UNITED NATIONS

E

Economic and Social Council

Distr.
GENERAL

ECE/EB.AIR/WG.5/2007/3
7 February 2007

Original: ENGLISH

ECONOMIC COMMISSION FOR EUROPE

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

Working Group on Strategies and Review

Thirty-ninth session
Geneva, 18–20 April 2007
Item 3 of the provisional agenda

REVIEW OF THE 1999 GOTHENBURG PROTOCOL

Report on the Workshop on Atmospheric Ammonia: Detecting Emission Changes and Environmental Impacts

Note by the secretariat

1. In accordance with the workplan of the Working Group (ECE/EB.AIR/WG.5/2006/9, item 1.8(c)), the Workshop on Atmospheric Ammonia: Detecting Emission Changes and Environmental Impacts was held on 4–6 December 2006 in Edinburgh (United Kingdom). It was organized and supported by the Centre for Ecology and Hydrology (CEH), the Department for Environment, Food and Rural Affairs (DEFRA), the Scottish Executive Rural Affairs Department (SEERAD), COST 729 and the NitroEurope Integrated Project (NEU). Background documents and presentations are available at www.ammonia-ws.ceh.ac.uk/documents.html.

2. The workshop was attended by 80 experts from the following 19 Parties to the Convention: Austria, Canada, Croatia, the Czech Republic, Denmark, France, Germany, Hungary, Ireland, Italy, the Netherlands, Norway, Poland, Portugal, Slovakia, Sweden,

Switzerland, the United Kingdom and the United States. The European Commission, the EMEP[1] Meteorological Synthesizing Centre – West (MSC-W), the International Institute for Applied Systems Analysis and the secretariat were represented.

3. Several bodies under the Convention provided input to the organization of the workshop: the Expert Group on Ammonia Abatement, the Task Force on Emission Inventories and Projections and the Task Force on Mapping and Modelling under EMEP, and the International Cooperative Programme on Mapping and Modelling under the Working Group on Effects.

I. AIMS AND APPROACH OF THE WORKSHOP

4. The objectives of the workshop were to:

(a) Assess the extent to which the existing critical thresholds for ammonia reflect current scientific understanding by:

(i) Examining the case for setting new ammonia critical threshold(s) based on current evidence of direct impacts of ammonia on different receptors;

(ii) Discussing the extent to which vegetation and sensitive ecosystems appeared to be differentially sensitive to ammonia versus other forms of reactive nitrogen (N); and

(iii) Debating the case for establishing indicative air concentration limits for indirect effects of ammonia which would be consistent with current critical loads for N;

(b) Assess the extent to which independent atmospheric measurements can verify where regional changes in ammonia (NH_3) emissions have and have not occurred by:

(i) Quantifying the extent to which estimated regional changes in NH_3 emissions have been reflected in measurements of atmospheric NH_3 and ammonium;

(ii) Distinguishing cases where the estimated changes in NH_3 emission are due to altered sectoral activity or the implementation of abatement policies, and

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

thereby assess the extent to which atmospheric measurements verify the effectiveness of NH_3 abatement policies; and

(iii) Making recommendations for future air monitoring and systems for assessing the national implementation of NH_3 abatement policies and considering the implications of any non-linearities for integrated assessment models;

(c) Review approaches for downscaling transboundary assessments to deal with ammonia hot spots in relation to operational modelling and monitoring by:

(i) Reviewing current emission and atmospheric dispersion modelling methods for downscaling NH_3 dispersion and deposition in hot spots;

(ii) Examining the status of methods for effect assessment and monitoring in hot spots; and

(iii) Recommending broad principles for assessment approaches in ammonia hot spots, including spatial approaches and interactions between transboundary NH_3 emission reduction targets and other policy measures; and

(d) Review mesoscale atmospheric transport and chemistry models in relation to their formulation and results for NH_3 by:

(i) Reviewing emission parameterizations used in the models, establishing comparability, spatial and temporal resolution and uncertainties;

(ii) Reviewing dispersion, air chemistry and deposition formulations identifying key differences and uncertainties; and

(iii) Assessing the overall performance of the models against measurements and against a common reference, and thereupon making recommendations for improving mesoscale models of NH_3 transport and deposition, including the implications of any non-linearities for source-receptor matrices and integrated assessment models.

