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AMMONIA EMISSION AND ABATEMENT OPTIONS IN AGRICULTURE

Report by the Chairmen of the Expert Group on Ammonia Abatement and the Task Force on Emission Inventories and Projections expert panel on agriculture and nature in collaboration with the secretariat

Introduction

1. In accordance with the work-plan for the implementation of the Convention (ECE/EB.AIR/79/Add.2, annex XII, item 1.9), and at the invitation of the Government of Poland, the Expert Group on Ammonia Abatement held a joint meeting with the panel on agriculture and nature of the Task Force on Emission Inventories and Projections on 29-30 April 2004, in Poznan, Poland. The meeting included a one-day workshop devoted to assisting countries with economies in transition in the areas of emission inventories and ammonia emission abatement options and costs. Experts from the following Parties attended: Austria, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Lithuania, Netherlands, Norway, Poland, Russian Federation, Slovenia, Spain, Switzerland, Ukraine and United Kingdom. A representative of the European Commission's Joint Research Centre (JRC) was present, as was a member of the Convention's secretariat. A representative of the European Fertilizer Manufacturers Association (EFMA) was also present. Proceedings of the workshop will be published by Poland and made available at: http://www.ibmer.poznan.pl/.

2. Mr. Jim WEBB (United Kingdom) chaired the meeting, with the assistance of Mr. Ulrich DÄMMGEN (Germany), Chairman of the panel on agriculture and nature of the Task Force on Emission Inventories and Projections. He thanked Poland for hosting the meeting, noting it was important to take account of abatement measures in Eastern and Western Europe, and in other regions, as well as to understand the wider aspects of ammonia reduction techniques, such as the effects on other pollutants.

3. The meeting was opened by Mr. T. KUCZYNSKI (Poland), who welcomed the participants on behalf of the Polish Ministry of Agriculture. He stressed the importance of sharing, with countries with economies in transition and countries acceding to the European Union, information on inventories and projections of ammonia emissions as well as tools and methods for their abatement.

4. The secretariat explained the background and mandate of the Expert Group, as adopted by the Executive Body at its twenty-first session, and reported on the status of ratification of the 1999 Gothenburg Protocol. As of April 2004, the Protocol had nine ratifications, so needed seven more to enter into force. The work of the Expert Group was considered preparation for the review of the Protocol. In accordance with article 10, paragraph 2 (c), of the Protocol, the first review shall commence no later than one year after the Protocol enters into force.

I. AMMONIA EMISSION INVENTORIES AND ABATEMENT POTENTIAL

5. Dynamic emission calculation model for ammonia. Mr. H. MENZI (Switzerland) reported on ammonia emissions in his country, noting that under the Gothenburg Protocol Parties would have to report their ammonia emissions annually. Previous emission inventories in Switzerland were not sufficient to show the development of ammonia emissions over time because statistics on manure systems and management were scarce and relevant data on manure management were based on expert assumptions. Previous emission inventories, moreover, did not give reliable regional resolution. Switzerland had developed a dynamic emission calculation model (DYNAMO) as well as a representative survey on relevant farm management parameters. DYNAMO was a user-friendly empirical nitrogen-flux model. The stratified survey on farm management practices included housing, hardstandings, manure handling, etc. An assessment of abatement potential showed that full grazing of cattle resulted in large reductions in ammonia emissions. Storage techniques alone could also achieve a slight reduction. However, a higher rate of abatement could be attained through a combination of measures (full grazing, immediate incorporation of manure and storage).

6. Emissions from animal husbandry. Ms. B. AMON (Austria) reported on emission inventories in her country and research on emissions from animal husbandry. Austria had updated its ammonia and greenhouse gas inventory for the years 1989 to 2002, and aimed to reduce

uncertainties. Nearly 75% of ammonia emissions in Austria came from cattle. There was a need for: emission factors for straw-based systems; information on nitrogen excretion in organic and conventional systems; and activity data, including information on how farmers kept their animals and how they handled manure. The aim was to quantify emissions of ammonia, nitrogen gas and methane from the whole manure management continuum. It was important to ask whether there was a contradiction between animal welfare and environmental protection; for example, straw-based systems for pigs were considered more compatible with animal welfare, though detrimental to the environment.

