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Thirty-first session
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Item 3 of the provisional agenda***

DRAFT REVIEW OF THE 1999 GOTHENBURG PROTOCOL

Report by the secretariat

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1. The Executive Body at its twenty-third session initiated the first review of the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone in accordance with article 10 of the Protocol following the Protocol's entry into force in 2005 (ECE/EB.AIR/87, para. 51(b)). It decided that the review should be completed at its twenty-fifth session in 2007 and invited all bodies of the Convention to plan their work to this end. This document outlines the legal requirements for the review (section I) and, in the following sections, gives an overview of the various technical elements that might be considered by the Parties in their review, making reference to documents prepared by Convention bodies and programme centres for the review process. It concludes with proposals for further action.

2. The current draft document has been prepared for consideration by the twenty-sixth session of the Working Group on Effects, the thirty-first session of the Steering Body to EMEP[1] and the fortieth session of the Working Group on Strategies and Review. A final revised text will be presented to the twenty-fifth session of the Executive Body in December 2007.

I. LEGAL REQUIREMENTS FOR THE REVIEW

3. While the objective of the Protocol (article 2) is to control and reduce emissions of the prescribed pollutants to ensure that, in the long term, critical loads and levels are not exceeded within the EMEP region, the Protocol's goal is to move towards that objective through measures specified in the Protocol. The review process, which takes into account the objective and Protocol's measures, is spelled out in article 10 of the Protocol.

4. Article 10 of the Gothenburg Protocol requires that Parties keep under review the obligations of the Protocol and broadly specifies the modalities of such reviews. Paragraphs 2 (a) and (b) of the article are of importance in determining the content and structure of the review report, while paragraph 2 (c) deals with procedural matters for the review.

5. Paragraph 2 (c) of article 10 stipulates that the procedures, methods and timing for reviews shall be specified by the Parties at a session of the Executive Body. It also requires that the first such review should start no later that one year after the entry into force of the Protocol.

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[1] Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe.

In accordance with this requirement, the Executive Body initiated the review at its twenty-third session in December 2005, following the Protocol's entry into force on 17 May 2005. It also indicated the time frame for completion of the review – by its twenty-fifth session in December 2007 – and invited all Convention bodies to plan their work for the review.

6. Paragraph 2 (a) of article 10 specifies the subject of the review. According to its subparagraph (i), the Parties' obligations in relation to their calculated and internationally optimized allocations of emission reductions, referred to in article 7, paragraph 5, should be reviewed. Article 7, paragraph 5, requires Parties to arrange for the preparation of revised information on calculated and internationally optimized allocations of emission reductions for the States within the geographical scope of EMEP, using integrated assessment models, including atmospheric transport models or alternative assessment methods approved by the Executive Body. In other words, the Parties' emission ceilings (specified in annex II of the Protocol) should be reviewed in light of the revised information on calculated and internationally optimized emission reduction allocations.

7. Paragraph 2 (a) (ii) of article 10 requires the review of the adequacy of the obligations and the progress made towards achieving the objective of the Protocol. The relevant obligations to be reviewed here could include those under article 3, paragraph 1, on the achievement of emission ceilings; article 3, paragraphs 2 and 3, on the application of emission limit values to new and existing stationary sources; article 3, paragraph 4, on the evaluation of limit values for new and existing boilers and process heaters (see para. 13 below); article 3, paragraph 5, on the application of limit values for fuels and new mobile sources; article 3, paragraph 8 (a), on the application of measures to control ammonia emissions; and article 3, paragraph 7, on the application of measures to products. The results of the in-depth review of the Gothenburg Protocol by the Implementation Committee, scheduled for 2006 and 2007, should provide an assessment of the degree of implementation of most of these articles by the individual Parties to the Protocol.

8. Paragraph 2 (a) (ii) of article 10 also requires the review of progress made towards achieving the objective of the Protocol – that is, to control and reduce emissions of sulphur, nitrogen oxides, ammonia and volatile organic compounds caused by anthropogenic activity so as to ensure that, in the long term and in a stepwise approach, and taking into account advances in scientific knowledge, atmospheric depositions or concentrations of these substances do not exceed the critical loads and levels as described in annex I of the Protocol.

9. In view of the above, the review of the Protocol should include the following elements:

(a) A review of the emission ceilings in annex II;

(b) A review of the adequacy of the obligations listed in paragraph 4 above;

(c) A review of the progress towards achieving the objective of the Protocol as set out in article 2.

10. The results of the review should indicate (a) whether, in view of the latest scientific knowledge, the emission ceilings in annex II and the obligations of the Protocol are adequate for achieving the objective of the Protocol; and (b) what progress has been made towards achieving the objective.

11. Paragraph 2 (b) of article 10 requires that reviews take into account the best available scientific information on the effects of acidification, eutrophication and photochemical pollution, including assessments of all relevant health effects, critical levels and loads; the development and refinement of integrated assessment models; technological developments; changing economic conditions; progress made on the databases on emissions and abatement techniques (especially those related to ammonia and volatile organic compounds); and the fulfilment of the obligations regarding emission levels.