5. Ms. R. Brankin, Deputy Minister for Environment and Rural Development of Scotland, opened the workshop. She introduced the background and needs of the workshop, highlighting the dependence of future NH_3 strategies on sound scientific evidence. Mr. K. Bull (secretariat)

presented the history and development of the Convention and its Protocols, noting that the workshop was the first one specifically devoted to NH_3 that linked expertise across relevant subsidiary bodies of the Convention. Mr. M. Sponar (European Commission) described the European Union (EU) Thematic Strategy on Air Pollution, noting the increasing importance of NH_3 and highlighting the need for long-term development of an integrated approach to mitigate NH_3 in relation to other policies and other forms of N pollution.

6. On behalf of the organizers, Mr. M. Sutton (United Kingdom) explained that the workshop would consist of four separate working groups and two cross-cutting groups. Each group would produce conclusions and recommendations (sections II and III of this report) that were agreed by the workshop. A full report, including working group reports, background documents, posters and a list of participants, would be published and made available on the website given in paragraph 1 above.

II. CONCLUSIONS

A. Critical levels for gaseous ammonia

7. The current NH_3 critical levels (CLEs) for vegetation under the Convention, agreed in Egham (United Kingdom) in 1992, were based on measurements and observations from the 1980s, mostly from the Netherlands, and were set at 3,300 µg m^{-3} (hourly), 270 µg m^{-3} (daily), 23 µg m^{-3} (monthly) and 8 µg m^{-3} (annual). The workshop concluded that these levels required revision in light of new evidence from field-based experiments and surveys.

8. The existing annual CLE (8 µg NH_3 m^{-3}), when expressed as an equivalent deposition of N to an ecosystem, was less protective than the current critical load for most, if not all, European ecosystems and habitats. Field-based evidence relating effects on vegetation to NH_3 concentrations measured over one year or longer showed that the current annual CLE was too high.

9. A new long-term CLE for the most sensitive vegetation types (lichens and bryophytes) and the associated habitats was proposed, based on observed changes to species composition in the field. Most of the evidence came from studies in the United Kingdom, but there was corroborative evidence from Italy, Portugal and Switzerland. The proposed long-term CLE for NH_3 for (a) sensitive lichen communities and bryophytes, and (b) ecosystems where sensitive lichens and bryophytes were an important part of the ecosystem integrity was set at 1 µg NH_3 m^{-3}.

10. There was less evidence available to quantify the concentrations at which long-term effects of NH_3 caused species changes in communities of higher plants. The workshop proposed a long-term CLE for higher plants of 3 µg NH_3 m^{-3}. This value was set for higher plants in general, but was particularly based on data from heathlands and forest ground flora. Given the larger uncertainties in this estimate, an uncertainty range was proposed of 2 to 4 µg m^{-3}, depending on the degree of precaution appropriate to different contexts.

11. On the basis of current knowledge, it could not be assumed that each of these new long-term CLE values would be protective for periods longer than 20–30 years. No assumptions had been made on the mechanism by which NH_3 exposure led to changes in species composition. Further details could be found on the website of the workshop. By emphasizing long-term rather than daily NH_3 concentrations, the NH_3 critical level was concluded to have the advantage of providing a practical tool complementing the critical loads approach which was simple to apply for cost-effective regulation and monitoring of NH_3 specific measures.

B. Detecting changes in atmospheric ammonia

12. The workshop discussed progress in the state of knowledge in deriving trends from measurements and their use to verify abatement measures or other causes for decrease in emissions of NH_3 to the atmosphere. The workshop identified clear progress in closing the gap between the observed and expected values for reduced N, as well as a better understanding of the reasons behind this.

13. The long-term measurements available followed the emission trend. Current measurements made it possible to evaluate policy progress on NH_3 emission abatement. In those countries where there were big (>25%) changes in emissions, such as in the Netherlands and Denmark, the trend followed closely, especially when meteorology was taken into account. In other countries, such as the United Kingdom, the trend was much smaller, but there was no significant gap between measurements and model estimates. In the Netherlands, there was still an NH_3 gap – a significant (30%) difference between emissions-based NH_3 concentrations and measurements – but the temporal trend was the same. The difference might be due to either an underestimation of the emission or an overestimation of the dry deposition.

