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EXECUTIVE BODY FOR THE CONVENTION ON
LONG-RANGE TRANSBOUNDARY AIR POLLUTION

Steering Body to the Cooperative Programme
for Monitoring and Evaluation of the Long-range
Transmission of Air Pollutants in Europe (EMEP)
(Twenty-fourth session, Geneva, 4-6 September 2000)
(Item 5 on the provisional agenda)

STRATEGY FOR EMEP 2000-2009

Prepared by the Bureau

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Executive summary

Vision

The Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) will continue to be the main scientifically based and policy-driven instrument for international cooperation to solve transboundary air pollution problems. In that respect it seeks to develop:

- **SCIENCE** - EMEP establishes sound scientific evidence and provides guidance to underpin, develop and evaluate environmental policies;
- **PARTNERSHIP** - EMEP fosters international partnership to develop solutions to environmental problems;
- **OPENNESS** - EMEP encourages the open use of all intellectual resources and products;
- **SHARING** - EMEP is transparent and shares information and expertise with research programmes, expert institutions, national and international organizations, and environmental agreements;
- **ORGANIZATION** - EMEP is organized to integrate the information on emissions, environmental quality, effects and abatement options, and to provide the basis for solutions.

A strong driving force for EMEP is now the impact of pollutants such as small atmospheric particles, surface ozone, NO_2, persistent organic pollutants (POPs) and heavy metals on human health. In addition, ozone damage on forests and crops, and eutrophication of rivers, lakes and regional seas are important issues, as well as the complex effects of acid deposition, heavy metals and POPs on soil, vegetation and aquatic ecosystems, including their recovery as emissions are reduced.

The environmental policy development in the European Community is another driving force for the further scientific work in EMEP, as are the enlargement of the European Union, the climate change policies driven by the Kyoto commitment to reduce greenhouse-gas emissions, and international agreements to reduce emissions from, for example, international shipping and aviation.

It is also becoming clear that some environmental problems in Europe need to be considered on a hemispheric or global scale. The work of EMEP should embrace developments in North American emissions and those elsewhere.

Another driving force of increasing significance in environmental policy development are the interests and concerns of individual citizens, local authorities, industry, non-governmental organizations, expert institutions and other bodies. This means that there will be a need for greater openness and transparency in the work of EMEP.

The priorities for the Convention now are:

- The review and extension of existing protocols; and
- The implementation of, and compliance with, existing agreements.

The successful implementation of the protocols requires a dedicated system for measuring their success. The follow-up of the compliance has to be done through a well-designed integration of monitoring, modelling and emissions assessments. Without a well planned, supported and visible science-based system for measuring compliance, it is likely that the protocols will fail in their mission. Tools need to be developed and applied to assess and verify that implementation is achieved and that it is cost-effective. At the same time exploratory work must continue on new substances that can be harmful to health and ecosystems.

The tasks of EMEP are formulated in five thematic areas:

- Acid deposition/eutrophication;
- Photochemical oxidants;
- Heavy metals;
- Persistent organic pollutants;
- Small particles.

The potential for scientific support is strong in all these five areas but requires systematic collection, analysis and reporting of information from monitoring networks, from emission inventories, from modelling studies, and on various abatement measures, and combining this information into integrated assessments. EMEP, via its technical centres, is well placed to do this. Transboundary and urban pollution issues are becoming increasingly interlinked, in particular for fine particles and nitrogen dioxide.

EMEP is reliant on the involvement of its participating countries to meet its objectives and responsibilities. EMEP should identify and take advantage of opportunities for strengthening the partnership with national and international research programmes in relevant scientific fields and develop mechanisms to incorporate these programmes into its work plan to improve the scientific quality of its work. There should be centralized activities at the EMEP centres providing European-wide analysis of transboundary air pollution, and strengthened partnership between the EMEP centres and national and international research and monitoring activities.

The European Community has a legislative system of its own. The European Community and its member countries are Parties to the Convention. In view of the danger of duplication of effort and in order to maximize the benefit, and minimize the costs, of monitoring and research, the opportunities for integration on a technical level between activities coordinated by the European Commission and those of the Convention should be driven as far as possible.

In order to best serve the Convention, EMEP will broaden its attention to the regional differences in environmental problems across Europe. In the Mediterranean the focus is more on mesoscale meteorological cycles, ozone and fine particle formation, while in North Europe long-range transport is important. In the Alps and in other mountainous regions local topography is a major constraint for the pollution distribution.

For rising global emissions the transport between the continents, and even globally, is becoming an important part of the European budget of the species controlled by the protocols to the Convention. In future EMEP will need to address these issues and interact with the appropriate international research programmes.

A success of the Convention, and EMEP, has been the ability to design modern, responsive, science-based research tools. But to analyse and optimize options for cost-effective reduction of effects, integrated assessment modelling needs further refinement, and it needs to take into account structural measures in energy, transport and agriculture in close association with national experts.

EMEP strategy analysis has identified the need to explain and convince signatories and the general public of the benefits of its work. The dissemination of information within EMEP and from EMEP should be transparent, two-way and easily accessible to everybody.

The work of EMEP is dependent on the long-term financing of the EMEP centres and the Parties shall be urged to implement the EMEP monitoring programme so that uncertainties in present observations, model estimates and emission inventories can be resolved.

Introduction: Why do we need a strategy document?

1. The protocols to the Convention on Long-Range Transmission of Air Pollutants aim to reverse freshwater acidification, forest dieback and eutrophication, exposure to excess ozone, the degradation of cultural monuments and historical buildings, and the accumulation of heavy metals and persistent organic pollutants in the soil, sea water, vegetation and in living organisms.

2. EMEP has provided the scientific evidence required to develop reasonable environmental policies. The monitoring network, the quality control system, the emission data and the modelling work have demonstrated the transboundary nature of the pollution problems and made it possible to quantify the source receptor relationships between countries and regions and convincingly communicate the results to policy makers and to the public. Through integrated assessment modelling the cheapest way to reduce emissions across Europe has been calculated to obtain the agreed reduction in the gap between current pollutant loads and levels and the critical loads and levels.