12. In addition to the above review requirements, article 3, paragraph 4, of the Protocol specifies that limit values for new and existing boilers and process heaters with a rated thermal input exceeding 50 MW_{th} and new heavy-duty vehicles shall be evaluated by Parties at a session of the Executive Body with a view to amending annexes IV, V and VIII no later than two years after the date of entry into force of the Protocol. Section V below deals with this issue and makes proposals for amending the annexes.

II. EMISSIONS, ATMOSPHERIC CONCENTRATIONS AND DEPOSITION LEVELS

13. EMEP continues to improve the extent and quality of reporting through development of an emissions review process and through its monitoring strategy adopted in 2005. The EMEP model used for developing the Gothenburg Protocol has also undergone considerable development and a new EMEP Unified model is used to model the movement of the pollutants covered by the Protocol. This section describes the reductions in emissions reported by Parties in 2006 for their 2004 emissions and compares these to the Protocol targets for 2010 (as specified in annex II to the Protocol). It also describes the levels of pollutants measured and modelled

across the EMEP region and notes the changes made to the EMEP model. Further information is available in EMEP technical reports.

A. Emissions

14. The EMEP Meteorological Synthesizing Centre-West (MSC-W) provided the following information.

15. Emissions of sulphur dioxide (SO_2) in Europe continued to show a clear downward trend. The total emission for all Parties to the Convention within the geographical scope of EMEP was estimated to be 14,896 Gg (SO_2) in 2004, which represents a decrease of 65% since 1990. This implies that, over the whole EMEP area, the emission target for SO_2, as set by the figures to be found in the Gothenburg Protocol, annex II for 2010 (equivalent to a 61% decrease), had already been reached in 2004. However, there are significant differences in the achievements of individual Parties. While about half of the Parties to the Convention have already reached their targets set by the Gothenburg Protocol, the other half still need to reduce their emissions.

16. For emissions of nitrogen oxides (NO_x), the situation is not as satisfactory. Total emissions of all Parties within the EMEP area fell to 17,741Gg (NO_2) in 2004, only 30% less than the 1990 levels. The Protocol target was a decrease of 39%. While 40% of Parties to the Convention have reached their targets set by the Gothenburg Protocol for 2010, further cuts in the total emission from the EMEP region are needed to reach the overall 2010 target.

17. Estimated ammonia emissions in the EMEP region have fallen by 22% from the 1990 levels; in 2004 they totalled 6,774 Gg (NH_3). The Protocol target for the EMEP region as a whole was a cut of 25%. The figures show that 65% of Parties to the Convention have already reached their target set by the Gothenburg Protocol and that the total ammonia emission in the EMEP area is now close to the Protocol target set for 2010.

18. For non-methane volatile organic compounds (VOCs), emissions in 2004 were 15,247 Gg, a decrease of 38% from 1990 levels. The Protocol target for 2010 was set at a 45% cut when considered across the EMEP region. Only about 40% of Parties to the Protocol had reached their 2010 targets in 2004. The Protocol goals require further reductions by 2010, which indicates some Parties still need to take action.

B. Measurements and modelled results

19. The EMEP Chemical Coordinating Centre and MSC-W provided the following information.

20. Nearly all (>95%) of the EMEP observation sites show significant reductions in the concentration levels of sulphur components in air and precipitation and in wet deposition fluxes during the period 1990–2004. Modelled results confirm this finding. Reductions are typically in the order of 50-60% for sulphate in air and precipitation and 75% for sulphur dioxide in air. The EMEP Unified model shows a decrease of 62% in 2004 compared with 1990 levels. The largest relative reductions for measured components in air are observed in central-continental Europe, while somewhat lower reductions are seen towards the outer boundaries of Europe. No general geographical pattern is evident in trends of sulphur concentrations in precipitation.

21. Trends in concentration and deposition levels of nitrogen compounds are more heterogeneous, and while some sites show significant reductions for some species, other regions do not show any significant trends at all. For oxidized nitrogen species, about 50% of the EMEP sites show average reductions in the order of 30% for nitrate in precipitation and slightly higher reductions for nitrogen dioxide in air. Trends of nitrate in air, however, are lower, with only 20% of the sites showing reductions of 30% or more. It should be noted that the assessment of trends of nitrogen species in air is impeded by the low number of sites conducting long-term monitoring; as a result, for large areas no information is available. However, the lack of a clear trend in measured decreases in air concentrations is reflected in modelled results, though here meteorological variability is of a similar magnitude to the expected fall. Trends in reduced nitrogen compounds are generally larger than the trends in oxidized species, with about 85% of the sites showing average reductions in the order of 45% during the period 1990–2004 for ammonia and ammonium in air. Trends of similar magnitude are generally observed for ammonium in precipitation, but at a lower fraction of the sites (50%).

