emissions and effects indicators. There are uncertainties. Address effects of natural contributions but exclude from policy?

u) Ask policy makers whether there is a need to study visibility.

3.1.3 Recommendations

The Group addressed 5 items in the afternoon:

What effects are still there?

Effects have been reduced but need to be further reduced after the Gothenburg Protocol and the NEC directive target years. The information below will be for use for policy purposes in EU and the Convention.

Effects:

The Group recognized that protecting public health and the environment are both important driving forces. Ultimate goal is to work on both health and the environment.

What are the remaining issues to tackle? What are the most important?

Effects to tackle:

-Health: PM, Ozone, NO2, metals/POPs (food chain), morbidity and mortality effects

Natural Environment: terrestrial eutrophication, remaining problems with acidification, ozone, heavy metals (in particular, mercury), POPs, coupling of all effects from pollution and climate change and land and water management, nitrogen enrichment and insect pests and diseases, pollution of ground water, aquatic eutrophication

-Materials: effects of multi-pollutants on corrosion and soiling of materials (SO2, PM, nitric acid), including cultural heritage

What are the (new) indicators?

Indicators should be workable into integrated assessment modeling and be informative and appealing to policy makers and the public.

-Health: Goal: Remove significant health effects (PM, ozone, NO2). Short-term and long-term exposure mean acute and chronic effects.

Indicators: DALY, What is life years lost for total pollutants short-term and long-term? number of premature deaths, time and # of people, number of hospital admissions, population-weighted exposure, # of people exposed to concentrations above certain level

-Environment: Goal: Sustain biological diversity and ecosystem structure function (each country will have individual reference conditions).

Indicators: critical loads/levels for biodiversity (e.g., 80% of species can occur in a specific ecosystem), allow for recovery, damage delay time, residual time to damage, recovery delay time, accumulative exceedances, exceedance of critical loads/levels, area of exceedance and % of area with exceedances, leaf injury in vegetation from ozone, crop yield losses from ozone, classify and quantify to the extent possible the damage of ecosystems related to air pollution.

-Materials: Goal: Further reduction of the rate of corrosion and soiling.

Indicators: Threshold/acceptable levels of deterioration of metals and stone materials; dose response functions for calculating threshold levels of pollutants, stock at risk and mapping of exceedances, including materials of cultural heritage, use findings for modeling effects of climate change on materials

-Linkages: Climate Goal: Understand the side effects and identify co-benefits; understand the impacts on air pollutants on climate change.

Indicators: Calculate the radiative forcing of scenarios. Optimize air pollutant reductions (e.g., methane gets ozone benefits and climate benefits), recognize the different environmental goals.

Indicators for Heavy metals/POPs: Identify what current air pollution policies result in change in exceedances of critical loads for metals and model effect levels for POPs.

Look at what we have achieved with respect to scientific knowledge and where are the gaps?

Then arrive at conclusions for our challenges in the future with respect to monitoring, evaluation, assessment and abatement strategies.

General remarks: Dose response functions are poorly understood. Monitoring can be optimized and should be more targeted and extended. More research efforts are needed for monitoring and need to be compatible with the calculation of indicators. Mapping methodology should continue to be harmonized and focused on the relevant scale (e.g., ecosystem specific parameters, PM on local scale). There is a high demand for further reducing uncertainties especially when exceedances of no-effects levels become smaller.

Health Research: Need studies to underpin relative risks for health effects; monitor health effects of relative risks. Need studies for effects for vulnerable groups. More knowledge of sources that cause health effects (chemical and physical composition of PM speciation). Measurement techniques and emission inventory development for PM species. Study effects of increasing ozone background concentrations on health.

Environment Research: More knowledge on dose response functions (classification of damage). Better define biological goal for biodiversity (policy and research need). Need to upscale pollution impacts on individual species to whole communities. Understand nitrogen cycle and to what extent current air pollution policies will help solve different kinds of eutrophication problems.

Materials Research: Need for quantifying the relevant importance of individual pollutants on materials. Develop methods and assess stock at risk of cultural heritage objects.

Linkages Research: Be aware of the climate change on effects of air pollution. Dose response functions for metals/POPs related to human health and the environment.

Scenario questions from the effects community:

What are the links with specific sources (ships, wood burning) and effects and non-air pollution problems (nitrate in groundwater), scale issues (local, regional, hemispheric), and other receptors (seas)?

What are relative contributions to effects of natural and anthropogenic emissions? Direct policies toward anthropogenic emissions taking into account natural emissions.

3.2 WG 2: Health and Cost-Benefit Analysis

William Harnett: ChairPaul Watkiss: Rapporteur
Titus Kyrklund
Mohammed Belhaj
Rainer Friedrich
Jean-Paul Hettelingh
Mike Holland
Sylvie Lemoine
Lourens Post
Jurgen Schneider

The group organised the discussion into three areas:

Theme 1. Health related – standards vs population weighted, different scales, ambition levels. Non-health.

Theme 2. Cost-benefit analysis. Role of CBA. Extended CBA. Uncertainty.

Theme 3. What are the main research needs for future period (2005 – 2010) in atmospheric pollution? The following views expressed by the group (though are not necessarily a consensus)

3.2.1 Health

- On the issue on whether to have limit values or a population weighted approach. As $PM_{2.5}$ has no threshold, there was broad support for population weighted focus to maximise health benefits (economic efficiency). However, there is also a need to drive down peak levels with limit values to ensure environmental justice. The group broadly concluded that both approaches were relevant in combination. Further discussion on the detail is needed, for example should we apply limit value everywhere? Should we have urban emissions ceilings? How to target population weighted reductions? Should we focus on an approach based on exposure?
- $PM_{2.5}$ and $PM_{10.}$ There should be a focus on $PM_{2.5}$ but the coarse fraction ($PM_{2.5-10}$) has some health effects and so warrants potential control. It would be useful to test how important the coarse fraction is with benefits analysis and compare to other pollutants.
- Particulate mixture – primary vs nitrates vs sulphates. If toxicity is different it makes a very big difference to policy and measures, but the evidence does not allow us to separate and apply different factors with high confidence at present. Sensitivity analysis is needed and we should highlight ‘no regrets’ policies (to improve robustness of measure selection: to avoid measures that we might regret later, should the evidence change).

- NO_2 as a gas. Studies show health effects at ambient levels, but this is possibly due to a correlation with ultra-fine. NO_2 is therefore an indicator for transport signal but there is a danger that not targeting the primary cause. Proposed that we keep the existing standard and review AND see if can replace by a better indicator. Highlight 'regrets' are possible. Note NO_2 is important because the current limit value is driving action in many areas.
- Additional issues were raised on competitiveness and employment. Health effects of unemployment**Environment**
- For ecosystems / biodiversity impacts. There is existing information from integrated assessment on exceedance (risk) and critical loads/levels. Critical load/level are effectively a threshold. There is also information on acidification on time delays of recovery or damage. This is available to CBA.
- Some countries use indicators that relate to biodiversity - this has some potential importance, but too early to apply yet at European scale and there is a need for more research and data collection at full scale.
- Crops, forests and materials are important and should not be ignored in the benefits analysis. There was a discussion of the importance of flux based approach (for crops and forests).

3.2.3 Role of Cost-Benefit Analysis

- Role of CBA. Previous analysis of EC policy mostly used CBA as final stage to compare costs and benefits. This is the approach also used in the US as it relates to air quality standards, i.e. make the decision, then undertake the CBA. CAFE will need to do this under the extended impact assessment, but it would be nice to know how costs and benefits compare earlier in the process
- CBA should not be used to assess the economic optimum (targets where marginal cost = marginal benefit) because of the uncertainties and gaps in the method.
- CBA should be used to assess costs and benefits of every scenario, and/or to assess ambition level of gap closure and targets
- Because we are dealing with multi-pollutant, multi effects, we are interested in relative importance of effects (e.g. $PM_{2.5}$ vs ozone), and also helps in comparing measures or policies. Can tell you how much bang for buck ('How much Environment for our Euro'). It has a potential role in prioritising
- The group concluded that CBA is a useful tool and should be used in an iterative process, but it is only one of a number of tools…
- The group considered the use of CBA and how significant a role it should play in the final decision-making. We considered the role ranking on a scale of 0 – 10 on application (zero CBA is ignored, ten it is used to decide the whole process). The group views ranged from 3 to 6.

3.2.4 Extended Cost-benefit Analysis

- Extended CBA analysis is very useful to address effects that cannot be monetised. The group were in favour of extended CBA.
- For example, impacts on ecosystems are an important factor for performing an extended CBA because the effects are not easily monetised. Precautionary principle (PP) in Europe (Critical loads). If we move to quantitative approach, CBA could help…..but does that mean PP measures fall out. Extended CBA brings these along
- Conclusion – extended CBA. Be good to consider uncertainty and extended CBA after a few results. Go through the results and extended CBA. Workshop to go through runs.

3.2.5 Other Issues that Affect CBA

A number of other issues were raised:

- Co-benefits need to be flagged up in the process (especially greenhouse gas emissions)
- Interaction with climate change is very important
- Leading baseline should be the leading baseline, i.e. we should clear on the preferred baseline. From CBA perspective, take Kyoto compliant scenario as reference case.
- Baseline - Uncertainty of what happen in the baseline with climate measures (for Kyoto) is large – might not reflect what happens down the road. This will affect the CBA results. Effectively, the baseline projection, and how incorporate Kyoto (because uncertainty), affect the relationship between the costs and benefits.

3.2.6 Uncertainty

- Where to focus – emissions, dispersion, impacts, valuation, etc
- The group discussed transparency, robustness, sensitivity, uncertainty, bias
- We have (good) transparency in CBA
- Agreed that sensitivity analysis is important part of confidence building process – issue who decides which sensitivity. The group concluded this should be based on the existing process and focus on what makes a difference.
- There is a need to compile bias (systematic error, consistent over or under prediction)
- Uncertainty. Should we aim for probability distribution (scientists). Policy makers would prefer something simple (policy makers make uncertain decisions all the time, which way does the bias go).
- The RAINS review identified need for uncertainty analysis. For CBA we should not do something separate, make clear what important uncertainties from CBA

perspective (may be different). Take RAINS and known bias. Restrict uncertainty to elements that we add on in CBA

- How complete should it be – cost-effectiveness work with a few endpoints where confidence is high. CBA should aim to cover all costs and benefits. CBA should not take the appropriate (conservative) approach that in RAINS, but perhaps not as far as Research. Even so, CBA is always a sub-total of effects – not cover everything
- Need mechanism for updating CBA methodology in the future as evidence emerges. This cannot be done on an ad hoc basis, need a quality assurance process, and ongoing peer review.

A number of other issues were raised

- Materials and crops should not be excluded.
- Big issues….Primary vs sulphate vs nitrates ….. valuation of mortality.
- VOLY vs VSL. Preference 'round the table' for VOLY, but some recognition need to do both to respond to peer review
- Opportunity costs – what costs if don't do it
- Discussed economic instruments and measures

3.2.7 Research Recommendations

- Work on exposure (attribution of the particulate mix, exposure modelling – how to deal with the person who lives in the street canyon, indoor air pollution)
- Long-term EU studies not restricted to PM only.
- PM mixture and composition studies and mechanism and super-sites (to better understand effects of all pollutants and their interactions, useful to have some monitoring sites in Europe that measure for broad range of pollutants in same location that can then be used for health studies. Covering just about everything).
- Consideration of secondary organic.
- Continued research is needed in CBA area. Need to keep CBA up to date. Need constant review and improvement. Multi-disciplinary. Systematic work on externalities in agriculture.
- More research on uncertainty (distributions – probabilities, vs what policy makers can use)
- Should not forget materials, crops and forests
- Biodiversity – extend impact description + how to assess impacts (and value) - changes in biodiversity from air pollution

3.3 WG 3A: IAM - Methodology, uncertainties and robustness

Participants
Helen Apsimon (chair)
Bernd Calaminus (rapporteur)
Katarina Borne
Anton Eliassen
Peringe Grennfelt
Tiziano Pignatelli
David Simpson
Sebastien Soleille
TS Panwar
Antonio Ballami Denti
Helga Kromp-Kolb
Markus Amann

3.3.1 Introduction

There have been major developments in modelling since Saltsjöbaden [2000] (EMEP Eulerian and other atmospheric modelling, effects modelling and integrated assessment). At the same time the range of pollutants and effects have increased, and with this the overall complexity. This makes it even more important to address uncertainties and robustness systematically.

3.3.2 Atmospheric science

Several questions have emerged from examination of trends and other work concerning atmospheric science (non-linearity, growing importance of ammonia chemistry and oxidised nitrogen, PM concentrations and components e.g. SOA, co-deposition and stomatal O3 fluxes). To progress future development and validation there is a need for new data and extension for current monitoring e.g. supersites giving a wider range of measurements with as fine resolution as possible including nitrogren in different chemical forms and chemical and physical characteristics of PM. Such monitoring is also important for identifying new questions, for use in source apportionment and for reliability of emissions. Appropriate funding is necessary.

There are also aspects to be explored such as the role of increasing background ozone due to hemispheric transport and sources still increasing like shipping and aviation.

Recognising the large interannual variability in meteorology integrated assessment based on an average of fairly normal years is important. However recognising the potential influence of climate change it will also be useful to examine the extreme year of 2003 both with respect to the atmospheric science and potential socio-economic response if such years are repeated (workshop?!).

3.3.3 PM

There are major uncertainties related to PM, especially with respect to health effects and the fraction responsible, which need to be addressed:

For emissions very few national inventories are yet available and national (including non-EU) and international effort is required to improve; different types of sources such as domestic wood firing become important and are very uncertain with respect to both emission factors and activity data.

Models underpredict, but are better for PM2.5 and factors such as water content help mass closure.

SIA is well modelled, but primary PM is far more uncertain.

Our understanding of SOA is too uncertain to use in IAM at the present time.

In order to respond flexibly to new understanding of the particle characteristics that are responsible for health effects, we need size differentiated and speciated emission inventories (including links to HM inventories) and to know how abatement strategies influence different chemical and size components including ultra-fines.

3.3.4 Emissions and abatement options

Recent work on regridding and spatial distribution of emissions has emphasised the importance of countries meeting their obligations to provide gridded emission data reflecting e.g. implementation of LCP-D.

In addition to emissions reporting of additional data on the state/type of technology is important in assessing appropriate abatement options.

There may be other sources of information in future such as EPER data and measured data from stacks.

Quality assurance is important for new pollutants covered such as PM (see above).

CLE scenarios leave relatively little margin for future improvement from technological measures in IAM optimised scenarios and other start positions should be considered as well.

As emission reductions become stricter technical measures become more expensive and cost uncertain. This emphasises the need to look at a wider range of abatement options - e.g. new technologies like fuel cells, hybrid vehicles, early introduction of EURO-standards, and non-technological measures such as taxation, trading, incentives for fleet renovation etc. Furthermore, abatement measures for sources not covered hitherto such as shipping and aviation need to be addressed in IAM, and new pollutants such as CO.

It is also important to recognise multiple benefits of abatement options and synergies with other policy issues.

There are also large uncertainties about future development. The examination of climate scenarios is a step forward in this direction, but further consideration is required on a range of potential scenarios. There needs also to be a review of models such as PRIMES and TREMOVE in a similar way to that for the EMEP and RAINS models.

3.3.5 General points

Collaboration/coordination of IAM related activities

There is a wide range of IAM related activities both on national and international level. IIASA has through its role as the EMEP Centre for IAM a wide responsibility as a long term support organisation for policy development (and implementation). This role includes close collaboration with parties and other stakeholders, initiatives to improve data input, submodels and related research etc. It is important that this role is recognised and that enough resources are allocated for IIASA and supporting organisations/integrated assessment projects to include new scientific knowledge, options to meet policy needs and alternative approaches to increase robustness and reliability of the model output.

Problems of scale

Although there are many limitations in assessment at sub-national or with a finer grid resolution it is important to improve treatment of population exposure concentrated in urban areas building on such studies as City Delta.

We need more information about urban emissions consistent with national emissions.

There are other situations where a balance needs to be found between local action and transboundary agreements such as control of ammonia.

On a larger scale there are uncertainties in boundary conditions such as imported fluxes (e.g. Sahara dust in southern Europe).

Optimisation and target setting

Strategies derived from IAM are very sensitive to the way targets are defined. Particular consideration needs to be given to target setting including PM where there is no threshold, and alternatives to gap closure need to be explored.

Targets based on annual average might not be equally successful in episodic situations. It will be useful to test strategies on some severe episodes.

Strategies dealing with uncertainties

From a scientific perspective uncertainties exist in a number of categories:

a) Lack of scientific understanding

Basic science and monitoring requirements are indicated above.

Resources to EMEP and broader atmospheric modelling activities such as EuroDelta and to other extensions of concepts used in IAM such as dynamic modelling in relation to critical loads (and the relative importance of sulphur and nitrogen deposition).

b) Assumptions, simplifications

Systematic investigation of factors that may cause bias in the results and scenario analysis (workshop?!).

c) Statistical variance in input data, etc.

More information on the variance of input data is required to enable statistical analysis.

Extreme situations (e.g. episodes/years/scenarios).

d) Socio-economic and technological development

Scenario analysis to consider range of development in different sectors and associated projections of activity data.

Broader range of abatement options (as discussed above).

N.B.: All this has to be done with respect to different targets to prove robustness of strategies.

3.3.6 Immediate Priorities

The most pressing need is for a wider range of scenario analysis e.g. in interannual variability, baseline scenarios, PM, different targets and sensitivity analysis. This is also a good first step for understanding uncertainties.

3.4 WG 3B: Integrated Assessment Modelling - Use in Future Policy Development

Chair: Richard Ballaman
Rapporteur: John Rea
Attendees: Francis Altdorfer, Markus Amann, Bruno Cerald, Armond Cohen, Harald Dovland, Hans-Christen Hansson, Guy Landrieu, Lars Lindau, Linda Nordstrom, Daina Ozola, Nicola Robinson, Bernt Scharer, Till Spranger, Catarina Sternhufvud, Leonor Tarrason, Matti Vainio
Lars Lindau, John Rea, and Bruno Celard made introductory presentations based on their discussion papers prepared for the Workshop (see http://asta.ivl.se/backgroundmaterial.htm).

3.4.1 Pollutants

The incorporation of Particulate Matter (PM) within Integrated Assessment Modelling (IAM) for both CAFÉ and UNECE is an important development. PM is considered to be the highest priority at present due to the severe health effects associated with it. However, optimising five pollutants in IAM and subsequent negotiations may lead to too much complexity in the policy debate. Prioritisation could be possible, but may be considered too difficult to sell politically. It is worth noting that Nitrogen compounds are central to all key effects.

Methane – Ozone (O_3) is likely to remain a pollutant of concern for decades (no threshold means the problem is more intransigent), so should we not include methane (CH_4) now? It is a precursor of O_3, but its control can be linked to that for ammonia (NH_3) – and would therefore give extra impetus to the need for additional agricultural controls, i.e. a reduction of animal numbers. Further work will be required before a decision can be taken on what to do in a policy context, but we may be miss a trick on an effective O_3 strategy if we ignore CH_4 in the current round of proposals.

First estimates indicate that there can be only 1ppb reduction possible with feasible technical European NO_x and VOC measures up to 2020 – and this would be at the expense of increasing the lifetime of CH_4; while a reduction of 3ppb could be achieved by global background measures, in which CH_4 would be a major player.

It would be helpful to include CH_4 in an IAM sensitivity analysis to help inform any policy decision. For this purpose it should be included in RAINS as abatement options and costs, rather than being another factor driving the model optimisation. The geographical scale of modelling will be an issue – hemispheric models may be needed to produce efficient ozone reductions. However, such reductions should be attractive to non-UNECE countries as measures are relatively cheap and effective. This would seem to make sense from the broader strategic LRTAP point of view.

The US already has a major programme on CH_4. Initial conclusions could be included in the NECD review, but final conclusions will probably need to run into post-Kyoto and hemispheric discussions over the next decade.

3.4.2 Effects

The political drivers over the next few years are likely to be dominated by climate change and human health considerations, although acidification and eutrophication are still on the agenda.

Understanding and incorporating the interactions between air pollution and climate change will be important in the forthcoming initiatives. The ancillary benefits and disbenefits of climate change measures for air pollution policies need to be calculated. Likewise, the benefits and disbenefits of air pollution for climate change policies also need investigation. For now this will mostly focus on measures, but, in the longer term, modelling needs to develop a better understanding of the links between the Carbon and Nitrogen cycles (including both chemical and physical factors). We will also need a better understanding of the Nitrogen cycle – specifically the links between NO_x, NH_3, nitrate, and N_2O.

Answering the question of which elements of PM really cause the health impacts requires a significant European research effort (led by the Commission's DG Research), which should be coordinated with US HEI programme. There is also a need for more research on biodiversity (e.g. the effects of eutrophication) and ecosystem recovery (e.g. dynamic modelling).

Air pollution risks could be compared with other effects in society, e.g. passive smoking. What would be an acceptable risk to society? Cost curves could be used to determine an appropriate level of expenditure for a given risk.

3.4.3 Scale

Modelling at regional scale needs to link to modelling at a hemispheric scale for many air pollution issues.

The group discussed the need for more links between regional modelling and local scale modelling. City-Delta has provided a good approximation of local scales, enabling RAINS to address urban background concentration for cities of around 200,000 population. However, it is not easy to see how to get finer resolution e.g. at street canyon level. The need for such a capability is open to discussion. The City-Delta relationships may need further validation by national experts in the longer term as their use develops. Plans to develop a meso-scale EMEP model for the UK will be also be useful in making the modelling more robust.

3.4.4 Source categories

The EMEP model is still not able to capture all PM components (e.g. secondary organic aerosols), making validation difficult. This means these PM components are not addressed in scenarios. Finding solutions to these issues is likely to take a few years, so the current approach to policy development will need to continue for now.

Implementation of the new EMEP Monitoring Strategy at level 2, which will deliver chemical speciation data on a regional scale, will be crucial to delivering the evidence base for model development. There is also a need for more total $PM_{2.5}$ monitoring in urban areas to help define exposure. Linking capabilities between urban and regional stations (twinning) will be valuable in defining source contributions. Personal exposure is also a research need to help relate real exposures to measured ambient levels.

A lot of work is required to improve both the methodologies for, and quality assurance of, primary PM inventories. Countries need to make a bigger effort to construct accurate inventories, aided by more effective support and guidance from international organisations. The group was not clear on whether emission factors, particularly for $PM_{2.5}$, are good enough at present, and this question will be a key task for TFEIP. If they are not, reliable inventories will not be available for some time.

PM inventories need to be a clear priority for TFEIP, to help Member States respond to the desire for national $PM_{2.5}$ inventories to be included within the review of the EU NECD. Speciated data are also needed, but this should probably be delivered separately (either by an expert group or contract – perhaps using IIASA expertise).

The ARTEMIS project will help identify real world road transport emissions. Effort is now required for other areas, particularly shipping and aviation, where European and global inventories exist, but are in need of further development.

Until inventories and modelling improve, there are arguments for basing controls on sector specific measures rather than optimised IAM outputs. Regardless, further IAM development is also required, including research on ‘no regret’ measures and decision taking in conditions of uncertainty.

3.4.5 Air Quality Target Setting

There is no doubt that IAM is a very useful tool and input to the policy process, but it is important to avoid the idea that IAM results can be translated directly into policy proposals.

The group did not come to a firm conclusion on the most appropriate approach to address non-threshold pollutants, and the targeting of background levels instead of, or as well as, hotspots, but several possible variations on a theme were discussed.

An approach based on reducing concentrations or exposures, perhaps using a Population-Weighted Reduction (P-W R) metric, was suggested. Some felt there may be an equity issue if abatement is focused on particular areas, and it might be better to use an approach based on reducing background monitoring everywhere. Either approach would be easily amenable to IAM, and would be similar to that already used in the NECD in the determination of O_3 precursor emission ceilings.

There was a discussion on possible indicators for PM for use in target setting. There was a debate on the appropriateness of setting an air quality limit value (LV) for $PM_{2.5}$. Local or even national contributions are typically less than 50% of the observed levels in urban areas. It was argued that effective controls would be better expressed as National Emission Ceilings, perhaps in conjunction with the P-W R or other local concentration gap closure approach. There is the additional difficulty of setting a realistic LV to apply throughout the EU – what is achievable for Milano would be unchallenging for most of the rest of the Union. Black smoke might be a more practical metric for control, but the scientific evidence for its adoption is not sufficient as yet (for instance, there is no dose-response function). PM_{10} may remain a more effective driver of local strategies.

It was noted that the US has already had a similar debate, resulting in a $PM_{2.5}$ air quality standard of $15ug/m^3$. This may have been due to a political imperative to have off-on type answer driving enforcement action. The US system has a useful gradation in possible responses to non-compliance with four levels available to the regulator.

The group agreed that a mixed strategy involving both limit value and gap closure (possibly P-W R) should be explored. The appropriate balance between metrics seeking to maximise efficiency (P-W R) and equity (LV) will be a political decision informed by IAM. As for acidification and eutrophication in the Gothenburg Protocol, the possibility of binding square relaxation should be considered to improve efficiency if a gap closure approach is adopted for human health. Another option would be to set up cost curves to show the costs of improving lifespan by an agreed number of months. This could be driven on either a grid or country basis, and could incorporate a *de minimis* cut off, as adopted for O_3 in the NECD and Gothenburg Protocol. Alternatively the IAM output could be turned back into emission ceilings, using the exposure metric as an indicator for reporting and public information.

The acceptability to countries of any new approach will need to be carefully investigated, with timing and presentation being crucial. Representativeness of monitoring sites for determining population weighted exposure is a separate issue that goes wider than the target-setting debate to include the effectiveness of compliance assessment for any ambient air quality target.

3.4.6 Communication

There are a number of target audiences for communication on IAM: national experts; the wider policy community/politicians; and the public. Effective communication is a highly complex task, with a major risk of IAM being thought of as a black box. Trust will be crucial and will be helped by the peer review process. The IIASA workshop planned for January 2005 will be important for developing understanding in policy community. There is also a need to involve politicians earlier in process to get buy-in and start to develop understanding. Trans-Atlantic cooperation on regular peer review of the tools used for modelling could be helpful.

Will the public be interested, or is it all too complex? A simple leaflet could be a useful resource (building on the conclusions of the 2003 London workshop). Developing easy to understand indicators might also be an effective way of getting public understanding and buy-in. Any initiative needs to be combined with other environmental goals to show the context. It might be helpful to relay information using journalists and local contacts, rather than direct communication from the centre.

It is important to remember that communication is a two-way street – we need to engage, not just sell.

3.5 WG 4A: Energy and Industry

Participants:

Peggy Farnsworth, Chair	Andrzej Jagusiewicz
Alec Estlander, Rapporteur	Christos Malikkides
Jenny Arnell	John Murlis
Jean-Guy Bartaire	Bob Nieuwejaers
Suzie Baverstock	Daniel Sosland
Svante Bodin	Klara Sutlovicova
Åsa Ekdahl	

The group recognized continued emissions of pollutants that contribute to particulate matter, acid deposition and ozone from the energy and industrial sectors.

Thus there is a need to take action for reducing these emissions.

The group discussed general issues related to these sectors and made concrete recommendations to guide any further action.

3.5.1 General issues 1

- Consider long-term environmental quality objectives and indication of associated emission reduction in setting interim goals and developing measures.
- Need to consider synergies between AP measures and climate policies, and those areas where one confounds the other.
- Include hemispherical issues in future policies.
- Consider BAT and environmental quality approach critically, which one guiding, how implement?
- Environmental technology industries important driver, *cf*. ETAP.

3.5.2 General issues 2

- Promote consistency in developing, consolidating and implementing new and existing legislation
- Pace of change in legislative development presents problems for industry, implementing authorities in a number of cases
- Interactions AQ - other legislation to be considered

- Implementing existing legislation identified as issue for new MS:S, some would wish more time
- Industrial investors would prefer more stability
- Non-technical measures to be included in policies (energy efficiency incentives, decoupling, structural changes...)
- Transparency and involvement needed.

Energy Sector	**Issue**	**Recommendation**
Energy policies	Growth rate	Demand side management, new business models and energy services analyses to be included
Energy sources	Wood combustion	Exchange of practices and technical development needed, also semi-ind scale, important source!
Energy measures	Maket based instruments	Explore fees, ET options (NOx fees, combined ET:s, US experience)

Industrial sector	**Issue**	**Recommendation**
Industry emission	VOC:S	Stock-taking of earlier measures (prot, dir, conv:s), then targeted VOC strategies, including products.
Industry policy	SME:s	Increasing role, implement controls coherently
Industry practice	Operations	Benchmarking operations and maintenance on processes, pollution control technology

3.5.3 Detailed considerations

Group members presented the following more detailed considerations on two central issues.

On environmental technology:

> Taking into account the need for pollution prevention at the source, political decision process should encourage further penetration of clean products and technologies on a European scale

A whole mix of policy instruments should be used to remove barriers to application of these products and technologies.

On energy growth rate:

Studies in the US states show than growth in demand for electricity can be substantially reduced by cost-effective investment in energy efficiency, the growth being reduced to as low as zero. Thus there is a need to incorporate efficiency enhancement in energy planning and scenarios.

3.6 WG 4B: Summary Transport (including shipping, aviation, non-road machinery and agriculture)

Chair: Rob Maas, Rapporteur: André Zuber

3.6.1 The problem

Transport and agriculture contribute to emissions of PM (40 percent), VOC:s (40 percent), NOx (60 percent) and NH3 (90 percent). Between the years 2000 and 2020 the emissions are projected to substantially decline for PM, VOC:s and NOx, but remain essentially the same for NH3. The relative contribution of shipping, aviation and agriculture is expected to rise. These emissions contribute substantially to acidification, eutrophication, ground-level ozone and increased level of anthropogenic PM.

An overall analysis {of cost-effective measures} to reach environmental and health targets of the air pollution policies will guide the actual measures to be taken at the EU wide level, national and local level and part of the seas. Also cost of inaction should be assessed. However, a number of observations and recommendations can be made for policy makers:

Research still needed on toxicology and risk to human health (of pm-species) and the biodiversity effects. Source apportionment of different pollutants to address the appropriate sources. Improved emissions inventory especially on non-road machinery and shipping.

3.6.2 Road transport

Road transport is exposing the urban population to high levels of air pollution. City authorities need common guidance (consistent with EU legislation) for local action, such as to introduce low emission zones and different charging schemes to change transport demand as well as to stimulate more environmentally friendly transport system (car sharing, low weight cars etc).

For long range transport demand can be addressed through intra-modal changes by harmonised infrastructure charging schemes and other charging schemes. For freight the environmental effects of heavier and longer vehicles should be analysed as well as the needed road transport network that can accommodate such vehicles, and other aspects such as road safety.

Internalisation of externalities in the transport costs should be applied for all modes.

Legislation has to be continuously updated to keep pace with technical progress on vehicle technology and transport technologies. Fuel independent emission standards for all compounds (including CO2) could stimulate the use of alternative fuels, and hybrids but should lead to the most cost-effective measures.

Early introduction of new euro-standards via subsidies and charges should be stimulated and the EU should guidance how this could be done.

The implementation of EU policies through subsidies and various funds in the transport sector (TEN) and in agriculture (CAP) must be consistent with other EU policies such as achievement of air quality standards (‘cross compliance’).

3.6.3 Shipping

The marine emissions (SOx and NOx) are expected to be larger than land-based emission in the near future: a number of measures are likely to be cost-effective to set in place but the policy instrument for national and local authorities are limited. Nevertheless measures aiming at long term solutions would include EU members ratifying the MARPOL Annex VI in order to amend the protocol for improved emission limit values. Methods to assign emissions to countries have to be developed and agreed in the EU, UNECE and the UNFCCC.

In the short term measures should include both new and old ships. National and local measures could be taken such as incentives to introduce and favour environmentally enhanced ships: port charges, in harbour electricity supplies and trading schemes. Because of the ‘Prisoners dilemma’ it is more effective to take joint action. Possibility to introduce national and EU emissions standards should be considered and depending on the cost-effectiveness introduced in a harmonised way.

3.6.4 Aviation

The contribution of aviation to ozone in Europe is not to be neglected. The emissions of non-LTO phase of flights contribute as much as the LTO phase to the ground-level ozone.

The national authorities can take individually set environmental standards on aviation but can better work together through the ICAO to achieve harmonised standards for aviation. A benchmarking approach could be useful to reduce the emissions from the sector.

Also ground based operations and ground transport to the airport should be considered in an integrated way in assessing the environmental effects and possible measures.

3.6.5 Agriculture

The emissions of NH3 from agriculture are virtually unabated. The national authorities have power to introduce measures, but so far few measures outlined in the ammonia annex in the Gothenburg protocol have been implemented. Awareness-raising of farmers to make more efficient use of nutrients and pesticides is needed to facilitate implementation of measures. Consultants could *e.g.* be financed via the agricultural budget of the EU.

EU legislation such as the IPPC directive can be extended to include cattle farms and other large production units.

Consistency with CAP and “cross compliance”, *i. e.* consistency between different policy areas of the Community also needed.

Trade off and synergies with other environmental problems such as climate gases (CH4 N2O)

And nitrogen leaching to water.

Ammonia reduction should be related to the ambitions for sec PM, acidification and eutrophication, the latter needs to be strengthened to protect nature conservation areas (Natura 2000).

3.6.6 Off-road machinery

Better estimates of numbers of units, sizes, emission factors and fuels used. (Register)

Effective measures could be introduced such as fuel regulation, retrofitting, environmentally related charges.

Building and demolition activities should be done with environmental standards and guidance/requirements set by the financing part (local authorities): The requirements could be backed by guidance from EU.

And don’t forget the snowmobiles.

3.6.7 Most important messages

- Cost-effective approach and internalisation of external costs.
- Division of competence, who should take action. Subsidierity.
- Shipping
- Policies that improve technology and drives innovation

3.7 WG 5: Strategies to solve the local-urban pollution situation. One program for clean air – local, regional and global issues under the same strategy

Chairman: Ducan Laxen Rapporteur: Martin Lutz

Members:

Antonio Bellarin-Denti	Kees Cuvelier	Reinhold Görgen
Gin Luca Gurrieri	Gunnar Jordfald	Menno Keuken
Guido Lanzani	Leendert van Bree	Helga Kromp-Kolb,
Filip Lefebre	Mita Lapi	Federica Moricci
Stephan Jacobi	Finn Palmgren	Ulrik Torp
Kerstin Meyer	Tim Oxley	Kurt Waltzner
Jaroslav Santroch	Kerstin Meyer	Carine Wilhemsen
Laurence Rouil	Marc Rico	Keimpe Wieringa
Gabriela Zanini,	Philippe Tunis	

3.7.1 Introduction:

The Commission has invited the workshop participants to provide answers to a list of open questions relevant for the development of the thematic air quality strategy in Europe. As guidance for the discussions the WG selected those questions it thought were most important in relation to reducing air pollution in urban areas.

The following topics were discussed aimed at providing advice to the Commission:

3.7.2 Questions related to the format of revised air quality standards for PM

a) Given the advice of WHO and the CAFÉ WG on PM what range or level of annual $PM_{2.5}$ would be appropriate proposal for a limit value ?

The reason for raising this question is that the Commission aims at proposing limit values for $PM_{2.5}$ as part of the CAFÉ strategy, which the 6th Environmental Action Programme (6EAP) requires the Commission to present by July 2005.

There was consensus that, as expressed in the 6EAP, a future $PM_{2.5}$ limit value should aim to yield a reduction of health risk as much as reasonably achievable. This was recognised to be especially important for $PM_{2.5}$, as there is no known threshold below which there are no effects. There was a discussion on whether a decision on a $PM_{2.5}$ LV could be made before the revision of the NECD. No agreement could be achieved on this issue of timing and the need to link the revision of the NECD and the proposal for a $PM_{2.5}$ LV.

Quite a number of participants felt unable to provide an answer to the above question, because the future concentration levels of $PM_{2.5}$ depended strongly on the reduction of the secondary PM, which in turn would be determined by the revised NECs. The revision of NECs, however, depends on results of the integrated assessment modelling work by IIASA, which will probably not be available in time for the Strategy. It is for this reason that the Commission has decided to move the revision of the NECD to 2006.

So, it was argued that a robust proposal for a $PM_{2.5}$ limit value could only be derived in conjunction with a proposal for revised NECs, using the cost-effectiveness calculations of IIASA as a basis. Delaying the decision on the $PM_{2.5}$ limit value would also allow more time for development of an approach to supplement the limit value concept, which aims to achieve an effective widespread reduction of PM related health risk (see question (e) below).

On the other hand, the Commission said that sufficient information could be gathered by beginning of 2005, including from IIASA, to allow it to derive a limit value for $PM_{2.5}$. Other participants considered it important to choose a $PM_{2.5}$ limit value primarily on health grounds, not taking into account achievability, thus a decision could be made now. They also expressed doubts over whether the NEC could deliver the expected health improvement, given that the NECD will trigger a reduction of secondary aerosol, which is likely to be less toxic than other combustion related PM components, like elementary carbon and metals.

In terms of what value to choose, and in the absence of reliable adhoc information which could supplement the advice of the CAFÉ Working Group on particulate matter, the group could only refer to the recommendation of the PM Position Paper that an annual mean of 12-20 µg/m³ $PM_{2.5}$ could be an appropriate range to be used as an objective for the integrated assessment modelling underpinning a future proposal for a limit value. If compliance with the limit value is to be required at traffic sites, as currently applies, some working group members thought it would be important to add to IIASA's results (which will only be for urban background sites) an appropriate increment reflecting the $PM_{2.5}$ produced by local traffic.

In this context, the group also discussed the question of the additional benefit of a supplementary 24h limit value. It was accepted that most attention should be given to annual mean concentrations, as WHO evidence showed greater effects associated with long-term exposure. The group wished to see a 24-hour LV retained, but were unsure about the value of linking this to short-term measures, as currently required when the alert level is exceeded. A member of the group reported that even where stagnant meteorological conditions in Northern Italy meant that local sources dominated, short term measures were not very effective.

The group recognised that a 24-hour LV helped with reporting data to the public and they supported durable measures aimed to reduce short-term exposure.

Potential conflicts with the annual LV in terms of stringency should be avoided, although if the LVs are to be tightened then the focus should be on making the annual mean more ambitious.

b) Should the existing NO2 limit value be maintained?

The group did not discuss this question in any detail. It recognised that WHO has endorsed keeping the current limit value. As one reason given by WHO for retaining this limit value was that it was a marker for traffic pollution, several group members expressed the need for a marker that would better reflect the health impact of traffic pollution, e.g. elementary carbon or particle number.

c) Assuming $PM_{2.5}$ will get the focus, what should happen with PM_{10}?

The group agreed that the coarse fraction should still be controlled given the evidence of health effects (as concluded by WHO).

Unlike $PM_{2.5}$, controlling the coarse fraction requires action mainly on a local level. So, in order to enhance transparency concerning the requisite administrative level of action, it might be useful to set a separate objective for the coarse fraction rather than having limit values for $PM_{2.5}$ and PM_{10} side by side (with $PM_{10,}$ the focus on the coarse fraction is diluted by the inclusion of the $PM_{2.5}$ fraction within the PM_{10} measure).

With reference to the Commission's Position Paper on PM, it was thought by some group members that a target value for PM_{10} or the coarse fraction would be more appropriate than limit value, given the limited scope for measures against non-exhaust traffic emissions, which largely fall into the coarse fraction. But no consensus could be reached, because others took the view that a legally binding standard was needed to ensure control of fugitive industrial emissions of coarse PM.

d) How to frame AQ standards given the huge differences in exposure between different regions/MS and between hot spots and urban background?