3. The Convention and its subsidiary bodies, including EMEP, are now at an important turning point. The 1999 Gothenburg Protocol and the Protocols on Heavy Metals and Persistent Organic Pollutants are due for ratification by Parties to the Convention in the next few years. The protocols will require significant investments and structural changes in the countries. EMEP should support countries in the implementation of the protocols through its centres, and also by facilitating the exchange of information and scientific knowledge between Parties. In addition, EMEP must seek to verify that the agreements operate as intended and provide further guidance to the Convention for the amendment of current policies and the development of new ones.

4. Several European-wide air pollution problems related to human health and ecosystem damage remain where national and transboundary aspects are closely coupled:

a) Fine particles and human health;
b) The recovery of acidified soils and ecosystems;
c) Ozone and human health, vegetation and ecosystems;
d) Eutrophication;
e) Nitrogen dioxide and human health;
f) Persistent organic pollutants, heavy metals and human health and ecotoxicological effects, and
g) Urban air quality and human health.

5. The legislative process in the European Community (EC) is parallel to the work under the Convention. In dealing with transboundary problems, it takes the same effects-based approach and shares, to a large extent, the same scientific models, databases and effects-related indicators. EMEP should serve the needs of the Parties to the Convention, to which all EC countries belong. To succeed, the opportunities for cooperation between the EC and the Convention, in the scientific underpinning of policy development and review, need to be exploited and reinforced.

6. The enlargement of the European Community (EC) and the climate change policies driven by the Kyoto commitment to reduce greenhouse-gas emissions are political developments of vital importance for the further work under the Convention. Moreover, it is becoming increasingly apparent that a number of the environmental problems in Europe will require consideration of emissions and atmospheric behaviour on a hemispheric or global scale, so that the future work of EMEP will need to reflect this. Both EMEP, and the Convention itself, are well placed to act as a bridge between North America, Europe and the rest of the northern hemisphere in this context.

7. Another important development over the past few years has been the increasing recognition of the need to involve stakeholders, the public, industry, NGOs and others in the process of developing abatement strategies. This is particularly important as emissions are reduced and objectives are approached and marginal costs of abatement increase. In this context EMEP has to provide robust and sound scientific results.

8. In this note the mandate of EMEP, the historic and current driving forces, and the contributions and capabilities of EMEP are reviewed. In conclusion, a strategy is presented for

the future development of EMEP. The challenge is to foster the international partnership required for utilizing the opportunities already given in the Convention, and to establish future international environmental solutions,

a) In the organization of scientific work;
b) In the strengthening of communication;
c) By making best use of existing infrastructure, products and tools;
d) By challenging intellectual resources;
e) By providing free access to the data, information and tools and the appropriate guidance for their use.

9. Reinforcement of the international scientific partnership in EMEP is required in the assessment of:

(a) Quality and applicability of past and present emissions and air concentrations measured and modelled;
(b) The measurement network, national programmes and other infrastructure;
(c) Gaps and uncertainties in the historic and current concentration and deposition distributions; and
(d) In developing a comprehensive scientific basis for further cost-effective, effects-based international environmental legislation.

I. MANDATE OF EMEP

10. EMEP was initiated in 1977 as a special programme under ECE. Its original main objective was to

"..... provide governments with information on the deposition and concentration of air pollutants as well as on the quantity and significance of long-range transmission of pollutants and fluxes across boundaries. Information on the relative importance of local and distant sources resulting from such a programme will guide national authorities in setting appropriate local and regional permissible emission levels, taking into account the implications of these levels. The information on the deposition and concentration of air pollutants will be a basis of abatement strategies in the regions affected…"

11. The Convention has stressed the importance of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) and the need for its implementation. It agreed that emphasis should be on, inter alia:

a) Monitoring using the framework of both national and international programmes;
b) The need to exchange data on emissions or transboundary fluxes and to make available the models used to calculate the latter;
c) The need to provide meteorological and physico-chemical data relating to atmospheric processes;
d) The need to monitor chemical components in other media, as well as a similar monitoring programme to record effects on health and the environment;

e) The desirability of extending the EMEP networks to make them operational for control and surveillance purposes.

12. The Executive Body is required, by article 10 of the Convention, to use the Steering Body of EMEP to play an integral part in the operation of the Convention, in particular in data collection and scientific cooperation. The annual costs of the international centres cooperating within EMEP for the activities in the work programme of the Steering Body shall be covered as described in the Protocol on the Long-term Financing of EMEP. These costs may be via mandatory and voluntary contributions to the General Trust Fund, or through contributions in kind.

13. As well as the more general requirements of the Convention itself, set out above, individual protocols require EMEP to carry out other tasks and to provide annually further information to the Executive Body, for areas relevant to the geographical scope of EMEP.

14. The NO_X Protocol requires EMEP to provide calculations of nitrogen budgets and transboundary fluxes and deposition of nitrogen oxides. The VOC Protocol requires EMEP to provide relevant information on the long-range transport of ozone. The 1994 Oslo Protocol requires Parties to report to EMEP data on emissions of sulphur, and EMEP to provide information on ambient concentrations and depositions of oxidized sulphur compounds and calculations of sulphur budgets. The Protocol on Heavy Metals requires EMEP to specify methodologies for heavy metals (HM) emission inventories, to receive emission data on HMs and to provide calculations of their transboundary fluxes and depositions. The Protocol on POPs requires EMEP to receive information on the levels of emissions of POPs and to provide information on their long-range transport and deposition. In the 1999 Gothenburg Protocol, EMEP is required to provide information on ambient concentrations and depositions of sulphur and nitrogen species, as well as, where available, ambient concentrations of volatile organic compounds (VOCs) and ozone, and calculations of sulphur and oxidized and reduced nitrogen budgets and relevant information on the long-range transport of ozone and its precursors.