22. Overall, the trend analysis of observed concentrations above gives similar results to EMEP Unified model estimates, indicating a strong correspondence between emission changes and changes in deposition fluxes at the regional scale.

23. Downward trends of high ozone concentrations over the last 10 to 15 years have been reported for several EMEP sites across Europe. Typical reductions have been in the order of about 30%. The inter-annual variability in peak values of ozone in Europe is large; however, the trends in the extreme values are sufficiently consistent and in line with numerical model calculations to indicate that an effect of the decline in European ozone precursor emissions is

evident. There is also strong evidence that the lower percentiles in the ozone values in polluted areas of Europe have increased, in particular during winter. An important contribution to this upward trend comes from a reduced titration effect in response to the reduction of European NO_x emissions. There is strong evidence that background ozone has increased. This is particularly true for the winter season. How much of this comes from a possible increase in hemispheric ozone, or from recirculation of European polluted air is unclear, however. Whereas a decline in ozone peak values, relevant for health impacts, has been observed in Europe (except for 2003), there is apparently no corresponding reduction in the long-term medium ozone concentrations relevant for vegetation damages.

C. The EMEP Unified model results

24. The EMEP model calculations referred to above took account of advances in scientific knowledge. Since 1999, EMEP has replaced its Lagrangian dispersion model with a new Eulerian Unified model. The Unified model involves significant changes in the calculation of air concentrations and depositions, in particular:

(a) The grid size of the model has been reduced from 150*150 km to 50*50 km. The finer resolution results in increased average calculated depositions on sensitive ecosystems and an increase in the estimate of unprotected ecosystems.

(b) The EMEP Unified model now calculates ecosystem-specific deposition. These more realistic values result in forests receiving more deposition than meadows and lakes. This also leads to an increase in the area of unprotected ecosystems.

(c) The EMEP Unified model has improved its deposition schemes and now estimates fluxes for ozone entering vegetation via the stomata. Flux approaches show more widespread ozone damage to vegetation over Europe.

25. The new dispersion model calculations systematically show an increase in the estimated depositions and concentration levels relevant for damage estimates. Calculations using the Protocol emission goals for 2010 show that the new methods give much higher values than those calculated in 1999. Comparing sulphur deposition estimates for 2004 with those for 2010 assuming full implementation of the Protocol, shows that, independent of meteorological conditions, the 2004 sulphur deposition values in European countries as a whole are already lower than those aimed at in the Protocol goals. To achieve the nitrogen oxide deposition targets, further reductions of emissions (about by 20%) are still required. For reduced nitrogen

deposition and for ozone fluxes, the further reductions needed from the 2004 levels might be masked by the expected meteorological variability in 2010.

III. EFFECTS ON HUMAN HEALTH, NATURAL ECOSYSTEMS, MATERIALS AND CROPS

26. The Working Group on Effects, its International Cooperative Programmes (ICPs), and the Task Force on the Health Aspects of Air Pollution provide the necessary information on effects on human health and the environment to assess the effectiveness of abatement measures. This section summarizes the results of work related to the review of the Protocol. More detailed information is available in a report prepared by the Working Group.

27. Monitoring and assessment of the effects of sulphur and nitrogen on ecosystems has showed some recovery in acidification but continuing risks of eutrophication. Sulphur deposition observed by ICP Forests and ICP Integrated Monitoring had decreased significantly by 2003, while nitrogen deposition had remained fairly constant. Sulphur and nitrogen deposition and acidified soils imply risks to forest ecosystems and unbalanced tree nutrition; in addition, ground vegetation species composition was linked to nitrogen deposition. Observations by ICP Waters and ICP Integrated Monitoring have shown a clear decrease in sulphate in surface waters since 1990 at almost all monitoring sites. This has resulted in less acidic surface waters, also less toxic to biota, and led to first signs of biological recovery. No trends were detected for nitrate concentrations in surface waters, and nitrogen continues to accumulate in most catchment soils with risks for biodiversity changes. The recovery achieved by sulphur emission decreases could be offset by the net acidifying effect of nitrogen processes and leached nitrate caused by nitrogen deposition.

28. Critical loads for acidification and eutrophication for all of Europe were updated in 2006 by the Coordination Centre for Effects (CCE) of ICP Modelling and Mapping. Risks for eutrophication were estimated as higher, more widespread and more spatially variable than those for acidification. The critical loads of acidification and eutrophication were exceeded for 12% and 46% of the European ecosystem area in 2000, respectively. The exceedance area for acidification declines to 8% in 2010, but the exceeded area for eutrophication remains unchanged. The Protocol’s long-term aim of closing the gap of critical load and level exceedances should remain based on sustainable health and environmental endpoints; integrated assessment modelling should account for the regional distribution of the sensitivity of ecosystems.

29. The dynamic modelling of ecosystem recovery from acidification achieved a major breakthrough in 2004. A Europe-wide dynamic acidification modelling framework is now ready to use target loads to assess damage and recovery times. Dynamic models to address nitrogen and carbon cycles and eutrophication are available for scenario analysis, but require further testing prior to regional application. According to models, acidified forest and surface water sites in many regions in Europe would need many decades for chemical and biological recovery even if the Protocol were fully implemented. In addition, ecosystems might not recover to their original status.

