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TRENDS AND OUTLOOK FOR IMPROVING AIR QUALITY

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Abstract:
Emissions of air pollutants derive from almost all economic and societal activities. They result in clear risks to human health and ecosystems. In Europe, policies and actions at all levels have greatly reduced anthropogenic emissions and exposure but some air pollutants still harm human health. Similarly, as emissions of acidifying pollutants have reduced, the situation for Europe's rivers and lakes has improved but atmospheric nitrogen oversupply still threatens biodiversity in sensitive terrestrial and water ecosystems. The movement of atmospheric pollution between continents attracts increasing political attention. Greater international cooperation, also focusing on links between climate and air pollution policies, is required more than ever to address air pollution. Successfully addressing air pollution requires further international cooperation. There is growing recognition of the importance of the long-range movement of pollution between continents and of the links between air pollution and climate change. Factoring air quality into decisions about reaching climate change targets, and vice versa, can ensure that climate and air pollution policies deliver greater benefits to society.

Key words: Air quality, PM, NMVOCs, NOx,SO265

1. INTRODUCTION

Emissions of the main air pollutants in Europe have declined significantly in recent decades, greatly reducing exposure to substances such as sulphur dioxide (SO_2) and lead (Pb). However, complex links between emissions and ambient air quality means that lower emissions have not always produced a corresponding drop in atmospheric concentrations. Many EU Member States do not comply with legally binding air quality limits protecting human health. Exposure of crops and other vegetation to ground level ozone (O_3) will continue to exceed long-term EU objectives. In terms of controlling emissions, only 14 European countries expect to comply with all four pollutant-specific emission ceilings set under EU and international legislation for 2010. The upper limit for nitrogen oxides (NO_X) is the most challenging — 12 countries expect to exceed it, some by as much as 50 %.

The energy sector remains a large source of air pollution, accounting for around 70 % of Europe's sulphur oxides (SO_X) emissions and 21 % of NO_X output despite significant reductions since 1990. Road transport is another important source of pollution. Heavy-duty vehicles are an important emitter of NO_X, while passenger cars are among the top sources of carbon monoxide (CO), NO_X, $PM_{2.5}$ and non-methane volatile organic compounds (NMVOCs). Meanwhile, energy use by households — burning fuels such as wood and coal — is an important source of directly emitted $PM_{2.5}$ (primary $PM_{2.5}$). 94 % of Europe's NH_3 emissions come from agriculture.

Air pollutant emissions in the EEA-32 and Western Balkans have fallen since 1990. In 2008, SO_X emissions were 72 % below 1990 levels. Emissions of the main pollutants that cause ground-level O_3 also declined and emissions of primary $PM_{2.5}$ and PM_{10} have both decreased by 13 % since 2000. Nevertheless, Europe still contributes significantly to global emissions of air pollutants.

2. Air quality: state, trends and impacts

In Europe, various policies have targeted air pollution in recent years. For example, local and regional administrations must now develop and implement air quality management plans in areas of high air pollution, including initiatives such as low emission zones. Such actions complement national or regional measures, including the EU's National Emission Ceilings Directive and the UNECE Gothenburg Protocol, which set national emission limits for SO_2, NO_X, NMVOCs and NH_3. Likewise, the Euro vehicle emission standards and EU directives on large combustion plants have greatly reduced emissions of PM, NMVOCs, NO_X and SO_2.

Many air pollutants, such as NO_X and SO_2, are directly emitted into the air following for example fuel combustion or releases from industrial processes. In contrast, O_3 and the major part of PM, form in the atmosphere following emissions of various precursor species, and their concentrations depend strongly on (changes in) meteorological conditions. To assess significant trends and to discern the effects of reduced anthropogenic precursor emissions, long time-series of measurements are needed.

Recent decades have seen significant declines in emissions of the main air pollutants in Europe. However, despite these reductions, measured concentrations of health-relevant pollutants such as PM and O_3 have not shown a corresponding improvement (Figure 1).

