Chapter 1

Introduction and background

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1.1 Historical background of EMEP

Air pollution was traditionally regarded to be inseparable from large cities and industrialisation, and political will to improve air quality did not arise until after the infamous London Smog disaster in 1952. The problems there, as well as in other European cities, were due to the combined emissions of sulphur dioxide - from sulphur contained in the coal - and tar and soot - from incomplete combustion in numerous small fireplaces. The problems were not solved instantly, but substitution of coal with cleaner fuels in city centres and a general switch towards electricity generated in large oil- or coal-fired power plants brought about marked improvements in the following years.

The large combustion units for electricity generation improved combustion efficiencies markedly in relation to the traditional small fireplaces. Moreover, tall stacks dispersed the emitted sulphur and nitrogen oxides well above the ground, to avoid harmful exposure to high concentrations. However, the strong economic growth in the period 1950-1970 also increased the total energy consumption, and the total emissions of sulphur dioxide in Europe were doubled.

The first public warnings were given by the Swedish scientist Svante Odén in 1967. He had seen that precipitation all over Europe was becoming more acidic, in a pattern which matched the sulphur dioxide emissions. Acidification of streams and lakes was already linked to fish deaths in Scandinavia, and Odén also warned about acidification of forest soils and forest productivity losses. A follow-up study with 11 participating countries was organised by the OECD, which concluded that ”air quality in any European country is measurably affected by emissions from other European countries” and that ”if countries find it desirable to reduce substantially the total deposition of sulphur within their borders individual national control programmes can achieve only a limited success.” (The OECD programme on long range transport of air pollutants. Measurements and findings. OECD, 1977).

This was the background for the beginning of the UNECE European Monitoring and Evaluation Programme for Transboundary Long-Range Transported Air Pollutants in 1977, EMEP. In total, more than 25 countries - almost every country in Europe - participate in the programme. With the establishment of the Convention on Long-range Transboundary Air Pollution (CLRTAP) in 1979, EMEP became an integrated part of this Convention, and was to play an important part in the development of emission reduction scenarios for the negotiations of emission control agreements in the form of Protocols to the Convention.

When EMEP was started, political tension between Eastern and Western Europe was still high. Increasing emissions of sulphur dioxide in Western Europe had been halted by the 1973 oil crisis, while the exploitation of high-sulphur brown coal and the emphasis of industrial growth caused emissions to increase further in the Eastern European countries. The results, in the form of reported dead forest trees and "new forest damage" were reaching full public and political awareness in the 1980's. What had previously been regarded as a purely Scandinavian crusade about a few fish in remote lakes now became of concern also in major European countries. More awareness occurred in the winters of 1985 and 1986, when prolonged anticyclonic situation over North Central Europe caused record high concentration levels of air pollutants in both East and West Germany. It was then abundantly clear that emissions were so high over large areas of Europe that purely local measures to reduce air pollutant levels were no longer sufficient. It was no longer a case of Norway, or Scandinavia versus the rest of Europe, it was a case of Europe versus itself (Lykke, 1977). This development did alert the public to the problems and paved the way for the Convention as an instrument for international agreements in form of Protocols to the Convention.

Subsequent negotiations resulted in binding agreements by countries to reduce emissions, particularly of sulphur dioxide, but also of nitrogen oxides, volatile organic hydrocarbons, heavy metals and persistent organic compounds. The last, and not yet binding, protocol, the Gothenburg protocol, aims at reducing sulphur dioxide emissions by more than 63% and emissions of nitrogen oxides and volatile organic compounds by 41 and 40%, respectively.

1.2 Organisation of the EMEP programme

The purpose of EMEP is to provide governments with the information on the extent of long-range transport and deposition of airborne pollutants. The practical work is split between the participating countries and 3 centres. The measurements are carried out by laboratories in the individual countries, under the guidance of a chemical co-ordination centre which also collects the measurement data. Two independent meteorological synthesizing centres - one in Moscow and one in Oslo - have been established to carry out dispersion modelling and evaluation of transboundary fluxes and source-receptor relationships.