30. Declining concentrations of acidifying air pollutants resulted in decreased observed corrosion of materials at the ICP Materials sites by 50% on average between 1987 and 1997. The corrosion rate of carbon steel decreased further from 1997 to 2003, though the rates for zinc and limestone increased slightly. Nitric acid and particulate matter (PM) currently contribute to corrosion in addition to sulphur dioxide. Exceedances of tolerable levels of corrosion for cultural heritage materials were often found. Particles also cause soiling of materials. The tolerable level for coarse PM (PM_{10}) for soiling of three selected materials is 12–22 $\mu g/m^3$ based on reasonable cleaning intervals.

31. New critical levels of ozone for crops and trees have been derived using an ozone flux method and can be used in integrated assessment modelling. The new method links ozone effects to plant uptake through stomata on leaf surfaces. Preliminary mapping with the EMEP Unified model indicates widespread exceedances with different spatial patterns from the concentration-based method used for the Protocol. ICP Vegetation has reported repeated damage to vegetation due to ozone across 17 European countries between 1990 and 2006. Trends observed reflect the spatial and temporal variation in ozone concentrations, with no marked decline or increase evident.

32. European-wide effects can now be estimated using a new pan-European land-cover database, merged from land-cover maps of the CORINE (Coordination of Information on the Environment) programme and the Stockholm Environment Institute. The land-cover map has now harmonized the work of the Working Group on Effects and EMEP Steering Body. The same map is being used to calculate critical loads and levels for terrestrial and aquatic ecosystems, and to calculate ecosystem-specific deposition of sulphur and nitrogen as well as ozone fluxes to vegetation.

33. The Task Force on Health reassessed the effects of ozone and PM on human health. Calculations using the sum of maximum daily eight-hour means above ozone concentration of 35 parts per billion (SOMO35) show that ozone contributes annually to over 20,000 premature

deaths across Europe. Current policies are not expected to change the exposure or health impacts significantly in the future, though the number and magnitude of ozone peak concentrations have declined markedly over the last decade. The long-range transport of PM contributes significantly to a wide range of acute and chronic health problems in Europe attributable to fine PM ($PM_{2.5}$) from anthropogenic sources. The estimate risk of all-cause mortality increases by 6% per 10 $\mu g/m^3$ of $PM_{2.5}$. Present exposure to $PM_{2.5}$ from anthropogenic sources lead to 288,000 premature deaths annually and to a life expectancy reduction of 8.6 months on average in the European Union (EU).

IV. NATIONAL EMISSION CEILINGS

34. Based on current reduction plans, most of the 23 Parties that have ratified the Protocol will meet the emission ceilings listed in tables I-IV in annex II to the Protocol. These reduction plans will cause emissions to decline further after 2010. Sulphur emissions will decline much more than required by the Protocol. The envisaged “gap-closures” for acidification, eutrophication and ozone will be met, although the area where critical loads and levels will still be exceeded after 2010 remains larger than foreseen during the preparation of the Protocol. Emission ceilings for NO_x seem to be hard to meet for several parties and even the sum of the emission ceilings for all Parties that ratified will most probably only be met a few years later than 2010. Note that Parties that ratified the Protocol emit less than 50% of the total emissions in the EMEP domain.

35. The European Community and its Member States are all Parties to the Convention and many are Parties to its Protocols. EU directive 2001/81/EC, on national emission ceilings for certain atmospheric pollutants, mirrors the Gothenburg Protocol and sets, for the same pollutants covered by the Protocol, upper national emission limits for each Member State to be met by 2010 and later years. The ceilings of the directive are either equal to, or stricter than, those of the Protocol. The EU Thematic Strategy on Air Pollution, adopted by the European Commission in 2005, concluded that the long-term objectives of the EU’s Sixth Environment Action Programme were impossible to meet by 2020, even if all technically feasible measures were applied. The Strategy therefore lays down interim objectives for 2020. These are expressed as improvements in environmental and health effects between the years 2000 and 2020, which require further emission reductions by the European Community. The Thematic Strategy announced the revision of the National Emission Ceilings directive by 2006. Currently, the European Commission foresees a new legislative proposal by February 2008 with revised national emission ceilings for 2020 and later years based again on integrated assessment modelling (GAINS). Most preparatory work for the revised directive is done, but it will take into account the decisions of the EU Heads of State on renewables and greenhouse gas reductions.

36. The emissions ceilings listed in tables I–IV in annex II to the Protocol were negotiated on the basis of indicative values calculated by the RAINS model for Parties within the geographic scope of EMEP. Since 1999, the Centre for Integrated Assessment Modelling (CIAM) has continued to develop the RAINS model in the light of improved scientific knowledge and understanding. In 2004, a group of peer reviewers concluded that RAINS was fit for its purpose of supporting the review and revision of national emission ceilings, provided that uncertainties were sufficiently taken into account. Recommendations were also made to extend the model to the local and hemispheric scales as well as integrating consideration of abatement measures for greenhouse gases.