7. Harmonizing ammonia emissions modelling. A representative of the European Agricultural Gaseous Emissions Inventory Research Network (EAGER Group) explained that the network was initiated to attain comparability in inventories and to allow a coordinated implementation of the Gothenburg Protocol. The EAGER Group had held two workshops, aiming at congruency between emission models and emission inventory approaches. He recommended that all countries should adopt the total ammoniacal nitrogen (TAN)-flow approach and that modelling should be extended to all nitrogen and carbon species.

8. The mass flow approach, including nitrogen species other than ammonia. Mr. DÄMMGEN described the mass flow approach, including nitrogen species other than ammonia, and related problems. The CORINAIR Atmospheric Inventory Guidebook favoured the mass flow approach for nitrogen and carbon species dealing with the flow of TAN. Such models should be expanded to account for other losses of nitrogen and carbon to provide a complete nitrogen and carbon balance.

9. Modelling ammonia emissions as input to dispersion models. Mr. N. HUTCHINGS (Denmark) discussed the linkages between deposition data and emissions. He said the EMEP atmospheric dispersion model included seasonal ammonia emissions as an input, which were currently taken from the annual values of ammonia given in national emission inventories. It aimed to reflect average climate and abatement measures. He reported moreover on a simple dynamic mass flow model developed (Pinder et al., 2004) for dairy cattle and slurry that was extended to other animals. This model was used to show inter-annual and seasonal variation, respond to abatement measures and improve emission information. Results indicated that differences in emissions between summer and winter were fairly large, though it was possible that seasonal variations were overestimated.

10. European greenhouse gas emission from agriculture. Mr. A. LEIP (JRC) reported on European greenhouse gas emissions from agriculture and the possibilities for improving the European Commission's inventory under the United Nations Framework Convention on Climate Change. The main areas of concern for the Commission were the emissions of nitrous oxide from agricultural soils, ammonia emissions from enteric fermentation and the nitrogen balance in livestock production systems. Important issues for the latter were the availability of activity data

e.g. from the Statistical Office of the European Communities (EUROSTAT), as well as linkages to the EAGER Group. JRC had developed a list of parameters that would help improve the greenhouse gas inventories from the agricultural sector in the framework of the Eurostat farm structure survey (2000). A number of countries had been surveyed on storage capacities and stocking capacities for animal waste. He noted that there would be an expert meeting on greenhouse gas emissions from agricultural soils from 21 to 22 October 2004 (following the next meeting of the Task Force on Emission Inventories and Projections from 18 to 20 October 2004) in Ispra (Italy) and that JRC sought further cooperation with groups under the Convention, such as the Expert Group on Ammonia Abatement. He showed results from a questionnaire for the reporting of nitrous oxide emissions from agricultural soils under the United Nations Framework Convention on Climate Change, which would be the basis for the expert meeting. JRC was also involved in projects with the new countries of the European Union, including one projecting the impact of agriculture on greenhouse gas fluxes in Eastern Europe, and a workshop on the common agricultural policy (CAP) and the impact of structural changes in agricultural systems on greenhouse gases and air pollutants. He described the Eurostat land use/cover area survey, a survey of 5000 farmers in 15 countries of the European Union. The survey asked questions about technical practices (irrigation, winter cropping, sowing), the use of fertilizers, plant protection products, agri-environmental measures, erosion, etc.

II. PROJECTED AMMONIA EMISSIONS FOR 2020

11. Experts discussed baseline projections for 2010, including economic development, manure policy, emission abatement measures and their application rates, as well as uncertainties in ammonia emissions for 2010. Calculations by the Netherlands forecast a 33kilotons reduction (24%) since 2000. Calculations by the United Kingdom showed projected ammonia emissions dropping substantially between 2005 and 2010, a further slight decrease and then a levelling-off. These projections were based entirely on projected decreases in numbers of cattle, pigs, sheep and hens that were expected to cease around 2010. Where the United Kingdom was not seen to be actively taking measures to reduce emissions in agricultural emissions, the natural levelling-off of numbers of farm animals would bring about the necessary reductions, according to projections. Decreases in dairy cow numbers were mainly due to increases in milk yields; nitrogen excretion would increase and hence so would emissions per cow. Increasing the housing period of cattle was likely to increase ammonia emissions. All projections were subject to large uncertainties.