In order to avoid an excessive economic burden on the most polluted areas, where it may be difficult to meet a stringent LV, while at the same time not requiring measures to reduce health risk elsewhere, in areas below the LV, a concept was introduced that required everywhere a population-weighted percentage reduction of current concentration levels towards a defined regional background level. This approach would maximise the health benefits for pollutants with no threshold for effect.

The group discussed how such an approach could work. It was emphasised that the approach should be kept as simple as possible. This may require population weighting to be avoided.

In conclusion the group endorsed the idea of a relative reduction in exposure, as defined by measured concentrations, as a supplement to the exiting approach of a flat limit value, which should, though, be kept, in order to ensure a minimum standard of protection of people in the most polluted areas.

3.7.3 Are there changes in assessment (monitoring and modelling) required?

In order to facilitate better assessment of the causes of health effects of PM, minimum requirements should be set for monitoring different compounds and metrics of PM, notably $PM_{1.0}$ and elemental carbon. More measurements of particle numbers should also be encouraged.

The idea of setting up a limited number of super-sites was endorsed. Such sites would need to be at locations representative of the urban background, of typical traffic hotspots and, as a supplement to the EMEP network in the regional background. Consistent and harmonised criteria and requirements are necessary for instrumentation and operation of these sites.

3.7.4 Changes in the ozone Directive needed?

There was a limited discussion on ozone. The following specific points were made:

- there should be a review of the list of VOC species

- attempts should be made to take account of the growing evidence that no threshold exists for health effects of ozone.

- more research on possible synergistic effects of ozone and PM may be warranted.

- the interdependence between average ozone levels and conversion of NO into NO_2 should be examined.

- the effectiveness of short-term measures should be evaluated.

- the AOT40 indicator for effects on vegetation and forests should be reviewed and consideration given to the flux-based approach and to the introduction of factors to recognise the variation in uptake of ozone in different geographic/climatic regions.

3.7.5 Institutional question, here concerning the involvement of cities in the strategy development process – CLRTAP and CAFÉ

There was broad consensus that exchange of (best) practices between local/regional authorities should be enhanced. So, the Commission was encouraged to include in its CAFÉ strategy mechanisms to exchange information including organising more frequent workshops.

For the CLRTAP, the TFIAM and TFMM should invite cities to participate in their work, in particular where this concerns resolving the urban scale with appropriate modelling tools, data on emissions, control options and costs.

3.7.6 Which measures should be specifically considered in CAFÉ strategy and review of the Gothenburg protocol?

The following list is thought to be most important from an urban perspective:

- Maritime emission in harbours and near relevant shipping routes

- Stricter emission standards for off road machinery

- Future EURO V/VI standards should be as strict as possible, taking the recommendation of the UBA as a basis

- make sure that emission test cycles reflect the full range of real world driving conditions, especially those in urban areas, in order to reduce uncertainties in the projections of vehicle emissions

- when setting future vehicle emission standards, put more attention on the NO2/NOx ratio of diesel vehicles emissions, in order to avoid loosing NOx control benefits in terms of reduced NO2 pollution

- more focus on the particle number with respect to setting future particle emission standards for vehicles

- tightening of vehicle inspection requirements

- explore the options to require retrofit of emission control technology to vehicles, which exceed a certain age or do not fulfil certain emission standards

- strengthen links to the Agenda 21 process and to the EU thematic strategy on the urban environment

- EU funding of road infrastructure must be based on sustainability, i.e. to avoid investment in road capacity, so that environmental objectives cannot be met;

- internalisation of environmental costs into road transport costs (according to the white paper on transport), aimed to shift transport towards less polluting modes

- acceleration of the liberalisation of rail transport in the EU, in particular harmonisation of technical requirements for the operation of cross-border rail services for freight transport (technical terms)

- air quality objectives should be integrated with the development of a European Climate change strategy

3.7.7 Future needs in terms of research, data, information and modelling tools

The group did not give emphasis to discussion of this item, but the following issues have been noted:

- studies to assess the exposure and health impact in urban areas
- development of better methods for source attribution
- quantification and abatement of non-exhaust PM, in particular resuspension and abrasion of road surface, tires and brakes

3.8 WG 6: Hemispheric Air Pollution

Chair: Oystein Hov
Rapporteu: Frank Raes

3.8.1 Why an interest in hemispheric air pollution?

There is scientific evidence that conventional air pollutants such as ozone, particulate matter, POP's, which are considered in regional programmes such as CAFÉ and CLRTAP, also travel long distances and can be transported from one continent to another.

Evidence has been presented in three lectures during the workshop, i.e. by Tarasson, Fowler and Hov. A recent book also summarizes the evidence: "Inter-continental transport of air pollution" by A. Stohl (Ed.) Springer 2004.

The group points out that the evidence is fundamentally based on long term air pollution monitoring programmes such as EMEP. Recently, observations from space have shown inter-continental transport of e.g. desert dust.

As emissions of the relevant pollutant are reduced within Europe and North America (NA), emissions arising from outside the area will be an increasing component of the overall problem. In some cases the issue is becoming so significant as to point to the need for policy action both inside and outside Europe + NA, if adequate progress within Europe + NA is to be achieved.

The group however points out that Europe and NA are still a major emitters, and that its pollutants have impacts downwind. Europe pollutants, e.g. are exported to sensitive areas such as the Arctic and the Siberian Boreal forest.

The group further points out that the major impacts of conventional air pollutants are close to where the emissions are. This should be remembered in particular when discussing how pollution from S.E. Asia might impact on the US or Europe.

Since conventional air pollutants travel on a hemispheric scale, it is needed to look not only at their effects on human health and ecosystems, but to consider also effects on climate. Climate indeed responds more to disturbances at regional and global scales.

3.8.2 Air pollutants for which strategies beyond domestic ones might be needed

The group identified a range of pollutants for which hemispheric transport is already significant (see Table), and for which further control strategies beyond domestic emissions controls might be required.

Hg and POP's travel travel long distances and become a global problem because they go through cycles of evaporation, condensation, deposition, re-evaporation, … and therefore can "hop" from warm to colder areas.

Current and projected trends in ozone precursors in the northern hemisphere contribute significantly to background ozone concentrations in Europe, North America and Asia.

Today two thirds of the O3 precursors are originating in Europe and NA, one third in S.E. Asia. Within a decade the ratio might be half half.

Methane (CH4) is a "fuel" for ozone production which is globally present. Non-methane hydrocarbons (NMHC) are consumed in regional plumes down-wind the continents. An important issue is that the occurrence of oxidized nitrogen, the "catalyst" in ozone production, is becoming a more wide spread phenomenon. Even when emissions in Europe and NA have been decreasing, the emissions from ships have been increasing, and might dominate to sources on land within a decade.

Ship emissions of sulphur (and most probably of carbonaceous particles and particulate matter in general, although no long-term monitoring data exist to support this) also contribute substantially to concentrations and deposition in Europe and limit the effectiveness of current control measures.

Mineral dust from deserts or arid areas travels long distances and may lead to exceedances of PM standards, e.g. in Southern Europe.

	Rg	Hs	Gl	issue	policy frameworks
Hg, POP	X	X	X		UNECE/UNEP
heavy metals, PAH	X	X			UNECE/UNEP
CH4, CO >bg O3	X	X	X		UNECE/UNFCCC
NMHC >bg O3	X	X			
oxidized N, PAN >bg O3	X	X		shipping	UNECE/IMO
reduced N	X				
particulate matter	X	?		shipping	UNECE/IMO
SO2, sulfate	X	X		shipping	UNECE/IMO
BC/OC	X	?		shipping	UNECE/IMO
mineral dust	X	X		desertification	

Rg: regional problem, Hs: hemispheric problem, Gl: global problem

3.8.3 Scientific and structural issues

The group identified the following scientific issues that should be addressed to better understand the importance of hemispheric transport of pollutants and its effects:

- quantification the inter continental fluxes and the budgets of individual continents, i.e what is emitted, produced, deposited, imported and exported.
- quantification of the strength of ship emissions and understand their processing in the marine environment
- boundary layer – free troposphere exchange and role of clouds in atmospheric long-range transport

- interaction of air pollution with marine and terrestrial bio-geochemical cycles
- effects of climate change (e.g. desertification, heat waves, etc.) on air pollution and vice versa, the effect of conventional air pollutants (ozone, particlec, ..) on climate.

These issues are addressed in a number of international programmes under the International Geosphere-Biosphere Programme (IGBP), such as IGAC, ILEAPS, and SOLAS.

Closer to the policy making arena scientific assessment programmes such as EMEP (CLRTAP) and IPCC (FCCC) should make use of each others experiences in the area of hemispheric and global air pollution.

The group believes the assessment of hemispheric air pollution would greatly benefit from a better access to tools that are available but dispersed among research groups and organizations. These tools include:

- emission inventories,
- chemistry transport models,
- monitoring stations (in particular coastal and mountain stations)
- an integrated monitoring programme such as proposed by IGOS/IGACO

Such access and integration is now being facilitated by the Network of Excellence ACCENT, funded by DG RTD.

3.8.4 Institutional issues

For POPs and Hg global action is already being taken through UNEP and this is linked to the UNECE process. It is important to continue this collaborative work.

The regulation of methane is dealt with under the UN Framework Convention on Climate Change (FCCC). Because of its importance for background ozone a dedicated coordination re. CH4 emissions reductions with the UN-ECE might be effective. The regulation of atmospheric emissions from ships in international waters is only slowly addressed under the International Maritime Organization (IMO). Links with UN-ECE exist but should be made more effective (see Table)

A relationship between air pollution and climate change is obvious: they have common sources (fossil fuel burning, agriculture, …), conventional air pollutants affect climate, climate change affects air pollution, both policy frameworks are eventually concerned about reducing effects on humans and ecosystems.

The group recommends that further links between UNECE and UNFCCC should be developed, considering the commonalities and differences. As concrete steps the group sees:

- great potential for exchange of experiences between the two scientific assessment programmes, EMEP and IPCC (see above)

- the role of cost-effectiveness studies (integrated assessment) as a driver for integrating air pollution and climate change policies.

In general, the group believes that the UNECE has a good position to take the lead in activities regarding hemispheric and global air pollution issues. However, the current work programme of the UNECE/CLRTAP is not adequate for it. The nature of the Convention will need to be adapted if is to be fully relevant to hemispheric issues. Options might include:

- strengthen collaboration and joint action with other States or regional networks (e.g. EANET, UNEP,)
- opening the Convention to other States outside the UNECE region.

The group recommends that UN-ECE should establish a *Task Force on Hemispheric Transport*, e.g. under EMEP. The task of this task force would be to

- further develop the scientific basis
- engage in capacity building and discuss the EMEP "acquis" in particular with partners in S.E. Asia,

3.8.5 Appendix: Answers to specific questions raised by EU policy makers

- Should changes be proposed in monitoring requirements?
    - ➢ Expand EU monitoring requirements from urban to regional and coastal areas and hemispheric background (mountains)
- What about "supersite" monitoring of PM?
    - ➢ Strong support: combine gas and aerosol. Refer to the new EMEP monitoring strategy
- Any changes to 3rd Daughter Directive on Ozone?
    - ➢ Implement a better balance between urban and background monitoring
- Main research needs for the period 2005-2015 in atmospheric pollution in the EU and in the world?
    - ➢ See main text above
    - ➢ Investigation of hemispheric transport and effects of toxic substances
- Which measures should we specifically look into? Why?
    - ➢ Not just end-of-pipe technologies, new technologies, non-technical solutions, taxation
- Ideas for reducing ship emissions?
    - ➢ Reduce sulphur in fuel
    - ➢ Reduce NOx (SCR)

- Consider different levels of legislation: harbour, coastal areas, open seas
    - Improve IMO / UN-ECE relationships
- Given that *hemispheric pollution* is becoming increasingly important, what would be the pros and cons of introducing a NEC ceiling for methane?
    - Only pros (GHG, O3, cost) , EU leadership
- What, if anything, should we say about the institutional framework to control transboundary air pollution given:
    - There is a lack of an effective institutional framework (see main text for proposals)
- What would be your three favourite questions for web consultation
    - Should the EU take a lead in solving hemispheric, global air pollution problems?
    - Do you agree with the EU's focus on competitiveness rather than environment?
    - How much would you like to pay per month not to die 6 to 9 months earlier?
- What about using economic instruments, like (national) taxation/charging or (either national or EU-level) emission trading
    - OK as long as they do not reduce the environmental benefits
- Should the Thematic Strategy encourage, discourage or be neutral?
    - encourage

APPENDIX A - Agenda

<u>Monday 25 October 2004</u>

13.00-13.15 Welcome and general introduction. Lars Ekecrantz, Sweden

13.15-18.00 Plenary session 1 Chairman: Rob Maas, The Netherlands

- EU thematic strategy on air pollution. *Matti Vainio, EU-CAFÉ*
- North American Strategies. *Bill Harnett, US EPA, United States*
- Scenarios and strategies for 2020. *Markus Amann, IIASA, Austria*

14.50-15.10 Coffee

- Abatement programs in urban areas and their interlinkage to EU strategies. *Martin Lutz, Senate Department of Urban Development, Berlin, Germany*
- European air pollution trends 1980-2010. *Leonor Tarrason, EMEP/MSC-W Norwegian Meteorological Institute, Norway*
- The CAFE cost – benefit analysis. *Mike Holland, EMRC, UK*
- New concepts and ideas in air pollution strategies. *Richard Ballaman, Swiss Agency for the Environment*

16.45-17.00 Refreshments

- Assessment of health effects in an air pollution strategy. *Jürgen Schneider, UBA, Austria*
- New developments on air pollution effects to ecosystems – Ozone and acidification *Jean-Paul Hettelingh, RIVM, the Netherlands*
- Will recent scientific findings redirect policy? *Oystein Hov, Norwegian Meteorological Institute, Norway*

18.20- 18.45 Planning for working groups

19.30 Dinner

<u>Tuesday 26 October 2004</u>

08.30-10.00 Working groups. Session 1

The working groups will be asked to discuss the scientific basis and policy options and make proposals with regard to recommendations and conclusions for an European air pollution control strategy. They will be asked to respond to certain questions given to them.

10.00-10.30 Coffee

10.30-12.00 Plenary session 2. Chairman: Peggy Farnsworth, Canada

- Some key results with calculations with the MERLIN model. *Rainer Friedrich, Universität Stuttgart, Germany*
- Reviews of the RAINS model. *Peringe Grennfelt, Swedish Environmental Research Institute, Sweden.*
- The assessment of European control measures and the effects of non-linearities. *David Fowler, Centre of Ecology and Hydrology, UK*

12.00- 13.00 Lunch

13.00-18.30 Working groups. Session 2

Workshop dinner - Hosted by the European Commission

<u>Wednesday 27 October 2004</u>

08.30- 10.00 Working groups. Session 3

10.00-10.30 Coffee

10.30- 12.45 Plenary session 3: Chairman: Martin Williams, UK
Rapp: John Munthe, Sweden

Reports from the working groups. Conclusions and recommendations from the workshop. A discussion of and outline of an European air pollution strategy/policy.

12.45-13.00 Close of workshop
Concluding remarks. *Harald Dovland, Ministry of Environment, Norway*

13.00- 14.00 Lunch

Working group themes
The working groups will be asked to discuss the scientific basis and policy options and make proposals with regard to recommendations and conclusions for an European air pollution control strategy for short, medium and long term perspectives. They will also be asked to discuss the future development of inventories (emissions, critical loads etc) and research in the area of air pollution. They will then be asked to respond to certain questions given to them**.**

1. Health and environmental effects: The impact of different alternative abatement strategies.

2. Cost-benefit analysis – use the results to support a cost effective European air pollution strategy.

3. Integrated assessment modelling. Discussion of uncertainties and robustness. Use the results for an European air pollution strategy.

4. Sector issues: Clean cars and ships. Liberalisation of the energy market. Nuclear phase out and renewable energy strategies. Carbon trading. Post Kyoto. The CAP reform.

5. Strategies to solve the local-urban air pollution situation. One program for clean air – local, regional and global issues under the same strategy.

6. Strategies to solve the hemispheric air pollution problem. One program for clean air – local, regional and global issues under the same strategy.

APPENDIX B – List of Participants

Workshop on Review and Assessment of European Air Pollution Policies
25-27 October 2004, Gothenburg, Sweden

Altdorfer, Francis ECONOTEC Rue du Delta 35 BE-7000 Mons Belgium T. +32 65 31 63 43 F.+ 32 65 84 30 91 francis.altdorfer@econotec.be	Amann, Markus International Institute for Applied Systems Analysis (IIASA) Schlossplatz 1 AT-2361 Laxenburg Austria T. + 43 2236 807 432 F.+ 43 2236 807 533 amann@iiasa.ac.at
ApSimon, Helen Imperial College London Department of Environmental Science and Technology Prince Consort Rd London SW7 2AZ United Kingdom T. + 44 171 594 9266 F.+ 44 171 594 9292 h.apsimon@imperial.ac.uk	Arnell, Jenny IVL Swedish Environmental Research Institute Box 5302 SE-400 14 Gothenburg Sweden T. + 46 31 725 62 35 F.+ 46 725 62 90 jenny.arnell@ivl.se
Ball, Michael University of Karlsruhe, French-German Institute for Environmental Research (DFIU/IFARE) Hertzstrasse 16 DE-76187 Karlsruhe Germany T. + 49 721 608 4467 F.+ 49 721 758909 michael.ball@wiwi.uni-karlsruhe.de	Ballaman, Richard Swiss Agency for the Environment Forest and Landscape Air Pollution Control Division CH-3003 Bern Switzerland T. + 41 31 322 64 96 F.+ 41 31 324 01 37 richard.ballaman@buwal.admin.ch
Ballarin Denti, Antonio Department of Mathematics and Physics Catholic University Via Musei 41 IT-25121 Brescia Italy T. + 39 030 2406 714 F.+ 39 030 2406742 a.ballarindenti@dmf.unicatt.it	Bartaire, Jean-Guy EDF, Energy Branch 1 Place Pleyel FR-93282 Saint-Denis Cedex Frace T. +33 1 43694461 F.+33 1 43693487 jean-guy.bartaire@edf.fr
Baum, Ellen Clean Air Task Force 269 White Road ME 04008 Bowdoinham USA T. + 1 207 666 5676 F.+ 1 207 666 8841 ebaum@catf.us	Baverstock, Suzie UNICE Group HSSE BP plc, Chertsey Rd Sunbury-on-Thames TW16 7LN Middlesex United Kingdom T. +44 19 32 768 301 F. baverssj@bp.com
Belhaj, Mohammed IVL Swedish Environmental Research Institute Box 5302 SE-400 14 Gothenburg Sweden T. + 46 31 725 62 25 F.+ 46 725 +62 90 mohammed.belhaj@ivl.se	Bertills, Ulla Swedish Environmental Protection Agency SE-10648 Stockholm Sverige T. +4686981502 F.+4686981585 ulla.bertills@naturvardsverket.se

Bodin, Svante Ministry of the Environment SE-10333 Stockholm Sweden T. +46 8 4052038 F.+46 8 140987 svante.bodin@environment.ministry.se	Borne, Katarina Göteborg University Box 460 SE-40530 Gothenburg Sweden T. + 46 31 7731957 F.+46 31 7731986 katarina@gvc.gu.se
Borowiak, Annette European Commission, DG-JRC Ispra Emissions and Health Unit Via E. Fermi, 1, T.P 441 IT-21020 Ispra (VA) Italy T. + 39 0332 789956 F.+ 39 0332 785869 annette.borowiak@jrc.it	Brignon, Jean-Marc INERIS Parc Technologicue Alata BP2 FR-60550 Verneuil en Halatte France T. + 33 3 44 55 61 29 F.+ 33 3 44 55 68 99 jean-marc.brignon@ineris.fr
Bull, Keith UNECE Room 346 Palais des Nations CH-1211 Geneva Switzerland T. + 41 22 917 2354 F.+ 41 22 917 0621 keith.bull@unece.org	Calaminus, Bernd University of Karlsruhe, French-German Institute for Environmental Research (DFIU/IFARE) Hertzstrasse 16 DE-76187 Karlsruhe Germany T. + 49 721 608 4582 F.+ 49 721 608 45 82 bernd.calaminus@wiwi.uni-karlsruhe.de
Celard, Bruno EUROPIA (European Petrolium Industry Association) Boulevard du Souverain, 165 BE-1160 Brussels Belgium T. + 32 2 566 9102 F.+ 32 2 566 9111 bruno.celard@europia.com	Cohen, Armond Clean Air Task Force 18 Tremont Street Suite 530 MA 02108 Boston USA T. + 1 617 624 0234 F.+ 1 617 624 0230 armond@catf.us
Cuvelier, Kees JRC- IES TP280 IT-21020 Ispra (VA) Italy T. + 39 0332 785 075 F.+39 0332 786 291 kees.cuvelier@jrc.it	Dovland, Harald Ministry of the Environment P.O. Box 8013 Dep. NO-0030 Oslo Norway T. + 47 22 245995 F.+47 22 242755 harald.dovland@md.dep.no
Dutchak, Sergey Meteorological Synthesizing Center “East” Ul. Arhitektor Vlasov, 51, RU-117393 Moscow Russia T. +7 095 1200241 F.+7 095 1252409 sergey.dutchak@msceast.org	Ekdahl, Åsa EUROFER Rue du Noyer 211 BE-1000 Brussels Belgium T. + 32 2 738 79 33 F.+ 32 2 738 79 68 a.ekdahl@eurofer.be
Ekecrantz, Lars Ministry of the Environment Stockholm Sweden	Eliassen, Anton Norwegian Meteorological Institute P.O Box 43 Blindern NO-0313 Oslo Norway T. + 47 22 96 30 00 F.+ 47 22 96 30 50 anton.eliassen@met.no

Erisman, Jan Willhelm ECN P.O. Box 1 1755 ZG Petten The Netherlands T. +31 224 564155 F.+31 224 568489 erisman@ecn.nl	Estlander, Alec Finnish Environment Institute (SYKE) Environment Management Division P.O Box 140 FIN-00251 Helsinki T. + 358 9 40 300 423 F.+ 358 9 40 300 491 alec.estlander@ymparisto.fi
Farnsworth, Peggy Transboundary Air Issues Branch Environment Canada 351 St. Joseph Boulevard, 11th Floor QC K1A 0H3 Gatineau Canada T. (819) 994-9535 F.(819) 994-3479 peggy.farnsworth@ec.gc.ca	Fenger, Jes National Environmental Research Institute Frederiksborgvej 399 DK-4000 Roskilde Denmark T. +45 4630 1105 F.+ 45 4630 1214 jfe@dmu.dk
Ferreira, Francisco Cardoso Faculdade de Ciencias e Tecnologia / UNL DCEA / Quinta da Torre PT-2829-516 Caparica Portugal T. + 351 21 2948374 F.+ 351 21 2948374 ff@fct.unl.pt	Fiala, Jaroslav Czech Hydrometeorological Institute Na Sabatce 17 CZ-143 06 Prague 4 Czech Republic
Folkert, Rob National Institute for public Health and the Environment P.O Box 1 NL-3720 BA Bilthoven The Netherlands T. + 31 302 743831 F.+ 31 302 744433 rob.folkert@rivm.nl	Forsberg, Bertil Umeå University YMK SE-90187 Umeå Sweden T. + 46 90 7852751 F.+46 90 7852456 bertil.forsberg@envmed.umu.se
Fowler, David Centre for Ecology and Hydrology Bush Estate, Penicuik Midlothian EH26 0QB United Kingdom T. +44 (0)131 445 4343 F.+44 (0)131 445 3943 dfo@ceh.ac.uk	Friedrich, Rainer IER Universitaet Stuttgart Hessbruehlstr 49 A DE-70565 Stuttgart Germany T. + 49 711 7806112 F.+49 711 7803953 rf@ier.uni-stuttgart.de
Gregor, Heinz Detlef Federal environment Agency Bismarckplatz 1 DE-14193 Berlin Germany T. + 49 30 8903 3846 F.+ 49 30 8903 3104 heinz-detlef.gregor@uba.de	Grennfelt, Peringe IVL Swedish Environmental Research Institute P.O Box 5302 SE-40014 Gothenburg Sweden T. + 46 31 725 62 34 F.+ 46 31 725 62 90 grennfelt@ivl.se
Gurrieri, Gian Luca Regione Lombardia Via Stresa, 24 SE-20125 Milan Italy T. + 39 02 6765 5461 F.+ 39 02 6765 6912 gian_luca_gurrieri@regione.lombardia.it	Görgen, Reinhold German Ministry for Environment Postfach 120629 DE-53048 Bonn Germany T. + 49 1888 305 2430 F.+ 49 1888 305 2402 reinhold.goergen@bmu.bund.de

Hansson, Hans-Christen ITM Stockholm University SE-106 91 Stockholm Sweden T. + 46 8 674 72 90 F.+ 46 8 674 76 39 hc@itm.su.se	Harmens, Harry Centre for Ecology and Hydrology, Bangor Orton Building, Deiniol Road Bangor, Gwynedd LL57 2UP United Kingdom T. + 44 1248 370045 F.+ 44 1248 355365 hh@ceh.ac.uk
Harnett, Bill U.S. Environmental Protection Agency Research Triangle Park NC 27711 USA T. +1 919-541-4979 F.+ 1 919-541-4979 Harnett.Bill@epamail.epa.gov	Hettelingh, Jean-Paul RIVM, the Netherlands P.O. Box 1 3720 BA Bilthoven The Netherlands T. +31-30-2743048 F.+31-30-2744435 jean-paul.hettelingh@rivm.nl
Hjorth, Jens European Commission - DG Joint Research Centre Via E Fermi, 1 IT - 21020 Ispra Italy T. + 390332789076 F.+ 390332785466 jens.hjorth@jrc.it	Holland, Mike EMRC 2 New Buildings, Witchurch Hill RG8 7PW Reading United Kingdom T. + 44 118 984 3748 F.+ 44 118 984 3748 mike.holland@emrc.co.uk
Hov, Oystein Norwegian Meteorological Institute P.O.Box 43 NO-0313 Blindern Norway T. +47 22963360 F. oeh@nilu.no	Jacobi, Stefan European Commission DG Environment Avenue de Beaulieu 9, 6/122 BE-1160 Brussels Belgium T. + 32 2 29 67240 F.+ 32 2 29 69554 Stefan.jacobi@cec.eu.int
Jagusiewicz, Andrzej Department of Monitoring UL. WAWELSKA 52/54 PL-00-922 WARSZAWA Poland T. 022/825 41 29 F. a.jagusiewicz@gios.gov.pl	Jimenez Mingo, Jose Maria European Commission, DG-JRC Ispra Institute of Environment and Sustainability, Emission and Health Unit Via E. Fermi, 1, T.P 441 IT-21020 ISPRA (VA) Italy T. + 39 0332 786223 F.+ 39 0332 785869 jose.jimenez@jrc.it
Johannessen, Tor Norwegian Pollution Control Authority P.O Box 8100 Dep. NO-0032 Oslo Norway T. + 47 22 57 34 87 F.+ 47 22 67 67 06 tor.johannessen@sft.no	Johansson, Matti United Nations Economic Commission for Europe Bureau 350, Palais des Nations CH-1211 Geneva Switzerland T. + 41 22 917 2358 F.+ 41 22 917 0621 matti.johansson@unece.org
Jordfald, Gunnar Norwegian Institute for Air Research NILU P.O Box 100 NO-2027 Kjeller Norway T. + 47 63 89 80 00 F.+ 47 63 89 80 50 gj@nilu.no	Karlsson, Per-Erik IVL Swedish Environmental Research Institute P.O Box 5302 SE-400 17 Gothenburg Sweden T. + 46 31 725 62 0 F.+ 46 31 725 62 90 pererik.karlsson@ivl.se

Keuken, Menno TNO Knowledge for business P.O. Box 6050 NL-2600 JA Delft The Netherlands T. +31 15 269 69 00 F.+31 15 261 24 03 m.p.keuken@mep.tno.nl	Knudsen, Eva IVL Swedish Environmental Research Institute Box 5302 SE-40014 Gothenburg Sweden T. + 46 725 62 26 F.+ 46 725 62 90 eva.knudsen@ivl.se
Kromp-Kolb, Helga BOKU- University, Vienna Tuerkenschanzsstrasse 18 AT-1180 Vienna Austria T. + 43 1 470 58 28 16 F.+ 43 1 470 58 28 61 helga.kromp-kolb@boku.ac.at	Kucera, Vladimir Swedish Corrosion Institute Kräftriket 23 A SE-104 05 Stockholm Sweden T. +46 8 674 17 00 F.+ 46 8 674 17 80 vk@corr-institute.se
Kvaeven, Berit Norwegian Pollution Control Authority P.O Box 8100 Dep NO-0032 Oslo Norway T. + 47 22 57 34 00 F.+ 47 22 67 67 06 berit.kvaven@sft.no	Kyrklund, Titus Swedish Environmental protection agency SE-10648 Stockholm Sweden T. +46 8 695 1146 F. Titus.Kyrklund@naturvardsverket.se
Landrieu, Guy INERIS B.P n2 FR-60550 Verneuil en Halatte France T. +33 3 44556392 F.+33 3 44556899 guy.landrieu@ineris.fr	Langner, Joakim SMHI, Swedish Meteorological and Hydrological Institute Folkborgsvägen 1 SE-601 76 Norrköping Sweden T. +46 11 - 495 80 00 F.+46 11 - 495 80 01 joakim.langner@smhi.se
Lanzani, Guido ARPA Lombardia V.le Restelli 3/1 IT-20124 Milano Italy T. +39 02 69666347 F.+39 02 69666252 g.lanzani@arpalombardia.it	Lapi, Mita Fondazione Lombardia per l'Ambiente Piazza Diaz 7 IT-20123 Milano Italy T. + 39 02 80616150 F.+ 39 02 80616180 mita.lapi@flanet.org
Larsson, Stefan ACEA Rue du Noyer 211 BE-1000 Brussels Belgium T. + 32 2 7387364 F.+ 32 2 738 7310 sl@acea.be	Laxen, Duncan Air Quality Consultants Ltd 12 St Oswalds Road BS6 7HT Bristol United Kingdom T. + 44 117 9741086 F.+ 44 117 946 6271 duncanlaxen@aqconsultants.co.uk
Lefebre, Filip Vito (Flemish institute for Technological Research Boeretang 200 BE-2400 Mol Belgium T. + 32 14 33 68 47 F.+ 32 14 32 27 95 filip.lefebre@vito.be	Lemoine, Sylvie European Solvent Industry Group (ESIG) 4, av E. Van Nieuwenhuyse BE-1160 Brussels Belgium T. + 32 2 722 44 44 F.+ 32 2 722 41 49 sylvie.lemoine@exxonmobil.com

Lindau, Lars Swedish Environmental Protection Agency SE-10648 Stockholm Sverige T. +46 8 698 11 26 F.+46 8 20 29 25 lars.lindau@naturvardsverket.se	Lindskog, Anne IVL Swedish Environmental Research Institute P.O Box 5302 SE-400 14 Gothenburg Sweden T. + 46 31 725 62 11 F.+ 46 31 725 62 90 anne.lindskog@ivl.se
Lithass, Andris Latvian Hydrometeorological Agency Maskavas str.165 LV-1019 Riga Latvia T. + 371 7 032600 F.+ 371 7 145 154 lhma@meteo.lv	Lorenz, Martin Federal Research Centre for Forestry and Forest Products (PCC of ICP Forests) Leuschnerstr. 91 DE-21031 Hamburg Germany T. + 49 40 739 62 119 F.+ 49 40 739 62 480 lorenz@holz.uni-hamburg.de
Lundin, Lars Swedish University of Agricultural Sciences Department of Environmental Assessment P.O. Box 7050 SE-750 07 Uppsala Sweden T. +46-18-673109 F.+46-18-673156 Lars.Lundin@ma.slu.se	Lutz, Martin Senate Department of Urban Development Unit IX D, Air pollution and noise control Bruckenstrasse 6 DE-10173 Berlin Germany T. + 49 30 9025 2338 F.+49 30 9025 2524 Martin.Lutz@SenStadt.Verwalt-Berlin.de
Maas, Rob RIVM-MNP P.O Box 1 3720 BA Bilthoven The Netherlands T. +31 30 274 3529 F. rob.maas@rivm.nl	Malikkides, Christos Industrial Pollution Control Section Department of Labour Inspection Apelli 12 CY-1493 Nicosia Cyprus T. + 357 22405631 F.+ 357 22663788 cmalikkides@dli.mlsi.gov.cy
Marshall, David Clean Air Task Force P.O Box 950 NH 03242 Henniker USA T. + 1 603 428 8114 F.+ 1 603 428 8136 dmarshall@catf.us	Marzuoli, Riccardo Fondazione Lombardia per l'Ambiente Piazza Diaz 7 IT-20133 Milano Italy T. + 39 28061611 F.+ 39 280616180 riccardo.marzuoli@flanet.org
Meyer, Kerstin European Environmental Bureau 33. Bvd de Waterloo BE-1000 Brussels Belgium T. + 32 2 289 1307 F.+ 32 2 289 1099 kerstin.meyer@eeb.org	Mills, Richard The International Union of Air Pollution Prevention and Environmental Protection 44 Grand Parade BN2 9QA Brighton United Kingdom T. +44 (0)1273 878772 F.+44 (0)1273 606626 iuappa@nsca.org.uk
Moldan, Filip IVL Swedish Environmental Research Institute P.O Box 5302 SE-400 15 Gothenburg Sweden T. + 46 31 725 62 31 F.+ 46 31 725 62 90 filip.moldan@ivl.se	Moricci, Federica The agency for Environmental Protection and Technical Services APAT Via Vitaliano Brancati, 48 IT-00 144 Roma Italy T. +39 50072924 F. f.moricci@inwind.it

Moss, Jacob U.S EPA 1200 Pennsylvania Ave. N.W. MC6101A 20460 Washington, D.C. USA T. + 1 202 564 1388 F.+ 1 202 501 0394 moss.jacob@epa.gov	Munthe, John IVL Swedish Environmental Research Institute P.O Box 5302 SE-400 14 Gothenburg Sweden T. + 46 31 725 62 56 F.+ 46 31 725 62 90 john.munthe@ivl.se
Murlis, John European Academies Science Advisory Council EASAC 41, Royal Crescent W11 4SN London United Kingdom T. + 44 20 7602 0161 F.+ 44 20 7603 9165 john.murlis@btinternet.com	Nieuwejaers, Bob AMINAL-Flemish Ministry of Environment Koning Albert II laan 19 BE-1210 Brussels Belgium T. +32 2 553 11 40 F.+ 32 2 553 11 45 bob.nieuwejaers@lin.vlaanderen.be
Nordstrom, Linda M Norwegian Pollution Control Authority Postboks 8100 Dep. NO-0032 Oslo Norway T. + 47 22 57 34 27 F.+ 47 22 67 67 06 lmn@sft.no	Olivotto, Carmelita Environment Canada, Air Pollution Prevention Directorate Transboundary Air Issues Branch 351 St. Joseph BLVD, 11 Floor, Place Vincent Massey K1A 0H3 Hull, Quebec Canada T. + 819 953 4544 F.+ 819 953 8963 carmelita.olivotto@ec.gc.ca
Oudart, Benedicte CITEPA 10, rue du Faubourg Poissonniere FR-75010 Paris France T. + 33 1 44 83 68 83 F.+ 33 1 40 22 04 83 benedicte.oudart@citepa.org	Oxley, Tim Imperial College London Department of Environmental Science and Technology South Kensington Campus London SW7 2AZ United Kingdom T. +44 (0)20 7594 9297 F.+44 (0)20 7594 9266 t.oxley@imperial.ac.uk
Ozola, Daina Ministry of th environment of the Republic of Latvia Environmental Protection department Peldu iela 25 LV-1494 Riga Latvia T. + 371 7026516 F.+ 371 7820442 daina.ozola@vidm.gov.lv	Palmgren, Finn National Environmental Research Insititute Frederiksborgvej 399 P.O. Box 358 DK-4000 Roskilde Denmark T. +45 46301132 F.+45 46301214 fpj@dmu.dk
Panwar, T S TERI (The Energy and Resources Institute) Habitat Place, Lodi Road IN-110003 New Dehli India T. +91 11 24682100 F.+91 11 24682144 tspanwar@teri.res.in	Pignatelli, Tiziano ENEA - Italian Agency for New Technology Energy and the Environment -PROT/ATM Via Anguillarese, 301, S. Maria di Galeria IT-00060 Roma Italy T. + 39 06 30486766 F.+ 39 06 30484318 pignatelli@casaccia.enea.it
Pleijel, Håkan Göteborg University P O Box 100 SE-405 30 Gothenburg Sweden T. +46 31 773 25 32 F. Hakan.pleijel@miljo.gu.se	Post, Lourens CONCAWE Boulevard du Souverain, 165, Floor 3 BE-1160 Brussels Belgium T. + 32 2 566 91 71 F.+ 32 2 566 91 11 lourens.post@concawe.org

Raes, Frank European Commission DG-JRC Ispra Via E. Fermi, 1 IT-21020 Ispra (VA) Italy T. + 39 0332 789958 F.+39 0332 785704 frank.raes@jrc.it	Rea, John UK Dept for Environment, Food and Rural Affairs Zone 4/E14 Ashdown House 123 Victoria Street SW1E 6DE London United Kingdom T. + 44 20 7082 8401 F.+ 44 20 7082 8385 john.rea@defra.gsi.gov.uk
Rico, Marc Ministery of ecology and sustainable development Direction de la prévention des pollutions et des risgues 20 avenue de Ségur FR-75302 Paris 07 SP France T. + 33 1 42 19 14 33 F.+ 33 1 42 19 14 71 marc.rico@ecologie.gouv.fr	Robinson, Nicola European Commission Office BU9 6/107 200 rue de la Loi BE-1049 Brussels Belgium T. +32 2 296 1765 F.+32 2 296 9554 nicola.robinson@cec.eu.int
Rouil, Laurence INERIS Direction des Risques Chroniques Parc Technologique Alata - BPn 2 FR- 60550 Verneuil-en-Halatte France T. (+33) 344-55-61-13 F.(+33) 344-55-68-99 Laurence.ROUIL@ineris.fr	Santroch, Jaroslav Czech Hydrometeorological Institute Na Sabatce 17 CZ-14306 Prague 4 Czech Republic T. + 42 0244032400 F.+ 42 0241760603 santroch@chmi.cz
Sarkkinen, Seppo Ministry of the Environment PO Box 35 FIN-00023 GOVERNMENT FINLAND T. + 3589 1603 9685 F.+ 3589 1603 9433 seppo.sarkkinen@ymparisto.fi	Scavo, Kimber United States Environmental Protection Agency Office of Air Quality Planning and Standards Mail code C304-03 NC 27711 USA T. +1 919-541-3354 F.+1 919-541-4028 Scavo.Kimber@epamail.epa.gov
Schall, Oliver Federal Ministry for the Environment Germany Robert-Schuman-Platz 3 DE-53175 Bonn Germany T. + 49 228 3052431 F.+ 49 228 3052402 oliver.schall@bmu.bund.de	Schneider, Juergen Federal Environment Agency - Austria Department of Air Quality Control Spittelauer Laende 5 AT-1090 Vienna Austria T. + 43 1 31304 5863 F.+ 43 1 31304 5400 juergen.schneider@umweltbundesamt.at
Schärer, Bernd Umweltbundesamt Bismarckplatz 1 DE-14193 Berlin Germany T. +49 30 89032368 F.+49 30 89032282 bernd.schaerer@uba.de	Simpson, David EMEP MSC-W, Norwegian Meteorological Institute Chalmers University of Technology, Radio and Space Science Hörsalsv. 11 SE 412 96 Gothenburg Sweden T. +46 (0)31 773 1588 F.+46 (0)31 773 1986 David.simpson@met.no
Sjöberg, Karin IVL Swedish Environmental Research Institute Box 5302 SE-400 14 Gothenburg Sweden T. + 46 31 725 62 45 F.+ 46 31 725 62 90 karin.sjoberg.ivl.se	Skjelkvåle, Brit Lisa Norwegian Institute for Water Research P.O Box 173, Kjelsås NO-0411 Oslo Norway T. + 47 22 18 51 00 F.+ 47 22 18 52 00 brit.skjelkvaale@niva.no