14. On the European scale it was difficult to match the emission change, both because of lack of measurements, especially in the eastern part of Europe, and because of the confounding factor of the SO_2 emission reductions, which affect the ammonium concentrations in aerosol and rain water.

C. Assessment methods for ammonia hot spots

15. The workshop agreed that accounting for hot spots for either upscaling of fluxes or risk assessment for nearby ecosystems required a precise description of all processes involved. Hot-spot assessment should also account for background concentrations and deposition history.

16. The key uncertainties in the models were emissions and dry deposition. Sufficient local input data were required for making effects assessments and landscape analyses. For dry deposition, this required better knowledge of NH_3 compensation points and surface resistances for different ecosystems, their dependence on climatic variables and the deposition history for NH_3 and other pollutants.

17. The workshop concluded that using different models allowed the analysis of landscape interactions between sources and receptors with sufficient accuracy for a range of conditions to consider real cases and scenarios. It also allowed the assessment of local, tailored abatement measures.

18. The workshop agreed that scenarios from local-scale modelling could be used in a statistical way to provide estimates of within-grid cell recapture for national- and regional-scale models, linked with global descriptors of the spatial variability in land cover.

D. Regional modelling of atmospheric NH_3 transport and deposition

19. A range of chemical transport models was used across the Convention to model the emission, transport and deposition of atmospheric NH_3 on the national and regional scales. These models had been developed from a range of historical backgrounds and with different purposes. Six models were considered, ranging from the national scale up to the full European scale. The models differed in concept, particularly in their chemical scheme and in scale, ranging from Lagrangian models on the national scale via Eulerian models on the European scale to nested models coupling the European scale with the local scale.

20. Key uncertainties in the modelling of atmospheric NH_3 were linked to emissions (absolute level and spatial and temporal allocation) dry deposition parameterization, spatial resolution of the model and the description of vertical diffusion. All European-scale models (including the EMEP model) currently underestimated the measured NH_3 concentration. National models generally found better agreement with NH_3 measurements. The main reasons for the observed differences between the measured and modelled NH_3 concentrations were the spatial resolution of the models and the parameterization of the dry deposition process.

21. The concentration of ammonium aerosol was fairly well described by all models. However, both under- and overestimates of measured concentrations were found. The magnitude of the wet deposition of ammonium was in general reproduced well by all models.

22. None of the models routinely used the compensation point (bidirectional exchange scheme) as a parameterization in the dry deposition process of NH_3 . This was thought to be one of the reasons why some models tended to underestimate concentrations, particularly in summer. The main reason for not taking this process into account was the lack of a generalized database for the compensation point with respect to the main land cover types used in the models.

23. The siting of measurements played an important role in the comparison with modelled concentrations. Some stations in agricultural areas should not be used for verification of the Eulerian models with large grid size (50 km), because of the significant contribution of sources close to the measurement stations that cannot be simulated by the models on this spatial scale.

E. Reliability of NH_3 emission estimates and abatement efficiencies

24. Few countries had considered uncertainty in NH_3 emissions in detail. Results indicated that national estimates may be accurate to within ±20%. For countries that had created inventories using emission factors (EFs) measured elsewhere, the uncertainty may be around 100%. The greatest uncertainty was likely to be for emission estimates for regions within countries. Sensitivity analysis of the United Kingdom inventory showed that activity data and other information on a range of relevant farming practices were the inputs for which the system was most sensitive. Cattle diets, especially grass-based ones, were considered particularly uncertain.

25. The United Kingdom and Denmark reported a high level of agreement between modelled and measured NH_3 concentrations, while models still underestimated measurements in the Netherlands. A detailed discussion of the Dutch “ammonia gap” suggested that the EFs used in the Dutch inventory were accurate. The discrepancy was considered to result either from overestimation of abatement efficiencies or from overestimation of dry deposition velocities. Adjustment of either could eliminate the gap, but it was not yet known which was responsible.

26. The abatement efficiencies in the guidance document on ammonia to the 1999 Gothenburg Protocol were considered robust. While averages did not reflect the variability in data, quoting ranges may create uncertainty regarding which point in the range is most appropriate to use. Since data were obtained almost exclusively from Northern and North-Western Europe, abatement efficiencies could not be assumed to be applicable across the whole

UNECE region. Only a brief statement is given in the guidance document on the impacts of reducing emissions of NH_3 following spreading on losses of other N pollutants, because nitrate leaching and nitrous oxide emissions tend to be site- and season-specific.