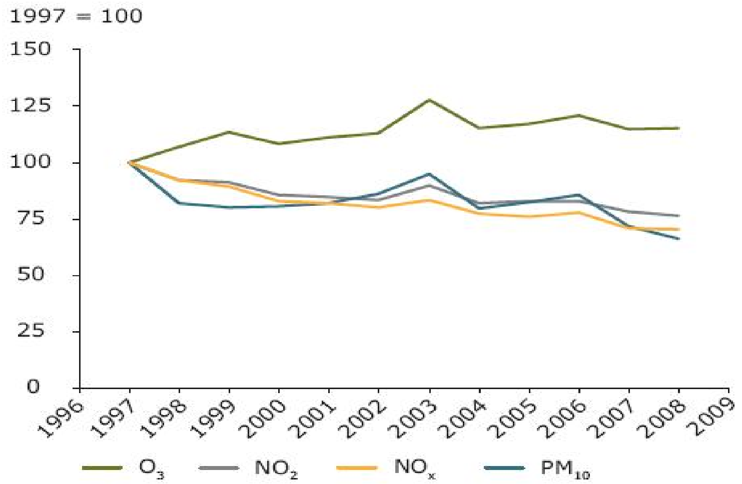

Figura 1. *Indexed trends in air quality*

2.1 Particulate matter PM10/PM2,5

Over the past decade, 20–50 % of the urban population was exposed to PM10 concentrations in excess of the EU daily limit values set for the protection of human health a daily mean of 50 µg/m3 that should not be exceeded on more than 35 days in a calendar year.

The number of monitoring stations in some areas of Europe is relatively small and therefore the data may not be representative for all of Europe for the analysed period (1997–2008). Measurements indicate a downward trend in the highest daily mean PM10 values. However, for the majority of stations, the observed change is not statistically significant. For a subset of stations operational for at least eight years over the period 1999–2008 and where annual mean values show a statistically significant downward trend, annual mean concentrations decreased by about 4 %.

While the annual average limit value of 40 µg/m3 is regularly exceeded at several urban background and traffic stations, there are hardly any exceedances at rural background locations (2) (ETC/ACC, 2009a). However, the Air Quality Guideline (AQG) level for PM10 set by the World Health Organisation (WHO) is 20 µg/m3. Exceedances of this level can be observed all over Europe, also in rural background environments.

The EU Air Quality Directive of 2008 includes standards for fine PM (PM2.5): a yearly limit value that has to be attained in two stages, by 1 January 2015 (25 µg/ m3) and by 1 January 2020 (20 µg/m3). Further, the directive defines an average exposure indicator (AEI) for each Member State, based on measurements at urban background stations. The required and absolute reduction targets for the AEI have to be attained by 2020. For 2008, only 331 of the PM2.5 measurement stations reporting to the European air quality database, AirBase, fulfilled the minimum data coverage criterion of at least 75 % coverage per year. This number of stations is expected to increase over the coming years, due to the requirements of the directive.

Current chemical transport models underestimate PM10 and PM2.5 concentrations, mainly because not all PM components are included in the models and because of higher uncertainties in PM emission inventories compared to other pollutants. However, by interpolating PM10 measurements, using assumptions on PM10/PM2.5 ratios and modelling results, PM2.5 concentration maps for Europe can be compiled and used to assess population-weighted concentrations as well as health impacts. The results indicate that PM2.5 pollution in EEA-32 countries may be associated with approximately 500 000 premature deaths in 2005. This corresponds to about 5 million years of life lost (YOLL).

Aceste numere sprijină estimările făcute cu un model precedent pentru UE-25 în timpul programului Aer curat pentru Europa (CAFE), program care a constatat efecte în mare măsură similare (CE, 2005).

These numbers support the previous model-based estimates made for the EU 25 during the Clean Air for Europe (CAFE) Programme which found largely similar impacts.

Focusing on PM mass concentration limit values and exposure indicators does not address the complex physical and chemical characteristics of PM. While mass concentrations can be similar, people may be exposed to PM cocktails of very different chemical composition.

2.2 Ozone

In 2008, the health-related O3 target (120 µg/m3, not to be exceeded on more than 25 days in any one year) was exceeded at 35 % of all rural background measurement stations reporting to AirBase. In urban areas about 20 % of the stations recorded readings above the target value to be attained in 2010. The WHO air quality guideline recommends a lower level than that set in the EU legislation, an average concentration of 100 µg/m3 (WHO, 2005; WHO, 2006; WHO, 2008). In the framework of the National Emission Ceilings Directive (EC, 2001a) impact assessment it was estimated that exposure to O3 concentrations exceeding critical health levels is associated with more than 20 000 premature (3) deaths in the EU 25 annually (IIASA, 2008).