A. Obligations of the Parties to the Convention

15. The contracting Parties to the Convention are obliged to carry out national research and development, to communicate with international partners, exploit and use existing data and research tools and to challenge their own intellectual resources, specified in the Convention as follows:

a) Instrumentation and other techniques for monitoring and measuring emission rates and ambient concentrations of air pollutants (article 7 (b));
b) Improved models for a better understanding of the transmission of long-range transboundary air pollutants (article 7 (c));
c) Meteorological and physico-chemical data relating to the processes during transmission (article 8 (e));
d) The need to use comparable or standardized procedures for monitoring whenever possible is emphasized (article 9 (b));
e) The establishment of monitoring stations and the collection of data shall be carried out

under the national jurisdiction of the country in which the monitoring station is located (article 9 (c));
f) The establishing of a framework for a cooperative environmental monitoring programme, based on and taking into account present and future national, subregional and other international programmes is emphasized (article 9 (d));
g) The desirability of extending the national EMEP networks to make them operational for control and surveillance purposes (article 9 (i));
h) The countries are also required to provide information on emissions for use in the model calculations performed by the Meteorological Synthesizing Centres.

II. DRIVING FORCES

A. Historic driving forces

16. EMEP started in 1977 and built on the results of a programme on long-range transport of air pollution run within the Organization for Economic Co-operation and Development (OECD) (1971-1977). At the outset there were three driving forces which were partly scientific and partly political:

a) The acidification of rivers and lakes in Scandinavia with the associated dieback of fish populations;
b) The need for independent scientific advice and consensus; and
c) A need for a constructive operational cooperation between Eastern and Western Europe within an area in which progress could be made without challenging the respective political systems.

These driving forces still exist but the emphasis has shifted for all of them, and new ones have emerged.

17. The first driving force has broadened considerably and includes in addition to freshwater acidification, acidification and eutrophication of forests, natural and farmed soils and other ecosystems, ozone damage to crops, the effect of air pollution on buildings and monuments, and the impact of air pollutants on human health, which is now considered to be of particular importance. The driving force is now both health-and ecosystem-damage-based and is European-wide, although focus shifts from one region to another. The state of the Scandinavian aquatic ecosystems remains a discussion between the Scandinavian countries and those emitter countries that affected them most, southern Europe is less involved, while ozone exposure is more of concern in southern Europe than acidification.

18. Scientific evidence indicates that the effect of acid deposition on aquatic ecosystem is to a large extent reversible and if the Parties adhere to the obligations outlined in the protocols, the situation of the Scandinavian aquatic ecosystems will gradually improve. Much more work is needed, however, to understand how acidic and nutrifying deposition and ozone exposure change as a consequence of the planned emission reductions, and how ecosystems in general recover. Human health can be seriously affected by small atmospheric particles, ozone and NO_2. A rather significant part of the small atmospheric particles arise from emissions of acidifying compounds. In addition, anthropogenic emissions of elemental and organic carbon are important. Natural emissions also play a significant role. However, there are important gaps in our understanding of the origin of

atmospheric particles. Ozone and small atmospheric particles have strong transboundary components and thus can only be reduced through international cooperation.

19. Of the three driving forces that were important in the early years of EMEP, only the political driving forces were European-wide. The second of the driving forces is increasing in importance and complexity as it is realized how all the important environmental issues related to the atmosphere, are interlinked: urban air quality, transboundary air pollution, climate change and ozone layer depletion.

20. The third driving force is important also today in that the countries of the European Community (EC), the accession countries to the EC and some new republics from the former Soviet Union are Parties to the Convention and in this way EMEP provides the best geographical and political platform to tackle the transboundary aspects of air pollution. It is also becoming clear that emissions from outside Europe will play an increasingly important role, so that the work of EMEP will need to embrace North America and the rest of the northern hemisphere.

B. <u>Current driving forces</u>

21. As discussed above, the three original driving forces behind EMEP are important also today but with a shift in emphasis. A strong driving force at present is the impact of pollutants such as small atmospheric particles, surface ozone, NO_2, POPs and heavy metals on human health. In addition, ozone damage on forests and crops, the eutrophication of rivers, lakes and regional seas are important issues, as well as the rather complex effects of deposition of acid, HM and POPs on soil, vegetation and aquatic ecosystems, including their recovery as emissions are reduced. The emphasis put on each of these issues varies from country to country in Europe, according to its particular situation. A common feature of all these issues is, however, that the pollutants involved all have a major transboundary component.

22. Many of these issues constitute together a basis for the recently adopted Gothenburg Protocol. The Executive Body has set its priorities for the next few years to be:

a) The review and extension of existing protocols;
b) The implementation of and compliance with existing agreements.

23. Environmental policy in the European Community is developed in parallel to the work under the Convention. The proposals for a European Community directive on national emission ceilings and for a new ozone directive are taking the same effects-based approach and to a large extent they share the same scientific models, databases and effect indicators. The European Community framework also includes air quality legislation under the Framework Directive for Air Quality, which requires air quality standards for several pollutants to be achieved over the next few years. Also for air quality the transboundary component is important. The environmental policy development in the European Community is therefore a strong driving force for the further scientific work in EMEP.

24. Another political driving force is associated with the enlargement of the European Community, the climate change policies driven by the Kyoto commitment to reduce greenhouse-

gas emissions and international agreements to reduce emissions from, for instance, international shipping and aviation.

25. Our knowledge of the damage caused by air pollution and of when, how and why damage occurs will develop further. As such knowledge develops, it serves as a driving force for new control policies. Determining the best control policies requires considerable knowledge about the processes related to the atmospheric transport, transformation and deposition of the pollutants in question.

26. In the future we can expect that a multitude of different issues involving transboundary air pollution will drive the EMEP activities. The types of damage that are important will vary between different regions in Europe, and the emphasis on the various issues will differ. The development of efficient control strategies for each of these issues will depend on the quality and extent of commonly shared scientific knowledge.

27. Another driving force of increasing significance in environmental policy development is the stakeholder involvement, taken as the interest and concern of individual citizens, local authorities, industry, non-governmental organizations, expert institutions and other bodies.

28. As the effect of current environmental legislation is evaluated, additional measures will have to be considered to meet interim and long-term objectives and/or limit values for acidification, groundlevel ozone, NO_2 and PM_{10}. Moreover, new measures and strategies may be required to meet limit values for previously unregulated pollutants; and policies need to be developed to off-set the negative effects of continued growth in some economic sectors, notably transport. It is clear that further and significant progress needs to be made if the Parties to the Convention are to be properly protected from the threat of air pollution. It is equally clear, however, that the closer we get to achieving the objectives the more we need to identify those solutions which are cost-effective, and the more searching will be the scrutiny of the work of EMEP.