37. As RAINS had a possible bias towards add-on technical solutions, it was recommended that more attention be paid to non-technical measures and structural changes in agriculture, transport and energy use. A systematic compilation of biases by the Working Group on Effects programmes (impact estimates) and by EMEP (emission estimates and dispersion modelling) was also recommended. Parties to the Convention were asked to check and improve their data supply. CIAM was asked to increase further the transparency of RAINS by making input data and the model available via its website and to give users the possibility to provide feedback. All recommendations have been taken on board in the workplan of the Convention.

38. Work has started to include the local scale (the EU City-Delta project), the hemispheric scale (the Task Force on Hemispheric Transport of Air Pollution), and the inclusion of measures in the fields of energy, transport and agricultural policies. Uncertainties and possible biases have become a recurring item at meetings of the Task Force on Integrated Assessment Modelling as well as at meetings on emission inventories, atmospheric modelling and the modelling of effects. Bilateral consultations held by CIAM with 21 parties led to an improved database of emission projections that is consistent with national statistics on energy, agriculture and transport, and with other international reports (e.g. with the United Nations Framework Convention on Climate Change).

39. Technical changes resulting from recent developments of the EMEP dispersion model are now incorporated into the RAINS model, namely those corresponding to the increased grid resolution and the new ecosystem specific deposition. Both improvements in the dispersion model description result in increased average calculated depositions on sensitive ecosystems and an increase in the calculated share of unprotected ecosystems.

40. Revisions of the maps of critical loads for acidity and for eutrophication have been included in RAINS, though there are no major overall changes to the maps. However, the critical

levels for ozone have been revised to incorporate scientific findings that suggest that for vegetation a flux-based approach should be used to define the critical level.

41. If the optimized "negotiating scenario" used in 1999 were recalculated, the above changes, together with changes in the emission projections for 2010 and beyond, would inevitably lead to a different result. However, it is expected that the major polluters would still need to decrease their emissions significantly; it is easy to argue that the Gothenburg emission ceilings were "no regret" values and were a positive step towards achieving the objective of the Protocol (see section X). However, calculations suggest that additional measures would now be needed to achieve the ambition level at the time of the adoption of the Protocol. New calculations are needed to re-evaluate fully the negotiated emission ceilings to decide how they might be revised.

V. EMISSION LIMIT VALUES

42. This section summarizes the work of the Expert Group on Techno-economic Issues on the evaluation of limit values in annexes IV, V and VIII and the annex amendment requirements of article 3, paragraph 4 of the Protocol (see para. 12 above). It also draws attention to the need to amend other annexes to the Protocol. The Expert Group provides further information in its report to the Working Group on Strategies and Review.

43. The Expert Group noted that emission limit values (ELVs) for SO_2 and NO_x for the large combustion plants (LCP) specified in annexes IV and V were partially different from those established by EU directive 2001/80/EC. The Expert Group also noted that relevant information on best available techniques (BAT) could be found in the Integrated Pollution Prevention and Control (IPPC) BAT reference (BREF) document for LCP (directive 96/61/EC). It suggested that this document could also be used for the assessment of ELVs for LCP installations and fuels that are not yet covered by the annexes (e.g. gas turbine installations, biomass).

44. Concerning heavy-duty vehicles and annex VIII to the Protocol, the Expert Group drew attention to the preparatory work in progress on EURO VI standards and noted that a proposed EU directive or regulation was expected in 2007. The development and implementation of this new EU legislation on EURO VI should be followed closely and, if appropriate, reflected in a revised annex VIII. For stationary engines, Parties may wish to consider the need to revise ELVs with regard to state-of-the-art engines and reduction techniques.

45. Also in annex VIII to the Protocol, sulphur content limit values are defined as 350 mg/kg for compression-ignition and 50 mg/kg for positive-ignition engines. These values could be

revised downwards since Parties that are EU Member States already follow directive 1998/70/EC, which since 1 January 2005 has limited petrol and diesel fuels to a maximum of 50 mg/kg. Furthermore, EU directive 2003/17/EC, amending directive 1998/70/EC, restricts from 1 January 2009 the sulphur content of petrol and diesel fuels further, to 10 mg/kg.

46. Further consideration of revisions to annexes may now be appropriate. For example, the Expert Group has compiled removal efficiencies and abatement costs for some activities (refineries and cement), which may help with decisions on amendments. As only a limited number of activities are covered in the Protocol, Parties may wish to consider the need for adding others with significant emissions. Parties may also wish to consider reflecting other national or international legislation – for example, revising annex VIII for off-road engines to reflect EU directive 2003/44/EC for recreational craft and directive 2002/88/EC for emissions from internal combustion engines installed in non-road mobile machinery.