27. “Soft” approaches to NH_3 abatement were those implemented using basic facilities and simple management approaches (e.g. applying manure during weather conditions associated with little emission). While these offered an economically attractive method of reducing NH_3 emissions, it was often difficult to know their uptake by farmers and their efficiency, and therefore to convince environmental authorities of their effectiveness or to measure the achievement in national reporting.

28. Experience from the adoption of abatement technologies in other areas, suggested that *ex ante* cost assessments tend to overestimate the cost of implementation. However, taking emerging technologies into the industry could lead to a reduction in abatement efficiency. A number of emerging abatement options would be discussed in the full report of the workshop, together with a summary of other developments that may affect NH_3 emissions.

F. Ammonia policy context and future challenges

29. Ammonia emissions are major contributors to eutrophication and acidification of ecosystems and secondary $PM_{2.5}$ concentrations in Europe. Reduction of NH_3 emissions in Europe has been on the agenda for more than a decade, first on a national scale (e.g. in the Netherlands) and more recently through international efforts. The latter include the Convention’s Protocols and EU directives and strategies.

30. The workshop considered the policy context of the NH_3 problem, including socio-economic, environmental, institutional and technological aspects, and the potential role of policy options in mitigating the ecosystem and health impacts of NH_3 emissions. The need to adapt tools used in policy analysis, such as integrated assessment models, and to consequently evaluate policies in view of new findings was also considered.

31. Ammonia policies were becoming interlinked with a number of other environmental and agricultural policies. In order to avoid the problem of “pollution swapping”, future policies needed to consider these interactions.

32. The workshop noted that, in responding to some of the policies like the EU Nitrates Directive (91/676/EC) or biodiversity-related directives, farmers in certain areas adjusted agricultural practices (e.g. by shifting application of manures from autumn to spring). This led to

different seasonal patterns of NH_3 concentrations, although there was little knowledge of the environmental consequences.

III. RECOMMENDATIONS

A. Critical levels for ammonia

33. The workshop recommended:

(a) A revision of the currently set values of the ammonia critical level, since the data reviewed show that the existing CLE values of 3,300 µg m^{-3} (hourly), 270 µg m^{-3} (daily), 23 µg m^{-3} (monthly) and 8 µg m^{-3} (annually) are not sufficiently precautionary;

(b) A new long-term CLE for lichens and bryophytes, including for ecosystems where lichens and bryophytes are a key part of the ecosystem integrity, of 1 µg m^{-3};

(c) A new long-term CLE for higher plants, including heathland, grassland and forest ground flora and their habitats, of 3 µg m^{-3}, with an uncertainty range of 2–4 µg m^{-3}; the workshop noted that these long-term CLE values could not be assumed to provide protection for longer than 20–30 years;

(d) Retaining the monthly critical level (23 µg m^{-3}) as a provisional value in order to deal with the possibility of high peak emissions during periods of manure application (e.g. in spring); and

(e) Research to improve the future estimation of NH_3 critical levels. This included addressing uncertainties relating to the shortage of observational data and long-term NH_3 concentration measurements, particularly in Southern and Eastern Europe. Similarly, there was a need for a better understanding of the mechanisms whereby NH_3 affected plants, especially over decadal timescales, so that predictive models could be constructed for extrapolation to other types of vegetation and land use in different climatic zones.

B. Detecting temporal changes in atmospheric ammonia

34. The workshop recommended:

(a) Exploring further the gap between measurements of NH_3 concentrations and model estimates, especially by: investigating high temporal resolution measurements; improving emission/deposition modeling; having a model inter-comparison with countries whose models do not show a gap and through uncertainty analysis;

(b) Fully implementing the EMEP monitoring strategy and improving the model treatments of NH_x in order to quantify the influence of a changing chemical climate. The EMEP monitoring strategy could be a good starting point for the development of a strategy focused on the appropriate questions. It was necessary to evaluate policies and indicators derived from them (in time and space). Using existing models, a pre-modelling study should select the monitoring sites that would eventually respond to the basic (policy) questions by using improved models and assessment tools. The best and most economically feasible instrumentation should be selected, and an extensive programme of quality assessment and quality control (QA/QC) should be used to make measurements comparable. After implementation, especially for trend evaluation, the monitors used should not be changed.