III. STRATEGY

Vision

29. The Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) will continue to be the main scientifically based and policy-driven instrument for international cooperation to solve transboundary air pollution problems. In that respect, it seeks to develop:

- **SCIENCE** - EMEP establishes sound scientific evidence and provides guidance to underpin, develop and evaluate environmental policies;

- **PARTNERSHIP** - EMEP fosters international partnership to develop solutions to environmental problems;

- **OPENNESS** - EMEP encourages the open use of all intellectual resources and products.

- **SHARING** - EMEP is transparent and shares information and expertise with research programmes, expert institutions, national and international organizations, and environmental agreements.

- **ORGANIZATION** - EMEP is organized to integrate the information on emissions, environmental quality, effects and abatement options, and to provide the basis for solutions.

A. Science

30. A system is needed to measure the success of the protocols to the Convention. To assess how the environmental goals are being fulfilled, monitoring, modelling and emissions must be integrated. Without a well planned, supported and visible science-based system for measuring compliance, it is likely that the protocols will fail in their mission. Tools need to be developed and applied to assess and verify that the implementation process is taking place and that it is cost-effective.

31. At the same time exploratory work must continue on new substances that may be harmful to health and ecosystems. In parallel with the follow-up of compliance, the scientific findings of EMEP can lead to new protocols or revisions to improve the cost-effectiveness of the abatement strategies advocated.

32. The five thematic areas of EMEP are:
   a) Acid deposition and eutrophication;
   b) Photochemical oxidants;
   c) Heavy metals;
   d) Persistent organic pollutants; and
   e) Small particles.

33. Scientific support in these five areas requires systematic collection, analysis and reporting of information from monitoring networks, emission inventories, modelling studies, and on abatement measures, and assessing the information. In this context, assessment may be defined as quantification, analysis and evaluation of air quality and deposition in relation to its causes and impacts.

34. A very significant task which will help in assessing the effectiveness of the Convention within quite a few of these thematic areas, is the utilization of the data produced by EMEP since 1977. The measurements collected since then represent a large and underexploited resource. However, sampling and analysis methods have varied between countries and over time, so to facilitate the scientific use of historical data, information on the data quality should be determined in dialogue with national experts.

35. Every year since 1977, the measured data produced by EMEP have been evaluated, and related to the pollutant emissions by means of models for atmospheric transport and deposition. These models have been improved over time. It would greatly increase the possibilities for interpreting the measurement data if these could be paired with calculated data from one consistent model run, as far as possible, covering the complete measurement period and

preferably carried out with the best operational model tools now available within EMEP. Such a possibility has up to now been blocked by the large requirement for computer time and the lack of meteorological data required by the new models. The development in computer technology and the extension of the meteorological re-analysis project at the European Centre for Medium-Range Weather Forecasts (ECMWF) back to 1979 now seems to make this possible. Of particular interest in this context is to find out what actually happened when the European sulphur emissions were reduced from their maximum of 60 million tons SO_2 around 1980 to half this value around 1995, and with different development over time in different regions of Europe. Such a large-scale experiment in atmospheric chemistry could reveal some scientific secrets.

36. At recent EMEP workshops (Helsinki, Dubrovnik), statistical methods that are particularly suitable for air pollution data analysis and interpretation were presented. The emphasis has been on measured data. A suitable collection of such tools with software and user instructions should be made freely available on the Internet by the Chemical Coordinating Centre (CCC). The software should be adapted to the structure of the EMEP measurement database. Tools should be evaluated and further developed in cooperation with the Parties.

37. To facilitate analysis and interpretation of measurement data, the EMEP centres should also provide models that can be run locally in the member countries. Alternatively, the model output could be provided to the user, with all other data required to run the model remaining at the centre, thus avoiding the transfer of large amounts of, for example, meteorological data.

38. Strategic elements are outlined below for each of the five thematic areas of EMEP. Goals are related to the effects of the pollutants, and this defines the products that are needed by the Parties and the subsidiary bodies of the Convention. The shortcomings of EMEP with respect to its goals and needs form a basis for the suggested improvements.

1. Acidification and eutrophication

39. The main goals are to:

a) Determine the state and trend of deposition fluxes for effects assessment;
b) Verify the reductions in emissions under the Sulphur and Nitrogen Protocols to the Convention, and the effect of these measures on the deposition fluxes, particularly in relation to exceedances of critical loads;
c) Calculate transboundary fluxes and provide source attribution of estimated or measured deposition fluxes in the form of contributions from emissions in one country to the deposition in a particular country or region;
d) Investigate the recovery of ecosystems.

40. The requirements for fulfilling these goals are:

a) Measurements and derived data are required on the European scale, with source allocation. The spatial resolution in model predictions should be 50 km or better;

b) The accuracy requirements are related to the use of the data in connection with effects assessments requiring that the difference between measurements and model results should generally

be less than +/-30%, with a minimum of systematic differences in error between different geographical regions. These accuracy requirements apply equally to the determination of deposition fluxes and to their source attribution, and put a combined demand on the quality both of measurements as given by station representativeness, geographical coverage, analytical methods, component spectrum, time resolution and quality assurance/quality control (QA/QC) procedures, and of modelling as given by the quality of emissions, meteorological data, land-use information and physical and chemical parameterizations;

c) Compliance monitoring, based on trends in measured concentration and deposition, requires long and consistent time series of well-documented measurements at sites that are representative of regions where critical loads have been exceeded. Alternatively, the compliance may be determined on the basis of the general agreement between the model and the measurements. Time series analyses require that long-term average values should be accurate or consistent to at least within 5-10%.

41. The improvements needed are:

a) The completeness of reported emission data should be improved, particularly concerning sectoral emission data and trends;

b) The modelling capability needs to be further developed, using the data provided by the measurement programme as well as other information, to provide a representative and sufficiently detailed overview of the deposition fluxes of sulphur and nitrogen compounds over Europe;

c) The importance of the level of oxidants for the design of control strategies for acid deposition should be clarified; the importance of re-emission of ammonia for the design of control strategies for eutrophication and acid deposition, and the accuracy of model estimates of both dry and occult deposition should both be clarified;

d) The monitoring system should be strengthened by using the recommended techniques for sampling and analysis in all countries; this is particularly important for future trend analyses and for determination of compliance; monitoring efforts need to be increased in eastern Europe and in the Mediterranean area, and for nitrogen compounds in particular; data quality objectives must be adopted at all working levels;

e) The national participation in interpretation and assessment should be increased and is essential to interpret time trends, to reconstruct historical emissions to determine site representativeness, and to relate EMEP data to other data from national networks and to assessments at the national level.