The original division of work has been modified with the development of the programme, and a new centre for integrated assessment modelling was established in 1998. The participating countries are now also being more active in the analysis and evaluation of data through a recently established Task Force for Measurement and Modelling. Other task forces include one for integrated assessment modelling, and one for emission inventories and projections. These task forces integrate technical contributions from the participating countries supporting and supplementing the work of the four Centres. EMEP as a whole is overlooked and led by the Steering Body of EMEP, in which all the participating countries are represented.

1.3 The Convention and the protocols

The scientific and technical co-operation under the Convention also involves the Working Group on Effects and its task forces. Together with EMEP the Working Group on Effects prepares material supporting negotiations of CLRTAP emission control protocols. The negotiations themselves are carried out by the Working Group on Strategies and Review. The first of these protocols was concerned with sulphur dioxide emissions. Nitrogen oxides were considered next, and after that volatile organic compounds were subject to negotiation. Subsequent protocols have included the combined effects of sulphur dioxide, nitrogen oxides, volatile hydrocarbons and ammonia in relation to acidification, eutrophication and photochemical ozone formation, as well as heavy metals and persistent organic pollutants.

PROTOCOLS TO THE UNECE CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION:

Protocol on Long-term Financing of the European Monitoring and Evaluation Programme (1984).
Protocol on Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30% (1985).
Protocol Concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes (1988).
Protocol Concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes (1991).
Protocol on Further Reduction of Sulphur Emissions (1994).
Protocol on Persistent Organic Pollutants (1998).
Protocol on Heavy Metals (1998).
Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (1999, not yet in force)

www.unece.org/env/lrtap/status/lrtap_s.htm

1.3.1 Acidification

The emissions and the effects of sulphur dioxide emissions, have been the concern of EMEP since its start. Under EMEP, emissions of sulphur dioxide in Europe have been reduced by more than 50%, and the decreased emissions are clearly reflected in reduced concentrations and deposition of oxidised sulphur compounds. The success does not only lie in the fact that the sulphur dioxide emissions have been reduced, but that the reductions have been planned according to scientific knowledge of atmospheric dispersion and deposition, as well as their effects. The second sulphur protocol of 1994 was the first to be based on an important principle, that of critical loads and critical levels, and the cost-efficient reduction of their exceedances.

CRITICAL LOADS AND LEVELS

The critical loads and levels are defined as the highest deposition or concentration of a particular pollutant, which may be assumed not to produce adverse effects in a given ecosystem in the long term according to present knowledge (Nilsson & Grennfelt, 1988).

In 1994, it was not possible to agree on emission reductions, which could avoid exceedances of the critical loads for sulphur in all ecosystems, and a 60% gap closure was adopted as the best solution. With the 1999 Gothenburg protocol to abate acidification, eutrophication, and ground-level ozone, it looks as if this gap is going to be fully closed for all but a few small areas in Europe.

1.3.2 Eutrophication

The Gothenburg protocol also recognises that emitted pollutants interact, both in the atmosphere, and in their effects on the ground. The acidifying effect of sulphur dioxide emissions is increased by emissions of nitrogen oxides and ammonia, but nitrogen species also act as fertiliser and interact with vegetation as well as with soil microorganisms. The deposition of nitrogen compounds may lead to unwanted fertilisation and eutrophication of some ecosystems, particularly heathlands and marine systems.

1.3.3 Photochemical ozone formation

The emissions of nitrogen oxides also interact with hydrocarbons from use of gasoline, solvents, incomplete combustion and from natural sources to form ozone, which in high concentrations is harmful for plants as well as for human health. This occurs particularly in connection with high-pressure situations in summer. Before 1980, photochemical ozone formation was mainly understood to be a problem in California and other exotic places. In Europe, local problems were seen in the Rotterdam area. It was not until 1983, when a voluntary collection of ozone concentration data from several European countries became available, and when first preliminary model calculations of ozone formation with the EMEP trajectory model were made, that the potential extent the problem was demonstrated.