C. Assessment methods for ammonia hot spots

35. The workshop recommended:

(a) Further developing dynamic NH_3 emission models to estimate the diurnal and seasonal changes in emission strengths from point sources (animal houses) and area sources (land spreading of animal manure). For area sources in detailed plot studies, this should include the effects of meteorological and soil variables;

(b) Synthesizing information from available databases to identify reference cases against which different models could be tested and compared. It was agreed that an inter-comparison of regional-scale and subgrid models would greatly help in highlighting the differences between the modelling approaches and the abilities of regional models to simulate local-scale interactions;

(c) Investigating scenarios of the possible effect of in-grid fragmentation of land use on net NH_3 fluxes. A sensitivity study would allow the investigation of the range of local recapture and possible effects on air quality. It was proposed that Parties should promote the development of deposition measurement methods that could apply to advective conditions (e.g. one measurement height) to allow verification of dispersion/deposition models.

D. Regional modelling of atmospheric ammonia transport and deposition

36. The workshop concluded that more data were needed to provide a generalized scheme for ammonia compensation points with respect to the main land cover types in models. The models should carry out sensitivity tests with implementations of the compensation point (bi-directional exchange) schemes to estimate the magnitude of the effect on the dry deposition in the model.

37. Currently, differences in model performance between countries were not fully understood. These might reflect (a) differences in the quality of the NH_3 emissions inventory, (b) differences in the model parameterization schemes, (c) geographical differences (climate, terrain), or (d) differences in measurement data sets. Hence a coordinated comparison of regional atmospheric ammonia models, using a common model domain, input database and measurement database, was urgently needed to assess relative model performance.

38. In many countries, better data (on emissions and monitoring) were available for national modelling efforts than those submitted under the Convention. EMEP reporting must be made more flexible to improve data availability.

E. Reliability of ammonia emission estimates and abatement efficiencies

39. The workshop recommended devoting effort to estimating the uncertainty of regional and national NH_3 emission inventories. In particular, there was a need for international collaboration to obtain better activity data regarding agricultural management practices across Europe. This information was not typically available from statistical sources and was a key uncertainty in regional emissions.

40. Moreover, there was a need for further measurement data to underpin regional estimates of NH_3 emissions. In particular, data were needed from Southern and Eastern Europe. The workshop recommended devoting more effort to examining the quantitative synergies and trade-offs that occur in abating different forms of nitrogen emission (NH_3, nitrous oxide, nitrate leaching).

41. Noting that “soft” approaches to NH_3 abatement were an economically attractive method of reducing NH_3 emissions, the workshop recommended putting further research effort into methods to quantify the achievement of such approaches, so that the benefits could be considered within the Convention.

F. Ammonia policy context and future challenges

42. Considering the N trade-offs, the workshop recommended the extension of currently used tools, verification of specific elements of the models, adaptation of monitoring networks, targeted measurement programmes, and possible revision of legislation in order to close existing loopholes and increase synergies in addressing nitrogen pollution at large. Priority should be given to measures aiming at reducing all kinds of nitrogen losses at farm level. Ammonia emission reduction policies must be analysed in a multi-effect (human health, greenhouse balance, acidification and eutrophication and related biodiversity loss), multi-media (air, water, soil), multi-scale (hot spots, regional, European, global) framework.

43. Considering the recommendation to lower critical levels for NH_3, there was a need for careful evaluation of the representativeness of EMEP modelling results for NH_3 concentration. It was also recommended to give further consideration to whether, and if so, how, the new critical levels would be used in addition to critical loads in formulating air pollution targets, especially on local or regional levels in areas with spatially variable NH_3 emissions and concentrations.

44. Considering the increase in springtime NH_3 emissions that had occurred in implementing some policies such as the EU Nitrates Directive, further research was recommended to quantify the seasonal dependence of environmental impacts of NH_3. More attention was also needed on how to monitor and incorporate impacts of other N-related policies in modelling tools.

45. It was recommended to explore possibilities of considering local Biodiversity Action Plans in larger scale modelling. Strategies existed to integrate them into the European scale, e.g. via the Flora Fauna and Habitats Directive and Natura 2000 network. However, the role of air pollution effects was often not explicitly taken into account even though N inputs had a large effect on biodiversity; there was room for improvement on local, national and European levels.