12. In Denmark, methods for calculating projections applied the mass flow principle, using total nitrogen (not TAN), as well as the need to update emission factors. The ammonia emission target for Denmark under the Gothenburg Protocol was 79kilotons by 2010; projected emissions were 88kilotons, based on existing calculations. There were expected to be side effects of nitrate legislation, since the whole of Denmark was considered to be a nitrogen-sensitive area. Many measures had already been applied, such as covering of manure during storage and rapid

incorporation or injection. The ammonia emission target for Poland under the Gothenburg Protocol was 466kilotons. Even without taking particular measures, emissions were already well below 300kilotons. In Ireland, projections for 2020 were extremely speculative, with economists projecting only as far as 2014, based on the European Union's CAP. The 2010 target for ammonia emissions under the Gothenburg Protocol was 116kilotons, while projected emissions were 110kilotons. Emissions peaked in 1999 at 127kilotons, representing a marked decrease over previous years. In Ireland 87% of ammonia emissions came from manure and 13% from fertilizers. In Switzerland, projections of ammonia emissions were considered impractical since it was impossible to predict how livestock production would develop. Official figures reported by the Ministry of Agriculture showed livestock increasing, though it was difficult to determine the impact of the expanded market in Europe. Based on known measures, projections showed a levelling-off of ammonia emissions between 2000 and 2020.

13. In Germany, there had been little change in emissions since the reduction in animal numbers resulting from reunification. There was a slight increase due to increased milk yield per cow and slight changes in grazing times. Current ammonia inventories included projections to 2020, but did not include non-agriculture sources. According to current projections, Germany might have problems fulfilling its commitments under the Gothenburg Protocol.

14. In Italy, it was assumed that the number of pigs and poultry would not increase in the near future, the number of dairy cattle would be reduced, but milk production would increase. This would lead to an ammonia emission reduction of around 13kilotons in the pig sector. For poultry, considering that many farms had already adopted best available technology (BAT), a 22kilotons reduction in ammonia emissions was foreseen by 2010. For the cattle sector, it was more difficult to estimate, but would approximate to the 10% reduction required under the Gothenburg Protocol. Other reductions would take place in the fertilizer sector.

15. In Austria, projections to 2020 showed a reduction in dairy cow numbers due to higher milk yields per cow, a slight reduction in calf numbers, a slight increase in suckling cows (an increase smaller than the decrease in dairy cows) and little change in the numbers of sheep and goats. The share of slurry and farmyard manure, the trend in animal housing and the share of low-emission manure application techniques remained uncertain. In Spain, the number of animals was expected to increase slightly in the coming years, thus increasing emissions. However, other factors, such as the size of farms, would allow for a decline. The trend was toward larger farms, which tended to be more environmentally efficient. The Spanish inventory was fairly comprehensive and, though it was fairly recent it did not take account of non-agricultural ammonia emissions. In Norway, the ceiling for ammonia emissions under the Gothenburg Protocol was 23kilottons, while projections for 2003 were estimated at 22.9kilotons, indicating that the target would probably be reached. There were, however, great uncertainties in agricultural emissions, which accounted for 89% of ammonia emissions in Norway.

III. COSTS OF AMMONIA ABATEMENT TECHNIQUES

16. In Italy various techniques were used in retrofitting farms and in housing pigs and poultry in an effort to reduce ammonia emissions. Costs clearly increased when combining both BAT and retrofitting, depending on the phase in which the various measures were introduced, though the abatement potential was high. In the United Kingdom, costing of abatement techniques usually followed the approach set out in the integrated pollution, prevention and control (IPPC) BAT reference (BREF) guidelines on calculation of annual costs (96/61/EC of 24 September 1996). In future, the United Kingdom would: review emerging techniques; cross-check calculated costs with actual farm costs; develop a range of costs for different farm sizes; and develop assessments of affordability.