Sliggers, Johan Ministry of Environment Directorate Climate Change & Industry PO Box 30945 NL-2500 6X The Hague The Netherlands T. +31-70-3394401 F.+31-70-3391310 johan.sliggers@minvrom.nl	Soleille, Sebastien INERIS Parc Technologique ALATA BP2 - 60550 Verneuil-en-Halatte France T. +33 (0)3 44 55 64 80 F.+33 (0)3 44 55 68 99 Sebastien.Soleille@ineris.fr
Sosland, Daniel L Environment Northeast P.O Box 313 ME 04856 Rockport USA T. + 207 236 6470 F.+ 207 236 6471 dsosland@env-ne.org	Spranger, Till Umweltbundesamt / Federal Environmental Agency Seecktstraße 6 - 10 13581 Berlin Germany T. +49 (0)30 8903 3155 F. till.spranger@uba.de
Sternhufvud, Catarina IVL Swedish Environmental Research Institute Box 5302 SE-400 14 Gothenburg Sweden T. + 46 31 725 62 10 F.+ 46 31 725 62 90 catarina.sternhufvud@ivl.se	Sutlovicova, Klara Centre for Transport and Energy Centrum pro dopravu a energetiku Jicinska 8 CZ-130 00 Praha 3 Czech Republic T. + 420 274 822 150 F.+ 420 274 816 571 cde@ecn.cz
Sverdrup, Harald Lund University P.O Box 124 SE-221 00 Lund Sweden T. + 46 46-222 82 74 F.+ 46 46-222 82 74 harald.sverdrup@chemeng.lth.se	Tarrason, Leonor Norwegian Meteorological Institute P.O Box 43 Blindern NO-0313 Oslo Norway T. + 47 22 96 33 30 F.+ 47 22 96 30 50 Leonor.tarrason@met.no
Thunis, Philippe European Commission, Joint Research Centre TP280 Via Fermi IT-21020 Ispra (Varese) Italy T. + 39 0332 785670 F.+ 39 0332 786291 philippe.thunis@jrc.it	Torp, Ulrik Danish Environmental Protection Agency Strendgade 29 DK-1401 Copenhagen K Denmark T. + 45 326 60100/ +45 326 60471 F.+ 45 326 60479 ut@mst.dk
Törseth, Kjetil Norwegian Institute for Air Research (NILU) P.O Box 100 NO-2027 Kjeller Norway T. +47 63898158 F.+47 63898050 kt@nilu.no	Urbanus, Jan CONCAWE Boulevard du Souverain 165 BE-1160 Brussels Belgium T. +32 2 566 9163 F.+32 2 566 9181 jan.urbanus@concawe.org
Vainio, Matti European Commission, DG Environment European Commission Enviroment Directorate General BE-1049 Brussels Belgium T. + 32 2 2996138 F.+ 32 2 296 9554 matti.vainio@cec.eu.int	Waltzer, Kurt Ohio Environmental Council 1207 Grandview Avenue, Suite 201 Ohio 43212 Columbus USA T. + 1 614 487 7506 F.+ 1 614 487 7510 kurt@theoec.org

van Bree, Leendert MNP- RIVM P.O Box 1 3720 BA Bilthoven The Netherlands T. + 31 30 274 2843 F.+31 30274 4483 l.van.bree@rivm.nl	Vasiljeva, Tamara Latvian Hydrometeorological Agency Maskavas str.165 LV 1019 Riga Latvia T. + 371-7032601 F.+371-7145154 epoc@meteo.lv
Watkiss, Paul AEA Technology Environment Building 154, Harwell Business Park Didcot OX11 0RA Oxon United Kingdom T. + 44 870 190 6592 F.+ 44 870 190 6327 paul.watkiss@aeat.co.uk	Vesa, Petri Pohjolan Voima Oy P.O Box 40 FIN-00101 Helsinki Finland T. + 358 50 3133 348 F.+ 358 969306407 petri.vesa@pvo.fi
Westling, Olle IVL Swedish Environmental Research Institute P.O Box 5302 SE-400 16 Gothenburg Sweden T. + 46 31 725 62 14 F.+ 46 31 725 62 90 olle.westling@ivl.se	White, Les Les White Associates 42 Bluntswood Road, Haywards Heath RH16 1NB Sussex United Kingdom T. + 44 1444 44 39 19 F. les@leswhiteassociates.com
Vidic, Sonja Meteorological and Hydrological Service of Croatia Gric 3 HR-10000 Zagreb Croatia T. + 385 1 4565 719 F.+ 385 1 4565 630 vidic@cirus.dhz.hr	Wieringa, Keimpe RIVM-MNP P.O Box 1 3720 BA Bilthoven Netherlands T. + 31 30 2744191 F.+ 31 30 2744433 keimpe.wieringa@rivm.nl
Wilhelmsen, Carine Ministry of the Environment - Norway P.O Box 8013 Dep NO-0030 Oslo Norway T. + 47 22 24 58 56 F.+47 22 24 95 63 carine.wilhelmsen@md.dep.no	Williams, Martin Defra Zone 4/D12, Ashdown House 123 Victoria Street SW1E 6DE London United Kingdom T. 020 7082 8374 F. Martin.Williams@defra.gsi.gov.uk
Williamson, Tim National Society for Clean Air and Environment NSCA 44 Grand Parade BN2 9QA Brighton United Kingdom T. + 44 1273 878779 F.+ 44 1273 606626 twilliamson@nsca.org.uk	Wilson, Katherine Entec UK Ltd Windsor House, Gadbrook Business Centre Northwich CW9 7TN Cheshire United Kingdom T. + 44 1606 354 808 F.+ 44 1606 354 810 wilsk03@entecuk.co.uk
Zanini, Gabriele ENEA Via Martiri di Monte Sole 4 IT-40129 Bologna Italy T. +39 051 6098121 F.+39 051 6098675 zanini@bologna.enea.it	Zuber, André European Commission, DG Environment European Commission Enviroment Directorate General BE-1049 Brussels Belgium T. + 32 2 298 4995 F.+ 32 2 296 9554 andre.zuber@cec.eu.int

Ågren, Christer The Swedish NGO Secretariat on Acid Rain P.O Box 7005 SE-402 31 Gothenburg Sweden T. +46-31-7114515 F.+46-31-7114620 cagren@acidrain.org,	Åsen, Eli Marie Ministry of the Environment P.O Box 8013 Dep NO-0030 Oslo Norway T. +47 22 24 60 22 F.+ 4722249563 ema@md.dep.no
Åström, Stefan IVL Swedish Environmental Research Institute P.O Box 5302 SE-400 14 Gothenburg Sweden T. + 46 31 725 62 05 F.+ 46 31 725 62 90 stefan.astrom@ivl.se	

APPENDIX C - Background papers

Workshop on

Review and Assessment of European Air Pollution Policies

Gothenburg, Sweden
October 25-27, 2004

The potentials of alternative fuels and their contribution to the reduction of air pollution and GHG emissions

Contribution to working group theme No. 4:

Clean cars and ships. Liberalisation of the energy market. Nuclear phase out and renewable energy strategies. Carbon trading. Post Kyoto. The CAP reform.

in the context of the activities of DFIU/IFARE

prepared by

Michael Ball, Bernd Calaminus

French-German Institute for Environmental Research (DFIU/IFARE)
University of Karlsruhe
Germany

For further information, please contact:

Michael Ball

Tel.: +49-(0)721/608 4467
Email: michael.ball@wiwi.uni-karlsruhe.de

It is a well known fact that in the coming decades the world is likely to be facing such challenges as the impacts of an increasing global energy consumption and the implications of future shortcomings in the supply of fossil fuels, like oil or natural gas. Many geologists and oil experts predict the world oil production to peak already at around 2010. This will especially concern the transport sector as it depends almost entirely on the supply of oil.

In this context, it is important to evaluate the resources and long-term perspectives of fossil fuels with regard to the development of the global energy and fuel demand. In addition, both air pollutants and greenhouse gases from road transport are expected to increase due to an increasing mobility, especially in developing countries. Road transport in combination with an increasing urbanisation will further give rise to urban air pollution. A more stringent legislation on the composition of the conventional fuels gasoline and diesel with regard to reducing the content of sulphur or aromatics as well as new emission limits for vehicles are pushing the development of both clean cars and fuels; the European Biofuel Directive further aims at promoting the use of biofuels[1]. It is therefore crucial both from an environmental and also resource-economic point of view, to assess the realistic potentials of alternative fuels in the transport sector and the implications for national energy systems that come along with their usage. Alternative fuels can finally also contribute to a diversification of energy supply and help increase energy security.

In Figure 1 an overview about the currently most discussed alternative vehicle fuels and respective generation pathways is presented, distinguishing fossil and renewable primary energy sources. It can be seen, that the possible alternatives are quite numerous, not only with respect to the alternative fuels themselves, but also with respect to the primary energy basis and the chosen production process. The most important primary energy carriers for the production of alternative fuels are, on a fossil basis, *natural gas*, and on a renewable basis, *biomass*.

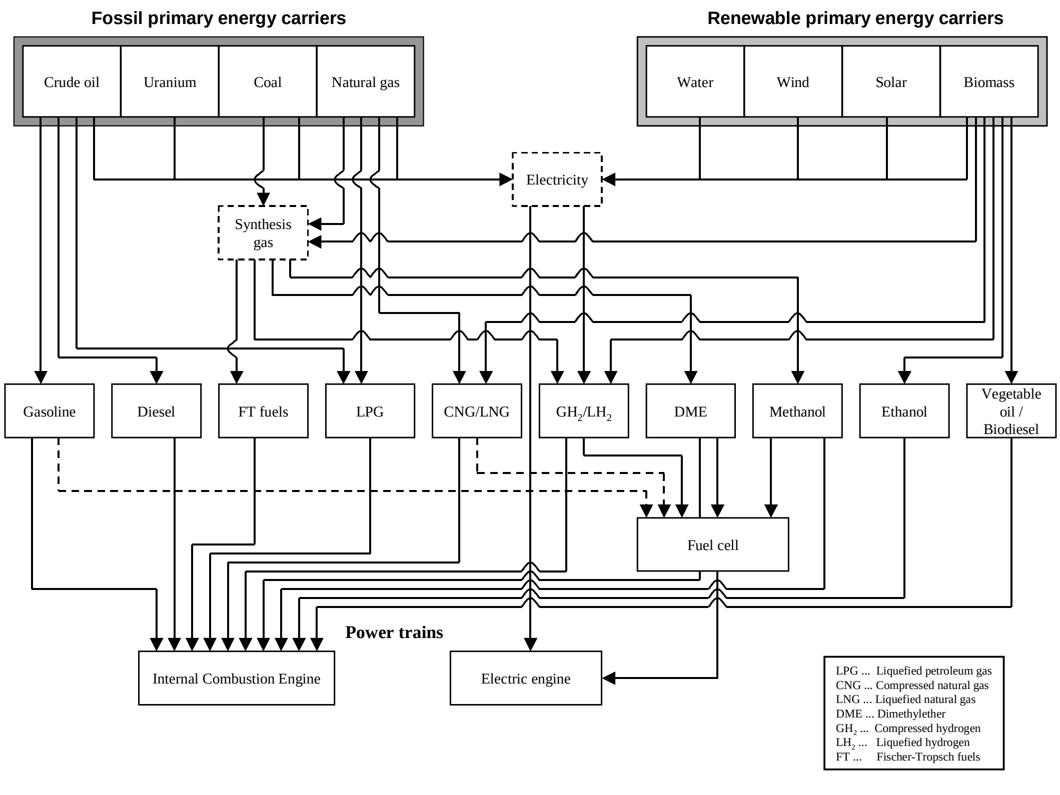


Figure 1: Production chains for alternative fuels for mobile applications

[1] See also Directives 1998/69/EC, 2003/17/EC and 2003/30/EC.

With the exception of „conventional“ biofuels such as ethanol or biodiesel, most alternative fuels are synthetic fuels, that are produced on the basis of synthesis gas, a mixture of hydrogen and carbon monoxide. According to the primary energy source, synthetic fuels (*Synfuels*) are distinguished as *GTL (Gas to Liquid)* and *BTL (Biomass to Liquid)* fuels. With respect to air pollution, synthetic fuels are especially attractive as they are practically free of sulphur and aromatics. In addition, synthetic diesel fuels such as DME lead to negligible particulate emissions. Another clean fuel that also has to be looked at in the “after oil age” is *Hydrogen*. However, concerning the implementation of a hydrogen economy, the strategies currently followed by policymakers, electricity suppliers and car manufacturers and also within these different interest groups are quite controversial.

As Figure 2 illustrates, in the automotive sector, there are currently two parallel strategies being followed, one concerning the development of alternative power trains (e.g. improved internal combustion engines, hybrid cars, fuel cell cars), the other concerning the development of alternative fuels (e.g. biofuels, hydrogen). The long-term vision should be to synchronise these strategies in order to allow for renewable transport fuels, especially hydrogen, and its use in fuel cell cars.

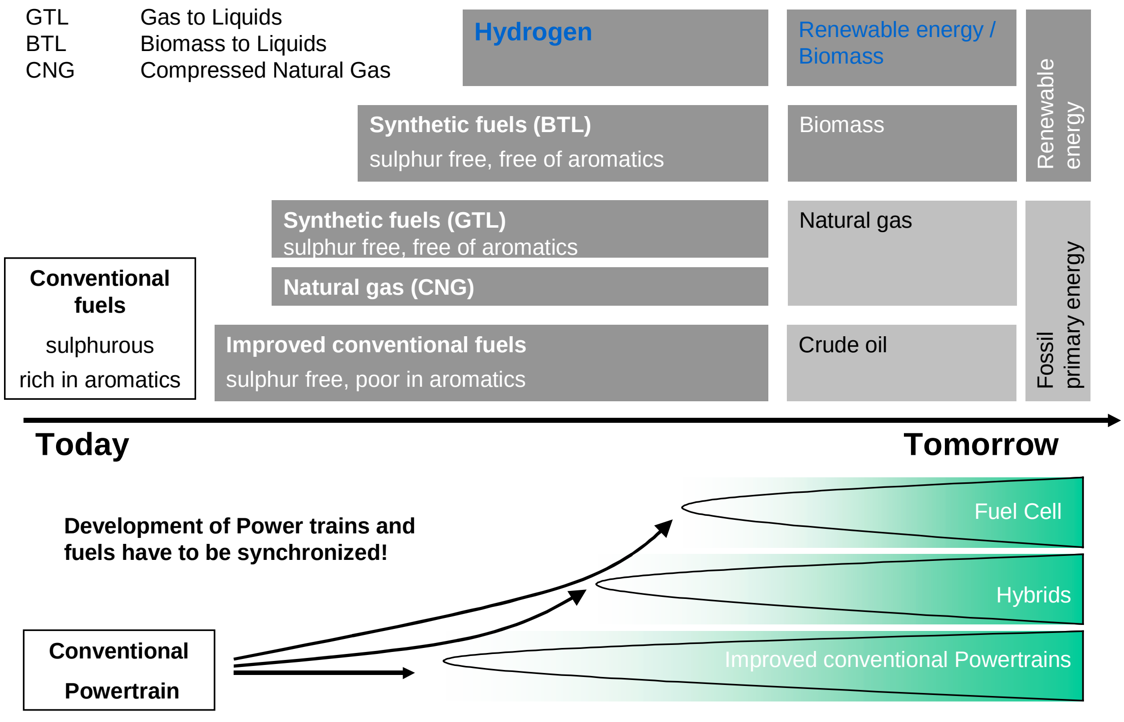


Figure 2: Co-evolution of fuels and powertrains

Besides their use in the transport sector, some fuels such as LPG or DME also offer the possibility to be used in household applications (e.g. for cooking and heating) or as chemical feedstock. Considering the possibility of using different feedstock for their production, such *multi-source, multi purpose fuels* allow for more energy diversification and a more flexible product strategy.

It becomes clear, that there are many competing fuels and also car concepts (e.g. improved conventional ICE, electric/battery cars, hybrid cars, fuel cell cars). It is therefore important to assess their potential areas of application as well as aspects concerning their integration into the national energy system. This includes first of all an assessment of the techno-economic characteristics of the complete well-to-wheel process chains for the different fuel supply options and also a consideration of resource-economic limitations, such as availability of light fuel oils or biomass, as this is important to derive potentials for future development. Concerning the large scale integration of alternative fuels in a national energy system, it has to be investigated, how they could possibly affect the national energy mix which in turn also determines how the future electricity and heat demand can be met.

In the context of renewable energies both their potentials for the production of transport fuels (e.g. hydrogen from wind energy by electrolysis or biofuels from organic waste) and their possible contribution to direct electricity and heat generation have to be considered under economical and ecological perspectives. Finally, the necessary investments as well as the consequences for CO_2 emissions and primary energy consumption on national level have to be estimated. Such an investigation also needs to include assumptions on e.g. the development of the car fleet, transport-related fuel consumption and infrastructure considerations, especially for fuels for which such an infrastructure still has to be implemented (e.g. hydrogen).

Conclusions

As outlined above, more emphasis should be put on estimating realistic potentials of alternative transport fuels at national levels, both with respect to reducing emissions of air pollutants and GHG but also for reasons of energy security. In this context, it seems particularly important to consider the implications of alternative fuels on the national energy system in an integrated approach. Such an approach should – both from an economical and ecological point of view – look at the competition between different primary energy carriers (fossil and renewable) at national level, and how they could best contribute to meeting the future demand for both electricity/heat as well as transportation fuels. The results of such an assessment could possibly help emphasizing the role of alternative vehicle fuels in air pollution reduction policies.

Ongoing activities of DFIU/IFARE in the field of alternative fuels

- **Project "Long-term perspectives of the energy mix in France and Germany"**
  Partners: European Institute for Energy Research (EIfER), Karlsruhe; Fraunhofer Institute for Systems and Innovation Research (ISI), Karlsruhe
- **Project "Designer fuels derived from biomass through Fischer-Tropsch-Synthesis"**
  Partners: Engler-Bunte-Institute (University of Karlsruhe), Research Centre Karlsruhe (FZK)
- **Project: "Development of a bottom-up energy model to assess the integration of a Hydrogen economy in the German energy system"**
  Partners: Fraunhofer Institute for Systems and Innovation Research (ISI), Karlsruhe
- **Project: "Large-scale integration of renewable energies into the European energy system"**
  Partners: European Institute for Energy Research (EIfER), Karlsruhe; Fraunhofer Institute for Systems and Innovation Research (ISI), Karlsruhe; Bremer Energie Institut, Bremen

Selected references in the context of working group them No. 4

Ceuster G. de; Herbruggen B. van; Logghe, S.; Proost, S.: *TREMOVE 2.0 Model Description*. Report for European Commission DG ENV, K.U. Leuven, Belgium, April 2004, http://www.tremove.org

COPERT III (2000), software for the calculation of air pollutant emissions from road transport, financed by the European Environment Agency (EEA), developed by the Aristotle University of Thessaloniki, Greece, http://vergina.eng.auth.gr/mech/lat/copert/copert.htm

European Commission: *A Technical Study on Fuels Technology related to the Auto-Oil II Programme. Volume II: Alternative Fuels*. Final report, DG Energy and Transport, 2000

European Commission: *Green Paper - Towards a European strategy for the security of energy supply*. COM(2000) 769 final, November 29, 2000

European Commission: *Communication on alternative fuels for road transportation and on a set of measures to promote the use of biofuels*. COM(2001) 547 final, November 7, 2001

European Commission: *Market development of alternative fuels*. Report of the Alternative Fuels Contact Group, DG Energy and Transport, 2003

European Commission: *Directive 98/69/EC of the European Parliament and of the Council of 13 October 1998 relating to measures to be taken against air pollution by emissions from motor vehicles and amending Council Directive 70/220/EEC*. Official Journal L 350, 28/12/1998

European Commission: *Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market*. Official Journal L 283, 27/10/2001

European Commission: *Directive 2003/17/EC of the European Parliament and of the Council of 3 March 2003 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels*. Official Journal, L 76, 22/03/2003

European Commission: *Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport*. Official Journal L 123, 17/05/2003

EUCAR, CONCAWE, Joint Research Center of the European Commission (JRC, Ispra): *Well-to-wheels analysis of future automotive fuels and powertrains in the European context*. January 2004, http://ies.jrc.cec.eu.int/Download/eh/31

General Motors, LBST (2002): *Well-to-wheel analysis of energy use and greenhouse gas emissions of advanced fuel/vehicle systems - a European Study*. Ottobrunn, September 2002

The European Hydrogen (Based) Society (HySociety). Database prepared by Fraunhofer ISI, Karlsruhe, 2004

Krüger, R.: *Systemanalytischer Vergleich alternativer Kraftstoff- und Antriebskonzepte in der Bundesrepublik Deutschland*. Dissertation, VDI-Verlag Fortschrittsberichte Reihe 12, Nr. 499, 2002

Murray, J; Lane, B.; Lillie, K.; McCallum, J.: *The Report of the Alternative Fuels Group of the Cleaner Vehicles Task Force. An Assessment of the Emissions Performance of Alternative and Conventional Fuels*. DTI Automotive Directorate, London, UK, January 2000

RICARDO: *Support for updating the RAINS model concerning road transport*. Final report, prepared in the framework of EGTEI, November 2003, http://www.citepa.org/forums/egtei/egtei_index.htm

RAINS WEB version, August 2004, http://www.iiasa.ac.at/web-apps/tap/RainsWeb/

Yamashita, K.; Barreto, L.: *Integrated Energy Systems for the 21st Century: Coal Gasification for Co-producing Hydrogen, Electricity and Liquid Fuels*. IIASA, Interim Report IR-03-039, 2003

An Extract From:

Prospects for International Management of Intercontinental Air Pollution Transport

Terry J. Keating[1] J. Jason West[2] Alexander E. Farrell[3]

[1] U.S. Environmental Protection Agency, Office of Air & Radiation, 1200 Pennsylvania Ave NW, Mail Code 6103A, Washington DC, 20460 USA *keating.terry@epa.gov*
[2] American Association for the Advancement of Science Fellow, U.S. Environmental Protection Agency, Office of Air & Radiation, 1200 Pennsylvania Ave NW, Mail Code 6103A, Washington DC, 20460 USA *west.jason@epa.gov*
[3] University of California, Energy Resources Group, 310 Barrows Hall, Berkeley, CA 94720-3050 USA *afarrell@socrates.berkeley.edu*

Published in:

Stohl A (ed) (2004) Intercontinental Transport of Air Pollution (The Handbook of Environmental Chemistry, Vol 4 Part G). Springer-Verlag, Berlin p 295-320, http://www.springerlink.com/openurl.asp?genre=volume&id=doi:10.1007/b10681

The following text is extracted, with some modification, from a book chapter. In this extract, we begin by setting the historical context for understanding new scientific findings about intercontinental transport, addressing how the spatial scale of air pollution has changed historically and the forces that are now pushing towards greater international linkages. We identify some of the existing international regimes for addressing the international transport of air pollutants and consider the prospects for effectively addressing intercontinental transport through policy actions and regimes at the national, regional, and hemispheric or global scales. For further discussion of how international environmental policy regimes evolve and the role of science in that evolution, the reader is referred to the full chapter. The other chapters of the book provide an excellent overview of the current state of this rapidly evolving field of science.

1 Changing Views of Air Pollution: the Historical Context for Intercontinental Transport

1.1 The Evolution of the Spatial Scale of "Air Pollution"

The history of air pollution science and management has been one of gradually evolving views of what air pollution is and what components of air pollution are relevant for policy action to control emissions. This shift in emphasis among different components of air pollution is a result of 1) the improvement in our scientific understanding of air pollution through time, often driven by new measurement and observation techniques, creating an awareness of new problems, and 2) the success of emissions control efforts, effectively addressing some problems and allowing other problems to come to the forefront of policy awareness.

Figure 1 shows the evolution of the problems and pollutants emphasized in air pollution science and management in the United States. The earliest efforts at air pollution management were local efforts focused on the mitigation of smoke, soot, and odors [2]. As these readily perceptible problems came under control in the 1960s, air pollution control efforts shifted focus to the control of ozone, SO_2, CO, NO_2, lead, and total suspended particulates (TSP). In the 1970s, awareness of these issues led to national ambient air quality standards, industrial controls, the removal of lead from gasoline, and the addition of catalytic converters on vehicles. Beginning in the 1970s and extending through the 1980s, attention focused on understanding acidifying deposition, eventually leading to significant SO_2 emissions controls. In the 1990s, problems such as CO came under control with changes in fuels and vehicle controls. Ozone, however, remained a stubborn problem, and the effects of changes in emissions of NO_X and volatile organic compounds (VOCs) became understood as subtle and difficult to predict [3]. Meanwhile, epidemiology developed the strongest evidence so far of the health effects of air pollution, identifying particles – first PM_{10}, then fine particles ($PM_{2.5}$) – as most responsible [4]. In the near future, there is a clear trend towards increasing concerns over emissions of mercury, airborne toxics and persistent organic pollutants (POPs), and greenhouse gases (GHGs) that contribute to climate change. In addition, the results of continuing research on the health effects of particles may focus control efforts on specific chemical components and their sources.

As this shift in focus between different pollutants has taken place, our concept of the spatial scales relevant for pollutant transport through the atmosphere, and thus air quality management, has also changed. Initially, air pollution was conceived as a localized

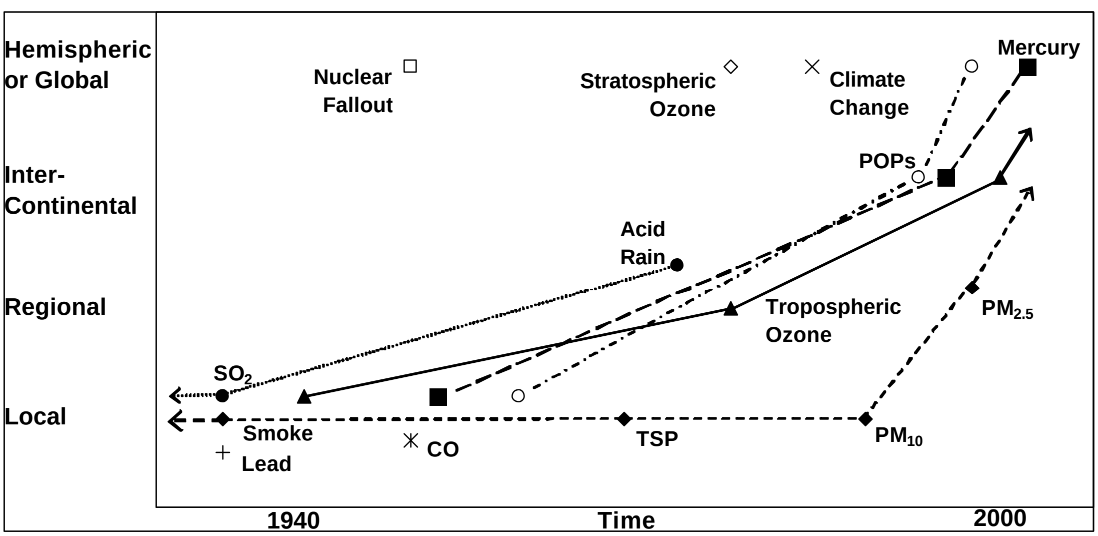


Figure 1 – Evolution of the perceived spatial scale of air pollution problems in the United States. Points indicate approximately when scientific consensus emerged that public policy action should be considered. While some pollutants have always been conceived of as local problems, some pollutants like O_3 and particles (first TSP, then PM_{10}, and then $PM_{2.5}$) have been reassessed over time as relevant on larger spatial scales. Other problems were conceived of originally at broader scales, such as acid rain at the regional scale, and there are several problems that have always been viewed globally.

phenomenon and air pollution control efforts were focused on the urban scale. The resolution of urban "smoke" problems, as well as the gradual demographic changes toward more regional development (itself driven in part by urban air pollution), made air pollution more regional. In the 1970s and 1980s, the perceived spatial scale of air pollution changed remarkably through studies that revealed that acidifying deposition is strongly regional, and even international, with transport between the US and Canada and between the nations of Europe [5, 6]. The regional nature of ozone, which was originally understood as an urban problem beginning in the 1950s, became a focus of management efforts in the 1990s as downwind jurisdictions discovered that they could not attain ambient standards because of emissions in upwind jurisdictions [7]. As emphasis on particle control has shifted to fine particles, the spatial scale of management efforts has also shifted from the urban to regional scale.

While our understanding of the geographical scale of conventional air pollution has expanded over time, other atmospheric problems were conceived of, from their inception, as global problems. These include studies of the transport of radioactive particles, climate change, and stratospheric ozone depletion. Measurements of chlorofluorocarbons (CFCs) in remote regions demonstrated that transport of long-lived species occurs [8]. Studies of the effects of CFCs on stratospheric ozone put atmospheric transport in a clearly global and very-long-term perspective, and led to the Vienna Convention and the Montreal Protocol, one of the earliest and most successful global agreements managing the global atmospheric commons [9].

Recently, the understanding of the transport of conventional air pollutants on international and now intercontinental scales, has taken a major step forward through the scientific research described in this volume. Satellite imagery, as well as analysis of surface observations, has provided vivid illustrations of individual events in which Saharan dust is transported to the Caribbean and Asian dust is transported to western North America. Analyses of the trends in ozone observed at remote sites have provided evidence of the hemispheric transport of ozone and the increasing hemispheric burden of ozone in the free troposphere [10].

This same evolution of the perceived spatial scale of air pollution has occurred concurrently in Europe, though with slightly different emphasis on different problems, such as the earlier recognition of acidifying deposition as a regional problem in Europe. Developing nations are observed to follow the same historical progression, but fall at different places along this path depending on the status of economic development and the severity of air pollution problems. While many developing nations are at the stage of controlling smoke and other urban pollution problems, as the United States was in the mid-1900s, they do so now with a more complete understanding of the picture painted in Figure 1, and of the relative priorities and complex relationships between air pollution problems.

1.2 The Tightening Vise of Air Pollution Management

Four current pressures create a "tightening vise" that is increasingly faced by air pollution managers in industrialized nations. First, air pollution management has historically emphasized the control of local sources of pollution, with a relative lack of control of regional sources. Through time, this has led regional and international sources to contribute proportionally more to air pollution problems. Consequently, there has been an increasing emphasis on the control of pollutants that are transported over longer distances, as air quality managers look to force upwind jurisdictions to control their share of emissions. This same trend is now extending to the intercontinental transport of pollution.

Second, having already exhausted the cheapest and easiest controls, further local emissions reductions come at increasingly higher economic and political marginal costs relative to controls in upwind areas, although in some cases technological innovation may reduce the actual control cost.

Third, while the cost of local control is increasing, air quality standards have become more stringent, reflecting an increased environmental awareness and improved understanding of health effects. This third pressure is manifested in the new ambient standards for ozone and fine particles in North America and for ozone in Europe.

The fourth pressure arises from the rate and spatial pattern of global development, which is causing emissions of air pollutants and their precursors to increase most rapidly in the developing nations of Asia, Africa and Latin America. In addition to industrial emissions, often from inefficient and uncontrolled processes, emissions from biomass burning and windblown dust (caused in part by human contributions to desertification) also contribute, sometimes dramatically, to international pollutant transport.

The net result is that the regional or global background contribution to pollutant concentrations is growing, while standards are becoming increasingly stringent and local pollution controls are becoming increasingly expensive and difficult to achieve (see Figure 2). Thus, air pollution managers are increasingly in a "tightening vise" of pressures from the industrialized world and growing emissions from the developing world. These pressures create an increased motivation for industrialized nations to help decrease emissions overseas. These foreign emissions, however, not only derive from different sources, but their management involves a very different set of actors with different priorities and technical and regulatory capabilities.

1.3 Overlapping Problems, Multi-Pollutant Strategies and Co-Benefits

Figure 1 suggests that the scope of air pollution concerns on the local, regional, and global scales is complex, and that the relative importance of different problems varies with spatial scale. These concerns are also interrelated to a significant degree. One example is that emissions of SO_2 contribute to fine particle formation on a local and regional scale, contribute to acid deposition regionally, and influence the global climate.

The nature of intercontinental pollutant transport is different for different pollutants, although many management concepts are common. In most cases, intercontinental transport contributes only a fraction of the pollution at a given location, with the remainder coming from local or regional sources, as portrayed in Figure 2. For ozone

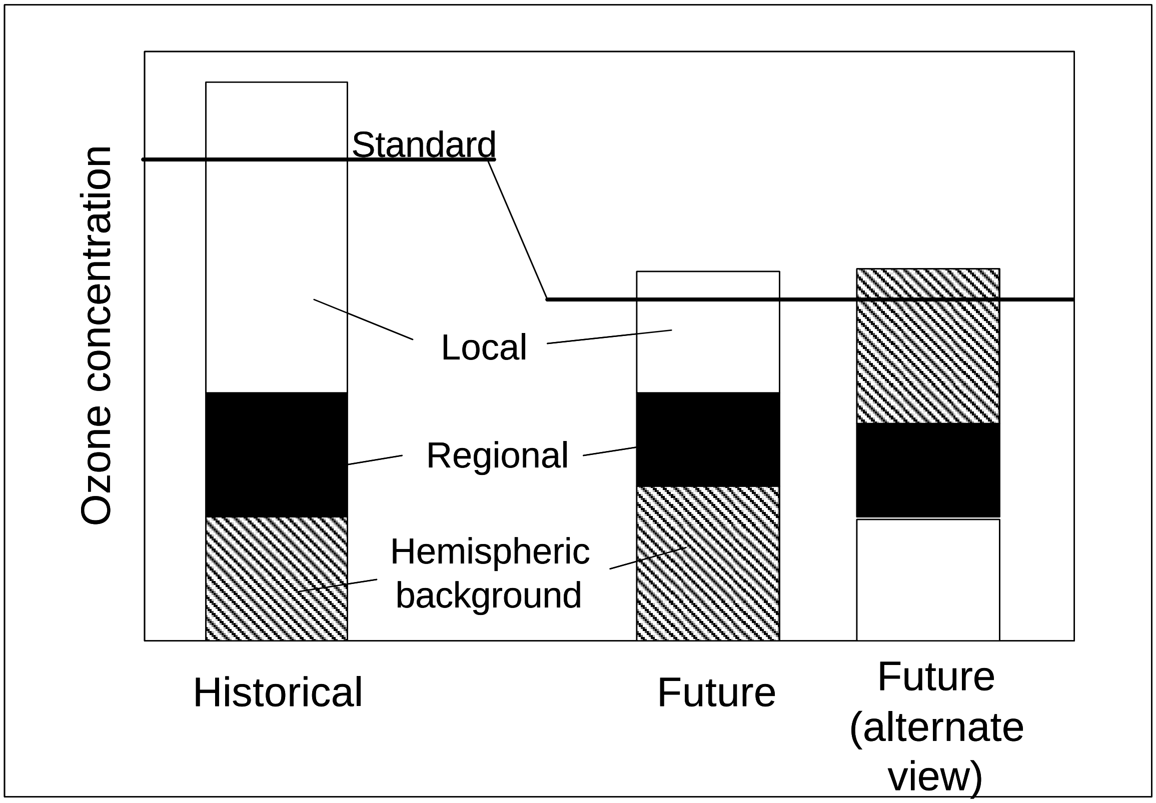


Figure 2 – The "tightening vise" of air pollution management, shown here (schematically) for ozone from the perspective of an industrialized nation. From the historical view to the future, air pollution managers succeed in reducing their local contribution to ozone, and work regionally with other jurisdictions to reduce the regional contribution. But the hemispheric background increases, while their air quality standard becomes more stringent. In the alternate view of the future, the hemispheric background, not the local pollution, pushes ozone above the standard, and the local air quality authorities blame other nations for their exceedance of the standard.

and mercury, the contribution of intercontinental transport occurs mainly through the build-up of concentrations in the free troposphere on a hemispheric scale. For fine particles, on the other hand, transport during discrete meteorological events may be more important. For ozone and mercury, therefore, emissions throughout the hemisphere may be important; while for fine particles, there is a more clear direction of flow from source continents to receptor continents. Interestingly, the emissions that one would choose to control can differ depending on the scale of influence one cares about. For ozone, controls on emissions of VOCs will reduce local concentrations, while NO_X controls are likely to have more regional benefits [3]. For the global background of ozone, however, recent modeling results suggest that controlling emissions of methane in addition to NO_X will be most effective, while changes in emissions of VOCs are less relevant [11].

There are also close linkages between air pollution – especially the long-range transport of air pollution – and climate change. Ozone is a GHG, and fine particles also influence climate by altering the Earth's radiation budget regionally to cause a net cooling or warming [12]. The linkage to the long-range transport of pollutants is particularly important because urban-scale pollution occurs over too small a scale to have a meaningful influence on the global climate. In the case of particles, there has been recent interest in controlling emissions of black carbon, both because of its benefits for human health and as a way of more quickly reducing human contributions to climate change [13].

In addition to the many scientific linkages between air pollution and climate, important policy linkages result from the fact that many air pollutants and GHGs share common sources. Many actions to address emissions of some pollutants may also affect emissions of other pollutants, such as the effect of GHG mitigation on aerosol concentrations and climate [14, 15]. Likewise, there has been increased recognition of the "co-benefits" of GHG mitigation in terms of reduced air pollution [16, 17], and studies to plan the control of GHGs and air pollutants simultaneously [18].

Together, understanding of these scientific and policy linkages has led to an acknowledgment of a complex pollution control landscape, where there are multiple sources of pollution, causing emissions of multiple pollutants, in turn causing multiple impacts that become manifest in inter-related ways on local, regional, and global scales. Likewise, policy linkages extend to other goals, such as providing transportation and energy, which can overlap with environmental goals. Interest in multi-pollutant strategies comes not only from governments, which want more efficient policies, but also from industry, which wants to have more long-term certainty in regulations to aid business planning.

Given this complex landscape, the main question for air quality managers in industrialized nations becomes increasingly: How to plan local air quality management strategies, accounting for international pollutant transport, together with climate change and other economic and social priorities at the same time? Meanwhile, air quality managers will increasingly be inclined to pursue emissions controls overseas, where those emissions controls will be tied together with overlapping environmental and development priorities.

2 Status of Current International Air Pollution Control Regimes

To effectively manage the international or intercontinental aspects of air pollution, some form of an international regime is necessary. International regimes that address transboundary air pollution can be found at the binational, regional, and global scales. Some existing regimes are listed chronologically in Table 1.

At the binational level, existing regimes include cooperative agreements between neighboring nations, which identify joint goals and obligations, such as the Canada-U.S. Air Quality Agreement [29] or the La Paz Agreement between Mexico and the U.S. [30]. Binational regimes may also take the form of technical cooperation between more distant nations, such as existing cooperative agreements between the U.S. and China [31] or between Norway and Poland [32].