47. Some Parties have drawn particular attention to annexes that should receive immediate attention. For example, table IV of annex V, which lists limit values for NO_x emissions for new stationary engines, has created difficulties for several countries in their ratification process. Finland has offered to begin work on proposing revisions to table IV that would apply the same ELVs to all engines, from small-unit spark ignition engines and compression engines up to large engine plants.

48. Parties may also wish to give special attention to the problems of the level of detail of the technical annexes. Some Parties to the Convention have indicated that, while they are able to meet the overall emission ceilings specified in annex II, they had had or were having trouble ratifying the Protocol because of the level of detail in some of the annexes. Some delegations have suggested that simpler annexes and/or more flexible approaches to applying their provisions (e.g. through relaxed timescales for some countries) might encourage better implementation of the Protocol.

VI. THE ROLE OF HEMISPHERIC TRANSPORT

49. The Executive Body established the Task Force on Hemispheric Transport of Air Pollution under decision 2004/4, to improve the understanding of the transport of air pollution across the Northern Hemisphere. The Task Force provided an interim report in 2007 informing the review of the Protocol without prejudice to further work to be completed by 2009.

50. Observations provide a wealth of evidence that ozone and fine particle concentrations in the UNECE region and throughout the Northern Hemisphere are influenced by intercontinental

and hemispheric transport of air pollutants. The processes that determine the overall patterns of transport at this scale are relatively well understood, and our ability to quantify the magnitude of transport is improving.

51. For ground-level ozone, there is a hemispheric background concentration of 20-40 parts per billion that includes a large anthropogenic and intercontinental component. The preliminary results of the Task Force model intercomparison suggest that local and regional emission changes of ozone precursors (nitrogen oxides, VOCs and carbon monoxide) have the largest impact on air quality, but that changes in intercontinental transport can have small, but significant, impacts on surface ozone concentrations. Perturbation experiments focused on methane suggest that a decrease in global methane concentrations may have as large, or larger, impacts on surface ozone concentrations as similar decreases in the intercontinental transport of other ozone precursors, as well as decreasing climate forcing of both methane and ozone.

52. For fine particles, the impact of intercontinental transport on surface air quality is primarily episodic, especially associated with major emission events such as fires or dust storms. The Task Force intercomparison suggests that the impact of intercontinental transport of anthropogenic PM on annual surface concentrations is smaller than that for ozone, but significant.

53. The intercontinental transport of both ozone and fine particles has large impacts on total atmospheric column loadings, which have significant implications for climate change.

54. The significance of intercontinental transport may change in the future due to changes in the magnitude and spatial distribution of emissions and due to the influence of climate change.

55. Further efforts of the Task Force will reduce the uncertainties in the estimates and provide detailed information of the importance of intercontinental transport of air pollution and its significance for achieving policy objectives.

VII. RELATION TO CLIMATE CHANGE ISSUES

56. The report of the Task Force on Integrated Assessment Modelling draws attention to the synergies between air pollution and climate change. There are close links between sources, abatement measures, and atmospheric transport and chemistry; there are synergistic and antagonistic effects in abatement measures, changes in source-receptor matrices due to climate change, and changing critical loads due to changed precipitation patterns. There are also links with the carbon and nitrogen cycles.

57. Model studies by the Working Group on Effects indicate that climate change influences ecosystem processes and long-term impacts of air pollutants. These interactions are complex and there are possible positive and negative impacts on the acidification and eutrophication processes caused by sulphur and nitrogen deposition. Climate change can decrease nitrogen retention and increase organic acid leaching from soils, which might lead to delays in recovery from acidification. For vegetation, stomatal uptake of ozone might decrease across most regions of Europe in a future climate. Consequently, ambient ozone concentrations would increase and result in enhanced radiative forcing. Ozone-induced productivity losses would continue to affect the global carbon cycle by reduced sequestration. According to model calculations, climate change has significant impacts on materials; these are direct or in combination with air pollutants, and they can be positive or negative, depending on effect and geographical location. Effects include (i) degradation of stone and masonry through corrosion, thermal stress, freeze-thaw cycles, and salt volume changes due to variation in relative humidity; (ii) corrosion of metals; and (iii) wood degradation through increased fungal growth and rapid changes in relative humidity and temperature.

58. CIAM has developed the GAINS model (an extension of RAINS) to explore synergies with climate change and the possibilities for developing integrated strategies. Results have shown that when air pollution and greenhouse gas emissions are considered together, there are larger abatement potentials and lower costs. Even so, there are possibilities of antagonistic effects such as the air pollution effects stemming from the use of biofuels. Further work is needed to include the potential of non-technical measures in the analyses.

59. It is recommended to bring the assessment and design of policy strategies for air pollution and climate change together and to estimate costs jointly. Otherwise potential synergies might not be explored and trade-offs might be insufficiently identified. In addition, the awareness of the relationship with topics such as energy security might improve the effectiveness of environmental policy.