17. In Poland, research on ammonia emission abatement techniques and costs was scarce. In accordance with a Council of Ministers regulation of 24 September 2002 on investments in the breeding of animals, environmental impact reports were obligatory. Poland had made cost calculations of emission reductions based on the available data and statistics from other countries. The Ammonia abatement potential depended on animal production, the structure of farming (large vs. small, intensive vs. extensive), regulations to control ammonia, and the technical and economic availability of measures in housing, manure storing and spreading. In predicting future ammonia emissions, further knowledge on critical loads of ammonia for various ecosystems was needed. Further development of data on the effects of ammonia on particulate matter <2.5µm (PM 2.5) or tropospheric ozone formation, transport distances and wet deposition was also needed.

18. Spain was currently implementing the IPPC BREF concerning agriculture. A common methodology on ammonia abatement was necessary, since calculation costs in the BREF differed widely from country to country. Calculations had been made based on the IPPC reference document on BAT for intensive rearing of poultry and pigs. Costs were calculated for feeding techniques, animal housing, storage and spreading and were based on the technical description (building capacity, feed storage bin, distribution auger, power requirements, etc.), as well as assumptions (feed storage, prices of protein feed, weight, feed consumed, ratio occupation of the building, cleaning and disinfection). A two-year project was under way to evaluate BAT and to estimate ammonia emissions. Effective and low-cost conditional BAT would be promoted.

19. In Germany, cost calculations did not take sufficient account of affordability. Abatement measures included housing, feeding, storage and application. For storage, calculations had been made for covering slurry stores and enlargement of storage capacity. Regarding the rapid incorporation of fertilizer, 50% of costs were attributed to manure and the other 50% to the farm at large. Incorporation of manure after application was the most cost-effective measure for reducing emissions, as was the trailing hose for pigs. The use of band-spreaders for cattle slurry

was less effective. The merits of deep and shallow injection of manure were currently being debated.

20. New development on animal housing systems and their costs in the Netherlands. In the Netherlands, agreement was reached with the farmers' union on a 50% emission reduction potential for various animal housing measures. One technique for housing rearing pigs was partly slatted floors with concrete slats and manure surface cooling. Another system had a convex floor with concrete slats and slanted walls in the manure pit, which reduced the emitting surface for each pig. In addition, the system of bio-scrubbers doubled the manual labour, but the ammonia emissions were low. For farrowing sows including piglets, effective housing was the farrowing pen with floating cooling fins or with manure pans beneath the floor. The latter were developed in France for hygienic reasons and resulted in high reductions of ammonia. Another method was the farrowing pen with coated water and manure channels. For mating and gestating sows, one method was the flushing system with manure gutters and odour peaks. One of the newest methods was the group housing system without straw with slanted walls underneath. For weaned piglets, convex floors with triangle iron slats were cost-effective.

21. Particulate matter (PM10) emissions in agriculture. The Expert Group discussed the need for more comprehensive information on particulate matter emissions. Agricultural sources of particulate matter included both plant and animal production. Plant production included both food and non-food production. Animal production included particles from feed management on the farm and in nature. Other emission sources included on-field burning of stubble and straw. An expert meeting in The Hague (Netherlands) on 16-17 June 2004 would prepare a draft version of a guidebook chapter on particulate matter. The results would be presented to the Task Force on Emission Inventories and Projections. A workshop on control technologies for particulate matter would be held on 23-25 June 2005 in Indianapolis (United States) as part of the Air and Waste Management Association's Sixth International Urban Air Quality Forum.