2. Photochemical ozone formation

42. The main goals are to:

a) Assess the exposure of man, crops, forests and other ecosystems to ozone;

b) Verify emission reductions under the VOC and the Gothenburg Protocol;
c) Attribute to sources precursors contributing to ozone formation;
d) Establish trends for ozone over Europe.

43. The requirements for fulfilling these goals are:

a) The evaluation methodology must include emissions, chemistry, meteorology, landuse and surface properties. This can only be achieved by a model which describes the concentration of precursor chemical compounds and reaction products with appropriate spatial and temporal resolution;

b) Emission inventories should have the necessary detail, particularly with respect to chemical species and temporal variations, and national totals should be accurate within 10%. Emissions from natural sources, particularly emissions of VOC from plants, are also needed;

c) Improved methodology for source attribution for ozone is needed. Emission inventories for VOC and NO_X should have an uncertainty in total national emissions better than 10%. Accuracy and temporal consistency of data series are essential for trend assessment. High-quality exposure and dose data (i.e. integrated concentration exceeding some limit value over a given time period) are required for the assessment of effects on man and the environment;

d) The assessment needs both measurements and models which can be used to generalize the measurement results, and an understanding of the exposure and the effects mechanisms. At present, mapping of AOT40 and AOT60 doses are required for 50 km x 50 km grids. More sophisticated plant uptake mechanisms may require more accurate exposure or damage estimates;

e) Regional sites for ozone measurements can be placed 50-200 km apart, depending on the local conditions and surroundings of the sites. Specific sites for emission verification and compliance monitoring are located closer to the emission areas and have larger variability. Site representativeness of both existing and new sites needs to be carefully evaluated;

f) Since ozone concentrations vary only slightly across regional sites, measurements of other primary and secondary components are needed to evaluate models, particularly with respect to the chemical transformation processes. Such measurements are also needed to study trends and compliance, e.g. with respect to VOC emission reductions;

g) Ozone and its precursors on the hemispheric or global scale are strongly influenced by photochemical ozone formation on the European, national and local scales, and vice versa. A description of these phenomena requires a linking of models for different scales. Understanding the interactions between ozone formation on the different spatial scales requires models which resolve the most important spatial scales.

44. The improvements needed are:

a) The quality of the emission survey and the measurement data needs to be assessed in all parts of the network and for all components, and better data quality will be called for to meet the

requirements; QA/QC procedures for ozone, nitrogen dioxide, and VOC will need to be reviewed and further improved;

b) In particular the demand for very high-quality data for trend studies could be met by a limited number of carefully selected and dedicated sites ("supersites" or "trend sites");

c) The photochemical models should be further developed to reach a good performance in all regions, e.g. to clarify the importance of long-range transboundary transport for the high ozone concentrations in Mediterranean countries;

d) Clarify the importance of North American sources of NOx and VOC for the ozone concentrations in Europe;

e) Clarify further the magnitude of areas where ozone is VOC-controlled rather than Nox-controlled. Clarify the significance of situations where reduction in NOx emissions leads to higher ozone, for the design of control strategies for ozone;

f) Improve methodology to estimate the population exposure to ozone and small particles in urban as well as rural areas.

3. Heavy metals

45. The main goals are to:

a) Quantify of national emissions, minimizing emission uncertainties for cadmium, lead and mercury, and later for copper, zinc, arsenic, chromium and nickel;
b) Assess of emission reductions of the same substances for compliance;
c) Calculate transboundary fluxes, deposition and source attribution; trend analysis;
d) Contribute to research on effects on human health and the environment.

46. The requirements for fulfilling these goals are:

a) The Protocol on Heavy Metals specifies limit values for emissions from stationary sources but does not set specific national emission reduction goals. In order to detect reductions in emissions of less than 30% measurements of both air and precipitation need to be accurate within 5-10%. Likewise, a 10% accuracy in national total emissions is needed;

b) For model estimates, historical emissions and detailed emission inventories, including particle size distributions, characteristics of large point source emissions, and chemical speciation of mercury in the emissions are needed. Natural emissions and re-emissions of mercury and its hemispheric and global cycling needs to be assessed, including mercury from non-European anthropogenic sources;

c) To analyse for trends and compliance, well characterized sites are needed as to representativeness, source regions and meteorology;

d) Heavy metal models need further development, including the linking of local, regional and, as in the case of mercury, hemispheric processes. The reaction rate coefficients for the chemical reactions involving mercury, the physical transformations and exchange processes between various media need more accurate determination.

47. The improvements needed are:

a) The methods to assess and verify heavy metal emissions need improvement;
b) The size distribution of particulate matter needs to be understood and included in dispersion models for heavy metals;
c) A limited number of carefully selected and dedicated sites for trend studies and model validation is urgently needed;
d) Existing methods and QA/QC protocols should be reviewed and strengthened considering the data targets;
e) The regional concentration and deposition patterns of mercury are influenced by the hemispheric and global mercury distribution, which should be better characterized;
f) The adsorption to, and transformation of, heavy metals on particles, as well as the parameterization of dry and wet removal processes, are not well characterized and must be studied;
g) The relationship between changed emission of heavy metals and their residence time in different compartments, needs further study;
h) Improvement and validation of models, leading to the development of operational models.

4. Persistent organic pollutants

48. The main goals are to:

a) Quantify national emissions, quantifying and minimizing emission uncertainty especially for pesticides;
b) Determine of the source-exposure relationships through improved understanding of exchange processes between atmosphere, soil, sea and biota;
c) Improve and validate models leading to the development of operational models;
d) Assess of transboundary fluxes, as well as deposition and concentrations of selected POPs in the atmosphere, soil, sea and biota, to evaluate the harmful effects on ecosystems and human health;
e) Establish trends for compliance;
f) Analyse how different environmental compartments respond to emission reductions.