60. Agriculture is the dominant source for anthropogenic emissions of ammonia, methane and nitrous oxide (N_2O). Some mitigation options (e.g. changes in cattle feed or reduction in the use of fertilizer) will reduce all three pollutants, but some ammonia measures would increase emissions of greenhouse gasses (e.g. injection of manure and low emission housing increases N_2O-emissions and covered storage of slurry will increase methane emissions). Moreover, some ammonia measures would increase emissions of nitrate to groundwater. An integrated approach is recommended to avoid negative side effects of a policy solely focussed on ammonia.

VIII. PARTICULATE MATTER

61. While the Protocol does not aim to address the problems of PM pollution, it was recognized at the time of its adoption that steps taken to cut emissions of the Protocol pollutants were likely to result in decreases of PM concentrations. However, increasing concern about PM (see para. 33 above) prompted the Executive Body to establish an Expert Group on PM at its twenty-second session in 2004. The Expert Group provided the following information.

62. PM causes substantial adverse health effects where premature deaths can primarily be attributed to the fine fraction ($PM_{2.5}$). There are also significant health effects associated with PMcoarse ($PM_{2.5-10}$). So far, no threshold could be identified below which no adverse effects are to be expected.

63. In many countries, more than half of the $PM_{2.5}$ regional background concentration may be attributed to long-range transport. The transboundary contribution to the PM concentration is mainly due to secondary particulates, which are formed from the emission of precursors such as SO_2, NO_x and NH_3 and certain VOCs. In urban areas, local sources can contribute significantly to the total concentration; but still long-range transport is highly significant. For PMcoarse concentrations the transboundary contribution is smaller but still significant.

64. Many relevant sources of PM, such as production processes and energy industries, are already subject to control under protocols to the Convention. However, some important sources of primary PM emissions, e.g. in non-industrial combustion, are not included.

65. With currently available technical measures, there exists a potential for further reduction of primary PM emissions of 40% of the projected 2020 total PM within the EU27. In non-EU countries within the EMEP area, this amounts to 70%, one third of which could be achieved by full implementation of current regulations and two thirds by applying further measures.

66. It may be concluded that $PM_{2.5}$ concentrations can be cost-effectively reduced in the Convention area on the basis of a common harmonized abatement strategy. While most of the technical work under the Convention has focused on $PM_{2.5}$, it should be recalled that PMcoarse has a smaller, but still significant, long-range component and could also be controlled in this way.

67. A number of potentially complementary options are available to control PM under the Convention: initiatives to increase the number of Parties to the protocols; technological measures using emission limit values, and/or best available techniques; non-technical measures; national

emission ceilings not to be exceeded at a future date; sector targets; and ambient air standards for PM to be met at a future date.

68. Therefore, it is recommendable that any process to negotiate new national emission ceilings should consider the reduction of both primary and secondary $PM_{2.5}$ in ambient air as an additional objective alongside the reduction of acidification, eutrophication and tropospheric ozone.

69. Known uncertainties in current emission inventories mean that if emissions ceilings for primary PM2.5 are considered as a control option, the possibility of either a provision for adjustments in the light of methodological changes to the inventories, or expressing ceilings relative to a base year, should be considered.

IX. NORTH AMERICA

70. For Canada and the United States, the Gothenburg Protocol established individual commitments for each country, but allowed flexibility in how these commitments were met. The requirements included: (i) identification of a transboundary region for ozone – a Pollutant Emission Management Area (PEMA) where emission reductions would result in reductions in transboundary flow; (ii) commitments from Canada and the United States to work toward achievement of the air quality standards for ozone in both countries and implement reductions for NO_x and VOC in the PEMA; and (iii) for acid rain, commitments from Canada to go beyond its 1994 Sulphur Protocol obligations and from the United States on sulphur emissions for the first time under the Convention. Since there was no evidence of transboundary pollution leading to eutrophication, there were no commitments on ammonia for either country in the Gothenburg Protocol.

71. Canada and the United States utilized their bilateral agreement (the 1991 Canada-US Air Quality Agreement) to address acid rain and ozone. Both countries have met their obligations as identified in the Ozone Annex of the Canada-US Air Quality Agreement. For further information on each country's commitments and progress, please see the 2006 progress report on the Canada-US Air Quality Agreement at
http://www.ec.gc.ca/cleanair-airpur/caol/canus/report/2006canus/toc_e.cfm

72. Both countries have agreed that the commitments made in the Ozone Annex are sufficient to address transboundary ground-level ozone at this time. Currently, Canada and the United States are taking steps to consider whether to negotiate an Annex to the Air Quality

Agreement to address PM and related air pollution issues of concern, such as acid rain, regional haze and visibility in the Canada-United States border region.

73. The Canada-US Air Quality Agreement was established to provide "a practical and effective instrument to address shared concerns regarding transboundary air pollution". Initially, the Agreement was intended to address the primary pollutants responsible for acid rain. However, the Agreement also confirmed the commitment of the Canada and the United States to consult on, and develop, the means to address other transboundary air pollution issues.