At the regional level, examples of existing multinational regimes range from initial agreements acknowledging shared interests, such as the Malé Declaration; to regional scientific cooperation, such as the East Asia Network (EANET) and the Arctic Council's Arctic Monitoring and Assessment Program (AMAP); and well-developed policy regimes, such as the Convention on Long-Range Transboundary Air Pollution (LRTAP Convention). Signed in 1979 and encompassing the United States, Canada, and all the nations of Europe, the LRTAP Convention is one of the most successful international environmental regimes. Over time, it has developed a robust analytical support structure that includes a number of working groups, task forces, and international cooperative programs, including the Cooperative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollution in Europe (EMEP). Eight protocols have been negotiated under the LRTAP Convention addressing financing of scientific cooperation and obligations to reduce emissions related to acidification, ozone, POPs, heavy metals, and eutrophication.

At the global level, existing regimes range from technical cooperation under the auspices of multinational organizations, such as the United Nations Environment Program (UNEP) and the Organization for Economic Cooperation and Development (OECD), to multilateral treaties, such as Vienna Convention and Montreal Protocol for the protection of stratospheric ozone, the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, and the Stockholm Convention on Persistent Organic Pollutants.

While these existing regimes provide possible foundations for building future regimes to address intercontinental transport, additional institutional infrastructure will be required. Not all regions of the world are engaged in an international environmental policy regime that has the potential to address transboundary flows of air pollution, and some existing regimes are only in the early stages of development. Intercontinental pollutant transport can occur on spatial scales that exceed those of existing regional air pollution regimes. But given differences in the transport characteristics of pollutants, not all intercontinental pollutants may be appropriate to address through global regimes.

3 Prospects for Future Regimes

There are several possible levels at which governments can address intercontinental transport, including actions taken unilaterally, bilaterally, or multilaterally on regional, hemispheric, or global scales. Actions at these different scales, however, are not equally likely to be successful in the short and long term.

3.1 National and Bilateral

At the national level, nations have incentives to reduce their own emissions, to the extent they will benefit from decreased air pollution within their own borders. The incentive to reduce emissions to address intercontinental transport is currently weakest among the developing nations, where emissions are growing rapidly. In many developing nations, awareness of environmental quality is growing, but these nations may lack the technical expertise to understand the sources and effects of air pollution, and may lack the

Table 1. Some International Agreements Addressing Transboundary Air Pollution

Agreement	Geographic Region	Pollutants Addressed	Reference
1979 Convention on Long-Range Transboundary Air Pollution (LRTAP)	United States, Canada, and 47 European Nations		[19]
1984 Geneva Protocol on Long-Term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollution in Europe (EMEP)			
1985 Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes By At Least 30 Per Cent (1st Sulphur)		SO_2	
1988 Sophia Protocol Concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes (NO_X)		NO_X	
1991 Geneva Protocol Concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes (VOC)		VOCs, O_3	
1994 Oslo Protocol on Further Reduction of Sulphur Emissions (2nd Sulphur)		SO_2	
1998 Aarhus Protocol on Persistent Organic Pollutants (POPs)		15 POPs	
1998 Aarhus Protocol on Heavy Metals (Metals)		Hg, Pb, Cd	
1999 Gothenburg Protocol to Abate Acidification, Eutrophication, and Ground-level Ozone (Multi-Effects)		SO_2, NO_X, VOCs, NH_3, O_3	
1985 Vienna Convention on the Protection of the Ozone Layer	Global (185 Ratifications)		[20]
1987 Montreal Protocol on Substances that Deplete the Ozone Layer		CFCs, and other O_3 depleting substances	
1992 United Nations Framework Convention on Climate Change (UNFCCC)	Global (188 Ratifications)	GHGs	[21]
1997 Kyoto Protocol			
1995 ASEAN Cooperation Plan on Transbounary Pollution	10 Southeast Asian Nations		
2002 ASEAN Agreement on Transboundary Haze Pollution		Visibility, Fine Particles	[22]
1996 Arctic Council	8 Arctic Nations	POPs, Metals	[23]
1998 East Asia Network	12 East Asian Nations	SO_2, Acidification	[24]
1998 Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia	8 nations on the Indian subcontinent		[25]
1998 Harare Resolution on the Prevention and Control of Regional Air Pollution in Southern Africa and its likely Transboundary Effects	Southern Africa Nations (3 primary participants)		[26]
2001 Stockholm Convention on Persistent Organic Pollutants (POPs)	Global (151 Signatories)	12 POPs	[27]
2003 UNEP Global Mercury Assessment	Global	Hg	[28]

regulatory capabilities and experience to effectively control the sources. Lacking this expertise, developing nations will not only have reduced capabilities to address their own air quality problems, but will be less likely to participate meaningfully in international regimes addressing transboundary air pollution.

Even where scientific, technical, and managerial expertise exists in industrialized nations, transferring this expertise to developing nations can be expensive, but ultimately worthwhile. Given the importance of developing nations' emissions for existing and projected intercontinental transport problems, it is implausible that international regimes to address intercontinental transport will be effective without first taking steps to build capacity in developing nations to understand and manage air pollution. Capacity-building actions should, therefore, be a short-term priority for any series of actions to address intercontinental transport. Such capacity-building, whether undertaken bilaterally with individual developing nations or multilaterally through regional or global regimes, need only focus on providing support for developing nations to address their own air pollution problems. Industrialized nations will benefit from such pollution control efforts through reduced international or intercontinental transport, and through the other benefits that motivate development support currently.

Unilateral actions by industrialized nations to improve scientific understanding of pollutant transport are important, but sponsorship of cooperative actions to develop a shared understanding can produce greater international legitimacy and can better support international agreements.

3.2 Regional

Regional regimes have proven effective at reducing international pollution among neighboring countries, and regional regimes are growing among developing nations. Although current regional regimes do not cover the geographic scope of intercontinental transport, they offer existing functional structures that can serve as a basis for further cooperation with other nations and regimes. Regional regimes have the advantage of dealing with nations that are often similar in development characteristics and have shared regional interests, which as discussed previously, is a common characteristic of successful regimes.

Because of the scale of transport, regional regimes are most likely to be effective for fine particle pollution and acid deposition, but will not be able to cover all relevant source nations for ozone, mercury, and POPs. In North America and Europe, regional agreements focusing on the control of NO_X as a regional precursor to ozone are already in place. With respect to fine particles, regional regimes should work within their boundaries to confront the causes of widespread particulate emissions from windblown dust, exacerbated by desertification, and forest fires, as well as the important industrial and urban sources of particles. Given the health effects associated with fine particles, investment in capacity building activities related to fine particle control is likely to be very beneficial.

The LRTAP Convention, which has a geographical scope stretching from North America, across Europe, and into Central Asia, provides an existing forum where meaningful progress can be made towards addressing the intercontinental transport of multiple pollutants. It is also a framework through which capacity-building activities engaging developing nations can be further encouraged. Likewise, the inception of regional pollution regimes in Asia and Africa, with a foundation in developing a shared scientific understanding of air pollution problems, is encouraging and should be supported by industrialized nations.

As pressure mounts to address intercontinental transport over larger spatial scales, there will be pressures for regional regimes to expand their boundaries, or to work together with regimes representing other regions. Both should be encouraged, as regional agreements provide useful existing structures.

In addition, environmental managers increasingly use market-based mechanisms, such as emissions trading, to reduce overall control costs. The potential for cost savings has motivated discussion of emissions trading under the Kyoto Protocol, but agreeing upon the rules for international trading has proved contentious. Trading in GHG emissions, which are long-lived and relatively homogeneous, is relatively simple compared to trading pollutants that are more heterogeneous and have strong local or regional components, such as fine particles, ozone, mercury, and POPs. Any trading system for these pollutants would have to be designed to take source-receptor relationships into account and avoid the creation of emissions hot spots.

3.3 Hemispheric and Global

Regimes on a hemispheric or global scale are the only regimes that can fully address some problems of intercontinental transport. This observation has led some scholars to speculate about the potential for a new hemispheric treaty on air pollution [33]. Hemispheric and global regimes, however, lose some of the characteristics that make regimes successful. At this scale, the commonalities of interests, shared borders, and regional objectives that support the development of regimes are weaker, while inequities between industrialized and developing nations are highlighted.

While developing nations have shown a great willingness to participate in global environmental regimes, they are less frequently willing and able to participate at the level of reducing their own emissions. Although the Montreal Protocol is a very successful global regime, for example, some developing nations still produce CFCs. Likewise, no binding emissions reduction commitments for developing nations are currently contemplated under the UNFCCC. The prospect of using a global regime to leverage meaningful emissions reductions from developing nations, therefore, is not likely to be successful in the short-term unless significant incentives are made for developing nations to participate. Incentives in the form of development aid for clean energy infrastructure can advance the developmental and environmental priorities of both developing and developed nations.

A global regime currently exists for POPs and has momentum to address this problem globally for several important pollutants. For mercury, a global regime has recently been created to focus on scientific assessment and capacity building. Given that scientific understanding of mercury transport is weak in relation to other pollutants, scientific cooperation is important at this stage. Beyond an assessment, actions in industrialized nations to control their own emissions, and capacity-building and financial support for projects that reduce mercury emissions in developing nations will be important.

No global regime exists for ozone or other traditional air pollutants. The creation of such regimes may be part of a long-term solution for these problems, but it is not clear how these regimes might evolve. Under the UNFCCC, significant actions may be taken to address emissions of the precursors of ozone and fine particles, since both affect climate change. Methane emissions are already addressed by the UNFCCC, and their control will benefit climate change efforts as well as air quality management efforts.

As mentioned earlier, however, achieving agreement among many parties in a global regime can be time-consuming. We therefore are not optimistic that global regimes can bring meaningful emissions reductions in the short term, and should therefore not take priority over the types of bilateral and regional activities discussed earlier.

References

1. Young OR (1999) The Effectiveness of International Environmental Regimes: Causal Connections and Behavioral Mechanisms In: Choucri N (ed) Global Environmental Accord: Strategies for Sustainability and Institutional Innovation. MIT Press, Cambridge
2. Krier J, Ursin E (1977) Pollution and Policy: A Case Essay on California and Federal Experience with Motor Vehicle Air Pollution 1940-1975. University of California Press, Berkeley, CA
3. National Research Council - Committee on Tropospheric Ozone Formation and Measurement (1991) Rethinking the ozone problem in urban and regional air pollution. National Academy Press, Washington, DC
4. Schwartz J, Dockery DW, Neas LM (1996) Journal of the Air and Waste Management Association 46: 927
5. National Acid Precipitation Assessment Program (1991) Summary Report of the U.S. National Acid Precipitation Assessment Program. National Acid Precipitation Assessment Program - Office of the Director, Washington, DC
6. Organization for Economic Cooperation and Development (1979) The OECD Programme on Long Range Transport of Air Pollutants, Measurements and Findings, Second Edition, Organization for Economic Cooperation and Development, Paris
7. Farrell AE, Keating TJ (2002) Environmental Science & Technology 36: 2537
8. Lovelock JE (1971) Nature 230: 379
9. Parson EA (2003) Protecting the Ozone Layer: Science and Strategy. Oxford University Press, Oxford
10. United Nations Economic Commission for Europe (UNECE) (2003) Hemispheric Air Pollution: Trends and Intercontinental Transport of Photo-Oxidants, Particles and their Precursors across the Northern Hemisphere (Observations, Models, Policy Implications), EB.AIR/GE.1/2003/7, Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), Geneva
11. Fiore AM, Jacob DJ, Field BD, Streets DG, Fernandes SD, Jang C (2002) Geophysical Research Letters 29: 1919
12. Prather M, Ehhalt D, Dentener F, Derwent R, Dlugokencky E, Holland E, Isaksen I, Katima J, Kirchhoff V, Matson P, Midgley P, Wang M (2001) Atmopsheric chemistry and greenhouse gases

In: Houghton JT, Ding Y, Griggs DJ, Noguer M, van der Linden PJ, Dai X, Maskell K, Johnson CA (eds) Climate change 2001: The scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, U.K.
13. Hansen J, Sato M, Ruedy R, Lacis A, Oinas V (2000) Proceedings of the National Academy of Sciences of the United States of America 97: 9875
14. West JJ, Hope C, Lane SN (1997) Energy Policy 25: 923
15. Wigley TML (1991) Nature 349: 503
16. Working Group on Public Health and Fossil-Fuel Combustion (WGPHFC) (1997) Lancet 350: 1341
17. Cifuentes L, Borja-Aburto VH, Gouveia N, Thurston G, Davis DL (2001) Science 293: 1257
18. West JJ, Osnaya P, Laguna I, Martinez J, Fernandez A (2003) Co-control of urban air pollutants and greenhouse gases in Mexico City: Final report, Subcontract ADC-2-32409-01, U.S. National Renewable Energy Laboratory, Washington DC
19. http://www.unece.org/env/lrtap/
20. http://www.unep.org/ozone/
21. http://unfccc.int/
22. http://www.haze-online.or.id/
23. http://www.arctic-council.org/
24. http://www.adorc.gr.jp/
25. http://www.rrcap.unep.org/issues/air/maledec/
26. http://www.york.ac.uk/inst/sei/rapidc2/apina/
27. http://www.pops.int/
28. http://www.chem.unep.ch/mercury/
29. http://www.epa.gov/airmarkt/usca/
30. http://www.epa.gov/usmexicoborder/
31. http://www.epa.gov/oia/airandclimate/byregion/chinaair.html
32. http://www.nilu.no/informasjon/nilu-polska.html
33. Holloway, T, Fiore AM, Hastings MG (2003) Environ Sci Technol 37:4535

Acknowledgements: The authors thank Stacy VanDeveer, Dale Evarts, Tracey Holloway, and Andreas Stohl for their helpful suggestions. Any opinions, findings, conclusions, or recommendations expressed in this article are the authors' and do not necessarily reflect the views of the U.S. EPA or the AAAS.

Supporting document for discussions at Workshop on Review and Assessment of European Air Pollution Policies, 25-27 October 2004, Gothenburg, Sweden.

ICP Materials - use of results in the policy process

Vladimir Kucera, Johan Tidblad
Swedish Corrosion Institute, Stockholm, Sweden

Background

ICP materials has performed the exposure of materials in a network of test sites in a wide geographical zone of the signatories to the Convention in Europe and in North America. Two types of exposure have been performed - long-term exposure for evaluation of DRF and repeated one-year exposure for evaluation of trend effects.

Main results obtained

- Drf based on 8-years exposure (1987-1995) containing SO_2 as main pollutant for most materials
- Trend exposure (1987-2003) showing a substantial decrease in corrosion and of S-pollution
- Multipollutant exposure programme and EU 5FP MULTI-ASSESS project (1997-2004) including HNO_3 and particles for characterization of the new multipollutant situation
- Concept of acceptable levels of corrosion and pollution
- Mapping of selected areas of exceedance on different geographical scale
- Calculation of cost caused by pollution

Potential for policy process

The original DRF as well as the new functions from the multipollutant programme which will be obtained in the spring 2005 can be used both within the LRTAP Convention and within the EU activities (CAFE), figure 1.

EU

DG Research & DG Environment – CAFE

MULTI-ASSESS 5FP & CULT-STRAT 6FP

Use of results and dose-response functions for revision of Air Quality Directive 99/30/EC with focus on

- Threshold levels of pollutants
- Material indicators

UN/ECE
LRTAP Convention

WGE

ICP Materials

Use of results and dose-response functions for revision/issuing of Protocols with focus on

- Mapping of areas of exceedance at different scenarios
- Assessment of stock at risk
- Cost benefit analysis (in co-operation with CIAM and NEBEI)

Figure 1 The work within ICP Materials and the EU Projects MULTI-ASSESS and CULT-STRAT serve as bridging between the activities of UN/ECE and EU.

Supporting document for discussions at Workshop on Review and Assessment of European Air Pollution Policies, 25-27 October 2004, Gothenburg, Sweden.

Questions to be discussed

Despite that the results are both unique and innovative they have so far not been used to a greater extent for policy purposes. Answers of the following questions are of interest:

- What is needed for realisation of the potential policy purposes within UN/ECE and EU?
- How important is the field of cultural heritage in the policy process?
- How should the Convention work be used and linked to the activities on Global climate changes?

Future developments in air pollution strategies/policies

Johan Sliggers

Can the Convention on LRTAP and the EU deliver what is needed in the coming decades? This is the key question for the EU and the Convention.
Currently, it is expected that the Gothenburg Protocol will enter into force at the beginning of 2005. Therefore, a follow-up to the Saltsjöbaden workshop, held in 2000, is organized for October 2004 in Gothenburg, Sweden. This workshop on "Review and Assessment of European Air Pollution Policies" aims at discussing possible objectives and targets for human health and environmental effects for the medium term, 2010-2020, as well as the long term. The workshop will consider the development of the Convention's strategy for the review of the Gothenburg Protocol as well as the European Commission's Clean Air for Europe (CAFE) programme for the preparation of its thematic strategy.
This paper tries to summarise some issues for the Gothenburg workshop that are important for future developments in air pollution strategies/policies in Europe and North America.

Outline
This paper will first look back to the Saltsjöbaden workshop to see what were then seen as the elements for future strategies. Next, the paper will deal with the interrelation of the Convention with the work within the European Union (EU). In addition, this paper will examine:

- Developments: topics that are being addressed at the moment;
- Further needs: subjects that need to be addressed; and
- Challenges: issues that need to be resolved.

Finally, the paper concludes on the future of the Convention and the EU.

Strategy workshop, Saltsjöbaden

After the adoption and signing of the Gothenburg Protocol, a workshop, held in April 2000 in Saltsjöbaden, Sweden, formulated the future needs for regional air pollution strategies:

- Health would become more important, especially as a consequence of the growing concerns about exposure to particulate matter;
- Given the rising interest in health-related exposure to pollutants, urban air quality problems would need to be part of a regional approach to air pollution control;
- Non-technical measures as well as measures to combat climate change should be addressed and would lead to more cost-optimal solutions;
- Policy indicators that were appealing to both the public and politicians should be developed to explain the benefits of air pollution abatement with regard to human health and nature; and
- Cost-benefit analysis would be more important to quantify both the damage from air pollution and also the benefits of pollution abatement in physical as well as in monetary terms.

To address these elements a large work programme was set up to prepare the review of the Gothenburg Protocol following its entry into force.

The Convention and the European Union

Although there were differences in the ambition levels of the emission ceilings set, for some EU States these levels were slightly higher in the Gothenburg Protocol than in the NEC Directive, both instruments were based on the same technical and scientific information. They made use of the Convention's scientific networks and the European Commission's project-oriented funding.

Complementing and cooperating

The air pollution policies of the Convention and of the EU are moving ever closer. Furthermore, the EU - recently enlarged to 25 countries - encompasses a large part of Europe. Yet, one should not fall into the obvious trap that only one regime could or should survive. Both now work closely together. They are heavily dependent upon each other and complement each other's strong and weak points. Of course, there are obvious differences between the two such as the geographical size of the regions that they cover, the institutions themselves and their compliance regimes. But both address transboundary air pollution in Europe and they work together to achieve common goals. They use one another's work but address different work items to avoid duplication and waste of resources.

The Convention and the EU have "played leapfrog" in strengthening technological obligations and the Convention has increased the area over which such obligations take effect. Although since 1 May 2004 the EU has encompassed 25 countries, it should not be forgotten that to the East there are a further 20 Parties to the Convention. And it is not only to the East that the Convention has additional value. It also stretches West across the North Atlantic to play an important role in harmonizing technology through that subregion also.

Developments

In the EU and in the Convention's scientific networks and groups many topics are currently being addressed. The developments of five of the most important are discussed below.

Health

Evidence is growing that current levels of (ground-level) ozone and particulate matter cause significant health problems; as a result, a quarter of a million people die prematurely in Europe. Particle emissions (primary particles) and the formation of particles in the air (secondary particles) are large-scale problems like acidification and photochemical pollution.

More emphasis on health does not mean that the Convention will neglect the environment. Acidification is not yet solved even though exceedances of critical loads are decreasing as a result of abatement measures and they will continue to do so. Eutrophication due to deposition of nitrogen compounds is a great threat to biodiversity and will be so for decades to come. "Background" ozone levels, the levels that are due to emissions across the Northern hemisphere and measured throughout the year between high ozone episodes, are rising slightly year by year; these give cause for concern as the concentrations are approaching levels known to damage plants.

Agriculture and products

Acidification was the original focus for the Convention and expertise was concentrated on emissions from fuel combustion. When eutrophication emerged as an environmental problem, ammonia came into the picture and agricultural knowledge was added to the expertise of the Convention. Although they had already featured in the Protocol on VOCs, products from industry and agriculture were important in the development of the Protocol on Heavy Metals and the Protocol on POPs. The issue will receive renewed attention now that the Protocols have entered into force (in 2003) and their reviews have started.

Changing the scales

EMEP has now developed a deposition model using grids of 50 km x 50 km and with an increased number of air layers. Downscaling further to urban background or even street level, which would be needed to include human exposure to air quality levels into integrated assessment modelling, is something that would overstretch the EMEP model. However, a significant part of the air pollution levels even in cities (the so-called urban background, which includes secondary pollutants such as ozone and secondary particles such as ammonium nitrate and sulphate) has a transboundary origin.

To extend the Convention's effects-based approach to particulate matter, it is essential to deal with the scale at which people are most affected, that is in urban areas. The European Commission's Auto-oil programme, which used a number of pilot cities, and the more recent City Delta project, may be able to indicate to what extent it is cost-effective to implement reduction measures at a city scale. This would need to be related to or supplemented by Europe-wide action to reduce the exposure of populations to particulate matter.

There is recent evidence that existing EU limit values, for example for particulate matter, are particularly difficult to meet in urban areas and this has fuelled discussions within the CAFE programme. The question arises: Might there be a way around the difficulties of attaining a uniform air quality standard in urban hot spots without preventing improvements elsewhere? Again, elements developed by the Convention, like the gap-closure approach, could help the EU to supplement its traditional concept of simple limit values so that maximum health benefits could be achieved in a cost-effective way.

Moving away from the European scale, the Convention increasingly focuses attention on the Atlantic and on the global movement of pollution. "Background" (global) ozone levels are rising and mercury and POPs are being dispersed across the Northern hemisphere. Hemispheric models are being developed by the EMEP. Further expansion of modelling to the global scale will be necessary to reap benefits from integrating the problems of air pollution with those of climate change.

Cost-benefit analysis

Damage estimates related to air pollution are often compared with abatement costs. A reduction in air pollution results in less damage, a benefit that can be compared with the costs of the reduction. Besides the cost-benefit analysis assessing the environmental benefits, monetary benefit calculations were made for the implementation of the Gothenburg Protocol. This was the first time that monetary cost-benefit analyses played a role in the negotiation of an international environmental agreement. The results showed that almost all countries benefited from abating air pollution as required by the Gothenburg Protocol; benefits were two to five times the calculated abatement costs. Cost-benefit analysis, especially monetary ones, will become more important on the future. Currently the methodology developed under the Convention is being further elaborated under the CAFE programme.

Dynamic modelling

At the time of the adoption of the Gothenburg Protocol it was recognized that there was a need to assess the long-term effects of deposition changes in order to understand the sustainability of deposition loads. Therefore, increasing attention has been given to assessing delays in recovery, both in regions where critical loads are no longer exceeded and in regions where there is still excess deposition. Knowledge in this respect will become more important when we approach critical loads. For this, dynamic models have been developed under the Working Group on Effects for use with integrated assessment models.

Further needs

The developments above are mostly scientific or technical and they demonstrate the way one can respond to such issues. In this paragraph the developments considered are those that are necessary because of changing circumstances or the need to raise the profile of activities.

Quality of emissions data

There is a need to improve the overall quality of emission inventories and emission projections. Despite the emissions guidelines and the emission inventory guidebook that assist countries in calculating their emissions and projections, the emission data reported by countries are not always comparable. The possibilities for data checks are limited and data recalculations by countries themselves sometimes show great differences with earlier data. Better quality emissions data and an insight into how data are calculated are needed, especially now that obligations are becoming more stringent. Furthermore, to achieve a stronger compliance regime an important step is to increase the quality of the reported data. Already, work is under way to develop quality assurance programmes under the Convention.

An important step to better quality assurance and quality control (QA/QC) of emission data has been taken by the Task Force on Emission Inventories and Projections who proposed an inventory improvement programme in 2003. It set about drawing up procedures for reviewing inventories and is developing a standardized format for informative inventory reporting. Such national inventory reports should indicate the methodologies used and include any assumptions, uncertainties, recalculations and QA/QC applied.

In the future, as obligations in protocols become more demanding, it may be considered necessary to validate emission data through verification by independent auditors. Such a procedure already exists, for example, under the United Nations Framework Convention on Climate Change.

Setting indicators for human health and biodiversity

Integrating air pollution policies has many advantages not at least the cost savings. To appreciate the benefits, indicators should be used to demonstrate the results. Various indicators may help to relate emissions to effects on human health and the environment.

For health, it shows how illnesses (morbidity) and premature death (mortality) due to air pollution can be expressed as "disability-adjusted life years" or, more simply, the loss of healthy life years. However, this concept is not widely accepted, so we continue to use the more traditional health indicators, e.g. the number of people exposed to high concentrations, the numbers of hospital admissions, the number of premature deaths.

For natural ecosystems, critical loads are generally related to the physical-chemical state in soils and surface waters. When chemical changes occur as a result of critical loads being exceeded, there will be effects on the flora and fauna, e.g. changes in biodiversity. For the Netherlands, calculations have linked the abundance of plant species (a nature quality index) with the causes of biodiversity loss.

Such relationships between acid and nitrogen deposition and biodiversity need to be established. The first step might be to use critical loads for biodiversity and calculate accepted pressure-based indicators. For example, estimate the percentage areas of (specific) natural ecosystems where deposition exceeds the level for sustainable biodiversity, and calculate the level of that excess. The second step would express the effects of air pollution in terms of suitable effects indicators, for example showing changes in ecosystem properties such as species abundance or extinction rates. The use of such biodiversity indicators may link air pollution regulation and international biodiversity goals such as those of the EU Habitats Directive and the 1992 Convention on Biological Diversity. Until such a concept is fully developed and accepted, indicators such as percentage areas of ecosystems where deposition exceeds the levels for sustainable biodiversity, together with estimates of the exceedance, should prove appealing.

Communications
At present interest in air pollution seems to have waned. Much of the attention of the media, the public and politicians is now focussed on climate change. It is important to keep up an active communication strategy to increase the profile for the need for air pollution abatement.

Challenges

The Convention and the EU are working on many topics and Parties do have a clear idea of how to address several of them. However, some issues are much more difficult, complex or even controversial. These are the challenges for the future.

Particulate matter
If particulate matter is to be included in the review and possible revision of the Gothenburg Protocol and the NEC directive it will be a major challenge. Many aspects of linking emissions of particulates to effects are poorly understood or quantified:

- Emission inventories have problems including natural emissions;
- Atmospheric transport models have problems matching the concentrations that are being monitored. Contributions from natural emissions (e.g. sea salt) and resuspended dust are not fully understood;
- Health standards for particulates are still under development. Although it is recognized that particulate matter causes many health problems, the links between health effects and those particles responsible are unclear;
- Monitoring of small particles (PM2.5, particulates less than 2.5 micrometre in diameter) is difficult and experience of such monitoring is limited.

A good deal of work and innovation is required to include particulate matter in future air pollution strategies. One approach might be to set an emission ceiling for anthropogenic emissions of PM10 and/or PM2.5 plus technical obligations (best available technology / techniques, emission limit values).

Air pollution and climate change
Air pollution and anthropogenic climate change (i.e. global warming) are closely connected in a number of ways. Both are caused to a large extent by the burning of fossil fuels; sulphur and nitrogen oxides (NOx) cause air pollution, carbon dioxide (CO_2) contributes to global warming. In addition, agriculture influences both acidification and eutrophication (through NOx and ammonia emissions) and climate change (through emissions of methane (CH_4), nitrous oxide and CO_2). Forestry also plays a role, but can act as a source of VOC emissions and a sink for the greenhouse gas CO_2.

In addition to sharing a number of sources, climate change and air pollution also share some gases. Air pollutants such as NOx, VOC and CH_4 (precursors of ozone) and aerosols/fine particulates not only affect air quality but also contribute to global warming.

It is interesting to note that almost half of all "heat-related deaths" in Western Europe during the summer of 2003 were attributed to air pollution with ozone and fine particulates. Both of these are also important greenhouse gases. In fact, in the Northern hemisphere, ozone is the second most important greenhouse gas after CO_2. But neither ozone nor aerosols/fine particulates are covered by the Kyoto Protocol.

Currently, a project to include the greenhouse gases covered by the Kyoto Protocol, including their abatement measures and costs, in the RAINS model, is almost finalised. The extended model will be able to indicate the benefits of adjusting energy policy to meet both air pollution objectives and those for climate change at the same time.

The first model runs give a good indication of how the extended RAINS model works and how it might be used for integrating policies for air pollution and climate change. Calculations show that with the right choices, European climate policies can lead to significant cost savings for traditional air pollution policies and they would provide additional health benefits (e.g. fewer premature deaths from PM2.5).

For acidification and air quality, the issue of integration is likely be addressed by the Convention in its review and possible revision of the Gothenburg Protocol and by the CAFE programme for possible amendments to the air quality daughter directives and the NEC Directive.

Ratification and compliance
Roughly 4-5 years usually pass between the signing of a protocol and its entry into force. Obligations in the protocols such as meeting emission ceilings and emission limit values are generally timed to take effect even later. Technologies listed in their annexes are sometimes out of date even before their application becomes obligatory. But revision of a protocol cannot start before its entry into force, so technical annexes cannot be changed until that time.
It is essential that Parties to the Convention ratify protocols more quickly. Ratification of the Gothenburg protocol by the 15 EU countries that have not done so should be particularly easy for these countries because they are also bound to sometimes slightly stricter ceilings in the NEC directive.

In the EU, States do not "ratify” directives. The European Commission proposes legislation and, provided the Council and the European Parliament agree, obligations take effect for all members on a specified date. The European Commission has the power under the Treaty of European Union to ensure that the member States comply with their obligations.

In the Convention's early years there was no call or need for a compliance regime. Under the terms of some of the protocols, Parties have access to various mechanisms for settling disputes, including arbitration and submission of the dispute to the International Court of Justice.
In time the need for introducing a compliance system grew stronger and in 1997 the Executive Body established the Implementation Committee. One could argue that the subsequent control of compliance by the Commission is tougher than under the Convention. Yet, this conclusion would be too hasty. The Executive Body chose not to seek a punitive route for dealing with non-compliance. It believed that gentle pressure including "naming and shaming" was the best approach.
To develop the compliance regime further, a system of auditing performance could be introduced such as that negotiated in 2001 for the Kyoto Protocol.

Future of the Convention and the EU

Air pollution policies in the Convention and the EU can be characterized as science-based, science-policy interactive, innovative and "of the countries and for the countries". These qualities have provided a strong and active air pollution policies both in the Convention and in the EU that has proved very successful and productive.

Value added
In the past the Convention has showed the way in fighting air pollution; with the EU and its other Parties it will continue to do so in the coming decades. The role of the Convention is vital, not only in Europe but across the UNECE region in North America and Central Asia. Stretching West and East of the EU, the Convention includes nations of great economic and social disparity.

15 October 2004

Factors influencing the estimation of the health benefits of further reducing European air pollution, which may not be as significant as is being suggested to the Commission

CONCAWE discussion paper for DG Env/CAFÉ work shop, Gothenburg 25-27 Oct. 2004

1. *The study on health impacts from chronic exposure to $PM_{2.5}$ that has been selected as the basis for the concentration-response function has some unexplained findings which put its validity into question.*

The American study[1] (the 'ACS-study') used for concentration-response modelling of particulate matter in CAFÉ detected an association in mortality rates with ambient $PM_{2.5}$ levels for people with a high school education or less, but not for people with higher education levels. Further, the study found an increase in lung cancer rates for men, but not for women. The authors did not provide explanations for these findings.

Regarding the apparent effect of educational level on health status, a plausible explanation was recently provided[2]: the ACS-study collected personal details for the study subjects only once, in the early phase of the observation period. Therefore, there were no data regarding smoking cessation of study subjects over the course of the observation period. Data were published in 2002 in the US by the Centers for Disease Control and Prevention that showed a strong relationship between educational level and quitting smoking: from 33.6% in lowly educated people to 74.4% in those with a graduate degree. These numbers clearly indicate the necessity to collect individual-level information on risk factors before a study can be interpreted as providing 'evidence' for a causal relationship between ambient $PM_{2.5}$ and health effects.

Another recent publication reported that general mortality rates tend to tail off towards the end of the month, suggesting stress-related factors play an important role[3]. This type of information is important for time-series studies of short-term effects, but not routinely provided for studies on ambient air pollution and mortality.

2. *Existing thresholds of effect will be masked in epidemiological studies if the exposure assessment of the pollutant is confounded.*

This was clearly demonstrated to be the case for $PM_{2.5}$ by Brauer and co-workers, using a real-world data set for personal exposures and ambient levels from Vancouver, Canada[4]. Personal $PM_{2.5}$ exposures contain more than just particles from ambient origin; therefore, exposure assessment using ambient data alone is confounded and studies using this metric will produce confounded results, showing no threshold even when this was explicitly assumed to exist.

---

[1] Lung cancer, cardiopulmonary mortality and long-term exposure to fine particulate matter. Pope, C.A. et al., JAMA, March 6, 2002-Vol 287, No. 9

[2] Particulate matter in ambient air and mortality: toxicologic perspectives. Green, L.C. and S.R. Armstrong, Reg. Toxicology and Pharmacology 38 (2003) 326-335

[3] Possible noncausal bases for correlations between low concentrations of ambient particulate matter and daily mortality. Valberg, P., Non-linearity in Biology, Toxicology and Medicine 1:521-530 (2003)

[4] Exposure Misclassification and Threshold Concentrations in Time Series Analyses of Air Pollution Health Effects M. Brauer, et al.; Risk Analysis, Vol. 22, No. 6: 1183-1193 (2002)

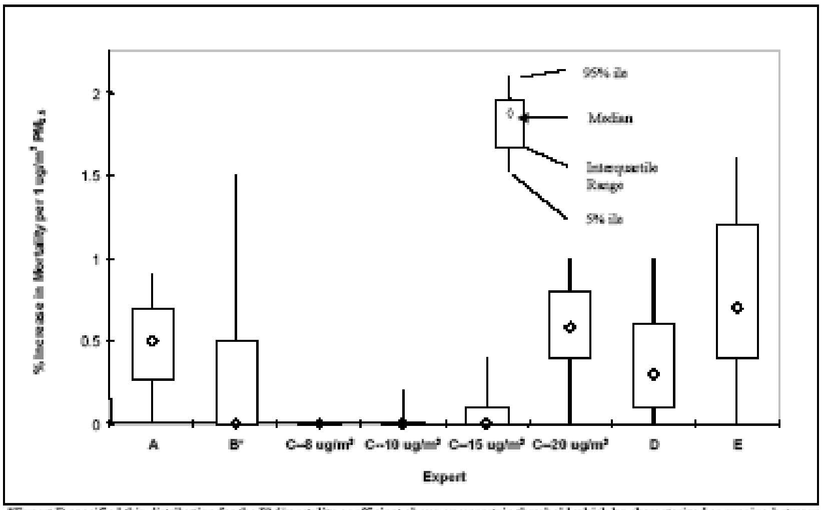
3. *Uncertainty analyses should examine a spectrum of scenarios including one in which there is no mortality associated with current low levels of particulate matter in ambient air and another one which assumes a threshold below which mortality does not occur*

A pilot project was recently conducted in the US for the EPA in which five experts were extensively interviewed regarding their views on the concentration-response function for $PM_{2.5}$ exposure and mortality[5]. All five experts placed at least a 5% probability on the possibility that there is no causal relationship between fine PM exposure and mortality. Therefore it appears reasonable to include this option in the range of scenarios for the uncertainty examination. Note that one of the five experts was also selected by CAFÉ as a reviewer for the CBA methodology.

The opinions of the five experts are presented in the figure below and clearly show that there is no consensus on either the slope of the risk function or the presence/absence of a threshold.

Figure ES-1

Comparison of Experts' Judgments about the Percent Increase in Annual Non-Accidental Mortality Associated with a 1 μg/m³ Increase in Annual Average Exposures to $PM_{2.5}$ (U.S. Baseline 8 to 20 μg/m³)



*Expert B specified this distribution for the PM/mortality coefficient above an uncertain threshold which he characterized as ranging between 4 and 15 with a modal value of 12 ug/m³

4. *The CAFÉ process should seek broader advice regarding current scientific views on causality, concentration-response functions and thresholds*

Hardly any experts from EU Member State Ministries of Health or National Public Health Institutes have participated actively in the CAFÉ steering group. As a result, the views of a limited number of people, convened by the WHO-European Centre for Environment and Health, have prevailed as 'what the experts tell me'. The convened groups were over-represented by active researchers in the field of ecologic epidemiology who tend to favour positive studies over negative studies, and use default no-threshold models (to be rejected statistically) as the base case in their study analyses.

---

[5] An expert judgment assessment of the concentration-response relationship between $PM_{2.5}$ exposure and mortality. Prepared for: Office of Air Quality Planning and Standards, US EPA, by: Abt Associates, Inc. Bethesda, Maryland, April 23, 2004

Discussion paper for the
"Workshop on Review and Assessment of European Air Pollution Policies"
Göteborg, 25-27 October, 2004

Christer Ågren

What an EU thematic strategy on air pollution could contain: List of contents

Introduction

1. Aims and objectives of EUs air quality policy

1.1 Long-term objectives
See e.g. 6th Environment Action Programme (Art. 2 and 7) and NEC Directive (Art. 1 + preamble paras 1 & 3,)

1.2 Interim targets
See e.g. NEC Directive (Art. 5) and Air Quality Daughter Directives

2. Current state of air quality in the European Union

2.1 Emissions in base year 2000 (SO_2, NOx, VOCs, NH_3, $PM_{2.5}$, PM_{10}, ...)

2.2 Concentrations and depositions

2.3 Quantification of current impacts and risks (e.g. concentrations compared to limit and target values of the Daughter Directives and to critical levels; population exposure and related health impacts; vegetation exposure and related impacts; ecosystem exposure (exceedances of critical loads) and related risks and impacts;...)

3. What will be the result of current policies - baseline projections up to 2020

3.1 Drivers: energy use and activity levels

3.2 Emissions
3.2.1 Emissions by 2010, 2015 and 2020
3.2.2 Attainment of NECs (Annex I) and indicative NECs (Annex II) by 2010?

3.3 Air quality – impacts on health & environment
3.3.1 Quantification of future impacts and risks (as for 2.3, above)
3.3.2 Attainment of interim targets?
3.2.2.1 NEC Directive (Art. 5)
3.2.2.2 Air Quality Daughter Directives

3.4 Links/interactions
3.4.1 International shipping and aviation
3.4.2 Developments in rest of Europe (non-EU countries)
3.4.3 Transcontinental transport of air pollutants
3.4.4 Interactions with LRTAP Convention

3.5 Conclusions from baseline projections

4. Policy scenarios (for investigating how to achieve current aims and objectives, and providing input for setting new interim targets)

4.1 Main policy scenarios investigated

4.1.1 Maximum Technically Feasible Reductions (MTFR) scenario

4.1.2 Cost-effectiveness scenarios

4.1.2.1 Various levels of ambition (several ones)

4.1.3 Low carbon scenario (reflecting a climate policy in line with the EU-target of maximum 2 ºC temperature increase from pre-industrial levels, i.e. reductions in EU CO_2-emissions of 30-45% between 1990 and 2025)

4.2 Alternative policy scenarios and scenarios for sensitivity analysis (examples)

4.2.1 Application of BAT (Best Available Techniques), including improved efficiency, assumed technology advances, fuel switch, etc

4.2.2 Analysis of sector-specific measures (e.g. shipping; large/small combustion plants; road-vehicles; non-road vehicles...)