Differences in chemical composition of the air and climatic conditions along the north-south gradient in Europe result in considerable regional differences in summer O3 concentrations: daily maximum temperatures averaged for the period April to September 1998–2009 show a clear correlation with O3 concentrations. In 2009, measurements during summer at single or several monitoring stations in Bulgaria, France, the former Yugoslav Republic of Macedonia, Greece, Italy, Portugal, Romania, Spain and the United Kingdom occasionally showed O3 concentrations above the alert threshold of 240 g/m3 (EEA, 2010c).

The strong dependence of O3 levels on atmospheric conditions suggests that the projected changes in climate leading to warmer temperatures could also result in increased ground-level O3 concentrations in many regions of Europe. Over the past two decades, a warmer climate is thought to have already contributed to an increase of 1–2 % in average O3 concentrations per decade in central and southern Europe.

2.3 Nitrogen dioxide and other air pollutants

Air pollutants such as NO2, heavy metals, and organic compounds can also result in significant adverse impacts on human health (WHO, 2005). The current EU annual and hourly limit values for NO2 have to be attained in 2010. Since NO2 pollution is especially a problem in urban areas, exposure to NO2 is discussed in more detail in the SOER 2010 urban environment assessment (EEA, 2010n).

2008 was the first year for which reporting on heavy metals and polycyclic aromatic hydrocarbon (PAH), the components covered by the so-called fourth daughter directive (EC, 2004), was mandatory; target values are applicable in 2013. Benzo(a)pyrene (BaP) is one of the most potent carcinogens in the PAH group. It is emitted mainly from the burning of organic material such as wood and from car exhaust fumes especially from diesel vehicles. Ambient air measurements from 483 stations are available for 2008, but sufficient data coverage remains a problem. High levels of BaP occur in some regions of Europe, including parts of the Czech Republic and in Poland, exceeding the target value defined in the Air Quality Directive. Measurements of Pb, As, Cd and Ni concentrations were reported for 637 stations in 2008. Exceedances of the target values are mainly restricted to industrial hot-spot areas.

2.4 Inter-continental transport of air pollution

In their 2010 assessment of the inter-continental transport of air pollution, the UNECE LRTAP Convention's Task Force on Hemispheric Transport of Air Pollution (HTAP) finds that ozone, particulate matter, mercury, and persistent organic pollutants are significant environmental problems in many regions of the world. For each of these pollutants, the level of pollution at any given location depends not only on local and regional sources, but also on sources from other continents and, for all except some persistent organic pollutants, natural sources. In most cases, mitigating local or regional emission sources is the most efficient approach to mitigating local and regional impacts of air pollutants.

For all of the pollutants studied, however, there is a significant contribution of intercontinental transport of air pollution. This contribution is particularly large for ozone, persistent organic pollutants, and mercury, and for particulate matter during episodes. Furthermore, reductions of methane emissions are as important as emission reductions of the 'classical' ozone precursors (NOX, NMVOCs, CO) to reduce intercontinental transport of ozone.

3. Outlook for 2020 on the air quality

The 2020 baseline outlooks are consistent with existing EU policies and include estimated impacts from the recent economic downturn.

It shows that, under the current policy scenario, emissions of the main air pollutants, excepting NH3, are all projected to decline by 2020 for the EEA-32 and Western Balkan countries. Compared with 2008 emission levels, the largest decreases in percentage terms are projected for emissions of NOX and SO,, a reduction of around 45 % by 2020 in the absence of additional measures to further reduce emissions. For PM and NH3 for which 2020 emissions are projected to be similar or slightly higher than in 2008, substantial reductions are technically possible, as shown by the maximum reduction scenarios for the EU 27.

Convention and the delayed revision of the EU NECD (EC, 2001a) are both expected to introduce stricter emission ceilings for 2020 for relevant countries and for the first time national limits on the emission of PM2.5.