This quickly alerted the biologists, who found clear evidence of the effect of ozone in plants at various stages of growth, and indications of reduced growth due to ambient ozone concentration levels. This information has been taken into account by governments, and nitrogen oxide and VOC emissions have been reduced. However, photochemical ozone formation is a very complicated chemical and physical process, involving not only emissions of nitrogen oxides and VOCs in Europe, but also global ozone and VOC concentration levels, and interactions with ozone from higher levels in the atmosphere. Adding that harmful ozone concentrations are linked with infrequent but persistent weather situations, the monitoring of surface ozone is going to be an important subject for EMEP also in the future.

1.3.4 Heavy metals

Clearly, once airborne, all pollutants are capable of travel over long distances. This also holds for toxic substances, such as the heavy metals like mercury, lead and cadmium. Emissions of lead and cadmium for the period of 1980-2000 and of mercury for the period of 1990-2000 have been reduced markedly. For Europe as a whole, the lead emissions are now 8 times lower than in 1980, cadmium 4 times lower, and mercury only half of those in 1980. However, the rate of reduction has varied considerably over different parts of Europe. As a rule, countries in the northern part of Europe are characterized by higher rate of emission reduction, and in the south-eastern part by relatively low rate.

Reduction of the emissions has led to decreased pollution levels. Following overall emission reduction, depositions caused by transboundary transport have diminished during the considered period. Nevertheless, contributions of transboundary transport are still considerable in most of European countries. Releases of heavy metals have been reduced in recent years, but it is important to establish safe levels and to make sure that the situation is under control. This particularly applies to mercury, which has been shown to increase in certain ecosystems in the Arctic.

1.3.5 Persistent organic pollutants

Environmental levels of the persistent organic pollutants, or POP's, show clear decreasing trends due to restriction of their production and use. In particular, a 50 percent emission reduction for PAHs took place during the period from 1980 to 2000. For pollutants such as PCBs and PCDD/Fs the reduction of European emissions for the same period amounted to 5-6 times. However, the ability of some POPs (PCBs or γ-HCH) to be accumulated in soil and seawater can essentially support atmospheric pollution by these substances due to re-emission process. The cycling of material between air, biota, soil and water bodies present challenges both for the monitoring and the understanding of the atmospheric transport of POPs, which include a number of compounds with different chemical and physical properties. Due to high persistence in the atmosphere, some POPs (HCB or PCBs) can be transported over long distances away from their emission sources. High contamination level of these substances is detected in remote regions such as the Arctic.

1.4 The EMEP Assessment

The following chapters will give an overview of EMEP since it was established in 1977 and highlight some major results. From its beginning, EMEP has maintained a strong principle of following, whenever possible, the whole chain of processes, from emissions, transport, atmospheric dispersion, chemical and physical transformations in the atmosphere, to deposition. This has been achieved by analysis of measurements at carefully selected sites in the respective countries, complemented with emission source-dispersion model calculations at the two meteorological centres. The results have been achieved through the combined efforts of scientists in the participating countries and the EMEP technical centres.

Emission data, dispersion modelling and measurement results will therefore be discussed for each of the subjects. Trends in measurement data are related to emission data trends when possible. Special thoughts have been given to the future development of EMEP, as some of the problems are in the process of being solved.

The measurements within EMEP were restricted to air and precipitation sampling with subsequent chemical analyses at national laboratories. The sampling frequency was daily, in order to capture the relationship between pollution and the meteorological situation. This approach made it possible to monitor the national laboratories' performances by circulation of synthetic and real samples, and it also allowed statistical and other checks on the consistency of the collected measurements. With time, both measurements and dispersion models have been improved and refined. These changes have occurred gradually, and without loss of the continuity of the records.

More than 25 years have now passed since the establishment of EMEP with important changes both politically and economically. Through this period EMEP has provided governments, and the CLRTAP, with information on the extent of transboundary transport and deposition of sulphur and nitrogen compounds, as well as of photochemical oxidant formation, heavy metals, POP's and aerosol particles.

1.5 References

OECD (1977) The OECD programme on long range transport of air pollutants. Measurements and findings. Paris.

Lykke, E. (1977) "Europe versus itself". Letter to the editor, *Nature* **269,** p372.

Nilsson, J and Grennfelt, P. (1988) Critical Loads for Sulphur and Nitrogen. Nordic Council of Ministers. Report 1988:15 Köpenhamn.