4.2.3 CAP-reform scenario (changes in EU agricultural policy)

4.2.4 Others (several alternatives...)

4.3 Benefits analyses

4.3.1 Monetized benefits

4.3.2 Other (non-monetized) benefits

4.4 Conclusions from policy scenario analysis

5. Overall conclusions and proposals

5.1 Overall conclusions from the analysis (link back to section 1: Aims and objectives)

5.1.1 How can the (interim) targets for 2010 be achieved?

5.1.2 Can the long-term objectives be attained by 2020, and if so, how?

5.1.3 Proposals for new interim targets for 2015

5.2 Proposals for measures (incl. new or revised EU legislation) accompanying this strategy

5.2.1 Additional (short-term) measures to help ensure attainment of already set (interim) targets of the NEC directive and the Air Quality Daughter Directives

5.2.2 Other proposed measures

5.3 Envisaged forthcoming proposals for measures

5.3.1 Revision of the NEC directive

5.3.2 etc.

5.4 Issues to be further investigated

5.5 Next steps for CAFE

Annex I: Excerpts from the 6th Environment Action Programme

Article 2: Principles and overall aims

...

2. The Programme aims at:

...

- contributing to a high level of quality of life and social well being for citizens by providing an environment where the level of pollution does not give rise to harmful effects on human health and the environment and by encouraging a sustainable urban environment;

...

Article 7: Objectives and priority areas for action on environment and health and quality of life

1. The aims set out in Article 2 should be pursued by the following objectives, taking into account relevant World Health Organisation (WHO) standards, guidelines and programmes:

...

— achieving quality levels of ground and surface water that do not give rise to significant impacts on and risks to human health and the environment, and to ensure that the rates of extraction from water resources are sustainable over the long term;

— achieving levels of air quality that do not give rise to significant negative impacts on and risks to human health and the environment;

...

2. These objectives shall be pursued by means of the following priority actions:

...

(f) on air quality, development and implementation of the measures in Article 5 in the transport, industry and energy sectors should be compatible with and contribute to improvement of quality of air. Further measures envisaged are:

— improving the monitoring and assessment of air quality, including the deposition of pollutants, and the provision of information to the public, including the development and use of indicators;

— a thematic strategy to strengthen a coherent and integrated policy on air pollution to cover priorities for further actions, the review and updating where appropriate of air quality standards and national emission ceilings with a view to reach the long term objective of no-excedence of critical loads and levels and the development of better systems for gathering information, modelling and forecasting;

— adopting appropriate measures concerning ground-level ozone and particulates;

...

— playing a leading role in the negotiations on and strengthening the links and interactions with international processes contributing to clean air in Europe;

— further development of specific Community instruments for reducing emissions from relevant source categories;

...

Annex II: Excerpts from the NEC Directive

Preamble. Whereas:

(1) The general approach and strategy of the Fifth Environmental Action Programme was approved by the Resolution of 1 February 1993 of the Council and the Representatives of the Governments of the Member States meeting within the Council on a Community programme of policy and action in relation to the environment and sustainable development and it sets as objectives that critical loads and levels for acidification in the Community are not to be exceeded. The programme requires that all people should be effectively protected against health risks from air pollution and that permitted levels of pollution should take account of the protection of the environment. The programme also requires that guideline values from the World Health Organisation (WHO) should become mandatory at Community level.

...

(3) Decision No 2179/98/EC of the European Parliament and of the Council of 24 September 1998 on the review of the European Community programme of policy and action in relation to the environment and sustainable development "Towards sustainability" specified that particular attention should be given to developing and implementing a strategy with the goal of ensuring that critical loads, in relation to exposure to acidifying, eutrophying and photochemical air pollutants, are not exceeded.

...

Article 1: Objective

The aim of this Directive is to limit emissions of acidifying and eutrophying pollutants and ozone precursors in order to improve the protection in the Community of the environment and human health against risks of adverse effects from acidification, soil eutrophication and ground-level ozone and to move towards the long-term objectives of not exceeding critical levels and loads and of effective protection of all people against recognised health risks from air pollution by establishing national emission ceilings, taking the years 2010 and 2020 as benchmarks, and by means of successive reviews as set out in Articles 4 and 10.

...

Article 5: Interim environmental objectives

The national emission ceilings in Annex I shall have as their purpose to meet broadly the following interim environmental objectives, for the Community as a whole, by 2010:

<u>a) Acidification</u>

The areas where critical loads are exceeded shall be reduced by at least 50 per cent (in each grid cell) compared with the 1990 situation.

<u>b) Health-related ground-level ozone exposure</u>

The ground-level ozone load above the critical level for human health (AOT60 = 0) shall be reduced by two-thirds in all grid cells compared with the 1990 situation. In addition, the ground-level ozone load shall not exceed an absolute limit of 2,9 ppm.h in any grid cell.

<u>c) Vegetation-related ground-level ozone exposure</u>

The ground-level ozone load above the critical level for crops and semi-natural vegetation (AOT40 = 3 ppm.h) shall be reduced by one-third in all grid cells compared with the 1990 situation. In addition, the ground-level ozone load shall not exceed an absolute limit of 10 ppm.h, expressed as an exceedance of the critical level of 3 ppm.h in any grid cell.

European AQ policy – status quo and outlook[1]

Jürgen Schneider

!Please note that this paper contain a personal view and is not an official coordinate position!

Introduction

Air pollution has decreased in Europe and other well developed countries in the last decades. This has been a consequence of a large number of measures to reduce the emission of harmful substances into the air. The main driving force for introducing those emission reductions were

a) well documented effects of high levels of local pollution on human health. Widely known examples of early episodic air pollution events (in the mid of the 20th century) include those in Donora, Pennsylvania (20 people died, 40 percent of the town's 14,000 inhabitants ill), in Meuse Valley (Belgium), where pollution became trapped in a narrow valley leading to 600 ill people and 63 being killed and last but not least the London smog event in 1952, where several thousands were killed over a two-week period in 1952.

b) effects on the environment. These included not only local effects, but also long range air pollution. In the seventies of the last century it became clear that air pollutants can be transported over wide distances (often several thousands of kilometres) and therefore cross national borders. As a consequence, effects like acidification of lakes and rivers or of forest soils occur in areas far away from any major emission sources (for instance in Scandinavia).

Nowadays, its obvious that air pollution cannot be successfully combated at a local or even national level alone. International frameworks are essential to coordinate measures among European countries. The most important framework is probably the European Union but which does not cover the whole European territory. Important is also the UN ECE Convention on Long Range Transboundary Air Pollution (http://www.ece.org/env/lrtap).

Present situation

Regulations for emission reductions have been implemented for most major polluting sectors. In the EU Member States (), several different complementary tools are used to reduce emissions of air pollution, including

- source related emission regulations for mobile sources (road and off-road) and stationary sources;
- product regulations (for fuels, solvents,..);
- regulations on air quality assessment and management, which aims at the improvement of air quality where it is not good;
- national emission ceilings;
- several cross-cutting regulations, including those on environmental impact assessment, strategic environmental assessment, etc.

These regulations have lead to a strong decoupling of economic growth (e.g., as indicated by the GDP) and the emissions of most of the classic air pollutants.

Problems with current legislation

Most of the current directives summarized in the para above have been successful in improving air quality. However, there are a number of problems in some of the details of some of the directives.

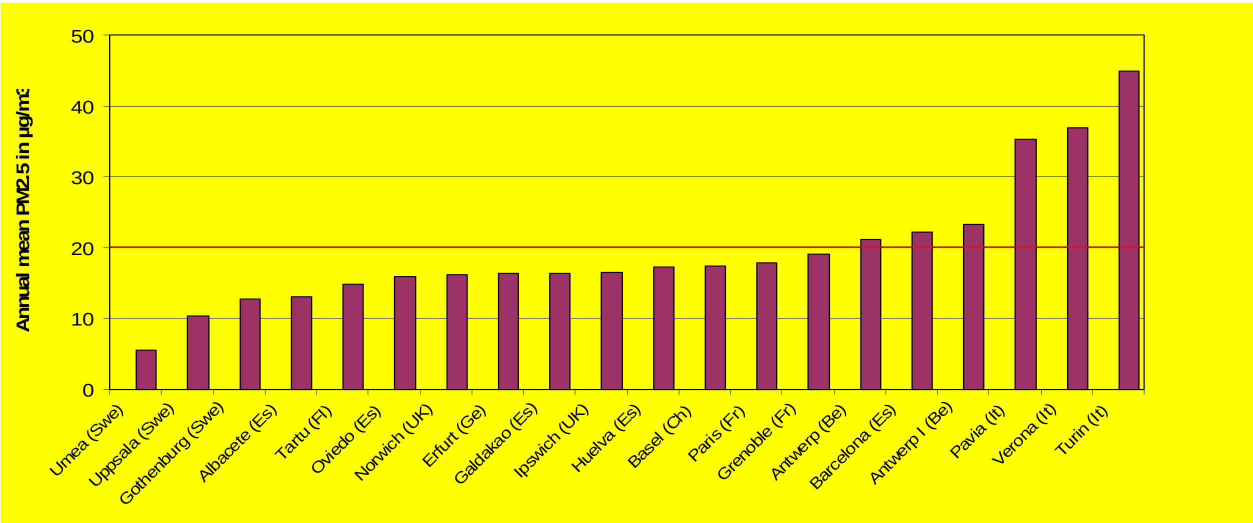
<u>Source related legislation & product regulations</u>: Some of the source related and product directives have been remarkably successful. However, as a matter of fact, important decisions on these items are now taken at a Community level. This ensures that measures are taken by all MS, but clearly limits the flexibility of single MS to establish more stringent requirements in some fields. It's also sometimes a rather lengthy process from a Commission proposal to the adoption of directives, transposition and

[1] This is not meant to provide a comprehensive overview, but rather to provoke discussion at the Gothenburg workshop.

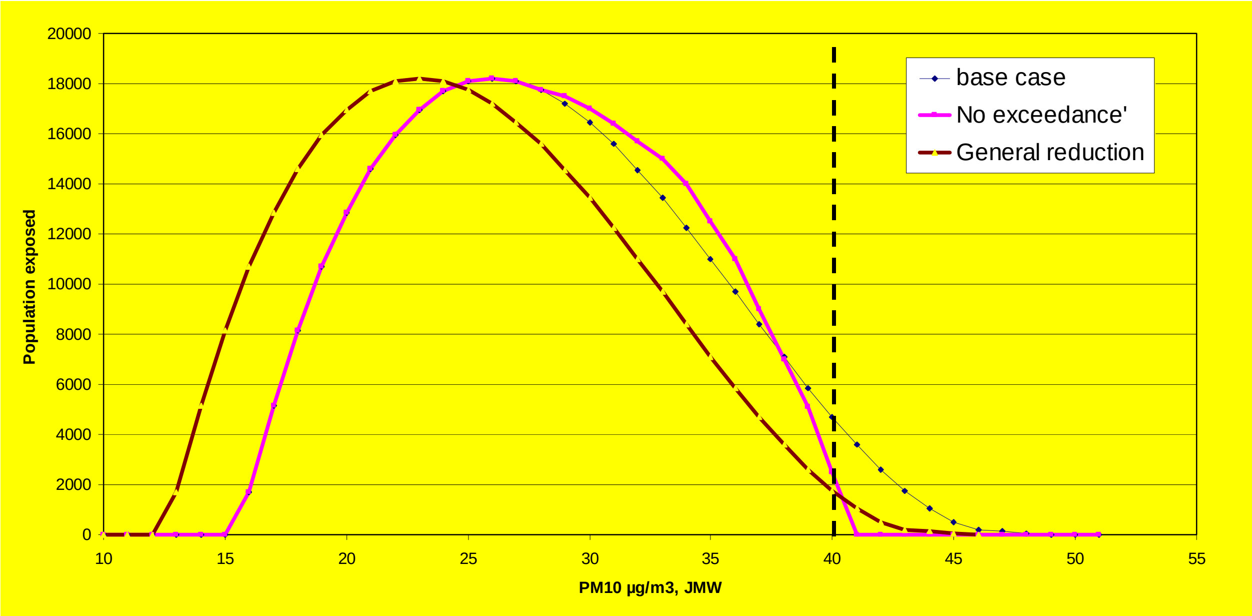
implementation at a MS level. This prevents rapid adaptation of current legislation to state-of-the-art regulations (EURO5,6). The agreements reached are also often compromises and do not necessarily represent best available technology (LCP directive). The effectiveness of one of the key pieces of legislation to reduce harmful effects of plants on the environment – the IPPC directive - still remains to be evaluated.

National emission ceilings: The NEC D (and the Gothenborg Protocol) was designed to reduce emissions of substances contributing to transboundary air pollution causing acidification, eutrophication and ground level ozone. Ideally, this directive should trigger additional cost effective measures to approach agreed environmental targets. It also leaves MS some flexibility in choosing appropriate measures to reduce their emissions cost effectively. Since the emission ceilings are linked to environmental objectives, they are formulated as absolute figures. However, this leads to some problems in particular if emissions have to be recalculated and change, e.g., due to changes in emission factors, (as has happened for the NOx emissions of HDV). For Austria, there are indications that for some of the pollutants no additional measures are required to comply with the ceilings (in other countries, the ceilings are widely overachieved), while for one pollutant (NOx) the ceiling seems out of reach and far beyond MFR (maximum feasible reduction). Alternative approaches (relative ceilings? ceilings for source groups?) could be considered. In any case, any regulation prescribing emission ceilings requires the establishment of high quality, robust, transparent, consistent, comparable, complete and accurate emission inventories in all countries.

Air quality framework and daughter directives: The FWD and its daughter directives establish AQ limit and target values to be met at a certain date for various pollutants. Some of the pollutants covered by this legislation have a rather strong regional/transboundary component (as ozone and PM); therefore, it is not easy to establish a fair and cost-effective balance of measures at different scales (local, regional and international) under the current legal instruments.
There is also some concerns about the application of a limit value concept for pollutants with no apparent no-effect level and which have very different concentrations in Europe (as with PM). Current air quality standards are to a large extent based on the concept of an effect threshold, below which significant health effects are not likely to occur. As stated, there might be no threshold for PM and ozone. Therefore, even if the Limit Value/Target Value is achieved, health impacts will continue. Vice versa, health benefits will accrue from a reduction in pollutant concentrations below the current standards. Figure 1 displays annual mean PM2.5 concentration from various cities in Europe. A limit value of 20 µg/m3 seems in this example in some regions almost out of reach, while it would not trigger any further reductions in other cities, while this would also lead to health benefits.



It is also doubtful if a policy focused on the abolishment of isolated exceedances of the limit value achieves the best health outcome for the population as a whole. This is schematically illustrated in the following graph:



The x axis contains annual PM levels, while the y axis shows the # of people exposed to different concentrations. If there is a linear concentration response function and no threshold, the 'no exceedance' case has only marginal health benefits compared to the base case, while the general reduction would be far more effective. Despite those considerations, the limit value approach might still be warranted e.g., to avoid that small groups bare an excessive risk.

Economic instruments: On a Community level, there is not much experience with economic instruments as a tool to reduce emissions of air pollution.

New clean air policy objectives in the European Union

The 6th Community Environment Action Programme (Sixth EAP) was adopted in July 2002 by the European Parliament and the Council (Decision 1600/2002/EC). This Programme sets out the key environmental objectives to be attained in the European Community. It also establishes, where appropriate, targets and timetables for meeting these objectives. One of the objectives of the Sixth EAP (Article 2) is to establish "... a high level of quality of life and social well being for citizens by providing an environment where the level of pollution does not give rise to harmful effects on human health and the environment".

Is there a need for additional measures?

Despite considerable progress in clean air policy in Europe, air pollution still poses a considerable threat to human health and the environment as a whole. Concerning health effects, numerous scientific publications have provided evidence for various health effects of different air pollutants. This evidence was recently reviewed and assessed (WHO, 2004; for PM: US EPA, 2003). Many different adverse effects have been linked to exposure to air pollutants like ozone and particulate matter (PM). The latter has been linked to an increased risk of cardiopulmonary disease and a reduction in life expectancy of a year or more for people living in European cities. Some of these effects occur at very low concentrations that were previously considered safe. Taken together, the evidence is sufficient to strongly recommend further policy action to reduce levels of air pollutants. It is reasonable to assume that a reduction in air pollution will lead to considerable health benefits.
There is also compelling evidence that deposition of eutrophying (and in some regions acidifying) pollutants has not been decreased to a level compatible with sustainable development (). Other problems include the long range distribution of certain pollutants, which can accumulate and cause harm to the environment and health (including certain heavy metals and POPs).

A recent analysis of IIASA (IIASA, 2004) indicated that the environmental problems linked to air pollution mentioned in the para above will not be solved in 2020 assuming a ‘business as usual’ (BAU) scenario (in the terminology of CAFÉ, this is called the baseline scenario).

Outlook

While additional measures are needed to achieve agreed environmental goals (e.g., as formulated in the sixth Environmental Action programme of the European Union), these are becoming increasingly expensive. This has several consequences.

1. There is a growing need for accurate information on the effect of air pollution on health and the environment as a basis for designing scientific, effective and well targeted strategies to further reduce these effects. For example, any new EU directive proposed by the European Commission should be assessed concerning its impact (i.e. concerning the costs and benefits). This requires robust, quantitative information. As a consequence, there is a need for research to focus on the remaining open questions.
2. As stated above, there are in principle different tools available to reduce air pollution. Any further measures should build on an evaluation of the effectiveness of existing tools. This requires an in-depth ex post analysis.
3. Any measures to reduce the emissions of air pollutants become potentially more effective if they are synergistic with measures to reduce other environmental effects. One example which has been recently well documented are the synergies (and sometimes trade offs) between measures to reduce the emissions of classical air pollutants and green house gases. Reducing the emission of greenhouse gases is a major challenge for the society. At least for the most important greenhouse gas, CO2, there are no end-of-pipe measures to reduce emissions, since it is the primary product of the combustion of carbon containing fuels. Therefore, other measures (increasing energy efficiency; structural changes; increase use of renewable energy sources) are needed.
4. In some sectors, technical measures have been far advanced. However, there seems often much room for non-technical measures, e.g., in the transport sector.

Some open questions

At this stage there are a number of open questions. Some of them are highlighted:

1. How should we design our future clean air goals? Even though there is common agreement that effects on health and the environment should be reduced cost effectively, there are a number of details to be discussed. How far should we go? How should we balance different effects which are not directly comparable? There are also additional considerations to cost effectiveness, e.g. on environmental justice: There are indications that the health burden caused by air pollution is not equally distributed among the population. There might be groups at increased risk, e.g., those living in the vicinity of sources and those with lower educational level. Concerning effects on ecosystems, not all ecosystem may be equally worth protecting.
2. Which instruments/tools should we use to further reduce air pollution? We have a lot of experience with some of the tools mentioned above. They are often, but not always complementary. How can we effectively combine, e.g. source related regulations, ceilings and limit values?
3. How can we link the different scales? There is a need to establish a coherent strategy which is capable of linking different scales effectively. Several scales have to be addressed simultaneously, in particular for pollutants like PM. Hot spots are of relevance, since health risks have to be reduced for those subjects which are exposed to highest concentrations. The responsibilities for measures usually lies with local authorities. Urban background concentrations are highly relevant for the general exposure of the population and therefore health effects. Regional background concentrations of PM and ozone are caused by emissions at a European scale. The same is true for acidifying and eutrophying pollutants. There is also increasing evidence that emissions outside Europe contribute significant to ozone levels observed in Europe.

4. How can we link up with climate change? There are tight links between classical air pollutants and greenhouse gases. There are common sources; common (and sometimes antagonistic) measures to reduce emissions; some of the air pollutants have a direct effect on radiative forcing, including ozone and PM. Up till now, it is open how these links are considered in designing synergistic and effective abatement strategies.

21.10.04

THEMATIC STRATEGY ON AIR POLLUTION

INDUSTRY PERSPECTIVES

Prepared by the UNICE Air Quality Working Group (AQWG) for the Workshop on Review & Assessment of European Air Pollution Policies Gothenburg 25-27th October 2004

Summary of Key Points

1. Industry has made and continues to make major contributions to reducing air pollution.
2. Industry is an active stakeholder group contributing to the Clean Air for Europe (CAFE) Programme.
3. It is crucial that further action be based:
    a. sound scientific information and advice;
    b. integrated analysis to find the least cost solution to controlling multiple pollutants with multiple effects to meet a set of agreed air quality objectives;
    c. understanding of the key uncertainties and their implications for policy; and
    d. understanding of the impact of additional costly measures on industry competitiveness, consumer prices and employment.
4. We welcome the use of integrated assessment modelling in the development of the Thematic Strategy on Air Pollution, complimented by other models such as TREMOVE where appropriate.
5. We suggest a series of optimised scenario runs which will allow decision makers to see the relationship between environmental ambition levels and costs over time, by Member State.
6. We suggest the use of 'sensitivity scenarios' to examine key areas of uncertainty in policy relevant terms.
7. Industry considers the current debate on specific measures to be premature (it needs to be informed by the results of the analysis suggest above). However members of the UNICE AQWG have provided comments on the following topics:
    a. Revision of the National Emissions Ceilings Directive
    b. Review of the Large Combustion Plant Directive
    c. Solvents
    d. VOCs from refuelling operations at service stations
    e. New passenger cars, light commercial vehicles and heavy duty vehicles
    f. Reduction of air pollution from existing vehicles
    g. Atmospheric emissions from ships
    h. Agriculture
8. We suggest that the Commission establish a monitoring programme on the health effects of air pollution designed to appraise the effectiveness in the EU of legislative initiatives taken under the Thematic Strategy on Air Pollution.

Introduction

The Thematic Strategy on Air Pollution is the first of seven planned thematic strategies all due for completion in 2005. Together, these thematic strategies are intended to deliver significant benefits to society particularly through health and environmental protection, something that all would wish to support.

In addressing such issues, industry believes it is in the interest of society as a whole that economic factors are fully accounted for in the design of sustainable policy. It surely makes sense to find the least cost solution to any given societal problem. In this regard we welcome the commitment to Integrated Assessment in the development of the Thematic Strategy on Air Pollution.

This paper outlines industry perspectives on the forthcoming strategy and recent discussions on possible policy measures.

Industry is contributing and real progress is being made

Industry has contributed enormously to society's efforts to improve air quality and undoubtedly we have much better air quality across Europe today than would have otherwise been the case. The CAFE modelling work so far also indicates we can expect further progress over the next 15 years applying current agreed legislation. For example:

- Over the past two decades, the European Electricity Industry has reduced its SO_2 emissions by 74% while the electricity production has increased by 65% during the same time period. Source: Environmental Statistics of the European Electricity Industry (2004).
- Emissions of tropospheric ozone precursors have been reduced by 30% between 1990 and 2001 (43% in new Member States). Source: European Environment Agency.
- Industrial VOC emissions have been reduced by a factor of 2 (47% on average and up to 64% in some sectors). Source: ESVOC.

What else needs to be done?

This for industry is the key question, and one that we believe must be answered through sound scientific analysis. It should involve an assessment of the extent of any residual problem, the contributors to such problems and the determination of the most cost-effective solution. Industry is participating in and contributing to the CAFE programme, working together with other stakeholders to help to ensure that policy makers have the best information and advice, on which to base their decisions.

From an industry perspective, it is essential that the Thematic Strategy and the accompanying legislative proposals are underpinned by such approaches.

What are the key process needs?

A structured process for "Risk Management" to ensure policy is informed by a clear understanding of the relationship between reduced effects (risk) and the cost to achieve such reductions (see "scenario analysis" below). Industry believes this to be the only way to ensure the determination of appropriate priorities and associated objectives (e.g., Air Quality Limit/Target Values) in a multiple-pollutant/multi-effect environment.

Optimised Integrated Assessment Modelling (IAM): Once the targets have been set via the risk management process, the optimisation capability of the Integrated Assessment Model enables the determination of the optimum, within the implicit uncertainty margins, suite of measures to deliver the objectives. Simply assessing a pre-defined European-wide measure for its costs and effects within IAM with subsequent cost benefit analysis is not appropriate or acceptable to Industry for the following reasons:

- given the complexity of a multi-pollutant/multi-effects environment the ability to account for potential synergistic/antagonistic effects of emission abatement options would be lost; and
- even if a cost-benefit analysis (CBA) indicates benefits exceed costs, this does not indicate that such a measure is cost justified since other measures may be more/much-more cost-effective.

Uncertainty Scenarios: As recognised in the RAINS peer review, "uncertainty scenarios" are an appropriate technique for assessing uncertainties. Industry would strongly support this since such scenarios can be run through IAM and CBA. In this way uncertainties can be expressed in policy relevant terms.

Global Competitiveness: Policy questions like: "What level of gap closure should we set as a target?" are intrinsically linked to the level of financial burden implied for EU society (to industries' costs, consumer prices and employment). Industry therefore believes it is vital to align policy with the Lisbon strategy aimed at "making the EU the worlds most dynamic and competitive economy". This implies a need to be scrupulous in avoiding any regret expenditure.

What information do we need?

The key information that we need for decision-making will be generated through the policy scenario work as part of the CAFE Programme. The following is an abstract from a previous paper (Policy Options Scenario Design, UNICE, June 16th 2004) which outlines industry views on some of the essential elements that should drive the design of the policy scenarios for CAFE. In addition it outlines the data outputs from these scenarios that should be made available to all concerned stakeholders.

1. The design of scenarios needs to recognise that CAFE is a multi-pollutant/multi-effect initiative i.e., a given scenario must simultaneously examine all key pollutants/effects within the Integrated Assessment

Modelling framework. This ensures that synergistic and antagonistic effects of particular abatement measures are appropriately accounted for.

2. The policy making process requires a clear understanding of the relationship between the cost and the environmental/health improvement. This is vital for establishing targets through an appropriate risk management process. The suite of scenarios examined using RAINS (and also TREMOVE for the transport sector) should therefore be designed to ensure that this "cost vs. reduced impact" relationship (for the EU and for each individual Member State) is provided to all stakeholders involved in the development of policy.

3. Scenario design should be based primarily on the recognition of the need to determine the <u>most cost-effective solution for a given environmental aim</u> using the optimisation capabilities of RAINS. This will ensure resources are directed wisely to address residual environmental/health issues, i.e. by controlling emissions on the basis of their environmental/health impact, rather than requiring controls on emissions even if they have negligible impact.

   Having said this, in some specific cases other considerations such as preservation of the internal market may prevail over the environmental/health driven approach mentioned above.

4. Vital outputs from each scenario will be for <u>each Member State</u>:
   a. the cost;
   b. a suitable indicator of the resulting state of the environment or health effect e.g., deposition of acidifying compounds (split between sulphur, oxidised and fixed nitrogen)/extent of exceedance of critical loads, air concentrations/health impacts; and
   c. the individual measures that have been picked by RAINS to enable comparison to the list of measures in the Commission's draft "Measures paper".

5. In designing the suite of scenarios "a stepwise" series of gap closures toward the "no-significant-effect" ultimate goal should be explored. These scenarios should be run for each of the time horizons i.e., 2010, 2015 and 2020. The output would be a set of cost versus gap closure curves for each Member State, over time.

6. As well as cost-effectiveness, achievability and feasibility should also be fundamental considerations in all scenarios.

7. An important addition to these scenarios will be specific "sensitivity scenarios" designed to explore the upper and lower boundaries of uncertainties (including modelling uncertainties), using RAINS in its optimisation mode. In addition, uncertainties in the dose response curve slopes (reflecting the confidence in the statistical fit of the epidemiological data) and the implications of potential "thresholds of effect" should also be examined.

8. In all cases, the detailed results of the scenario analysis (not just summary data or graphical representations) should be made available to concerned stakeholders. This can only serve to promote transparency and build stakeholder confidence in the robustness of the results used for policy design.

What should the Thematic Strategy look like?

According to DG Environment, the Thematic Strategy on Air Pollution will be an EC communication of a non-binding nature describing a roadmap towards improved air quality. It will be 15 pages in length and be accompanied by a selection of legislative proposals and an extended impact assessment. Other legislative proposals are anticipated to follow later.

Given that the CAFE process has not yet provided much of the detailed scientific information that is needed for drafting the Thematic Strategy, **industry considers the current debate on specific measures to be premature** and so it remains largely hypothetical. However, as certain potential themes are being discussed, industry has provided in the following sections some comments (including sector-specific comments) which may be useful to consider at this time.

Revision of air quality directives limit values

It is important that the current approach of setting air quality limit values is maintained, including for those pollutants where health specialists have not been able to confirm a threshold below which there are no health effects.

Revisions to existing air quality limit values should be considered in the light of new scientific evidence, particularly on the severity of the effects at given concentrations and exposure periods. The setting of air quality limit values should also take into consideration:

- the robustness of our current scientific understanding;
- the implementation practicalities (modelling and measurement capabilities);
- existing hemispheric background concentrations, natural concentrations and the distribution and frequency of natural air-quality-related events; and
- the cost-effectiveness of further control measures.

Where significant uncertainties remain, use could be made of target or guide values. Revisions clauses could also be used to allow revisions in the light of improved scientific understanding.

Revision of National Emissions Ceilings Directive

The proposal to revise the NEC Directive is expected to follow after the Thematic Strategy. Industry is ready to play its role as a key stakeholder in this activity.

Review of the Large Combustion Plant Directive

The existing Directive is a highly restrictive piece of legislation, without the sophistication of the IPPC Directive which allows for the accounting of differing environmental situations and cost-effectiveness to be taken into account in setting emission limits. Its requirements potentially conflict with the effects-based elements of the Air Quality Framework and National Emissions Ceilings Directives.

The electricity generation industry is due to invest a great deal in the next few years – 620 GW of new power investment have to be constructed requiring funds of 550 billion Euros. Regulatory stability is a prerequisite for ensuring a good environment for such investment and so it is crucial to avoid any major amendments to the Directive. However regulatory stability does not mean inactivity and the electricity industry would welcome any opportunity to open discussion with the Commission on innovative approaches to better protect the environment.

Solvents

The solvent emissions Directive is largely implemented, with many industries/Member States going beyond the minimum emission reductionrequirements. In addition, the IPPC directive (BREF on surface treatment using solvents under preparation) will further reduce VOC emissions from solvents. The new directive (2004/42/EC) on VOCs from decorative paints and vehicle refinish products will further contribute to reduce VOCs across the EU-25 by 2010, and result in conversion from solvent-based to water-based technologies where technically feasible.

Further controls on solvent VOCs should be considered in the context of:

- the existing regulations outlined above;
- the contribution to ozone formation due to natural VOC emissions and ozone precursors generated outside the EU-25;
- not all solvents are the same in their ability to create ozone; and
- specific and flexible approaches, as a measure that works for one type of solvent or application may not work for another.

Reviewing the Solvent emission Directive adopted in 1999 before its full implementation (scheduled for 2007) is not appropriate and is not fair to those industries investing in abatement systems/technologies in the context of a given piece of legislation. Directive 1999/13/EC will result in up to 64% VOC emission reductions from solvent using industries. These industries should have the time to depreciate their investment.

VOCs from refuelling operations at service stations ("Stage II")

The Oil Industry questions the need for EU-wide legislation mandating Stage II vapour recovery on the basis of cost-effectiveness. Moreover, the draft 2003 EPTC survey indicate that Stage II vapour recovery is already installed in 85-100% of service stations in Austria, Denmark, Germany, Hungary, Italy, Luxemburg, Netherlands, Sweden, and Switzerland.

New passenger cars, light commercial vehicles and heavy duty vehicles

- As 'common measures across the EU' are a prerequisite in the case of emission controls for new vehicles, optimized integrated assessment modelling is essential for a fair treatment of the road transport sector with respect to emission reductions and costs.
- The RAINS optimization model represents the road transport sector in an aggregated manner and analysis must be further elaborated using the TREMOVE model.

Heavy duty vehicles

Besides reductions of emission limit values of engine pollutants other measures should be evaluated such as:

- Improvements of the regulations regarding its effect on emission reductions in real traffic. Areas of improvements have been identified in connection with the ongoing regulatory work within UN/ECE and include the WHDC test cycles, off-cycle emissions and on-board diagnostics.
- The effect of increased size and weight of HDV to reduce emissions from the road transport sector.
- Improved enforcement activities regarding manipulation of engines and after-treatment systems.

Reduction of air pollution from existing vehicles

These additional measures could be helpful in addressing urban air-quality hotspots and are best considered at the local level:

- Alternative Fuels in captive fleets
- Scrapping of older vehicles.
- Exclusion zones for older vehicles.
- Inspection and maintenance activities.

Further reduction of atmospheric emissions from ships

Much has been made of the total ship emission figures - SOx, NOx and PM – and that for SOx and NOx total ship emissions will exceed emissions from land-based sources by 2020. Of course this is largely due to the very substantial reduction in emissions from land-based sources since 1990. The question is, given these large reductions, are further reductions required to meet defined environmental targets. Industry has pointed out many times that information on emissions alone are not grounds for proposing measures. Impact and cost-effectiveness of controls must also be considered. This is particularly the case as emissions of ships as far away as the middle of the Atlantic Ocean are included in the emission totals for Europe.

Agriculture

Industry supports the consideration of cost-effective measures to control ammonia emissions from this sector. Ammonia dominates the residual problems of acidification and eutrophication and is a major contributor to secondary PM. It is therefore critical to identify more appropriate abatement measures for this sector.

With respect to ozone and crop yield loss; it appears contradictory for industry to spend money on emission control measures aimed at protecting crops (and hence improving crop yields) if those same farmers are being paid subsidies to reduce their yield.

Monitoring of health end-points

Industry would like to suggest that the Commission establish a monitoring programme on the health effects of air pollution designed to appraise the effectiveness in the EU of legislative initiatives taken under the Thematic Strategy on Air Pollution.

Background paper for the
„Workshop on Review and Assessement of European Air Pollution Policies“
25-27 October 2004, Gothenburg, Sweden

ACHIEVING THE EU AIR QUALITY LIMIT VALUES - A CITY VIEWPOINT

Lucy Sadler [1] and Martin Lutz [2]
with contributions from Dominique Gombert [3]
[1] Greater London Authority (lucy.sadler@London.gov.uk) [2] Senate Department of Urban Development, Berlin (martin.lutz@senstadt.verwalt-berlin.de)
[3] AirParif (dominique.gombert@airparif.asso.fr)

ABSTRACT
The city authority in London is doing as much as it can to achieve the EU Limit Values, and national air quality objectives. Some of the measures are outlined here. Measures the Greater London Authority are undertaking to reduce PM_{10} and NO_2 concentrations are set out in the London Mayor's Air Quality Strategy, and London local authorities are generally further advanced than their colleagues in the rest of the UK.

While control efforts in Berlin have resulted in a significant improvement of the air quality within the last decade the Senate Department of Urban Development is currently developing an air pollution abatement plan which will spell out a suite of measures aimed at achieving compliance with the EU Limit Values for fine particulates (PM_{10}) and nitrogen dioxide (NO_2).

However, cities such as London, Berlin and Paris are finding that they cannot achieve them without some further assistance. In many cases, the national authorities and the EU are best placed to give the local authorities tools to increase the effectiveness of local measures. Greater dialogue between different levels of governance will assist in achieving the Limit Values, by informing policy makers at each level of the activities and problems with which each are faced. Cities also need to talk together to share best practice and raise these matters with their national authorities and the international organisations. This paper sets out some of the issues and suggests further measures needed.

INTRODUCTION
The EU has set health-based air quality Limit Values to protect the health of its citizens. There are three reasons why authorities on all levels, i.e. the European institutions, national governments, regional and city governments are to work together and to co-ordinate action to meet these objectives:

- It is a common problem that poor air quality damages health and quality of life, particularly affecting the most vulnerable in society – the very young and the old. High levels of air pollution are known to exacerbate cardiovascular and respiratory diseases, both of which are common causes of death in Europe. This will become increasingly important if, as is predicted, longevity increases in the European countries.

- Setting common environmental standards is more (cost-) effective. The EU has put in place several Directives to assist in meeting these environmental objectives, most notably those on vehicle emissions standards, fuel quality and national emissions ceilings, which have had a significant impact on air quality. Being largely compatible with the EU standards, a similar framework has been put in place in the UN-ECE, notably stimulated by several protocols under the Convention on Long-range Transboundary Air Pollution (CLRTAP). The EU can negotiate much more effectively with large manufacturers than individual member states. National governments have introduced incentives to accelerate the take-up of cleaner vehicle technology and fuels, while in turn manufacturers enjoy the benefits of a larger framework with consistent harmonised environmental standards. Local authorities are taking action including traffic management and cleaning their own vehicle fleets, showing the way for others to follow towards meeting the common objectives.

- Air pollution does not respect administrative boundaries, and a significant proportion of the air pollution problem in many urban areas is caused by pollution blown into that area, often across national frontiers, particularly in the case of ozone and PM_{10}. This highlights the need for international action.

European and national measures have resulted in a significant improvement of the air quality in large parts of Europe. However, there are many areas where meeting the air quality Limit Values requires significantly more action, especially for nitrogen dioxide (NO_2), fine particles (PM_{10}) and ozone. For NO_2 and PM_{10} this is mainly urban areas – where the majority of the EU population live – that have difficulty achieving the Limit Values. High ozone levels are mainly in more rural areas, but caused by emissions from urban or industrial areas[1], but levels are also increasing in urban areas. Ozone concentrations cannot be reduced by local action, but will result from reductions in the emission of other primary pollutants, and so are not discussed further.

There are significant local measures that can be taken, and some examples of the measures being taken by cities are set out in this paper. However, even with these, in cities such as London, Berlin, Paris and smaller cities such as Stockholm, Rotterdam and Munich, local measures are really struggling to meet the EU Limit Values. Although in London and Berlin, local measures are achieving significant reductions in pollution concentrations, there are at present no local measures that could meet the Limit Values. Therefore additional measures at national and international levels are needed. Indeed, in many cases it is these additional tools that are needed in order for measures at the local level to achieve their full impact.

These aspects and a number of emerging issues have been put into a resolution (see Annex) at the end of a city-conference[2] in Berlin in November 2003, which was signed by senior politicians from major cities in Europe. In sending the resolution *inter alia to* the European Commission and the European Parliament, the conference aimed to make the EU aware of the difficulties cities have encountered in meeting the EU air quality standards, and of the requirements at the European level when reviewing the European Directives on air quality and related emission sources. The resolution calls, among other things, for a better consistency between environmental objectives and available measures to control emissions on local, national and European level.

While stressing the major problems in meeting the air quality standards at city level, this paper points to a number of potential areas for action at different levels, in particular on the European level which should help achieving an improved protection of public health from air pollution, and the European air quality standards.