Depending upon the ambition level to be agreed, the 2020 emission ceilings will require further emission reductions between those projected under the current baseline scenario and the level of a maximum reduction scenario. A time horizon of 2050 has been suggested as an aspirational target year by which Europe's long-term objectives of achieving levels of air pollution that do not lead to unacceptable harm to human health and the environment should be met. Preliminary assessments indicate that in order to meet these objectives, for SO2 there should be an emissions reduction in the range 40–60 % compared with 2010, especially in northern and central Europe. For NOX and NH3 the required reductions are in the range of 70–90 % and for O3 precursors 70–80 %, in particular in southern, western and central Europe. In urban areas a 40–60 % emission reduction of PM would be needed (Maas et al., 2009).

Examples of possible actions by local, regional and national authorities to reduce air pollution in urban areas:

• establish low-emission zones that restrict access for more polluting vehicles;

• improve transport planning to encourage a shift of transport to less polluting modes including walking, cycling, and public transport;

• encourage cleaner fuels and vehicles including use of economic incentives;

• renew municipal vehicle fleets to introduce newer, cleaner vehicles;

• introduce retrofit programmes for road vehicles:

- particle filters to reduce PM emissions, and modern de-NOX technologies;
- shift to compressed natural gas vehicles;

• introduce congestion charging, differentiated parking fees or a city toll;

• introduce speed limits and traffic calming measures, for example imposing lower speed limits on main roads;

• implement short-term actions such as traffic bans during high pollution episodes;

• introduce measures to reduce emissions from non-road vehicles used for example in construction activities.

Households, commercial and institutional buildings:

• encourage fuel switching from more polluting to cleaner fuels, for example from coal to gas or electricity including use of financial incentives to achieve this;

• establish district heating schemes — heat and power cogeneration;

• implement rebate schemes that improve the insulation and energy efficiency of buildings;

• ensure industrial and commercial combustion sources (including for biomass) are fitted with emission control equipment or replaced.

• raise the awareness of citizens, provide easy-to-understand information on air quality and health effects of air pollutants;

• use air quality forecast and scenario tools to warn the general public and sensitive population groups about episodes of high air pollution.

According to the scenario that assumes that current policies and measures are fully implemented (IIASA, 2010a), the loss of statistical life expectancy attributable to the exposure to PM2.5 will be 4.1 months in the EU 27 in 2020, compared to 8.0 months in 2000. The predicted loss when assuming a maximum reduction (MRR) scenario is 2.9 months for the EU 27 in 2020. The environmental objective of the Thematic Strategy on Air Pollution (TSAP; EC, 2005) is 3.8 months.

The objectives of the TSAP states that the number of years of life lost (YOLLs) due to PM2.5 impacts should decline by 47 % between 2000 and 2020. The number of premature deaths attributable to the exposure to ground level ozone should decline by at least 10 %. According to the TSAP, the area of sensitive ecosystems that is not protected against excess nitrogen deposition threatening biodiversity should be reduced by 43 % in comparison to 2000 and the forest area receiving unsustainable levels of acid deposition should shrink by 74 %.

Distance-to-target analyses show to which extent the environmental objectives are predicted to be met in 2020, assuming the current policy and maximum reduction scenarios (IIASA, 2010a). The results indicate that none of the TSAP objectives set for the protection of human health and ecosystems will be reached by current policies alone. For years of life lost (YOLL) due to PM2.5 pollution, the achieved reductions will be approximately 5 % below the target. For O3 (premature deaths) the difference is very small: only 1 %. The highest absolute reductions predicted under the scenario are found for the acidification of forest soils, although a further reduction of about 8 % is still needed to obtain the TSAP objective. Concerning ecosystem eutrophication, the distance-to-target is estimated to be as high as 11% in 2020.

4.CONCLUSIONS

To improve air quality, the strategy of European air related legislation in recent years has been a twin track approach of establishing air-quality objectives together with implementing air pollutant emission reduction measures. The emission reductions reported have in general resulted from a combination of policy actions undertaken at both national and sectoral levels.

Despite progress in reducing emissions, many countries will not meet the 2010 national emission ceiling limits set by the NECD or the LRTAP Convention. Only 14 EU Member States anticipate that they will meet all four of the pollutant-specific emission ceilings in the NECD; with the remaining 13 indicating that they anticipate missing at least one of their ceilings (EEA, 2010g). Of the four ceilings, that for NOX remains by far the most difficult for many countries to meet — 11 Member States estimate they will miss the ceiling for this pollutant.
Despite past improvements, current air quality therefore continues to harm human health and the environment. Nonetheless, there is considerable potential to reduce emissions and further improve it.

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