74. In December 2004, the Canada-US Subcommittee on Scientific Cooperation published the Canada-US Transboundary PM Science Assessment. The committee was charged to summarize and understand the current knowledge of the transboundary transport of PM and its PM precursors.

75. A complete copy of the Canada-US Transboundary PM Assessment is available at http://www.msc.ec.gc.ca/saib/smog/transboundary/transboundary_e.pdf

76. The Air Quality Agreement will continue to serve as the primary mechanism to pursue further efforts to improve transboundary air quality, such as the consideration of a possible Particulate Matter Annex, including the geographic scope of such an annex, examination of cross-border emissions cap and trade, and joint modelling and analyses to support many of these areas.

X. PROGRESS TOWARDS ACHIEVING THE OBJECTIVE OF THE PROTOCOL

77. The objective of the Protocol is to control and reduce emissions of the prescribed pollutants to ensure that, in the long term, critical loads and levels are not exceeded within the EMEP region. When the Protocol was adopted, the Executive Body was provided with calculations showing the benefits of implementing the Protocol in terms of decreased exceedances of critical loads using the then-available critical load maps and modelled deposition data.

78. *Acidification.* From measurements and from dispersion model calculations made with reported emissions, it is clear that the deposition of acidifying substances in Europe has declined since the 1990, and that positive effects on the chemical composition of soils and lakes have been measured. However, there have been changes to the EMEP model, in particular improved resolution and ecosystem-specific deposition values. Such model improvements imply that, even with full implementation of the Protocol, the protection of ecosystems will be less in 2010 than

was expected at the time the Protocol was adopted. Dynamic models also demonstrate that time delays will be encountered before recovery takes place in many areas. Even so, the Protocol will achieve its goal of moving towards full protection, but the shortfall in protection expected from the 1999 estimates further emphasizes the need for additional measures.

79. *Eutrophication*. Deposition of both oxidized and reduced nitrogen remains a widespread problem for European biodiversity. Even estimates made at the time of adoption of the Protocol indicated that critical loads for nitrogen would still be exceeded over a majority of ecosystem areas in Europe. With the revised estimates of deposition made by EMEP, and with revised (lower) critical loads for nitrogen agreed by the Working Group on Effects, the impacts of nitrogen are considered to be even greater than previously thought. The Protocol, while still achieving some protection in some areas of Europe, will not address the widespread problems of excess nitrogen deposition.

80. *Ground-level ozone.* Although VOC emissions in Europe have declined in the past 15 years by more than 38%, no clear downward trend in ozone effects has been observed. While the frequency of very high ozone episodes may have fallen, background tropospheric levels have shown a steady tendency to increase. As a result, excesses over the thresholds used for defining critical levels of ozone (annex I to the Protocol) are still significant in many parts of Europe. New scientific research has shown that an “ozone flux approach” is biologically a more realistic description of the effects of ozone exposure to vegetation than the critical levels defined in the Protocol. Applying this method would mean that ozone effects to vegetation become more widespread over Europe and not merely a Mediterranean problem. Human health impacts of ozone were earlier estimated with an indicator (AOT60) that integrated the duration and absolute level of ozone exposure (similar to the critical level for vegetation). Systematic review has indicated that this would not provide protection against a number of severe health effects. A new proposed indicator (SOMO35) suggests that ozone impacts on health would continue to be widespread in Europe. There is a need to evaluate fully the effects of ozone on both human health and vegetation, but it is clear that, even with full implementation of the Protocol, critical levels will be exceeded and ozone effects on human health as well as damage to plants will still be widespread and significant.

XI. CONCLUSIONS

81. Depending on the views of the Parties, they may conclude the following:

(a) Recognizing the achievements of the Gothenburg Protocol and the effective measures Parties to the Protocol have taken towards their short- and long-term goals, but noting the difficulties highlighted in the current review, including the unsatisfactory state of signature and ratification, and also taking into account the latest scientific findings, a revision of the current Protocol or even possibly the negotiation of a new protocol needs to be seriously considered.

(b) Building upon the achievements of the Gothenburg Protocol, any revision or new protocol should consider setting new environmental targets for the current decade or longer (e.g. 2020), with the aim of ensuring further progress.

(c) To enable a cost-effective outcome, any revision or new protocol should take into account new scientific knowledge about primary PM and PM precursors, the hemispheric transport of air pollution and the potential synergies and trade-offs to climate change and the nitrogen cycle.

(d) Increased emissions from some sources and sectors that are not appropriately addressed by the current Gothenburg Protocol should be recognized (e.g. shipping emissions).

(e) In order to ensure appropriate links with climate change, new analysis tools such as models, specific to the geographic region or regional circumstances should be developed as needed. For example, for the geographic scope of EMEP, the possibility of setting additional non-binding aspirational goals should also be investigated.

(f) Any revision or new protocol should consider building more flexibility into some of the current annexes and obligations, e.g. with respect to timescales for the implementation of obligations.

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