49. The Requirements for fulfilling these goals are:

a) Methodologies are needed to establish and apply national, hemispheric and global emission inventories including verification procedures to assess accuracy. Measurements at a national level are needed to derive partitioning coefficients and kinetic parameters for the exchange between the media that determine the dispersion, transformation, degradation and accumulation of POPs;
b) POP multi-compartment models need further development and validation to be operational.
c) Indicative substances with representative toxicities and which cover a wide range of chemical and physical properties need to be selected and their emissions, physical-chemical properties, concentrations and contribution to exposure determined. The deposition of POPs needs to be

assessed across Europe, in particular for the indicative POPs. Assessment of POP transport between Europe and other continents in the northern hemisphere and at a global level is required.

50. The improvements needed are:

a) The methods to assess and verify POP emissions should be improved;
b) Establish 5 European sites as a first step, with common procedures for operation and QA/QC, and with only air sampling; deposition measurements to be started in a second step; one central laboratory should be responsible for the analyses in the starting phase, at the same time as laboratory comparisons and training of personnel in other laboratories take place;
c) Carry out exploratory measurements to identify components that may have to be included in EMEP;
d) Evaluate the size distribution of particles containing POPs and use the information to improve the description of the deposition of POPs;
e) Refine the knowledge of physical-chemical properties of prioritized POPs and their behaviour in different ecosystems;
f) Further development of multi-compartment models of POPs for evaluation of the transboundary transport at the regional and hemispheric scales;
g) Use measurements and comparison studies between different transport models to improve model formulation;
h) Describe how POPs are scavenged, in particular with snow;
i) Develop a limited set of components to represent a complex mixture of POPs.

5. Fine particles

51. The main goals are to:

a) Establish concentrations and population exposures of long-range transported fine particles;
b) Calculate transboundary fluxes of fine particles and their source attribution;
c) Develop interfaces with urban modelling and assessment;
d) Quantify the decreased visibility caused by airborne fine particles in Europe;
e) Determine the effects of fine particles on radiation forcing and climate change.

52. The requirements for fulfilling these goals are:

The present requirement is to provide yearly averaged concentrations of total aerosol mass and of aerosols with diameters of less than 10 µm or 2.5 µm, respectively, and relate them to emissions of primary particles and of precursors for secondary particles on a country-to-country, or a country-to-grid-square, basis. Further characterization is needed of chemical composition, size distribution and other physical parameters.

53. The improvements needed are:

a) Countries should provide national emission estimates based on a common methodology

for particles, particularly particles with aerodynamic diameter <2.5 μm and <10 μm;
b) All participating countries should measure and report concentrations of aerosols at representative EMEP sites; the measurements should be compatible with the measurements carried out in urban areas, to establish a data set that defines the rural background concentration levels across Europe;
c) Both measurements and emissions are required to be speciated with respect to particle size distributions and chemical composition, distinguishing between inorganic and organic, and between organic carbon and elementary carbon (soot), in order to verify source attribution;
d) Models should include aerosol dynamics to calculate changes in aerosol size distributions resulting from formation and condensation of secondary aerosols, and the depletion by deposition processes;
e) Clarify the importance of different pollutant sources for the concentrations of small particles in different areas of Europe.

6. Regional focus (Mediterranean, the Balkans, North Africa, Western Asia)

54. Not all parts of Europe are concerned with the same environmental issues. In the Mediterranean the focus is on mesoscale meteorological cycles and ozone and fine particle formation, while in northern Europe long-range transport is important. In the Alps and in other mountainous regions local topography is a major constraint for the pollution distribution. This does not jeopardize the European dimension of EMEP or the partnership with national science activities. On the contrary, it means that the national focuses together have much to contribute to establishing the European pollution picture.

7. Integrated assessment modelling

55. One of the biggest challenges for integrated assessment modelling remains increasing model complexity while keeping the model highly transparent. Another challenge will be to move from uncertainty identification towards supporting policy makers in uncertainty management. One of the main tasks is to foster closer links with experts working at the national level.

56. The integrated assessment modelling should integrate as far as possible input from national experts into models. The work should evaluate national reports submitted under the Convention and comment on the data and information received. The information from integrated assessment modelling could serve as an early warning of potential compliance problems. Swift and accessible distribution of data and modelling results via the Internet is important. As far as technically possible, the integrated assessment model should be made available via the Internet to all national experts for their use. Capacity building at the national level should be supported.

8. Recommendations

57. Based on an analysis of the goals and requirements for EMEP a whole, and suggested improvements, the following recommendations can be made regarding scientific aspects of EMEP.

a) All countries will reconsider their national measurement programmes reporting to EMEP, particularly in view of the recommendation to use standardized methods (i.e. the methods specified in the EMEP manual); the location of measurement sites should also be reviewed, particularly with respect to representativeness and geographical coverage; measurement programmes should be complete within each of the specific EMEP topics, i.e. acidification and eutrophication, photochemical oxidants, HMs, POPs and aerosol particles;

b) Countries should also, in cooperation with the Meteorological Synthesizing Centres (MSC-W and MSC-E) and CCC, identify sites which can be used for the evaluation of trends in the deposition of sulphur, nitrogen compounds, HMs, POPs, and the assessment of the fulfillment of protocol obligations; improvements with respect to the completeness in reporting of emission data are also needed for the analysis of these trends;

c) The acidification and eutrophication model is currently being improved; the spatial resolution of the model has been increased, and the mass conservation properties and the accuracy of the model results have improved; the goal with respect to accuracy of the EMEP model results has been set at ±30% when compared with observations for all components; in order to determine if this model is satisfactory, countries should consider carefully the deposition estimates within their own borders, including the representativeness of the national measurement sites used for model verification and validation;

d) The Eulerian model for photochemical ozone formation will represent a considerable step forward in the description of surface ozone concentration fields, and the interpolation of AOT40 and AOT60 figures from measurements; again, countries should consider carefully if their ozone measurements are satisfactory for model validation, and if their sampling sites are representative;