---

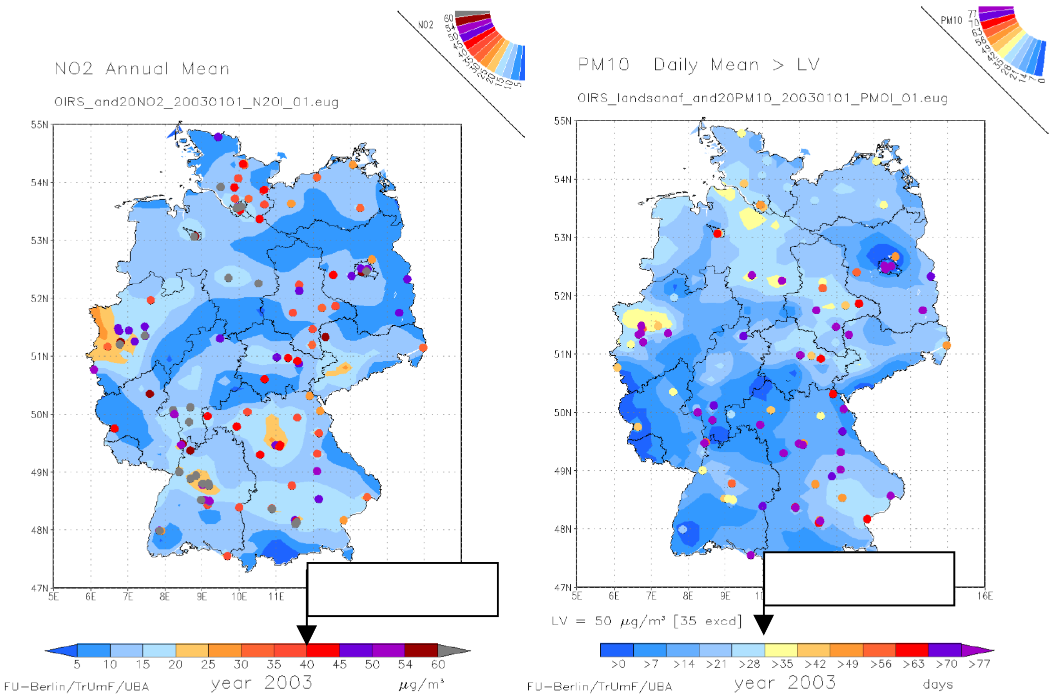
[1] Ozone is a secondary pollutant, caused mainly by reactions of pollutants such as nitrogen oxides and hydrocarbons.
[2] "Metropolitan challenges in noise and air policies: facing new EU regulations at local level", city conference hosted by the Senate of Berlin and funded by the Commission, with representatives from London, Paris, Prague, Rome, Stockholm, Stuttgart and Warsaw. For the resolution and the conference documentation see http://www.stadtentwicklung.berlin.de/umwelt/luftqualitaet/staedtekonferenz/index_en.shtml

MEETING THE EU LIMIT VALUES
According to the data reported to the EU, PM_{10} concentrations are rather high in relation to the PM_{10} Limit Values for 2005[3] (stage I). In 2001 the PM_{10} Limit Values were exceeded at 34% of the more than 700 monitoring stations in the EU, the majority being in hot spot sites in urban areas. Of the 750 cities where data were reported, 180 cities were in non-compliance with the 24 hour PM_{10} Limit Value. A number of cities, with a total of about 20 million people, have exceedances on more than 45 days at least at one monitoring station[4].

A recent survey in Germany revealed that between 70 and 120 urban areas do not expect to achieve the PM_{10} Limit Values by 2005, unless tangible additional measures are taken. Similar bad news is anticipated for NO_2, where around 70 towns are not expecting to comply with the annual NO_2 Limit Value in 2010. Figure 1 depicts the 2003 distribution of annual NO_2 concentration and of the number of days with exceedances of the 24h PM_{10} Limit Value in Germany, with a larger number of urban hotspots in non-attainment..

Moreover, for PM_{10}, there was a significant increase of regional background PM_{10} concentrations in Germany in 2002 and the first half of 2003, which makes compliance by 2005 harder to achieve than suggested above.
The same gloomy picture emerged from a survey among European cities recently performed by the city of Stockholm. 16 out 25 responding cities said that they encounter serious difficulties in meeting the PM_{10} Limit Values by 2005.

Figure 1. Measured distribution of annual NO_2 concentrations (left) and number of days above 50 µgm³ daily mean PM_{10} (right) in Germany in 2003. The coloured areas are generated by an "optimal" interpolation of model results and rural and urban background measurements, while the spots depict values recorded at traffic sites.[5]



[3] The EU Limit Values for PM10 is set for 1/1/2005, although in UK legislation it is referred to as 31/12/2004, hence in this paper, the dates will often be referred to as 2004/5.

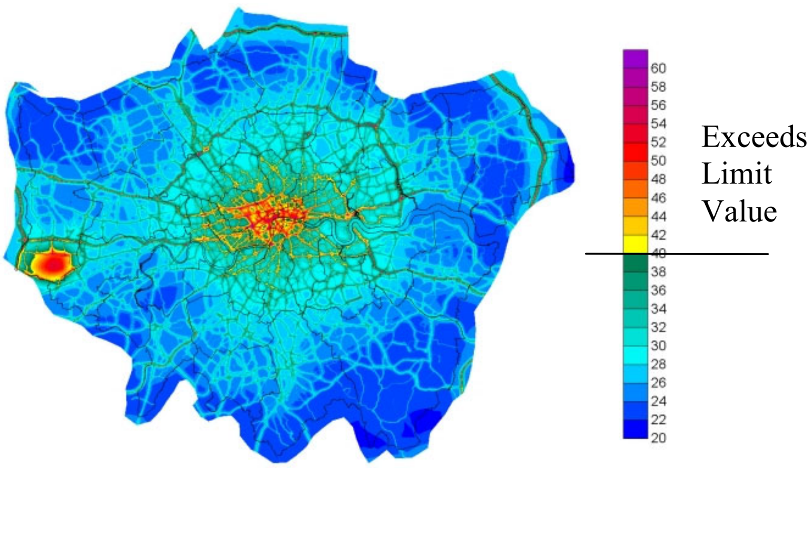
Different parts of the EU find different pollutants harder than others, for example south-eastern England has a much larger secondary PM_{10} contribution than the rest of the UK. In Spain, on the other hand, the contribution from soil erosion, re-suspension and even Sahara dust is quite significant. Northern Italy, with its high population density and resulting economic activity the coincidence of high emissions, surrounding mountains and frequent stagnant weather conditions in winter often leads to records levels of PM10. In the Scandinavian countries, wood burning, winter sanding and road abrasion from the use of studded tyres contribute significantly to the PM_{10} problem.

Different parts of the EU also have different ways of estimating the sources and concentrations, using different emissions factors, or different models and methodologies. However, these do not change the overall conclusions – that the NO_2 and PM_{10} Limit Values will be hard to meet in many urban areas in Europe.

Take **London** as an example. The Greater London area covers 1,600 km^2, and although much of the area will achieve the objectives, significant areas are estimated to exceed the EU Limit Values. These are mainly in central and inner London, near the main roads and around Heathrow airport.

Figure 2 and Figure 3 show modelled maps of the situation in London without further national measures, or the planned local measures for NO_2 and PM_{10} with respect of the EU Limit Values[7] - ie business as usual scenarios. In order to allow for the precautionary principle, weather from a fairly poor year have been used. It should be remembered that weather conditions do affect the PM_{10} situation considerably, and Figure 4 is showing a good weather year for comparison. In terms of scale, it should be noted that the area covered in these maps is 1,600km^2.

Figure 2. Modelled 2010 annual mean NO_2 concentrations in µg/m^3 (poor weather year[6])



[4] Taken from the 2nd Position Paper on Particulate Matter by the CAFE ("Clean Air for Europe") Working Group on PM (see http://europa.eu.int/comm/environment/air/cafe/pdf/working_groups/2nd_position_paper_pm.pdf)

[5] Source: Umweltbundesamt (German Environment Agency)

[6] 1997 is used, but weather year does not make as much of a difference for NO_2 as it does for PM_{10}.

[7] A semi-empirical modelling method is used, for more information see the background papers to the Mayor of London's Air Quality Strategy at: http://www.london.gov.uk/mayor/environment/air_quality/research/index.jsp

Figure 3. Modelled 2010 daily mean PM_{10} concentrations, in number of days above the EU Limit Value of 50 µg/m^3 (poor weather year[8])

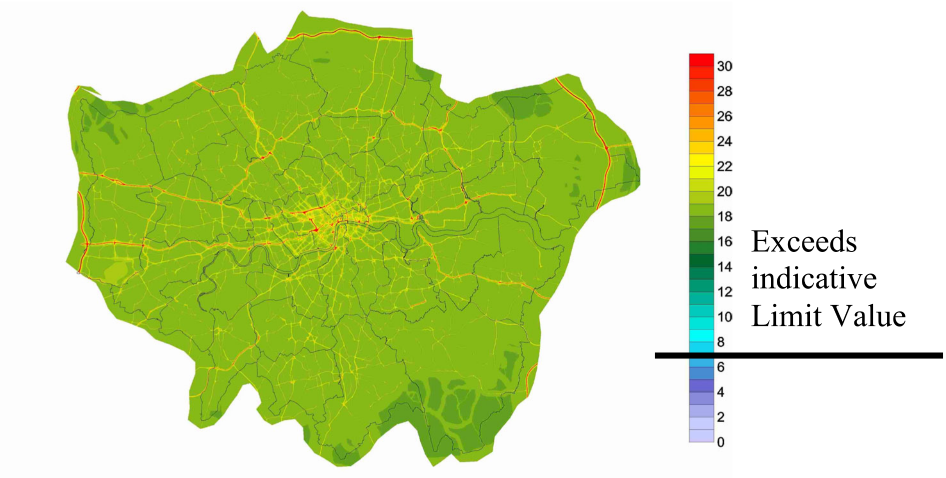


Figure 4. Modelled 2010 daily mean PM_{10} concentrations, in number of days above the EU indicative Limit Value of 50 µg/m^3 (good weather year)

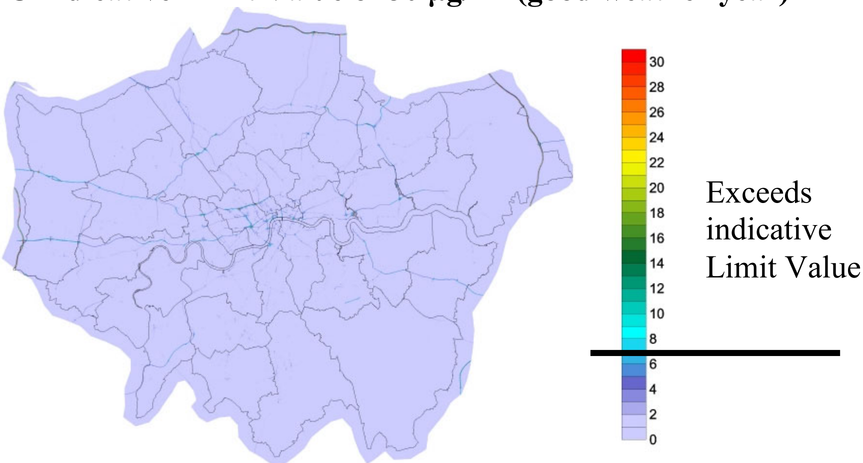
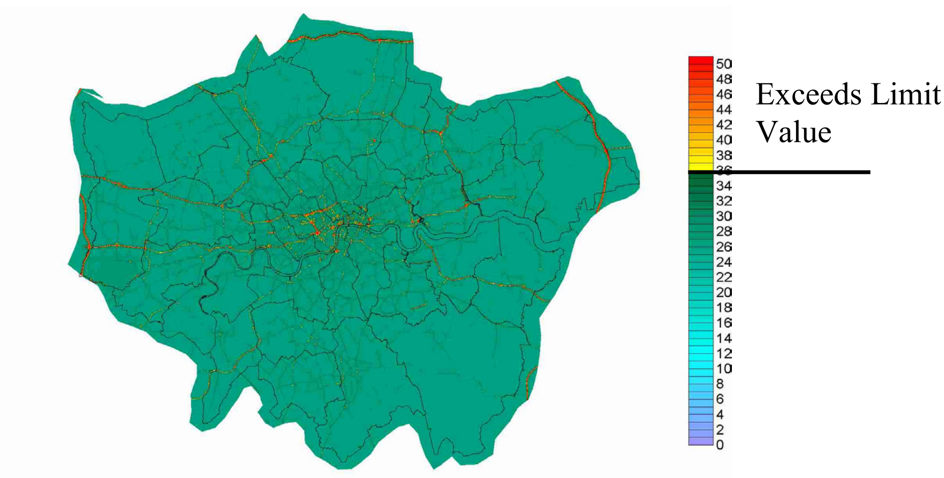


Figure 5. Modelled 2005 daily mean PM_{10} concentrations, in number of days above the EU Limit Value of 50 µg/m^3 (poor weather year[8])



[8] 1996 is used, which was a particularly bad weather year for PM_{10} in the UK.

Figure 5 shows the predicted concentrations for the 2004/5 PM_{10} Limit Value, including the measures within the London Mayor's Air Quality Strategy that are quantifiable[9].

In **Berlin** there is also a problem in achieving the EU Limit Values for NO_2 and, even more seriously, for PM_{10}. The annual NO_2 limit value is exceeded at all traffic sites. Street canyon modelling suggests non-compliance along several hundred kilometres of the main road network in Berlin. As Figure 7 indicates, only a weak downward trend could be observed during the last decade, which has diminished by now. Achieving the 2005 EU Limit Value for PM_{10} is harder for Berlin than London, and the impact of the large-scale background of PM_{10} is greater. Figure 6 illustrates the number of days with daily mean concentrations of more than 50 µg/m³ PM_{10} in 2003. By 2005 this must not be exceeded more than 35 times per calendar year. While in 2001, violation of the 35 days criterion was limited to the three traffic sites, the significant increase in regional PM_{10} background has resulted in non-compliance even in residential areas at the periphery of Berlin in 2003. This problem will be broader discussed later in this paper.

Projections of a scenario that assumes implementation of measures due to current legislation suggests by

Figure 6. Monitored PM_{10} levels in Berlin in 2003

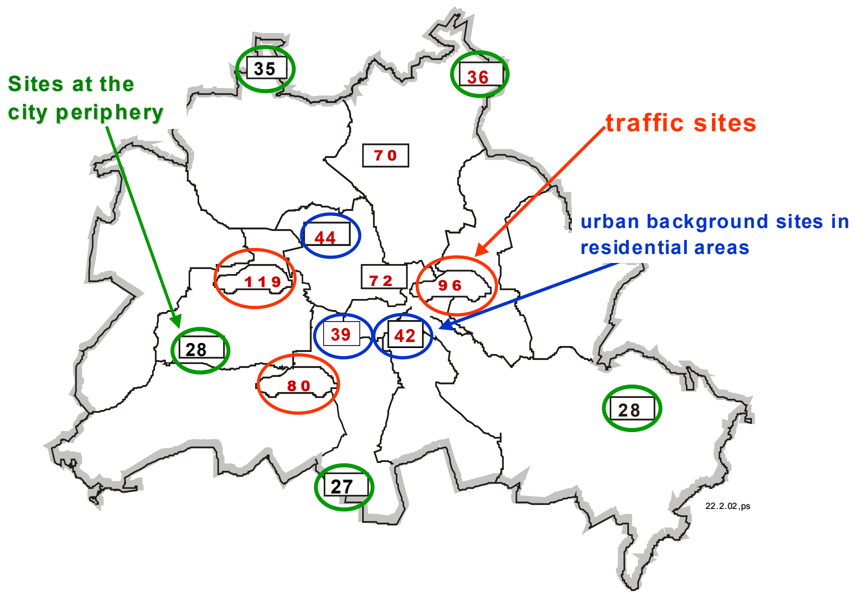
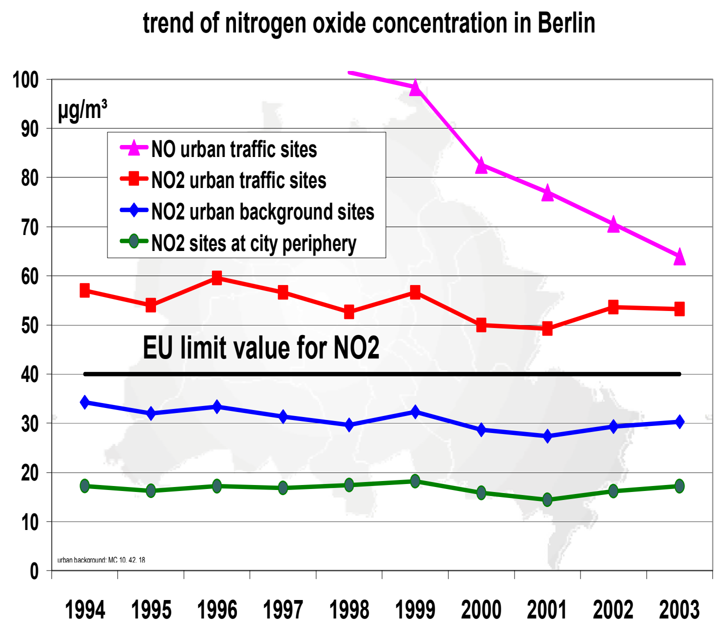


Figure 7. Trend of the annual average nitrogen concentrations at the various locations in Berlin



[9] It should be noted that for many of the measures it is not possible to reliably quantify their impact, and only measures that can be reliably quantified have been included in the modelling, which is likely to underestimate the impact of the measures within the Strategy. The business as usual map can be found in the Mayor's air quality strategy on www.london.gov.uk,

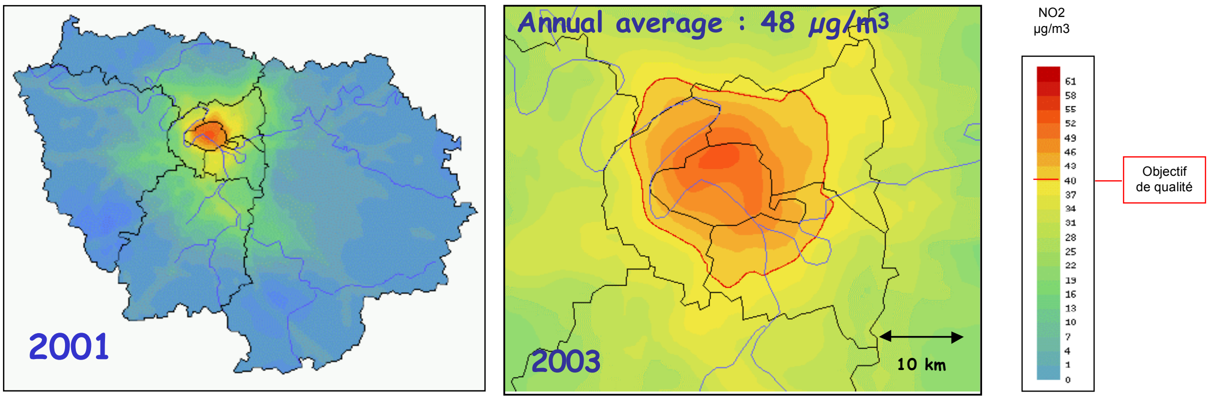
2010 only a moderate decline of the Berlin emissions of PM10 (by 7%) and of NOx (by 21%) in relation to 2002. In combination with a predicted decrease of the regional background PM_{10} an improvement of between 10 and 15% of the 2002 urban background PM_{10} can be expected. The corresponding decrease of NO_2 pollution ranges between 20 and 25%. Similar figures are estimated for the potential decrease of local traffic pollution. Taking into account the estimated reduction of urban and regional background concentration, total PM_{10} and NO_2 levels in the main road network will still be higher than the Limit Values. So, additional measures beyond current legislation are clearly necessary.

In **Paris** the situation is slightly different, and the main pollutants of concern are NO_2, ozone (O_3), and to a lesser extent PM_{10}. The French state regard the EU Limit Values in terms of the margin of tolerance for the year the data is for[10], so the data presented is slightly different to that for Berlin and London. Data given here is for 2003, which was a particularly bad year for air quality in Paris.
The 2005 PM_{10} EU Limit Value, plus the margin of tolerance (daily average 60µg/m^3 with 35 exceedences), was only exceeded at two roadside measurement sites in 2003, and the annual average (43 µg/m^3) was only exceeded at one site.

For NO_2 in 2003 the EU Limit Value, including the margin of tolerance (annual average 54µg/m^3), was exceeded at all the roadside measurement sites, and one of the background sites. The EU Limit Value level alone (annual average of 40µg/m^3) was exceeded at 70% of background sites. The maximum value in 2003 was 103 µg/m^3 on the Periferique ring road. Figure 8 shows modelled concentrations over central and Greater Paris for 2001 and 2003, and as illustrated in Figure 9 there is only a limited downward trend between 1997 and 2002, but a 5 % yearly decrease for NO_2 since 1994, suggesting – as is seen in London and Berlin – that the NO_2 concentration is ozone limited[11].

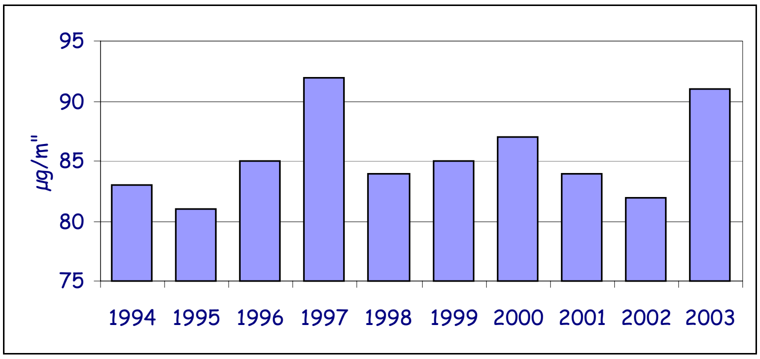
Achieving the EU Limit Value for NO_2 is of concern in Paris. A 50% reduction in NO_x emissions is needed to achieve the EU Limit Values, whereas a 32% reduction is expected from measures already in place. Figure 10 shows the NO_2 modelled for Paris in both 2000 and

Figure 8. Modelled NO_2 concentrations in 2001 for the whole of Paris and 2003 for central Paris



[10] Margin of tolerance are a set of temporary targets set within the EU Directive, for the period between the coming into force of the Directive and the attainment date for the Limit Value. These gradually approach the EU Directive levels. If air pollution exceeds the Limit Values plus the margin of tolerance an abatement plan must be set up within two years, published and sent to the European Commission.
[11] For more information on this, see the Mayor of London's Air Quality Strategy: Appendix A3 – Technical Information at: http://www.london.gov.uk/mayor/strategies/air_quality/index.jsp.

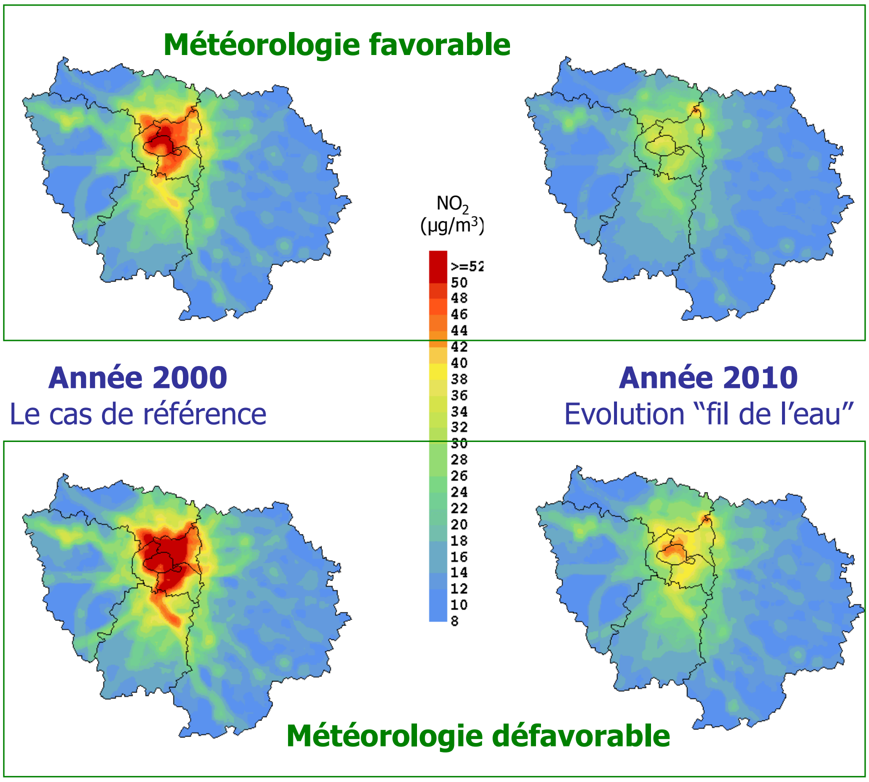
Figure 9. Recent measured NO_2 roadside average in Paris[12]
(Note: the scale on the left starts at 75µg/m^3)



2010, with 'favourable' and 'unfavourable' weather conditions. This shows that with favourable weather conditions, the NO_2 Limit Value is likely to be met in all but a very small part of the Periferique ring road. However a much more significant part of central Paris and the Periferique is likely not to meet the Limit Values under unfavourable weather conditions. Looking at this in terms of the risk of exceeding the EU Limit Values, with a business as usual case in 2010, between 95 to 634 km^2, depending on the weather, has over a 25% risk of exceeding the Limit Values in 2010, with 502km^2 for a weather year like 2003. This compares with the area ranging from 746 to 1007km^2 for the reference case in 2000. While this is a significant reduction, it still leaves a large area at significant risk of not meeting the Limit Values.

The Paris abatement plan, or "Plan de Protection de l'Atmosphère" (PPA), is expected to reduce NO_x emissions by 10.1%, so that in a more favourable year, the area at over a 25% risk of exceeding the Limit Value is limited to 52km^2.

Figure 10. Modelling of NO_2 in Paris for 2000 and business as usual in 2010, with both favorable and unfavorable weather[13]



[12] Based on a fixed number of 5 roadside monitoring stations

Figure 12. Backward-trajectories for an ozone episode in Paris on the 7th August 2003

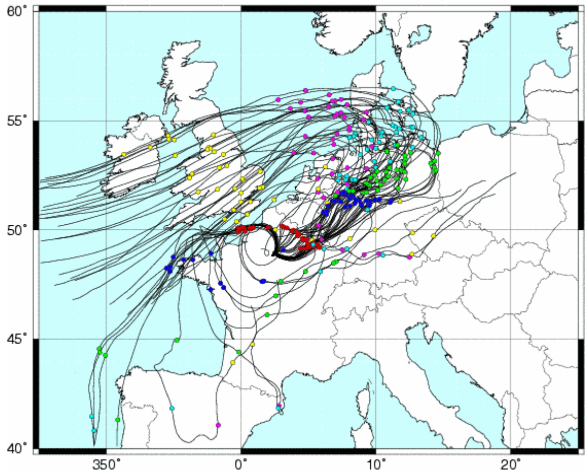
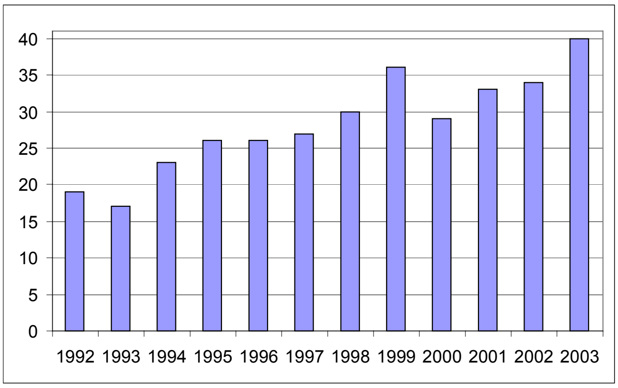
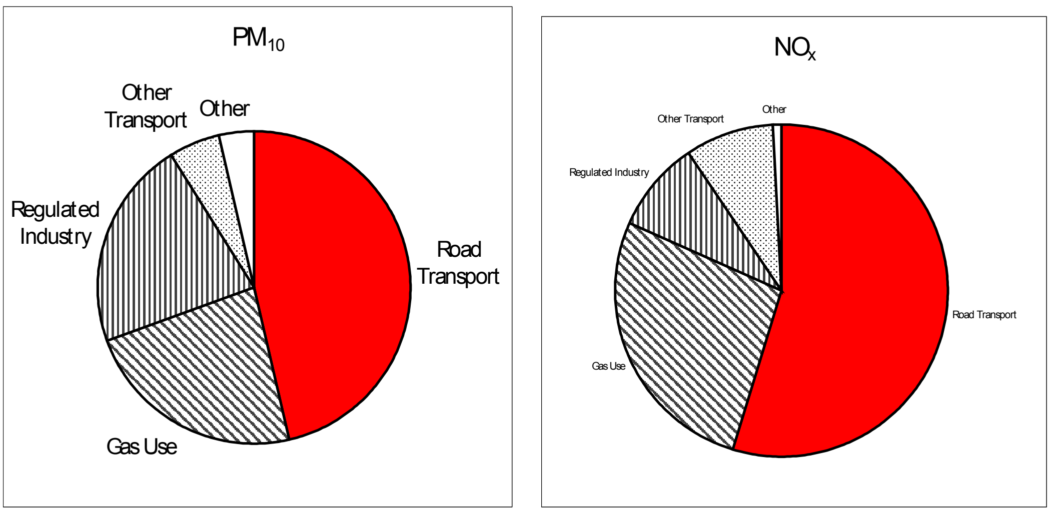


Figure 11. Recent annual average ozone measurements in Paris



The above discussion is all assuming that ozone levels stay constant. With higher ozone cities such as those discussed here, where NO_2 levels are ozone-limited, NO_2 levels are likely to be higher than those discussed here. This is significant, as increasing ozone levels, particularly in the summer is a growing problem for many cities, as Figure 11 shows for Paris. The French national target value of (8 hour average of 110µg/m3) is exceeded between 37 and 91 times a year at different monitoring sites. The French national ozone target is slightly more stringent than the EU Limit Value but required to be met now[14]. However, as with other cities, there is little Paris itself can do about ozone levels due to its secondary nature. For example during an acute ozone episode, 60% to 70% of the ozone concentrations in Paris were of long-range European nature, as shown in Figure 12.

Figure 13. Proportion of emissions of NO_X and PM_{10} from different sources within Greater London in 2001



[13] Translations: Le cas de référence = reference case, Evolution 'fil de l'eau' = business as usual predictions, météorologie = meteorology/weather, favorable = unfavourable, défavorable = unfavourable.

SOURCES OF POLLUTION

In most urban areas the major local source is road traffic. Figure 13 shows the estimated emissions sources in London in 2001 from PM_{10} and NO_x as an example. Figure 14 shows the results of a source apportionment of PM_{10} for Berlin estimated from pollution monitoring data[15] for 2002, and Figure 15 shows a source apportionment estimated through modelling of NO_2.

The proportion of primary emissions of both pollutants being predominantly from road transport is a common theme. However, in other respects the sources of NO_x and PM_{10} differ. For example, more distant sources producing secondary aerosol are very significant for PM_{10}, whereas for NO_2 this is much less so. The main source of emissions in Paris is also road transport, as shown in Figure 16. However, it should be noted that in the case of Paris that the emissions occurring within the city itself, given in Figure 16 below, account for only 10 % of the regional emissions for both PM_{10} and NO_x.

Figure 14. Estimated contribution to PM_{10} at a busy traffic spot from all sources for Berlin in 2002 (also accounting for secondary sources of PM)

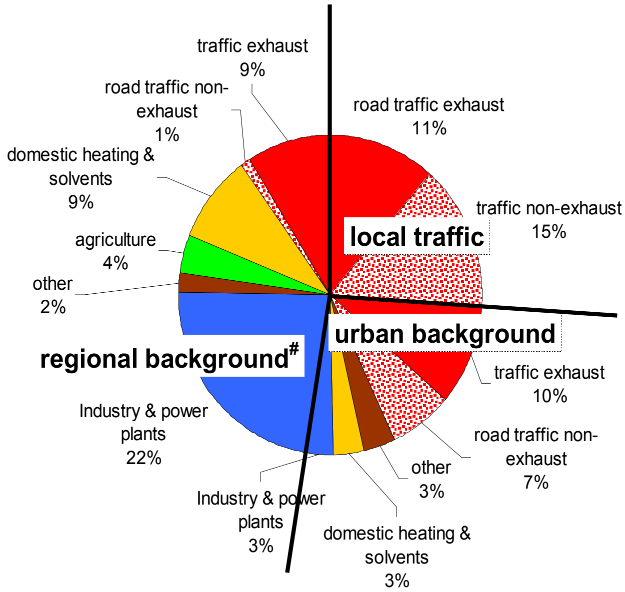
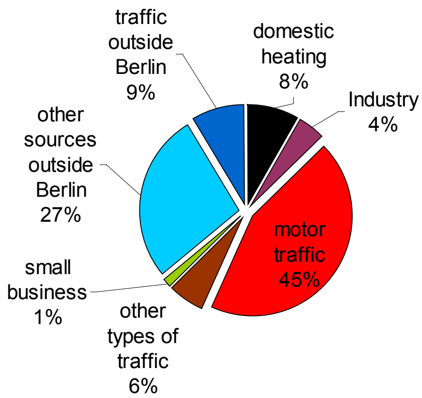


Figure 15. Modelled contribution to NO_2 urban background concentrations from all sources for Berlin in 2002



based on values recorded at the top of a radio tower 324m above ground

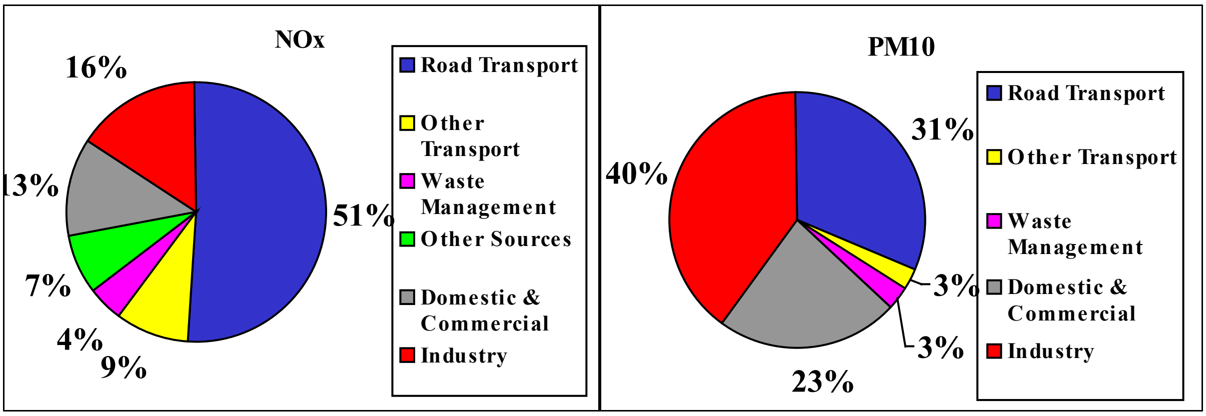
NO_2 POLLUTION

For NO_x the main sources other than road traffic are gas combustion and, in particular for London, airport-related emissions. It should be noted that this is purely in emissions terms, and height and temperature of emissions means that sources such as aircraft, gas use and industry usually have less impact on air quality per tonne emitted than ground level emissions such as road transport. Achieving reductions in concentrations of NO_2 through reducing emissions in large urban areas are also limited by the reactions of nitrogen monoxide (NO)

[14] The EU target value, to be met by 2010, is an 8 hour average of 120µg/m^3 not to be exceeded more than 25 days per calendar year, averaged over 3 years

[15] Again noting that different countries and cities use different estimation methods: the Berlin data is a result of a source apportionment exercise based on the evaluation of measured pollution data. So, unlike the emission data from London, it accounts, among other things, for the effect of differing distances between emitter and receptor of industrial stack emissions in comparison to traffic exhaust emissions. It is for the same reason, why aviation does not explicitly appear in Berlin's result, apart from the fact, that air traffic in Berlin is only a fraction of the air traffic around London. Also note that London does not include re-suspended road dust or construction specifically in the emissions inventory, but as a coarse fraction in the air quality modelling.

Figure 16. Proportion of emissions of NO_x and PM_{10} in the City of Paris



and ozone[16]. Figure 7 shows an example for such a differing trend between NO und NO_2 levels. Over the recent years NO_2 at Berlin's traffic stations remained virtually constant while NO levels have gone done by almost 40 %. At the same time mean ozone concentrations at Berlin's monitoring station at the edge of a motorway with more vehicles per day rose by the same ratio. So, while NOx - emissions may have decreased conversion from NO to NO_2 has been accelerated. Another possible factor hampering a decrease in NO_2 – concentrations is the potential shift of the NO/NO_2 – ratio of diesel vehicle emissions towards more NO_2. Regardless of the relative importance of the two NO_2 enhancing factors, European action is needed, because neither the problem of rising mean ozone levels nor any unfavourable change in the NOx-emission characteristic of diesel vehicles can be tackled on a local level.

Gas combustion, one of the main non-transport sources of emissions of NO_2, is already a very clean fuel. In London the substitution of coal by gas for house heating brought a significant reduction of sulphur dioxide and total particulate concentration, but it is the sheer number of buildings using gas that makes it a problem. Heating boilers are often replaced less frequently than vehicles, and the NO_x emissions improvement per boiler replaced is often less. Airport-related emissions occur only at certain locations, and much of these are emitted at height. Airport-related emissions are only an issue for air quality at a few locations, and in fact very few airports, but one of these is Heathrow Airport on the edge of London, within the urban conurbation. Road traffic to and from airports also has as strong an impact on the exposure of people. While ground-based airport emissions can be 'relatively' easily tackled, local airports and nation states have less control over aircraft. International agreements are often constrained by other countries including non-EU member states.

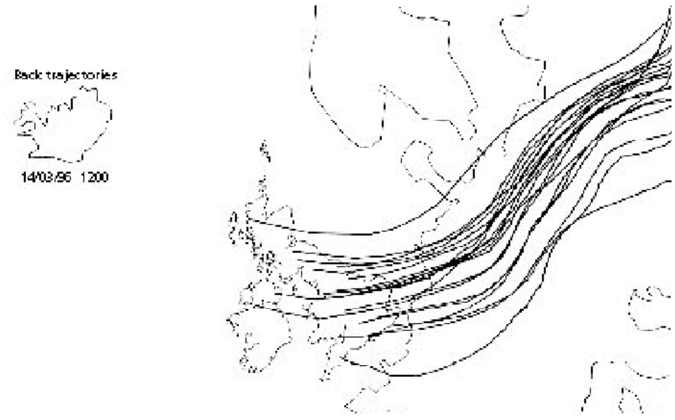
ORIGIN OF PM_{10} POLLUTION

PM_{10} is a particular problem. The indicative EU Limit Value is especially hard to achieve, yet the health research points to particles having by far the greatest health impact, especially the smaller particle fractions. It should also be noted that there are more methodology differences in the emissions estimation, monitoring and modelling of PM_{10}, between the different EU countries, than for NO_2.

The main contributors to PM_{10} other than road traffic exhaust emissions, are precursors of secondary PM_{10} (which are traffic as well as, industry, agriculture and natural sources), re-

[16] Only once a threshold is achieved when NO_2 reduction is no longer ozone limited, will reductions in concentrations be linear with emissions reductions. The rising levels of ozone also limit the ability to achieve these objectives due to the reaction of NO and ozone which in turn produces NO_2.