IV. UPDATING THE GUIDANCE DOCUMENT ON CONTROL TECHNIQUES FOR PREVENTING AND ABATING EMISSIONS OF AMMONIA

22. The Expert Group discussed procedures for updating the Guidance Document (EB.AIR/1999/2, chap.V) in preparation for the eventual review of the Protocol, once it entered into force. Mr. G. BONAZZI (Italy) proposed changes to the sections on housing of pigs and regarding techniques for housing systems for dairy and beef cattle, among other techniques. The Expert Group noted that it would be important to harmonize the Guidance Document with the relevant IPPC BREFs, in particular the BREF on intensive livestock farming, although this did not cover cattle. The Guidance Document could outline the principles involved, referring to the BREF document for more detailed explanations. A small informal working group comprised of experts from Denmark, Germany, Italy, Netherlands, Spain, Switzerland and the United Kingdom would

undertake the work, eventually using a web-based approach.

V. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

23. The Expert Group agreed that:

(a) Current inventories in many countries were not adequate to quantify changes over time, mainly due to a lack of data on agricultural activity;

(b) There was a need to address the continued absence in many countries of reliable agricultural activity data, in particular information on how countries were handling and housing animals, storing and handling manure and on the amounts and types of straw and how it was used. The Swiss experience in collecting activity data could be used as a model;

(c) Since the problem of agricultural activity data had not previously been sufficiently recognized in accession and East European countries, the convening of a meeting of the Expert Group with one day devoted to the specific problems of agricultural emissions in countries with economies in transition was appreciated and this area would require further attention in future;

(d) The EUROSTAT farm structure survey, which was carried out every ten years, could provide useful activity data, as could the EUROSTAT land use/cover area survey

(e) Several experts would work together to identify the most important categories of agricultural activity data to be included in future farm surveys and report to the Expert Group at its next meeting;

(f) The EAGER Group recommended that countries harmonize modelling along the lines of the TAN-flow approach to calculating national ammonia emissions as used in the DYNAMO (Switzerland), GAS-EM (Germany) and National Ammonia Reduction Strategy Evaluation System (United Kingdom) models, and also recommended that such models should be expanded to account for other losses of nitrogen and carbon to provide a complete nitrogen and carbon balance;

(g) It was important to reconcile reducing ammonia emissions with the need to avoid increasing emissions of other pollutants, such as nitrate, nitrous oxide and methane;

(h) There was a need to combine efforts in agriculture and environmental protection in order to improve information on farm practices, as well as to reconcile the need for improved animal welfare with the desire to reduce agricultural ammonia emissions;

(i) Emissions needed to be calculated on a seasonal basis in order to provide a link with dispersion modelling;

(j) Independent verification of emissions was needed. The most effective way to do this would be by comparing them with measured concentrations of ammonia in the atmosphere, using a single model;

(k) In anticipation of the Gothenburg Protocol entering into force it would continue its work preparing updates to annex IX to the Gothenburg Protocol on measures for the control of emissions of ammonia from agricultural sources as well as to the Guidance Document on Control Techniques for Preventing and Abating Emissions of Ammonia (EB.AIR/1999/2, chap. V), in particular the section on straw-based housing;

(l) Projections of animal numbers were considered too uncertain to be a reliable basis for future estimates of ammonia emissions; for dairy cattle, total milk production was seen as a better indicator of ammonia emissions than numbers of animals;

(m) Cost-effective measures to abate ammonia were often too expensive and, in certain cases, might mean that farms would be required to cease operations;

(n) Cooperation with the Expert Group on Techno-economic Issues should continue, in order to further develop information on costs and cost-curves for ammonia abatement techniques and their applicability and reduction efficiencies. The results of the meeting of the Expert Group on Ammonia Abatement, as well as the results of the questionnaire developed by the International Institute for Applied Systems Analysis (IIASA) on farm practices should be disseminated at the next meeting of the Expert Group on Techno-economic Issues (18 June 2004);

(o) A small informal group would do preliminary work on updating the Guidance Document taking into account the IPPC Bref (large pig and poultry units), in order to prepare for the eventual review of the Gothenburg Protocol. The group would be comprised of experts from Denmark, Germany, Italy, Netherlands, Spain, Switzerland and United Kingdom and would possibly meet in Spain during 2004;

(p) The Government of Spain would host the next meeting of the Expert Group in spring 2005, possibly in Segovia.