e) Trend and compliance analyses for the reduction of ozone exposures are much more complicated than for acid deposition and eutrophication; measurement series need to be carefully validated, and calibration of ozone instruments should follow rigorously the recommendations given in the EMEP manual, and the instructions of the World Meteorological Organization (WMO) calibration centre for ozone in Switzerland; continuation of VOC measurements are required in order to see if reductions in the concentrations of ozone precursors follow the reductions in VOC emissions specified in the protocols; reductions in the emissions of nitrogen oxides will be seen in the measurements of oxidized nitrogen compounds, which should be intensified;

f) The Eulerian atmospheric transport model was adopted for calculations of long-range transport and country-to-country depositions for some heavy metals; uncertainty of modelling results are on the level of a factor of two; emission estimates for heavy metals (first of all for lead, cadmium and mercury) need to be verified on a national basis, in order to provide reliable source-receptor relationships from models and measurements;

g) More exploratory work is needed for POPs; this relates to emissions, measurements and modelling; emission inventories for POPs need to be reviewed and improved for consistency and compatibility; measurements of POPs in air are to be started at five sites, using identical sampling methodology and with analyses at one central laboratory for the first year; there is an

apparent need for additional measurements in campaigns, with simultaneous measurements at several sites (10-20) across Europe; samples should be analysed at one central laboratory for consistent results; at the same time, measurements of new compounds should be contemplated; for the assessment of transboundary transport, deposition and concentrations of selected POPs, development of multi-compartment models for regional, hemispheric and global scales will be continued; special attention should be given to the understanding of the physico-chemical properties of POPs and their cycling between atmosphere, soil, water and biota;

h) In order to provide information on the long-range transport of airborne particles, measurements of the mass concentration of small particles at EMEP sites are urgently required; measurements should specify both particle size and chemical composition of particles; information from the countries about the emissions of primary particles have been requested from the Task Force on Emissions, EMEP should specify data requirements with respect to particle sizes and chemical composition; modelling work will consider both primary particles and secondary organic and inorganic particles; in the future, these models should be linked, providing a dynamic description of nucleation, coagulation, condensation and size-dependent deposition processes.

B. Partnership and openness

National contributions

58. The Parties to the Convention have committed themselves to research and development. The international partnership of the Parties to the Convention and the EMEP centres should be strengthened through interaction between EMEP and national research and monitoring programmes. The same quality control procedures and targets must be followed as those required for the core activities in EMEP.

59. The scientific contributions from the countries should be financed nationally, with the status of voluntary contributions in kind. In practice the contributions will often represent scientific extensions of the already existing nationally financed infrastructure for the measurement network. Plans for scientific contributions should be drafted by each country or by voluntarily formed groups of countries with similar interests in consultation with one or more EMEP centres, as appropriate. The EMEP centres may contribute to the work within their resources/priorities. Capacity building should be a part of the collaboration where appropriate. The EMEP Steering Body (and its Bureau) should discuss the proposals and make recommendations for contributions to be included in the EMEP work plan. Each year, the Steering Body of EMEP would review and discuss the progress in each of these tasks, and report its evaluations to the Executive Body.

C. Sharing

1. Information

60. The dissemination of information within EMEP and from EMEP should be transparent, two-way and easily accessible to everybody. It is particularly important to develop the EMEP web site further, and to make sure that the special information needs of, for example, the Working Group on Strategies and Review and the Implementation Committee are taken care of.

2. EMEP-European Community (EC) relationship

61. The European Community (EC) has a legislative system of its own. The EC and its member states are Parties to the Convention, and to maximize the benefit and minimize the costs of monitoring and research, the integration on a technical level between the activities coordinated by the Euroepan Commission and those of the Convention should proceed as far as possible.

62. The European Environment Agency (EEA) is developing the EUROAIRNET air quality monitoring network, which is mainly urban. It consists of monitoring stations that are in operation in the European countries today. EUROAIRNET is designed to provide monitoring data related to compliance, air quality surveillance, exposure/damage assessment, on-line forecasting pollution episodes, to inform and warn the population and to carry out short-term abatement actions to reduce episodic high concentrations, operational monitoring near specific sources, and research. The national EMEP sites are an important component in EUROAIRNET, and it should be evaluated to what extent EUROAIRNET sites could be adopted as EMEP sites and vice versa, with due attention to the objectives and quality requirements of both.

63. The project framework ‘Clean Air for Europe’ is being formulated by the European Commission's DG Environment. The aim of the programme is to identify or confirm key areas where action is required, to provide the necessary tools and databases, to perform various analyses so as to allow consideration of various options of environmental objectives and associated emission control strategies. Because of the similarities of the approach underpinning the 1999 Gothenburg Protocol and the National Emission Ceiling Directive, opportunities should be explored for cooperation between the Community activities and those under the Convention in the scientific investigations and analysis.

3. Stakeholders’ interests

64. The work carried out in EMEP should be transparent to, interact with and enjoy the confidence of, the stakeholders - the individual citizen, local authorities, industry, non-governmental organizations, expert institutions, countries and other bodies.

4. International programmes

65. Very considerable research activities in fields relevant to EMEP are carried out within international research programmes and projects. Interaction with, and utilization of results from, this research are essential for developing EMEP along with our improved understanding of the physics and the chemistry of the atmosphere.

66. The WMO/Global Atmospheric Watch (GAW) programme, with its mission to make reliable, comprehensive observations of the chemical composition and selected physical characteristics of the atmosphere, should contribute considerably to EMEP. The European regional components of GAW and EMEP have nearly identical goals and supplement each other.

67. Closer cross-organizational interaction with WMO is important in order to obtain the benefit of cooperation with respect to monitoring of air and precipitation in Europe. The monitoring activities should be harmonized in order to obtain a better overview of the relationships between urban and regional pollution, and between the regional and the global scale.

68. Monitoring, assessment and research on air pollution are also parts of international agreements like HELCOM; OSPARCOM; the Mediterranean and Black Sea Conventions; the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO). EMEP should benefit from, as well as contribute to, these activities.

69. The related efforts between EMEP, the Arctic Monitoring and Assessment Programme (AMAP) and the United Nations Environment Programme (UNEP) in the field of emission inventories, measurements and modelling of long-range transport at hemispherical and global levels should be coordinated.