Figure 17. Long-range transport of PM_{10}[17]



suspended road dust, construction dust, gas use and annual bonfire or firework events. Re-suspended road dust is especially variable around the EU, from Sweden, with its studded tyres and very high levels, to the UK that at present assumes low contributions. As Figure 14 indicates, non-exhaust emissions make up almost half of what Berlin's transport sector contributes to the PM_{10} pollution at the roadside measurement sites. Unlike the traffic exhaust emissions, this coarse part of the PM_{10} load cannot be tackled by improving vehicles emissions. Whether enhanced road sweeping could be a solution is currently being investigated in Berlin. Preliminary results have not revealed a tangible effect, similar to recent studies in Stockholm.

With regard to the problem of a high-level regional PM background, many other cities are similar to Berlin, with a significant contribution from secondary PM_{10} sources. London, Berlin and Paris all have around one third of their PM_{10} concentrations coming from sources outside the city[18], although this varies significantly from year to year and seems to be higher in those parts of Europe with a more continental climate. The secondary PM_{10} is often brought in from a particular wind direction. This long-range transportation of particles for the UK is illustrated by Figure 17. In both London and Berlin this is greatest in years with winds predominantly from the south-east, such as during London's particularly poor year for PM_{10} in 1996 and in a number of recent episodes with elevated PM_{10} levels covering whole eastern Germany.

Figure 18 below indicates this recent upward trend in the PM_{10} levels in Berlin. The two bottom trend lines reflect the PM_{10} concentrations recorded rural sites outside Berlin and at the city boundary stations. It can be seen that the upward trend in the PM load originating from areas outside Berlin triggered a similar increase of the urban PM_{10} background (the line with circle markers) and the PM_{10} load measured at traffic sites (the line with square markers). Hence, the worsening of the PM_{10} situation in Berlin between 2001 and 2003 is largely due to regional scale transport of particulate matter, which is a major obstacle to the achievement of the Limit Values by 2005 (and even more so for the indicative 2010 standard). This conclusion is supported by the downward trend of black carbon concentration (line with triangles) recorded at kerb sites stations in the city, which would not have been observed if the surge in PM_{10} were of local origin.

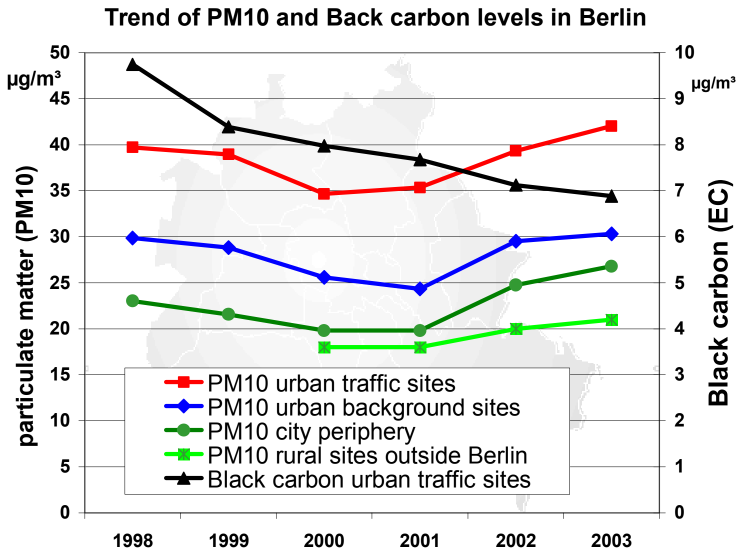
As mentioned above, PM_{10}, with its large secondary component is significantly affected by the weather, and some years can be much worse than others (see Figure 3 and Figure 4 above for London). Whether the recent surge in the regional PM_{10} background around Berlin is primarily due to poor weather conditions or imported emissions is difficult to substantiate.

---

[17] Source: UK DEFRA

[18] For London see the Mayor of London's Air Quality Strategy, and for the other cities from workshops at an environment conference held in London in July 2001 with London, Paris, Berlin and Moscow, and the proceedings of the city conference in Berlin in November 2003 (see http://www.stadtentwicklung.berlin.de/umwelt/luftqualitaet/staedtekonferenz/index_en.shtml)

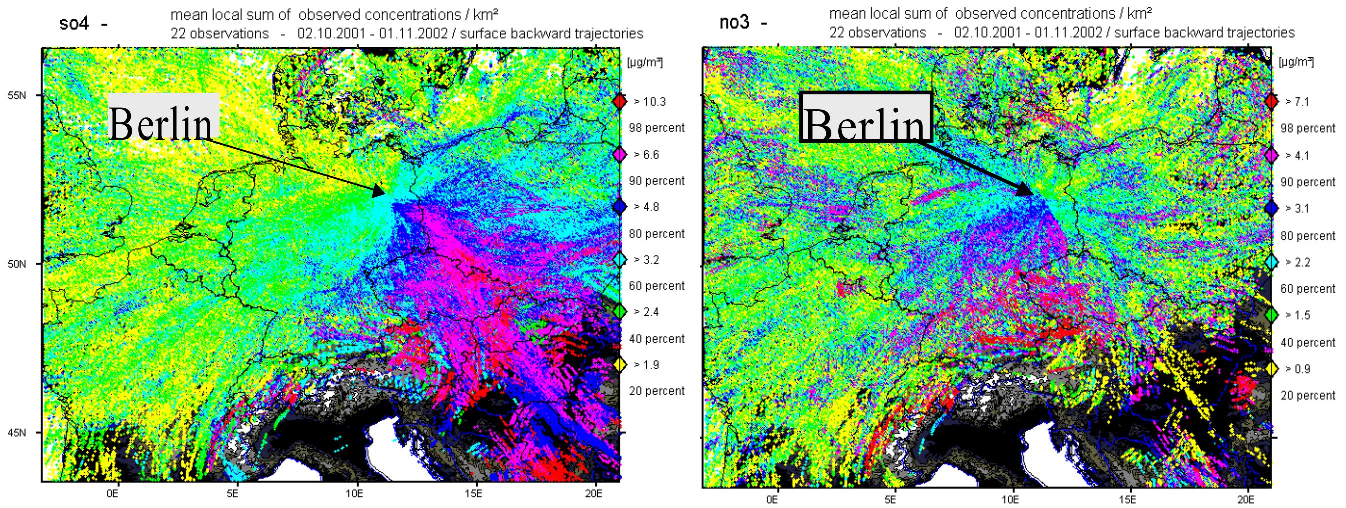
Figure 18. Recent trend of the annual average PM_{10} and NO_2 concentrations at the periphery, urban background and traffic hot spot locations in Berlin



However, a recent evaluation[19] of PM-episodes[20] in Germany, revealed that meteorology favouring accumulation and large-scale transport of atmospheric aerosol, such as those with low mixing height combined with moderate (south-)easterly winds and continental air masses, occurred much more frequent in 2002 and the first half of 2003 than in the years before. The worst example was a four-week episode in February 2003 which contributed to already half of the 35 days of allowed exceedances of the 50 µg/m³ PM_{10} threshold in north and eastern Germany. The following hot and dry summer acerbated this year's results of the highest PM_{10} concentrations for more than 5 years. However, in the second half of 2003 and the first half of 2004 meteorological conditions were less stagnant and dominated by easterly winds so that PM_{10} pollution has now dropped to the levels comparable with those in 2001.

This long-range transport was also modelled in Berlin using a statistics of 3-dimensional backward trajectories (Figure 19). Surface layer contacts of all trajectories are added up in a 1x1 km² grid over one year. For every grid cell concentrations of particulate matter or PM species measured in Berlin at the time of the arrival of each trajectory are stored and

Figure 19: Spatial distribution of potential source areas for sulphate (left) and nitrate (right) aerosol imported into the Greater Berlin area based on backward trajectory calculations[21]



[19] Source Umweltbundesamt (German Environment Agency)
[20] an episode has been defined as a situation with more than 10% of all German monitoring sites recording more than 50 µg/m³ PM_{10} on at least 2 consecutive days

eventually averaged over all those trajectories which met the surface layer in the said grid. As an example, the area in Figure 19 (left) appearing in red colours has been touched by all those trajectories which arrived in Berlin at a time when relatively high sulphate concentrations (i.e. more then 6.6 µg/m³ SO_4 which is the 90th percentile of the whole annual series) had been measured in the sampled PM_{10}. So, the red area gives an indication of the spatial distribution of the main sources for secondary sulphate aerosol imported into the Berlin area. It coincides well with the industrialised region in Southern Poland and in Slovakia where emissions of sulphur dioxide from industry and power plants are still relatively high. The spatial distribution for nitrate aerosol sources (right map in Figure 19) is quite different. Given the high traffic volume in Germany and the subsequent nitrogen oxide emissions the high nitrate levels in Berlin come from within Germany. This highlights the need for stricter control of industrial sulphur emissions in the new Member States, as well as of NO_x road transport emissions within Germany to reduce the imported secondary inorganic component of PM_{10} in north eastern Germany. Both measures cannot be pursued on a local level but rather by national and European activity.

Another example of quite how important it is to co-operate on reducing pollution is illustrated by modelling in the Netherlands that estimates that of the total 16.4µg/m³ of anthropogenic PM_{10}, only a third came from the Netherlands and the rest from other countries. Table 1 shows this in more detail, with the annually averaged primary and secondary inorganic concentrations of PM_{10} for the Netherlands by source.

Table 1 Sources of PM_{10} in the Netherlands (based on 1995 emissions)[22]

Dutch sources	Primary PM_{10} (µg/m³)	NH_x (µg/m³)	NO_y (µg/m³)	SO_x (µg/m³)	Summed concentration (µg/m³)
Industry	0.4	0.0	0.1	0.1	0.6
Energy	0.0	0.0	0.1	0.1	0.2
Transport [1)]	1.5	0.0	1.0	0.1	2.6
Agriculture	0.5	0.9	0.0	0.0	1.4
Others	0.5	0.1	0.1	0.0	0.7
Total	**2.9**	**1.0**	**1.4**	**0.2**	**5.5**
Other countries					
Industry	0.9	0.0	0.1	0.1	1.0
Energy	0.4	0.0	0.7	1.9	3.0
Transport [1)]	0.9	0.0	2.1	0.3	3.3
Agriculture	0.1	1.2	0.0	0.0	1.4
Others	0.7	0.0	0.5	1.1	2.3
Total	**3.0**	**1.2**	**3.3**	**3.4**	**10.9**
All sources					
All anthropogenic sources	**6.0**	**2.2**	**4.6**	**3.6**	**16.5**
Non-modelled other sources[2]					**18**
All sources					**34.5**

1) Including international shipping
2) Non-modelled part of the PM (18 µg/m3): sea salt, crystal and biogenous material and the northern hemisphere background.

---

[21] Source: Reimer, E., Free University Berlin, 2004
[22] Source: RIVM report of the Netherlands Aerosol Programme "On health risks of ambient PM in the Netherlands", October 2002, RIVM report 650010 033. Editors: Eltjo Buringh and Antoon Opperhuizen

LOCAL ACTION IN EU MEMBER STATES

Different member states are at different stages in their work towards meeting the EU Limit Values. This section describes by example measures taken forward by London, Berlin and Paris

London has produced its first London-wide air quality strategy, combining national and local measures considered necessary to achieve the Limit Values. The Mayor of London's Air Quality Strategy focuses on road traffic – both the largest source, and both where the most impact can be made and the Mayor has most powers. The air quality strategy links together with the transport, land use planning, noise, energy and other Mayoral strategies[23]. The transport and land use planning strategies take forward traffic reduction measures, and the air quality strategy concentrates on the cleaner vehicle issues. These all work together with UK national measures such as giving fuel duty concessions, tax incentives and grants for alternative fuelled or retrofitted vehicles.

Measures in the Mayor of London's (2002) air quality strategy include:

- cleaning the public vehicle fleets – these include buses (minimum of Euro II and particle trap by 2005, water diesel emulsion, selective catalytic reduction (SCR) and exhaust gas re-circulation (EGR) trials); taxis (introducing their first emissions standards), fire engines and police vehicles
- specific guidance for the 33 London local authorities to clean their vehicles and undertake other measures to reduce pollution, which is raising the standard of local action
- traffic reduction – aiming for a 15% reduction in traffic in central London, reducing the growth in traffic to zero in inner London, and halving the growth in outer London, through measures including the central London Congestion Charging scheme
- encouraging businesses to clean their vehicles by facilitating the uptake of government grants, and providing objective information on how operators can clean their fleets
- roadside testing of vehicle emissions
- using the planning system to reduce the impact of new developments
- incentives through the central London Congestion Charge scheme for the very cleanest alternatively fuelled vehicles
- feasibility study into a London low emission zone (LEZ).

An Low Emission Zone (LEZ) is an area from which older, more polluting vehicles are excluded, thereby increasing the proportion of cleaner vehicles in the area. The London Mayor is intending to introduce a Low Emission Zone by 2007 aimed at lorries, buses, coaches and taxis, covering the whole of Greater London. The London LEZ feasibility study reported in July 2003[24], and concluded that a LEZ would significantly reduce air quality exceedences. It recommended that the LEZ standard should be set at Euro II plus particulate trap (or equivalent) for lorries, buses and coaches, and would get more stringent in 2010.

---

[23] More information on all of these can be found on www.london.gov.uk, and following prompts for the Mayor's publications, then strategies.

[24] Further information on this study completed can be found on www.london-lez.org, further information on the Mayor's announcements can be found on www.london.gov.uk. Also covered by another paper given at this conference.

Berlin is in the process of updating its local air pollution abatement plans. At the same time, noise mitigation plans are being developed in three districts. Measures already in place in Berlin include:

- substitution of coal by gas, oil and district-heating for house heating purposes
- industry is to apply best available technology, e.g. de-NOx equipment on all power plants and larger industrial installations.
- particle filters for all public buses
- investment in a network of refuelling stations for compressed natural gas (CNG)
- grants for enhanced use of CNG-vehicles for taxis and driving schools
- similar programme for light duty vehicles and heavy duty vehicles powered by CNG
- containment of traffic flows by huge investment in public transport

A recently adopted transport development plan aims to reduce motor traffic flows in the city centre, *inter alia* by

- considerably enlarging the area with parking fees in several city centre districts
- re-routeing through traffic in the city centre on tangential roads
- extension of the tram network
- enhanced investment in cycling infrastructure

Additional measures are being considered, like

- the setting of tighter environmental standards for public bus services and the municipal vehicle fleet
- optimised traffic management aimed to ameliorate air and noise pollution in sensitive areas

Options for additional action are being investigated covering

- variants of a LEZ for diesel vehicles, which would reward vehicles with particle traps and lower NOx emissions
- enhanced street cleaning, in order to reduce re-suspension of road dust

The Federal Government pledged to introduce a tax discount for diesel cars equipped or retrofitted with a particle trap.

In France, air quality management has not been devolved at a local level, as it has in many other EU countries. The Atmospheric Protection Plans (PPA) are produced and implemented by national government, and their local administrators - and ***not*** by the cities and local authorities. The **Paris** PPA is behind schedule and was published in mid-2004, following public consultation. Decentralisation is an issue being pursued by the Paris authorities with the national Government to try to improve this.

While a 50% reduction in NO_x emissions is needed to meet the EU Limit Values in Paris, only 33% is expected from the measures currently in place. The PPA is estimated to reduce emissions by around 10%, and includes

- tighter controls on factories and industry
- low-NOx boilers introduced on all individual boilers replaced between 2000 and 2010,
- requiring all petrol stations over $1000m^3$/year to have vapour recovery on the pumps
- between 2000 and 2010 a reduction of 30% of emissions from diesel vehicles in the Ile-de-France by traffic management - includes introducing bus lanes and car free day
- reduce traffic through urban planning

Measures already in place include:
- measures to keep emissions from airports static, and;
- replacing the engines of 30 of the diesel trains
- speeding the replacement of better technology in the vehicles by 11%,
- replacing the kilometres at present travelled in slow utility vehicles and road maintenance vehicles by motorised two wheeled vehicles,
- use of water diesel emulsion in the city's buses.

EFFECTS OF LOCAL MEASURES

The impact of local measures are limited by the tools and funding streams provided by the EU and national governments and, by the affect of the large-scale PM background in Europe. Without the EU introducing the 'Euro Standards' and the cleaner, lower sulphur fuel Directives, the massive reduction in vehicle emissions would not have been possible. Government tax and duty incentives, as well as grants, reduce the cost of action to reduce emissions, and enable businesses, local authorities and others to adopt the cleaner technology options. It should be noted, however, that economic incentives for innovative vehicle emission control technologies are difficult to set unless the EU framework of emission standards has been adapted to technological progress. So, at least a Commission proposal for tightened vehicle emission standards is needed for national and local authorities to become active in this field.

Businesses, with the exception of a few companies that wish to promote their environmental profile, generally do not undertake measures that add to their costs. Therefore, to get the large majority of the businesses to reduce their emissions (and therefore the large proportion of the emissions reduced), the measures must either be legally required or financially beneficial. Expecting significant take-up of measures that are even cost neutral is optimistic, unless legally required.

Studies in both London and Berlin into Low Emission Zones (LEZs) suggest that this is the most effective measure to achieve air quality improvements. Estimates of the likely effect on PM_{10} traffic emissions of a London LEZ requiring at least EURO II plus particle trap for lorries, buses and coaches in 2007 shows a reduction of 9% from what would occur without intervention. If the zone is tightened in 2010 to a minimum of EURO III plus particulate trap for heavy vehicles, and ten year age limits for vans and taxis, a reduction of 23% from that which would occur without intervention.

However, even with the most ambitious zone, pollution would be reduced but the EU Limit Values would not be achieved. Whilst investigations in London suggest that the relatively new technologies such as selective catalytic reduction (SCR) has an opportunity to improve this situation further, the EU Limit Values will still not be met without further action. Bringing forward the production of Euro IV compliant heavy vehicles and Euro V compliant light vehicles could also have a significant impact[25].

For Berlin and other cities in continental Europe, a tangible reduction in the PM_{10} background needs to be achieved. While the tightening of European vehicle emission standards will achieve some of the reduction needed, additional reductions in secondary aerosols, especially in the accession countries, will be necessary.

---

[25] Further information on the SCR and Euro standard issues can be found on the Greater London Authority Website, www.london.gov.uk, under Mayor's publications - environment.

The scope for local measures aimed to achieve the EU Limit Values in many large cities is small – even with 'good' weather. Achieving the value even at a later date will also require action beyond the local level. Achieving the NO_2 and the indicative PM_{10} Limit Values for 2010 will also take further assistance on a wider level.

ISSUES THAT ARE BEING RAISED FOR ACTION AT DIFFERENT LEVELS

As explained above, local action is largely dependent on the tools and incentives provided by EU and national governments. A cost-effective balance between national, EU and local action is needed. Action at a local level to encourage take-up of cleaner vehicle technology is only going to be effective on a significant scale if it is slightly less, or at least no more, expensive to adopt the cleaner option. If the cleaner option is more expensive, then only public organisations and a very few of the most environmentally aware operators will adopt it - unless it is mandated, and many local authorities themselves may struggle to fund these options.

It seems that the EU Limit Values will be harder to meet than was originally expected. One of the reasons for this is that the later 'Euro Standards' are having less impact at low speeds and under stop-start conditions - i.e. in the urban areas where pollution is greatest. The 'Euro standards' are an essential tool in reducing air pollution. Euro I vehicles have made a huge impact. However between Euro II and Euro III the improvement has been far less, particularly for NO_x emissions. Indeed, under some duty cycles, such as for London buses, there is actually an increase in emissions[26]. It appears that manufacturers are meeting the 'Euro Standards' by reducing emissions where it is technically easiest, under steady-state extra-urban conditions, rather than under the more arduous stop-start slow speed conditions of urban areas. This is known as 'cycle-beating'. This means that the later Euro standards are not achieving emissions reductions where they are needed, in urban areas where there is the most problem in meeting the Limit Values. Greatest emissions benefit is being achieved on motorways, where generally fewer people are exposed to the pollution and where the pollution is often dispersed more easily. It is hoped that the Euro IV transient test cycle will help reduce this problem, but this remains to be seen, and needs to be ensured by the European Commission.

Light goods vehicles also account for an increasing proportion of urban emissions, and further Euro emissions standards for these vehicles would make a significant contribution to reducing pollution.

In terms of replacing the vehicle fleet to assist in achieving the EU Limit Values (mainly for 2010), the timing of the introduction of 'Euro Standards' (Euro V start from in late 2008 for light duty vehicles and 2009 for the more important heavy duty vehicles) lags behind what is needed. Encouraging early uptake of Euro V technology particularly for heavy duty vehicles would therefore be very effective in terms of achieving the Limit Values. Low Emission Zones, which the London study concludes could not be introduced before late in 2006 but would then become increasingly stringent, would have more impact if the higher Euro standards could be introduced earlier. An LEZ could be something that would encourage vehicle manufacturers to achieve the standards earlier, as when replacing vehicles, operators would want to buy vehicles that would be compliant for as long as possible. European wide co-operation on this issue would be of great benefit.

---

[26] This is also discussed in the London Low Emission Zone study available at: http://www.london-lez.org

For PM_{10}, a large proportion of the problem is secondary, over which the local authority has no control and which often limits the effectiveness of action at a local level. Many countries and cities have these same problems, and find that secondary emissions account for around one third of the concentrations (although in some years it is more and some years it is less, as discussed above). It is therefore essential that all Member States take action to reduce the particulate pre-cursors, to enable the Limit Values to be achieved, and improve the effectiveness of local action. While each city reducing its emissions to achieve the Limit Values will contribute to the reductions required, reductions from other areas are also needed. In the absence of a no-effect level for PM any reduction of the regional background level would pay off in reduced health effects, even and in particular in cities.

For $PM_{2.5}$, about which there is increasing health concern and discussion of further EU Limit Values, local transport emissions as well as secondary sources are particularly important. However, when focusing on smaller particles, the question arises whether to put more emphasis on certain PM components with greater health risk, like carbonaceous exhaust particles, in relation to secondary aerosol, like ammonium nitrate, which seems to be less toxic. If so, local action and setting of European emissions standards aimed to control such primary PM components would gain importance in comparison to combat precursors of secondary PM. Hence, this aspect needs more consideration when designing future air pollution control policies, not least because of its implications on the burden sharing between the local level and the European Union or the CLRTAP, respectively.

FURTHER ACTION AT THE EUROPEAN LEVEL

As discussed above, local action by cities will not be sufficient to achieve the EU air quality Limit Values. Additional larger scale measures are needed. It is essential that the Member States play their part in providing these additional measures. However, there are many issues that the individual state has great difficulty to tackle on its own, including actions affecting vehicle manufacturers, oil companies or aircraft, for which the EU and/or UN-ECE is better placed to act, but can only do so with the co-operation from Member States and countries. Whilst not an exhaustive list, some of the issues that cities, countries and the EU could work on together are outlined below. For some of these, discussions are already underway and where this is the case, cities need to be more closely involved and informed. While it may be difficult to achieve, it is important that all efforts possible are undertaken towards achieving the EU Limit Values.

With the automotive industry:

- Further Euro standards, especially for light duty diesel vehicles
- Encouraging manufacturers to produce vehicles meeting Euro IV and V standards earlier, or to 'leapfrog' Euro standards as some manufacturers did for Euro III/ IV petrol cars.
- The EU to ensure that transient testing means that emissions reductions are achieved under stop-start and low speed driving conditions, typical of in urban areas, as well as over the total test cycle
- To ensure that technologies are encouraged that reduce CO_2 emissions at the same time as reducing local air pollutants. This could well favour SCR over exhaust gas re-circulation (EGR) as a method of achieving the 2010 Euro standards.
- Encourage manufacturers to produce a greater variety of gas and electric vehicles, especially vans and lorries, together with adequate supporting infrastructure.

With the oil industry:

- Bring forward the introduction of sulphur free vehicle fuels.
- Look to faster introduction of lower sulphur limits for all other fuels, including rail and shipping
- Ensure that incentives designed to encourage the use of biodiesel do not result in negative impacts on local air quality.

With other transport sectors:

- Have an ever more sustainable European transport policy - i.e. more rail freight, and keeping the TEN under review.
- Seek reductions in aircraft emissions, both in terms of each aircraft and to encourage the use of cleaner aircraft. To move towards a technology stretching strategy in the International Civil Aviation Organisation (ICAO) 'Chapters' emissions system as used in the road vehicle 'Euro standards' rather than the present technology following system.

With other industry:

- Encourage or require Best Available Technique (BAT) emissions control in industry
- Further reduce emissions from large combustion plants.

With regulation:

- The Gothenburg protocol and the national emission ceilings Directive (NECD) is a good first step to assist in reducing secondary emissions. To reduce the secondary contribution which is such a great influence on the abilities of many states to achieve the Limit Values, this process needs to continue with further agreements to reduce the secondary PM_{10} pre-cursors by setting lower national emissions ceilings in the NEC Directive
- Avoid long transition periods for new EU member and accession countries meeting emissions standards, NECD ceilings and Euro Standards.
- A draft $PM_{2.5}$ Limit Value to be identified as soon as possible, as action to achieve the $PM_{2.5}$ limit would be different to that for PM_{10}. For example, by placing more emphasis on vehicle tailpipe and secondary sources, and less on re-suspended road dust or quarrying sources.
- Ensure that the regulation aimed at road user charging allows the type of congestion charge implemented in London to be implemented.

In terms of funding:

- Enhance the possibilities for EU Member States to grant economic incentives for users of “green” technology
- Interpretation of state aid and other rules that limit the ability to focus funding at the problem areas
- It should be considered to enhance regional funding for the implementation of environmental legislation, at least for a transitional period.

In terms of research:

- Clarify which pollutants should be tackled in the most cost-effective way in order to maximise health benefits. Where there is a choice, should NO_2, PM_{10} or $PM_{2.5}$, or any toxic PM component be prioritised? Also decide how this should affect present and future policies.

- Achieve greater harmonisation across Europe in assessing the achievement of Limit Values, so the same standards are being achieved. At present different countries - and even areas within countries - often have assessment methods that differ in practice, and lead to different conclusions on attainment.
- At present, it is not clear where the Limit Values are required to be met, eg is it dependent on exposure? The EC should clarify where the Limit Values are to be met.
- Given the need for compliance on a city or even street canyon scale, how can this scale be taken properly into account by the tools used within the Commission's Clean Air for Europe Programme or by the CLRTAP to set the next generation of environmental objectives and the requisite air pollution control strategy for Europe?

Timing of Directives for Limit Values and emissions reduction is also an issue, as is the length of time issues take to resolve at an EU level. Some of these measures have been discussed as possibilities within the review of the EU thematic strategy and CLRTAP protocols, and it is hoped that this will paper will provide a useful input from London, Berlin and Paris to this review. This workshop is part of this process. The cities of London and Berlin would be interested in discussing the topics considered in this paper with other cities, the EU and the CLRTAP[27].

ADDITIONAL ISSUES AT THE NATIONAL LEVEL

While the main focus of this paper is the additional measures at an EU level, it is important to also recognise the national issues that limit city-level action. These issues vary from country to country, and each country needs to find its own answers to these, and other issues. Some of the issues are highlighted below:

- Sufficient funding for local and city authorities adequately to implement emission reduction measures
- Allowing funding and other support to be focused at the problem areas
- Governmental support for EU initiatives and proposals aimed at reducing emissions
- Availability and stability of incentives and grant schemes
- Insufficient delivery of national measures
- Air quality has not always a local issue in all countries
- Pollution imported from other issues within the country
- More joined up Government policies.

[27] contact: Lucy Sadler at the Greater London Authority on lucy.sadler@london.gov.uk and Martin Lutz at the Senate Department for Urban Development in Berlin on Martin.Lutz@senstadt.verwalt-berlin.de

European Academies

easac

Science Advisory Council

Impacts of pollution from outside the European Union on Europe's environmental targets

Impacts of pollution from outside the European Union on Europe's environmental targets

Contents

Transborder pollution: Foreword

Public policies have to take account of the underlying science if they are to make any impact on the issue they are addressing. Equally, they have to accommodate what science tells about the boundaries of a phenomenon: if a problem originates at least in part from outside a country's borders, then a purely national approach to solving it is not going to be very effective. Such a reminder of the limits of national power may not always be welcome, but it can be the essential prelude to effective action.

I therefore strongly recommend this report to those who are tasked with devising and implementing effective policies for the improvement of Europe's environment. In a short statement it demonstrates that Europe's air quality is significantly impaired by sources of pollution that lie outside the EU. The statement grows out of discussions at a workshop hosted by the Academy of Athens, built around a background paper included in this report which details some of the relevant research. Both the statement and the background paper highlight actions that need to be taken to address the issues identified. These actions inevitably have a transnational character going beyond the countries of the EU, and thereby present something of a challenge.

On behalf of EASAC I should like to express my warm appreciation both to the Academy of Athens for the efficiency and generosity with which it hosted the workshop, and to the expert scientists from 12 different countries who contributed to making it a success. I should particularly like to thank David Fowler and John Murlis, respectively Chairman and Secretary of the EASAC Environment Strategy Group, for the skill and energy with which they wrote the background paper, organised the workshop and produced the subsequent statement.

Professor Uno Lindberg
Chairman, EASAC

Impacts of pollution from outside the European Union on Europe's environmental targets

Summary

Environment experts from the European Union's Academies of Science have considered evidence on trends in air quality in Europe and projections for the coming decades. Despite investment by the European Union's Member States, recovery from past damage in some important areas is slower than expected and in some cases the environment is expected to deteriorate further. This stems from the effects of pollution sources that lie outside the scope of European legislation. Action at an international scale is needed, and we urge the European Union to take immediate steps to consider how this might be done.

EU Directives have been agreed between Member States to protect Europe from the effects of major transboundary air pollutants, including acid deposition and ground-level ozone. The Environment Strategy Group of the European Academies' Science Advisory Council met in Athens in October 2003 to consider evidence about the effects of these international agreements on trends in air quality and the extent of recovery of the natural environment from effects of pollutant deposition. The analysis also considered the effects of air quality on human health, current trends and future prospects.

The Member States of the European Union have made considerable reductions in emissions and in doing so have delivered significant benefits to Europe's environment and the health of Europe's citizens. For some areas, the reductions in pollution impacts have been larger than expected. In other areas, however, the evidence showed that reductions in pollution are much smaller than expected. The areas of little or no improvement include some of the very sensitive upland regions in which the effects of acid rain on freshwater ecosystems were most severe.

The causes of this failure to respond to emissions reductions within the EU are interactions between pollutants that were not assessed in the first round of agreements and additional sources of pollutants that were poorly known or not included. The most important of these sources are emissions of sulphur and nitrogen compounds from shipping and major sources of the precursors of ground level ozone in North America and Asia.

It is now clear that emissions of the precursor pollutants geographically outside the framework for control are making important contributions to the environmental problems within Europe. Furthermore, existing controls and additional measures to control sources within Europe will fail to protect human health and the natural ecosystems of Europe from the effects of these pollutants in the absence of control measures taken to reduce emissions of precursor pollutants more widely in the Northern Hemisphere.

In order to tackle this problem, we urge the European Council of Ministers to support or initiate international discussions with non-EU countries in the Northern Hemisphere to control:

- emissions of tropospheric ozone precursor gases throughout the countries of the Northern Hemisphere to prevent surface ozone concentrations exceeding thresholds for effects on human health, agricultural crops and the biodiversity of semi-natural ecosystems throughout Europe; and
- emissions of sulphur dioxide and nitrogen oxides from international shipping to protect the acid- sensitive natural ecosystems of Europe.

Background

The Environment Strategy Group of the European Academies' Science Advisory Council met in Athens in October 2003 to consider evidence on the effects of external pollution sources on Europe's environmental targets.

A background paper for the Athens workshop (Annex I) provided summary details of the existing international Protocols and Directives in place to protect Europe from the effects of major air pollutants that contribute to transboundary air pollution problems in Europe.

These pollutants give rise to effects on human health, primarily through ingestion of aerosols and ozone, and to effects on ecosystems through action of acidified precipitation, ozone absorption and enhanced eutrophication. The secondary pollutants contributing to these problems also play an important role in the radiative forcing of climate, through the effects of aerosols and ozone.

The issue

The Member States of the European Union have made considerable reductions in their emissions and have thereby delivered significant benefits to Europe's environment and the health of Europe's citizens. However, there are areas of Europe in which the changes in pollution concentration or deposition in recent years are not consistent with the expected recovery of air quality. For some of these areas, the reductions in concentration are larger than expected, while in other areas the reductions in concentration are either much smaller than expected or levels have not changed at all. The areas of little or no improvement include some of the very acid sensitive upland regions in which effects of deposited acidity on freshwater biota were most severe.

The causes of these 'non-linearities' in the source/receptor relationships include interactions between pollutants that were not included in the first generation of long-range transport modelling and additional sources of pollutants that were poorly known or not included. The most important of these sources include emissions of sulphur from shipping and major sources of precursors of ground-level ozone in North America and Asia.

It is now clear that emissions of the precursor pollutants geographically outside the framework for control are making important contributions to the environmental problems within Europe. Furthermore, existing controls and additional measures to control sources within Europe will fail to protect human health and the natural ecosystems of Europe from the effects of these pollutants in the absence of control measures taken to reduce emissions of precursor pollutants more widely in the Northern Hemisphere.

Evidence for measurements and modelling

Current trends in the concentrations and deposition of these pollutants over large areas of Europe show that the effectiveness of existing international control measures, including those undertaken by the European Union (EU) and the United Nations Economic Commission for Europe (UNECE) within the Treaty on Long-Range Transboundary Air Pollution (LRTAP), is being eroded by emissions from countries and continents outside Europe and by emissions from shipping. The recognition that the effects of emissions over very large areas of the planet contribute to the pollution climate of the entire hemisphere has been shown to extend beyond the greenhouse gases into the pollutants with much shorter atmospheric lifetimes. Thus it is necessary to develop regulations operating on the same geographical scale as the emissions contributing to the problem.

The current UNECE protocols and EU directives include specific dates for review, to assess the modelling and measurement data and to show the extent to which the expected compliance and recovery are supported by the available measurements. The review date for the UNECE Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone is rapidly approaching and is likely to reveal non-linearities in several regions, in addition to those already identified. It will be very important to develop a strategy to show how the effects of the non-linearities can be reduced. It will be particularly important to separate the non-linearities arising through uncertainties in the science from those due to sources outside the control of the current protocols. It will then be necessary to develop strategies and agreements to limit the harm from the additional sources. Of course it is important also to emphasise that growing awareness of external influences on European air quality should not in any way lessen national commitments to reductions in emissions already agreed.

The steady increase in concentrations of surface ozone in the mid-latitudes of the Northern Hemisphere has brought annual mean concentrations within 10 ppbV of values shown to reduce the yields of sensitive crops, and within 20 ppbV of values shown to affect the respiratory systems of sensitive children and adults. Given the rate of increase in surface ozone concentrations, it is a matter of a few decades before the mean surface concentrations of ozone in some areas of Europe becomes damaging to human health, the health of natural ecosystems and crop yields.

Current uncertainties in understanding regional problems of eutrophication and global climate change highlight the role of aerosols in these problems. In the case of uncertainties in the effects of anthropogenic activity on global climate, the role of aerosols presents the major uncertainties in the anthropogenic contributions to radiative forcing of climate. The problem stems from weaknesses in understanding the sources, atmospheric processing and deposition of aerosols. These uncertainties include the role of resuspension of aerosols from the surface, for example the Sahara desert, which on occasion may lead to exceedences of air quality standards over large areas of Europe as well as modifying the albedo on a regional scale.

There is a considerable body of evidence from observations that there are large sources of particles observed throughout Europe that originate outside the geographical scope of the EU. They include Saharan dust, sea salt aerosols, wind blown dust and biomass burning. Whilst EU Air Quality standards refer to the number of episodes above a given level, care has to be taken with standard setting to exclude natural phenomena. The biomass burning associated with the forest and peat fires near Moscow in September 2002 led to the occurrence of particulate matter (PM) episodes in Finland, Denmark and the British Isles, while Saharan dust episodes have been shown to cause exceedences of PM standards in Southern and Mediterranean Europe.

Action required

- Controls on emissions of the precursor gases for tropospheric ozone throughout the countries of the Northern Hemisphere to prevent regional ozone concentrations exceeding thresholds for effects on human health, agricultural crops and the biodiversity of semi- natural ecosystems throughout Europe.

- Controls on the emissions of sulphur dioxide and nitrogen oxides from international shipping to protect the acid-sensitive natural ecosystems of Europe.

These controls can be achieved only through an international framework and will require concerted action by both the European Union and the United Nations Economic Commission for Europe.

As a first step, the impacts of sources outside the EU on Europe's environmental targets should be considered by the European Council of Ministers and by the Executive Body of the UNECE LRTAP within the review of the Gothenburg Protocol.

Annex 1 Background Paper: Will action taken within Europe alone achieve Europe's environment targets? The significance of influences from outside Europe on the European environment

David Fowler, EASAC ESG Chairman
John Murlis, EASAC ESG Secretary

Introduction

The aims of the October 2003 Athens Workshop are to review current evidence of the influence of sources external to Europe on current control measures, the changes in these sources needed to match measures taken within Europe and the likely changes between 2003 and 2020. The main external influences will include the emissions of other Northern Hemisphere regions, in particular North America and China.

In recent years, the European Union has agreed a wide range of measures to limit emissions of air pollution. These include Directives on acidic emissions from power stations, refineries and road transport vehicles, on emission of the precursors of tropospheric ozone from products, processes and road transport vehicles, and on toxic pollutants from a wide range of industrial and transport sources. It is expected that these measures will carry significant costs to the economies of European Union Member States.

In addition the Union has set itself some ambitious targets on environmental quality. It has been decided that these are of high strategic importance in improving quality of life for the citizens of the Union. The CAFE (Clean Air For Europe) programme of the Commission seeks to ensure that the effects of the measures agreed will add up to the targets.

During the period in which European environmental legislation has developed, a number of international treaties have also been agreed on limiting air pollution, including measures agreed within the framework of the UN Economic Commission for Europe (UNECE) Convention on Long Range Transboundary Air Pollutions (LRTAP). The signatories to the Convention include a number of nations outside the European Union, notably the United States of America and Canada. The protocols of the Convention limit emissions, but do not necessarily have a uniform effect in all countries. In some cases, signatories have agreed to a lesser effort than the European Union norm. In addition a number of significant emitters of air pollution outside the UNECE and the EU have yet to take action on a scale commensurate with the UNECE. There remains, then, the possibility that other Northern Hemisphere countries will continue to be significant emitters of air pollution beyond the dates set for European quality targets.

Emissions of sulphur and oxidised nitrogen have fallen across Europe. However, it seems that although deposition has fallen, too, it has fallen to a lesser extent. This points to substantial non-linearities, partly arising from unexpected interactions between pollutants and partly from the influence of sources outside the EU.

Oxidised nitrogen also plays a major role in the production of photochemical pollution. In this case, although peak levels are falling, there is an upward trend in mean levels. This may point to an increase in the tropospheric background levels of ozone, a major constituent of photochemical pollution, to which emissions of precursor pollutants, including oxidised nitrogen, from outside the EU contribute.

The decreases that have been achieved in nitrogen emissions over the last two decades seem to have had little impact on deposition of nitrogen species or on effects such as eutrophication across Europe.

The question this Workshop is addressing, now of crucial importance to policy makers, is whether the measures agreed by the European Union will achieve the targets set in the context of emissions within the Northern Hemisphere as a whole.

The workshop will consider evidence for non-linearities between emissions reductions and environmental improvements, and will take a view on the likely form of the relationship and in particular the influence of sources external to the European Union.

European environmental targets

(i) Protecting the environment

Targets for the protection of Europe's environment have been developed within the European Union through a series of Directives and within the Protocols of the United Nations Economic Commission for Europe Convention on Long Range Transboundary Air Pollution (UNECE – LRTAP). Increasingly, targets for environmental protection are agreed on the basis of effects. This is partly to ensure that the measures agreed address the problem and partly out of a concern for proportionality between investment in emission reductions and benefits of an improved environment.

The scientific demands of the effects-based approach have been considerable but there now seems to be a solid consensus that this is the way forward for protecting ecosystems against air pollution. In scientific terms, this has been the driver for a major international research project aimed at understanding the effects of air pollution on the environment. The expression of this work is the development of Critical Loads and Levels for ecosystem protection. Critical Loads and Levels define the maximum amount of deposition of air pollutants or exposure to air pollutants that specific ecosystems can support before damage occurs. Critical Loads and Levels vary geographically and are shown on maps. They also depend greatly on the state of knowledge and are therefore subject to revision as knowledge improves.

There are many complexities to the Critical Loads Approach (CLA), including for example the aggregation of area statistics, definitions of damage and the basics of soil chemistry and plant physiology. The CLA, however, has proved robust in international negotiations and the maps produced remain the best definition of ecological sensitivity of air pollution available to Europe's policy makers.

There has been considerable debate about the relationship between critical loads and levels and environmental targets. However, it now seems that the maps of Critical Loads and Levels do provide a widely accepted aspirational set of targets for European environmental policy, both at EU and ECE levels.

There are now comprehensive and evolving agreements on, for example:

- Critical Loads for protection of terrestrial ecosystems and fresh waters against SO_2 and NO_x
- Critical Levels for protection of vegetation against the effects of ozone

A useful summary, with links to detail, is at http://www.ace.mmu.ac.uk/Resources/Fact_Sheets/Key_Stage_4/Air_Pollution/10.html

(ii) Protecting human health

Targets for the protection of human health are provided in a series of European Union Directives and have increasingly become a part of the rationale for the Protocols agreed under the UNECE LRTAP.

Within the EU, a series of Directives has specified air quality targets in terms of concentrations of air pollutants and the periods over which they are assessed, from hourly to annual. The programme of Air Quality Directives, including the Air Framework Directive and the Daughter Directives agreed under it, are summarised in the DG Environment web site at: http://www.europa.eu.int/comm/environment/air/ambient.htm

In summary, there are now comprehensive standards for a number of major air pollutants, including SO_2, NO_x, ozone and suspended particulate matter. Many of these standards have entered into force in Member States and have become de facto targets for both Member States and the European Union. The European targets are summarised, with a particular example of the Member States' targets, in:
http://www.ace.mmu.ac.uk/Resources/Fact_Sheets/Key_Stage_4/Air_Pollution/21.html

Many of these targets depend on local sources, for example traffic pollution. However, as targets become more stringent and as local sources come under control, for example through European Directives on vehicle emission, the influence of sources further away from effected urban centres becomes more prominent. This has increased policy interest in uncontrolled and distant sources of air pollution.

It is widely accepted now that there are both local and regional dimensions to health impacts of air pollution and that there is a strong transboundary component to the pressures on health from air pollution.

(iii) Measures taken

Europe has invested heavily in measures to reduce the air pollution burden through, for example:

- EU Directives on large combustion plant
- EU Directives on vehicle emissions
- EU Directives on fuel quality
- UNECE Protocols under the LRTAP Convention
- EU Air Framework Directive and its daughter Directives

Details of measures taken under the EU can be found from links in the Air Page at http://www.europa.eu.int/scadplus/leg/en/s15004.htm and within the UNECE at http://www.unece.org/env/lrtap/

Although it is difficult to provide a meaningful figure, it is widely accepted that these have added greatly to costs for industry and for consumers across Europe.

Results and emerging issues: an assessment

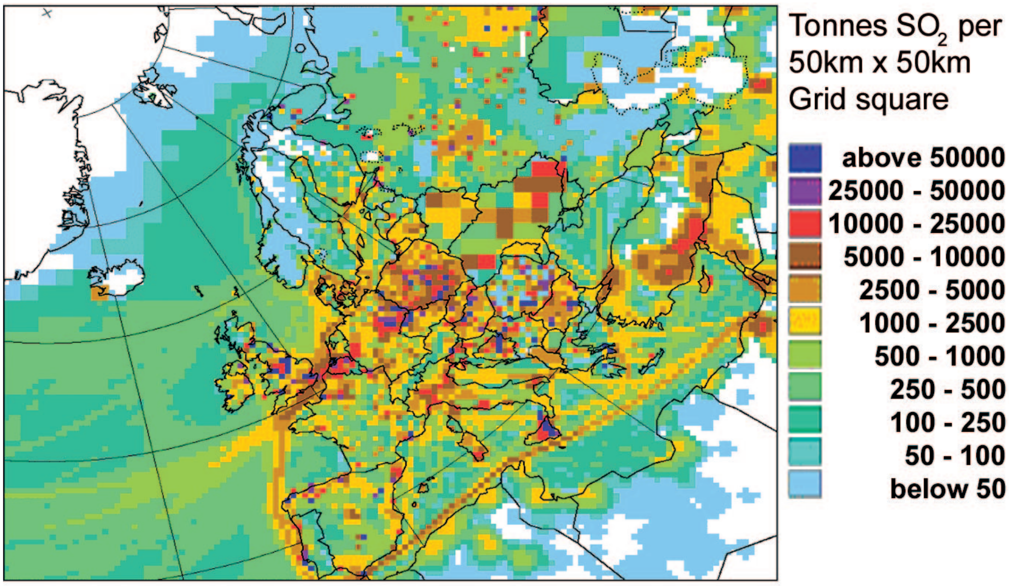
Despite the very considerable effort made to control sources of air pollutants, there is a wide consensus that much remains to be done. In particular, there is a growing feeling amongst the Member States of the European Union and UNECE that further action must be based on a full understanding of the current influences on the European pollution climate, including those sources that lie outside the European jurisdiction.

The following assessment considers four particular cases concerning the pollution climate of Europe in which sources outside the domain of the current control process significantly influence effects within Europe or the effects of European emissions.

(i) Sulphur

The very large reductions in European emissions have led to substantial reductions in concentrations, deposition and exceedences of Critical Loads. However, some important regions of Europe in which effects of acidification were widespread have experienced little or no reduction in deposited acidity, and show no signs of chemical or biological recovery. These areas include the NW fringe of Europe in western Britain, where the emissions of SO_2 from shipping in the eastern Atlantic has made an increasing contribution to the acidifying inputs, offsetting land-based reductions in Europe. These emissions are not currently controlled and are limiting ecosystem recovery from the effects of acid deposition (NEGTAP, 2001).

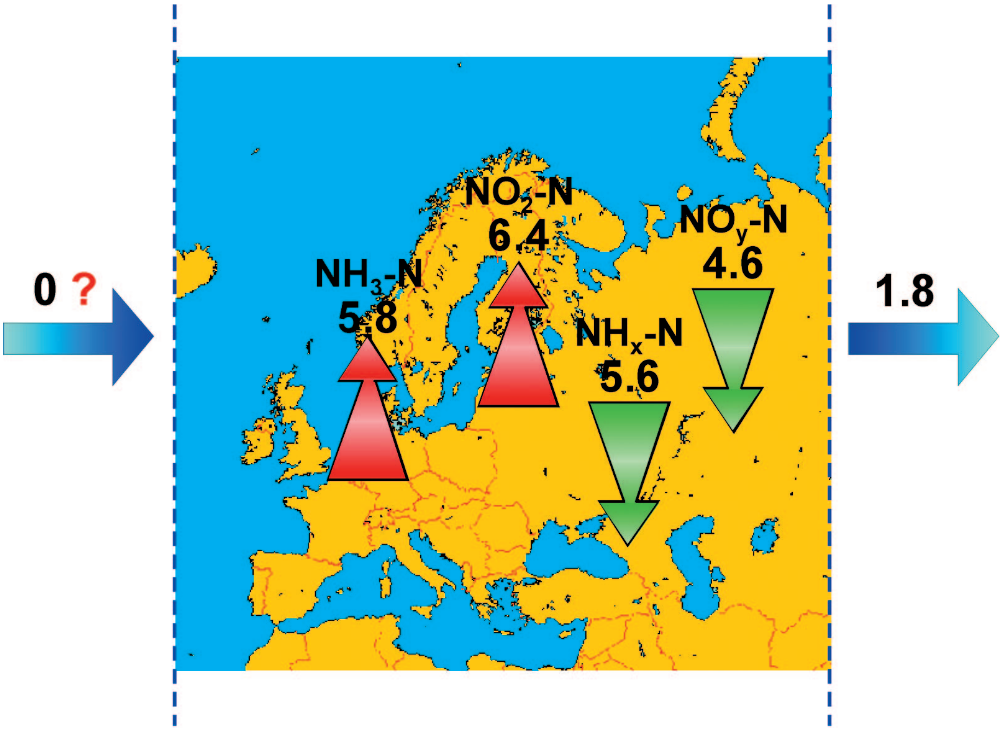
Figure 1 SO_2 emissions in Europe and the Eastern Atlantic, showing the shipping emissions in the Western Approaches to Europe, from Atlantic and in the North and Mediterranean Seas (EMEP/MSC-W, 2001)



(ii) Oxidized nitrogen

The timescale for oxidation and deposition of the nitrogen oxides is rather longer than sulphur dioxide, and as a result, a significant fraction of the emissions within Europe are advected out of the continent, generally to the east, contributing to eutrophication over Asia. There is also a smaller, but significant import of oxidized nitrogen from North America, which contributes to ozone formation over Europe and to eutrophication and acidification in Europe. The net budget for the EMEP domain is shown in figure 2, illustrating the issue. The budget shows that 30% of the oxidized Nitrogen emitted within Europe is deposited to the east, in Asia.

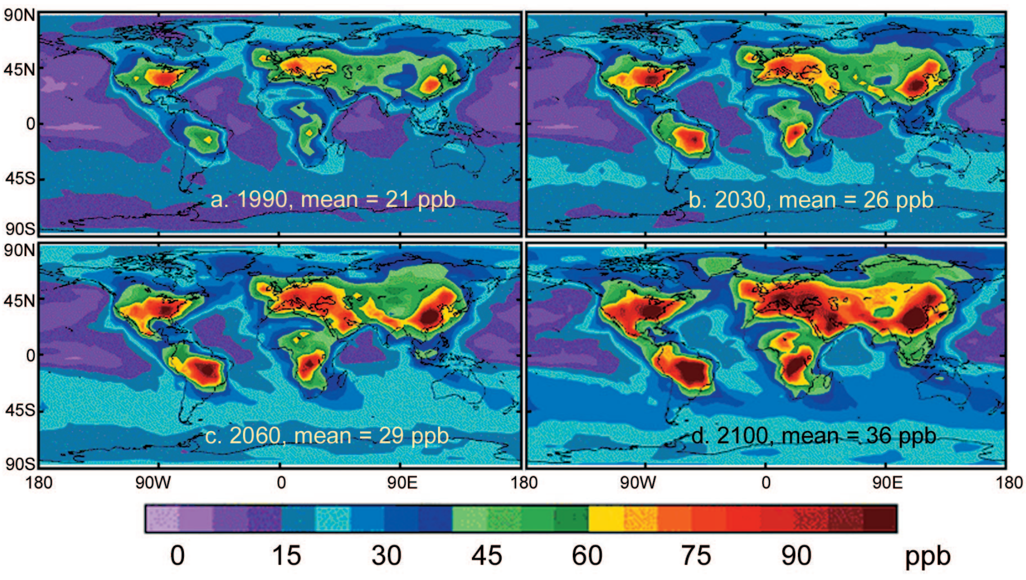
Figure 2 The annual atmospheric mean budget over Europe illustrating the net export of oxidising nitrogen (Mt) (EMEP/MSC-W, 1997)



(iii) Ozone

The photochemical production of ozone throughout northern mid-latitudes has created a zone of enhanced ozone concentration from the precursor emissions. The background concentrations between 30° N and 60° N are believed to be between a factor of 2 and 3 larger than in pre-industrial times (Prather et al, 2003). The consequence of the background surface ozone concentrations for European control strategies is that the controls on the NO_x and VOC emissions to date have reduced the peak concentrations substantially, but the growing background from emissions elsewhere in the Northern Hemisphere remains outside the control process. Furthermore, the background concentrations are now close to the thresholds for effects on vegetation and human health, and in the absence of controls in the other major emission areas, the background concentrations will in a few short decades be causing widespread damage to crops, natural ecosystems and human health.

Figure 3 Global surface ozone concentrations during the period 1990 to 2100 (Stevenson et al, 1998)



(iv) Aerosols

The primary concern over effects of atmospheric contaminants on human health in Europe is the link between aerosol concentrations and human mortality. The precise agent within aerosols responsible for the increased mortality in areas of high aerosol concentration remains unknown, but the physical properties and size are an important focus of current interest. Among the pollutants, the sources, atmospheric processing and fate of aerosols remains a challenge to the atmospheric science community, and the uncertainties in these factors introduce considerable uncertainty in the development of control strategies.

The contribution of Saharan dust to the chemical climate of the atmosphere over the Mediterranean basin leads to base cation deposition throughout the region. A base cation is essentially a positively charged ion from group 1 or 2 of the periodic table (ie the alkali metals or alkaline earth metals). The most environmentally abundant of these are sodium, potassium, calcium and magnesium. Base cations are important in the environment because their deposition has an impact on the surface pH. The deposition of base cations increases the alkalinity of the surface; the effect is to buffer or neutralise the effects of the acidity generated by deposition of sulphur or nitrogen (which in their mobile anionic form as SO_4^{2-} and NO_3^- leach calcium and magnesium from the soil) and to offer some protection from the effects of deposited acidity. However, the contribution to human health effects and climate effects of this particulate matter must also be considered.

The majority of the long-range transport of the pollutants with relatively short lifetimes in the atmosphere (days) occurs primarily in the aerosol phase. Thus the improvements in understanding needed for many of the key issues concerning atmospheric pollutants require correspondingly improved understanding of many aspects of the underlying processing of aerosols, their sources, transformations and removal from the atmosphere. In the absence of this improved understanding, control strategies developed to solve the currently known problems will produce less benefit than expected and further measures will be required.

Future action

The main questions for policy makers are now:

- What more needs to be done: can we measure the gap between what has been achieved in reducing levels of air pollutants and the targets set for protection of health and the environment?

- Where could further reductions in the key emissions (sulphur and oxidised nitrogen) come from?

- Future source apportionment: which sources of sulphur and oxidised nitrogen will have most influence in future?

Conclusions

The workshop will need to consider the evidence available and to highlight areas where further understanding is crucial to progress in the policy processes, especially:

- Evidence of need for further action
- Evidence for impacts of sources outside the EU
- Scale of reductions needed in Europe and externally

There are three levels of understanding:

- Those matters upon which there is broad scientific consensus
- Those areas in which there is a spread of opinion
- Those areas in which the current state of knowledge is inadequate to reach any sensible conclusion

From discussion of this background paper and other contributions to the workshop, EASAC will develop a timely statement intended to focus the attention of EU policy-makers on practical ways of addressing these important issues.

References

NEGTAP, 2001. 'Transboundary Air Pollution: Acidification, Eutrophication and Ground-Level Ozone in the UK', Report of the National Expert Group on Transboundary Air Pollution (NEGTAP) for the UK Department for Environment, Food and Rural Affairs, Scottish Excecutive, the National Assembly for Wales/Cynulliad Cenedlaethol Cymru and the Department of the Environment for Northern Ireland, CEH-Edinburgh., 314 pp

EMEP/MSC-W Report 1/97, July 1997. 'Transboundary Air Pollution In Europe. MSC-W Status Report 1997, Part 1: Emissions, dispersion and trends of acidifying and eutrophying agents Part 2: 'Numerical Addendum'

EMEP/MSC-W Note 1/01, July 2001. 'Emission data reported to UNECE/EMEP: Evaluation of the spatial distributions of emissions'

Prather, M., M. Gauss, T. Berntsen, I. Isaksen, J. Sundet, I. Bey, G. Brasseur, F. Dentener, R. Derwent, D. Stevenson, L. Grenfell, D. Hauglustaine, L. Horowitz, D. Jacob, L. Mickley, M. Lawrence, R. von Kuhlmann, J.F. Muller, G. Pitari, H. Rogers, M. Johnson, J. Pyle, K. Law, M. van Weele, and O. Wild, 2003. 'Fresh air in the 21st century?', Geophysical Research Letters, 30 (2), art. no.-1100

Stevenson, D.S., C.E. Johnson, W.J. Collins, R.G. Derwent, K.P. Shine, and J.M. Edwards. 'Evolution of tropospheric ozone radiative forcing', Geophysical Research Letters, 25 (20), 3819-3822, 1998

Annex 2 Participants at EASAC Workshop

Professor Marie-Lise Chanin	Service d'Aeronomie du CNRS, France
Dr Peter Collins	The Royal Society, London, UK
Professor Paul Crutzen Paul	Max-Planck-Institute for Chemistry, Atmospheric Chemistry Division, Mainz, Germany
Professor Richard Derwent	Imperial College, London, UK
Professor Brian Diffey	Clinical Director, Regional Medical Physics Department, Newcastle General Hospital, UK
Professor Giorgio Fiocco	Dipartimento di Fisica, Università di Roma "La Sapienza", Roma, Italy
Professor David Fowler	Centre of Ecology and Hydrology, Edinburgh, UK
Professor Vyvyan Howard	Developmental Toxico-Pathology Group, Department of Human Anatomy and Cell Biology, The University of Liverpool, Liverpool, UK
Professor Luc Hens	Free University of Brussels, Faculty of Medicine and Pharmacy, Human Ecology Department, Brussels, Belgium
Professor Ivar Isaksen	University of Oslo, Department of Geophysics, Oslo, Norway
Professor Klea Katsouyanni	Department of Hygiene and Epidemiology, University of Athens Medical School, Athens, Greece
Professor Nicolaos Matsaniotis	Academy of Athens, Athens, Greece
Professor Evangelos Moudrianakis	Foundation for Biomedical Research of the Academy of Athens, Athens, Greece
Professor John Murlis	Royal Society, London, UK
Professor Stamati Polymeni Nicolopoulou	University of Athens, Medical School, Department of Pathology, Athens, Greece
Professor Marianne Popp	University of Vienna, Institute of Ecology and Conservation Biology, Vienna, Austria
Professor Matti Saarnisto	Delegation of Finnish Academies of Science and Letters, Helsinki, Finland
Professor Sherwood F. Rowland	University of California, Irvine, USA
Professor John Sweeney	Department of Geography, National University of Ireland, Maynooth, Ireland
Dr Birgit Van Tongelen	European Commission, DG Environment, Brussels, Belgium
Professor Dimitrios Trichopoulos	University of Athens, School of Medicine, Department of Hygiene & Epidemiology, Athens, Greece
Professor Louise Vet	Director, Netherlands Institute of Ecology (NIOO-KNAW), Maarssen, Netherlands
Professor Christos Zerefos	University of Athens, Faculty of Geology, Athens, Greece

Annex 3 Members of EASAC Environment Strategy Group

Dr Marie-Lise Chanin	Service d'Aeronomie du CNRS, France
Professor Dr Franz Durst	University of Erlangen-Nürnberg, Germany
Professor Giorgio Fiocco	Università di Roma "La Sapienza", Italy
Professor David Fowler CHAIRMAN	Centre for Ecology and Hydrology, Edinburgh, United Kingdom
Professor Herman van Langenhove	University of Ghent, Belgium
Dr Claude Lorius	Laboratoire de Glaciologie et de Géophysique de l'Environnement, St Martin d'Hères, France
Professor Karl-Göran Mäler	The Beijer Institute Stockholm, Sweden
Professor Dr Marianne Popp	University of Vienna, Austria
Professor Matti Saarnisto	Delegation of Finnish Academies of Science and Letters, Finland
Dr John Sweeney	National University of Ireland, Ireland
Professor Louise E.M. Vet	Netherlands Institute of Ecology, Maarssen, Netherlands
Professor Christos Zerefos	National and Kapodistrian University of Athens, Greece
Professor John Murlis SECRETARY	Royal Society, United Kingdom

Improving Air Quality – the Policy Challenge to 2020

John Rea

Outline

In this paper I aim to review the current national and international approaches to reducing pollution impacts, discuss priorities for further action having regard to other drivers, and propose options for more robust approaches. While I have shamelessly stolen ideas from colleagues in the UK and elsewhere, the views expressed are my own and should not be taken as a statement of the UK position.

Current Situation

Within the EU we currently have a three-pronged approach to controlling air pollution: ambient air quality limit values (LVs), national annual emission ceilings (NECs) and sector specific measures (e.g. Euro standards, IPPC, LCPD). Controls aimed at improving ambient air quality and reducing deposition of transboundary pollutants have largely been designed separately from one another, with little consideration of the links between the issues. Climate change policy and measures have been developed completely separately from those addressing air pollution.

We now understand that the old distinction between ambient air quality and transboundary pollution is no longer justified. A significant percentage of particulate matter (PM) on even the most heavily trafficked streets is of transboundary origin, while ozone is largely a long range pollutant. Likewise, there are many interactions between climate change pollutants and air pollution (e.g. black carbon, aerosol, and ozone all affect both human health and radiative forcing, and climate change will affect the occurrence and severity of pollution episodes). Furthermore some of the measures introduced to control one problem can make another worse – the dieselisation of the European car fleet being a case in point (good for CO_2, bad for particles and NO_x).

So, how are the current measures doing? There is no doubt that there has been considerable progress on a number of fronts, but widespread exceedences are still occurring and are predicted to continue to occur for both NECs (particularly for NO_x) and LVs (largely PM_{10} and NO_2). There has also been mixed success in sector specific controls. For example, the Euro standards for vehicles have not always delivered the expected benefits on NO_2 (an unfortunate consequence of test cycles not reflecting real world driving conditions, or, if you are cynical, cycle beating), nor have the PM emissions limits yet resulted in the anticipated widespread fitting of particle traps on diesel vehicles.

What Pollutants Should be Priorities?

It is crucial that the next phase of controls focus on the pollutants of most concern. I believe there are three air pollutants that pose a significantly greater risk than the others and should therefore be the driving force for devising optimum strategies. These are particulate matter (PM), ozone and nutrient nitrogen.

<u>PM</u> is strongly associated with serious health effects and appears not to have an identifiable threshold. The latest advice from WHO suggests that exposure to $PM_{2.5}$ is reducing *average* life expectancy across North Western Europe by between 9 and 15 months. In terms of life years lost, this puts it up with road accidents as one of the major killers in society, behind only smoking and dietary factors. This estimate does not even cover all of the suspected effects of PM (the coarse fraction is also associated with serious health effects). There is a huge amount we do not yet understand about PM – how it causes these effects, what components of the mixture are the most toxic, even how best to measure it – but it is clear that we cannot wait for all the answers before taking further strong measures.

PM is a pollutant where our concern has grown because of increased understanding, not because levels are actually increasing. However background <u>ozone</u> concentrations are going up, thanks to increasing precursor emissions around the globe and reducing NO_x concentrations in cities. As with PM ozone appears to cause health effects without any threshold. The magnitude of the effects does not appear to be as high as for PM, but of course ozone also affects vegetation and ecosystems.

Nutrient Nitrogen (from both NO_x and ammonia emissions) appears to be where acidification was 25 years ago. There is growing evidence of widespread adverse effects in ecosystems happening now and associated with the deposition of nitrogen compounds (e.g. from the UK Countryside Survey 2000). While NO_x emissions are decreasing, there is no clear dependable downward trend in ammonia emissions.

Other pollutants seem far less important to me because either:
- the problem is largely solved (e.g. ambient carbon monoxide, benzene, sulphur dioxide, and lead);
- existing commitments and chasing my three priorities will deliver improvements anyway (e.g. NO_2 levels will drop because of existing controls reinforced by the need to further reduce NO_x emissions to address ozone and nutrient nitrogen concerns. The corner appears to have been turned on acidification by sulphur, and existing controls augmented by new sectoral controls on shipping ought to ensure further progress is made);
- the issue is genuinely less important (e.g. the effects of current deposition of heavy metals on ecosystems given the much larger amounts previously deposited since the start of the industrial revolution).

There is another group of air pollutants that may prove to be important – the persistent organic pollutants (POPs). But this is largely a separate issue as the controls tend to be chemical specific and rather more dramatic or ‘quantised’ in nature (if there is agreement that a chemical is a POP then percentage cuts aren’t the answer – all uses will need to cease as soon as practicable).

Overarching all of these considerations, we need to recognise that policies on, and controls of, greenhouse gases are increasingly likely to have a higher political profile than those addressing our priority pollutants (with the possible exception of PM). We need a much better understanding of the synergies and trade-offs between the two areas, and closer links in the development of strategies.

Comments on the Current Approach to Controlling Air Pollution

As noted above, with the benefit of hindsight, the current strategy can be characterised by the absence of a holistic approach in terms of both scale (linking local to national to international) and pollutant. That was one of the original justifications for the CAFE process, but there is a serious risk that it is just going to perpetuate the divisions. The current timetable appears to be driving the Commission to separate the consideration of ambient and transboundary targets, which would almost certainly lead to disjointed, and possibly ‘wrong’ answers.

Limit values appear to have had their day. They have had success in driving down emissions, but they don’t reflect current understanding of public health impacts of air pollution. There is no scientific justification for targets for non-threshold pollutants to depend on LVs – the risks faced just above and below the LV are almost identical. Much of the current effort at national level focuses on addressing hotspots. This is neither an efficient use of resources nor the best way to reduce health effects.

Even where thresholds are thought to exist (and it is unclear whether health advice based on epidemiology can ever really identify thresholds given the likely variation in sensitivity in any large population) we need much more clarity on where the LVs apply. Do they apply everywhere, or just where you stick your monitor? Either interpretation leads to illogical outcomes – you either end up trying to reduce pollution in places where nobody is exposed over the relevant averaging time, or you miss peak levels and leave yourself open to accusations of fixing the result by not monitoring in the ‘right’ place.

This is an example of how the current approach tends to gloss over the uncertainties in the underlying science. We need to be more honest with ourselves about the extent to which monitoring can guarantee an accurate picture of compliance with a LV. All it tells you is the pollution at that particular site over that particular period to a particular level of precision (unless you are measuring PM, in which case a number of other variables reduce the certainty still further). Meteorology and changing local sources further reduce the robustness of the conclusions, particularly when comparing the data with a fixed concentration. What at first seems an easily understandable way of measuring compliance is anything but.

Another example of poorly understood uncertainties is the accuracy of inventories, particularly those covering pollutants created by secondary (e.g. NO_x) or biological (e.g. NH_3) processes. This has led to countries signing up to unexpectedly stringent, or lax, emission ceilings. A further related example is where a lack of understanding of atmospheric processes (e.g. non-linearities, NO_x titration issues) can lead to agreements based on unrealistic assumptions about the effectiveness of measures.

This might all sound very negative, but I am certainly not saying that we need to step back from ambitious strategies and further measures aimed at reducing the effects of air pollution. Nor am I suggesting that previous agreements are bad or have been ineffective. They were the best that could be done at the time, but with our increased understanding we can now do better. We need to adopt a more intelligent approach to expressing targets to minimise the risks of unintended consequences, and to maximise the effectiveness of the political capital and resources we can call upon.

Some Suggestions for a More Robust Approach

Geographic scope and the role of UNECE: Any successful future strategy needs to link local, national, European and regional/hemispheric scales. CAFE was conceived as an ambitious and welcome attempt to link the first three of these – but even the recently enlarged EU is not big enough to address all four.

There is still a major role for a strong and vibrant LRTAP Convention. It needs to continue to provide fora to synthesise the cutting edge science on which any strategy will be based. But it also provides an opportunity to address the wider geographical scope necessary to ensure transboundary pollution is adequately controlled. In doing so, it could not only include agreements covering the entire UNECE membership, but also provide a focus for collaboration with other UN regional bodies.

Models and other tools for the job: Many of the tools required already exist. In particular the EMEP and RAINS models will continue to play a major role in defining the size of the problem. Other tools still need further development. For instance, there is a need for nested models extending and/or supplementing RAINS and EMEP allowing integrated modelling at finer scale, in particular the urban scale, where most human exposure takes place. There is also a need to complete the development of dynamic modelling approaches for ecosystem effects. The last phase of negotiations (leading to the Gothenburg Protocol and the NECD) included calls to define more understandably what would – and indeed would not – be achieved by the reductions in emissions being discussed. The critical load approach, valuable though it has been, cannot really answer this type of question, but dynamic modelling could (even if the answer – defining the number of decades to recovery – might not be what the public and politicians were expecting).

Cost benefit analysis and the related multi-criteria analysis will also be essential parts of the toolkit. In a world where the control of air pollution will be competing for attention with issues such as climate change and economic development it is essential that we use the available political influence as effectively as possible. This implies a need to ensure balance in effort between the different risks and pollutants. This is not a call to try to monetise everything – far from it. We sell ourselves short by not bringing in the wider benefits of measures that would reduce the effects of air pollutants, e.g. the societal benefit of reduced traffic, as well as wider environmental benefits such as biodiversity and habitats. These techniques will also be vital in understanding the links, both synergies and trade-offs, with climate change and the ancillary benefits of climate change measures.

How to express the targets: We now know there is no scientific justification for LVs for non-threshold pollutants. There seems to be a growing consensus for an approach that seeks to reduce average exposure, rather than focusing scarce resources on relatively small hotspot areas. This suggests that ambient air quality targets for PM need to be based on gap closure, albeit in a different form to that used for ecosystem targets. For ambient air quality the target for Member States could be expressed in terms of a Population-Weighted Reduction (P-W R) approach for annual means. Legislation would set a particular percentage P-W R in concentration. It would apply to concentrations above a baseline – perhaps the rural background, so that natural sources and secondary PM are excluded. The latter are beyond direct Member State control and would instead be targeted by the revised NECD. Progress towards such a target could, as now, be monitored by a combination of measurement and modelling, and the results could be published as easy to understand percentage improvements against the baseline. As both fine and coarse fractions of PM are associated with health effects there may be a rationale for retaining PM_{10} as the sole metric, rather than introducing two separate targets – the key consideration should be whether the implementation of measures would be radically different if separate metrics or $PM_{2.5}$ on its own were selected.

While there is no *scientific* reason to stick with LVs for PM, there might be a *political* desire to ensure the very worst sites are given particular attention. This could lead to the retention of some form of LV as a backstop, but it is important that this should be expressed in such a way that it does not dominate the implementation process. This is probably best done by ensuring it applies only where people are likely to be exposed for significant periods. It has been stated that clean air is a basic human right, but for non-threshold pollutants this needs to be expressed differently – everyone has the right to cleaner air, and a reduced risk of health effects.

NECs could also be expressed in a different way. To ensure countries deliver on the level of ambition to which they originally agreed, the targets should be expressed as percentage reductions on a base year, rather than absolute tonnage ceilings. This will make agreements more robust to technical developments in inventories, and is how commitments under the Climate Change Convention are expressed.

The availability of measures to reduce emissions: Regardless of how the targets are expressed, there is a more fundamental difficulty with any future strategy. In the short term at least, we are running out of cost effective technical measures to reduce emissions further. Where it is feasible we will also need to include structural measures in our strategies. But here we are in danger of biting off more than we can chew – many societies may not be ready to accept the implied restrictions on lifestyle. Non-technical measures can only work if society accepts them, and we have seen that fiscal environmental measures (such as the fuel duty escalator in the UK) can provoke protests of such magnitude as to be politically unacceptable.

This is an important point to debate. How do we break out of the apparent Catch-22? Can we design a far-reaching strategy when we don’t know with any certainty either what technology developed in the near future might deliver, or what society will accept as a legitimate restraint on the desire for increased standards of living?

Summary

In my opinion the next generation of strategies to control air pollution should focus primarily on reducing exposure to PM, with ozone and nutrient nitrogen reduction as second order priorities. These strategies should cover local, national, regional and hemispheric scales, and be underpinned by integrated assessment modelling and an assessment of their costs and the full range of benefits of their implementation.

Targets for countries should be expressed in terms of gap closure percentages, both for NECs and P-W Rs. The ancillary benefits of these strategies for other air pollution problems should be calculated, and, where necessary, sector specific controls introduced (e.g. on marine sulphur emissions). The links with climate change science and policy should be fully explored. There is an important debate to be had on the social acceptability of significant structural measures.

2004-10-22

European Air Pollution Policies/strategies, a discussion paper

Lars Lindau, the Swedish Environment Protection Agency

Aims and objectives

One of the objectives of the sixth EAP is to establish "-----a high level of quality of life and social well being for citizens by providing an environment where the level of pollution does not give rise to harmful effects on human health and the environment."

The sixth EAP defines non-exceedance of critical loads and levels as the long term objective for acidifying and eutrophying substances.

Current state

There have been considerable progress in air pollution policies and also the health/environment situation have improved significantly in Europe since 1990. But still we do have a serious problem. Particulates give rise to more than one year reduced life expectancy for the quite large European population. Oxidants will give a premature death for more than 10 000 people every year. Critical loads for acidification and eutrophication is being exceeded over large areas. The air quality directives for NO2, O3 and PM 10 will be exceeded in many of the large urban areas, 2005/2010.

The base-line scenario

IIASA has made calculations for the emissions 2010 and 2020 based on a business as usual scenario, the base-line scenario. The emissions of especially SOx but also NOx, VOC and particulates (PM 2,5) will be reduced substantially from 2000 till 2020. For land based sources about 65 % for SOx and about 45 % for the other substances. The naval sector will increase its emissions but still there is a total reduction, especially for SOx.

For NH3 it is worse, it is almost a stand still even if it is a bit below the demands in the NEC directive. The NH3 will be more problematic because it will control most of the acidification when SOx goes down.

The preliminary calculations with the RAINS model for the base line 2020 shows an improvement for the exposure and the health effects, from about a year to 5 months reduced life expectancy. 5 months is still a considerable health effect.

The calculations of critical loads/levels for acidification/eutrophication show not that much of improvement you could expect. There will still be large areas with exceedances.

If you use AOT 40 as the criteria for effects of ozone, then especially southern Europe will be affected. If you use the uptake of ozone then there will also be effects of importance in northern Europe.

To sum up, the air pollution problems in Europe will not be solved using a business as usual scenario.

Policy scenarios

There are obviously a very interesting scenario, a post-2012 climate measure scenario for 2020. If Europe shall have a chance to meet CO2 reductions of about or more than 50 % till 2050, we have to make significant progress till 2020. One possible scenario is 20 % reduction of CO2 till 2020. Such a scenario will give important effects with regard to reduction of SOx, NOx, VOC and particulates.

As mentioned above, NH3 will be the most important substance connected to acidification. A scenario including the CAP policy will be introduced. But there is a need for a more far-reaching scenario on the agricultural side, to see if the NH3 emissions can be reduced in a cost efficient manner.

The cost-benefit studies

The CAFE cost-benefit scenarios made by AEA Technology and the Merlin project have not been finalized yet. Previous studies made as a basis for the NEC directive showed quite clearly that almost all countries benefited from abating air pollution as required by the G5/2 scenario, a more far-reaching scenario than the Gothenburg protocol. Benefits were two to five times the calculated abatement costs. It is the high costs related to the health impact that give rise to the high figures on the benefit side. Very probably this will be the case also this time for 2020 even with more costly abatement programs.

An European air pollution policy-strategy

The strong driving forces to reduce emissions of SOx, NOx, VOC, particulates and NH3 are the climate change effects and the health effects. The latter according to particulates and ozone. There are good possibilities to find common solutions. A joint strategy to reduce CO2 and CH4 together with the air pollutants will be cost effective. The instruments and incentives from the air side will first of all be the ones for which there are experience.

We do already have experience with three legislative tools to reduce air pollution at the EU level, the air quality directives, the NEC directive and a number of source directives for automobile exhaust, the LCP directive, the IPPC directive, the VOC directive, the directive for non-road vehicles, there are some more. These three tools have worked effectively together even if there are obvious problems. One of these is linking the different scales together, urban, regional and hemispheric.

Source oriented directives

There is a lot of work going on relating to the EU emission standards for vehicles and there are also proposals for passenger cars, for heavy duty cars, for diesel and petrol driven cars. The NOx, VOC and particulate emissions can be reduced further. There is a similar development going on in North America. There is an obvious need to reduce the emissions as much as possible and a good starting point for the discussion is the German (UBA) proposal for further reductions, Euro V, model year 2008 and 2010.

The LCP directive is important and is now being implemented in countries. The time scale for meeting the limit values are for some installations rather long and it should be analyzed and assessed if they can be shortened.

In the CAFE program there is an important study about combustion plants less than 50 MW. Small scale installations can have significant particulate emissions and larger plants are important SOx and NOx emitters.

Stage II for the fuel recovery systems will be a cost effective measure to reduce VOC emissions for the EU as a whole.

Shipping is an obvious and growing source of SOx and NOx emissions and it is very important to find incentives for reduction of emissions. The solution have to be found at the EU level but with consideration of the IMO annexes. Some countries do have economic incentives which have been effective.

For the agricultural sector there are recommendatory annexes in the Gothenburg protocol and work is going on to develop them further. This sector is dominating the ammonia emissions and they are being increasingly important for the acidification and eutrophication effects. The possibilities to further strengthen the annexes and make them more mandatory should be investigated in the LRTAP as well as the EU context.

The air quality directives

To me, the directives for NO2, PM10 and O3 are functioning well and do not need to be changed. They are based on well documented health effects and they are very important when implementing a local/urban air pollution strategy.

The question is if there is a need for a PM 2,5 air quality directive. The problem is that a significant part of the exposure is coming from outside the urban area and often also outside the country. One possibility is to have recommendatory target value for PM 2,5 of 10-12 ug/m3 as an annual average.

The NEC directive

The exposure of particulates and consequently the emissions of SOx, NOx and particulates have to be reduced. The RAINS model calculations will give us information on possible cost effective scenarios with common targets for health impacts, ozone effects, acidification and eutrophication. The scenarios will be based on possible developments in the energy, traffic and agricultural sectors till 2020 mainly according to solutions to climate change questions. The base-line scenario shows reduced levels of SOx, NOx and VOC emissions 2020 compared with the NEC directive but there are good and needed possibilities for further reductions.

Other incentives

There is considerable experience of economic instruments to control SOx and NOx emissions effectively in a number of European a countries and there is also experience of trading systems, mainly in North America.

The development of the energy, traffic- and agricultural sectors till 2020 will be very important relating to air pollution. The incentives, legislation, subsidy systems used and being further developed will have a major impact also on the air pollution situation.

The hemispheric scale

A discussion of the hemispheric scale for the transport of air pollution will be very important in an European air pollution strategy. The ozone levels goes up year by year and mercury and many POPs is transported globally. Particulates is also a concern in this context.

LRTAP with lead countries (USA, Germany, UK,---) are running scientific workshops to better understand the matter. When is the time to assess the situation and take an initiative ? LRTAP has good contacts with other regional air pollution bodies around the world and will be a good place for such an initiative.

Summary

An European air pollution strategy should focus on:

*Combine the scales, local/urban, national, regional and hemispheric

*Link air pollution science and policies with climate change

*Priority to particulates and nitrogen

*An air quality directive for PM 2,5 as a recommendatory target value

*Keep the air quality directives as they are

*A revised NEC directive and Gothenburg protocol is needed (2020)

*Make the source directives more stringent

*An LRTAP initiative towards UNEP about the hemispheric problems