70. In some of the research funded bythe European Commission's DG Research in Framework Programme 5, the transport and chemical transformation of pollutants in the troposphere over Europe is studied. Some of the sub-projects of the International Geosphere-Biosphere Programme (IGBP) organize international research which is relevant to EMEP, such as the International Global Atmospheric Chemistry Project (IGAC) and Land Ocean Interaction in the Coastal Zones (LOICZ). EMEP should benefit from these major efforts.

71. Some of the projects in EUROTRAC-2 and North American research activities under the North American Research Strategy for Tropaspheric Ozone (NARSTO) are very relevant for EMEP and collaboration should be encouraged.

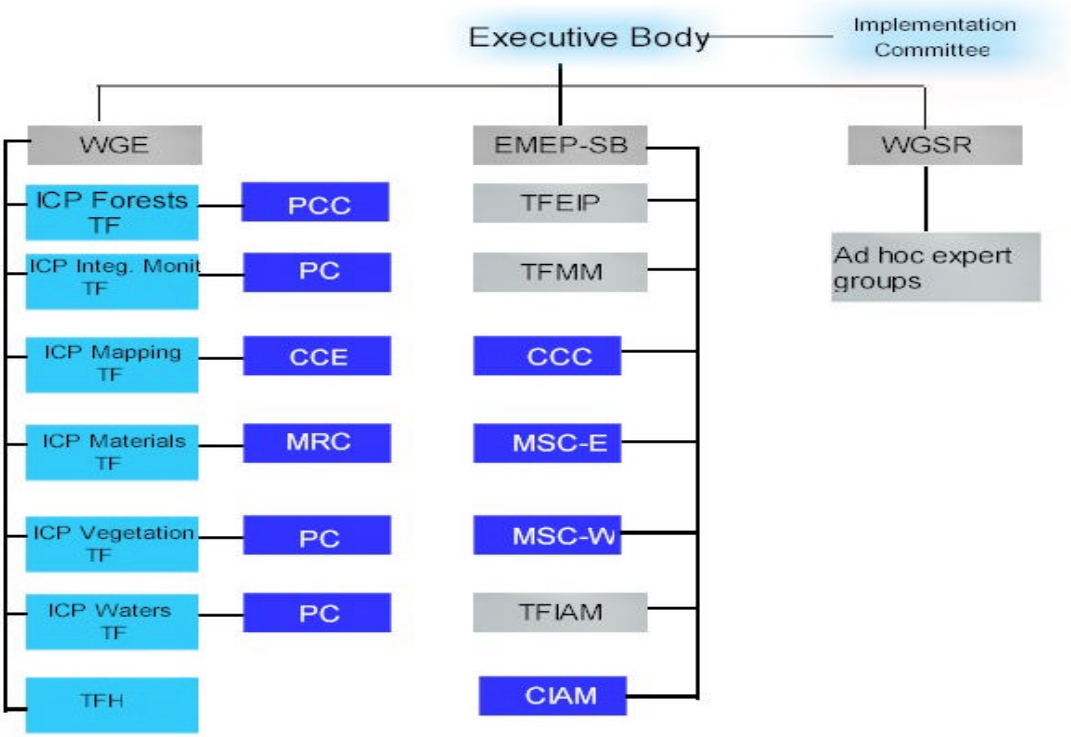
5. Global change science interaction

72. Transport between continents, within the hemisphere and also globally is an important element in the European budget for all the species controlled by the protocols to the Convention. Interaction with scientific work within the United Nations Framework Convention on Climate Cahnge, IGBP (IGAC) and projects within the World Climate Research Programme (WCRP) can provide information to determine the hemispheric or global component of the European pollution load. Emissions from aircraft and ships, and cooperation in international forums like IMO and ICAO are of importance for EMEP.

D. Organization

73. The organization of the work under the Convention is shown in the figure below. The new Task Force on Measurements and Modelling (TFMM) should be a forum for discussion of the work plan of EMEP, including the incorporation of national contributions, and for scientific evaluation and advancement.

74. Strengthening the overall cooperation within EMEP, and in particular cooperation involving better and broader use of EMEP products at a national level, will facilitate a wider acceptance of the protocols to the Convention, and further action towards their ratification.



75. National research and monitoring activities constitute an indispensable part of a well-functioning EMEP and Convention and it is important to ensure that such activities in fact are carried out and that they contribute to EMEP. Here the representatives of the Parties to the Executive Body of the Convention should take a responsibility for facilitating such activities in their country. The Steering Body of EMEP, its Bureau and the centres should all actively contribute towards establishing scientific cooperation with the national activities.

76. Appropriate links need to be maintained between EMEP and the Working Group on Effects (WGE) and the policy-making segment of the Convention represented by the Working Group on Strategies and Review (WGSR).

Long-term financing; geographical coverage; monitoring costs

77. Long-term financing of EMEP centres must be secured. There are large differences with respect to the levels of commitment for implementing the EMEP monitoring programme in the participating countries. In general, small countries are more committed than large countries to providing measurement data, but the costs of measurements relative to the GDPs of the different countries also show large variations related to national priorities. Lack of resources prevents

high-quality measurements in many countries, although these measurements are needed to resolve uncertainties in present model estimates and emission inventories.

78. While the measurements should continue to be under national jurisdiction, there are several possibilities for improving the measurement network and for providing the required information about ambient concentration levels and deposition rates. To obtain a set of measurement data of uniform data quality for components such as POPs and mercury, it appears most relevant to carry out a common pilot measurement programme of limited duration with collection of samples at previously identified sites, and analyse these samples in one laboratory only.

79. However, attention has repeatedly been drawn to the poor geographical coverage of the EMEP measurement network in eastern Europe and in the Mediterranean area. Since this is clearly linked with the lack of resources in some countries, it is necessary to address this problem, taking note of the following recommendations:

a) Develop bilateral or multilateral cooperation between several countries;
b) Involve cooperating organizations or networks, to the extent that these have common goals with EMEP;
c) Provide sampling equipment and chemical analyses from CCC, for a limited time at sites to be identified by the Steering Body;
d) In connection with the adoption of EMEP reference measurement methods in all participating countries, standardized sampling equipment (e.g. filter holders) should be made available for the use at selected sampling sites.