Policy options and tools for nitrogen management and ammonia emission reductions that could be included in revision of the Gothenburg Protocol.

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Summary: The focus of the UNECE Ammonia Workshop is on the revision of the 'Guidance document on preventing and abating ammonia emissions'. This note sets this task in relation to ongoing revision of the Gothenburg Protocol, especially concerning the willingness of parties to reduce emissions. The note emphasizes how it is important to see ammonia mitigation as part of reducing the waste of valuable nitrogen resources to air and water. For example, in 2022 (year of high fertilizer prices), nitrogen wasted from the EU agri-food system was worth around €60 billion, equivalent to the total cost of the Common Agricultural Policy. This illustrates how investment to reduce ammonia and wider nitrogen emissions can contribute to farm competitiveness across the UNECE region. The note distinguishes between those parties to the Air Convention who have already reduced ammonia emissions substantially, and those parties who have only recently or not yet started. Where a party has already halved its ammonia emissions, further action to halve emissions again are likely to be tough, requiring costly or controversial measures. However, this is not the situation for most Parties, where the first actions yet to be taken include many low-hanging fruit. In this case, investments can save costs by moving to a more circular system with reduced dependence on new nitrogen inputs. The note finishes by reflecting on the actions and tools available to policy makers to revise the protocol.

Systems thinking for ammonia and nitrogen

1. Nitrogen management and ammonia (NH_3) mitigation are intimately linked. Both represent multi-sectoral challenges, including agriculture, transport, energy and other sources, while the cascade of nitrogen interactions in the atmosphere and wider environment link ammonia with a wide range of other pollutants, including nitrogen oxides (NO_x) and nitrous oxide (N_2O) emissions to air, together with leaching/run-off to water of nitrates (NO_3^-) and other reactive nitrogen (N_r) compounds.
2. Inefficiencies in the use of reactive nitrogen contribute to the loss of these compounds to the environment, which represent both environmental pollution and a waste of economically valuable resources. In addition, denitrification of N_r back to di-nitrogen (N_2) represents one of the largest terms, thereby contributing with the other losses to 'nitrogen waste'[1] and the associated waste of money.
3. Reactive nitrogen compounds are intentionally manufactured to make fertilizers to support food and bio-energy production. The different loss terms contributing to total 'nitrogen waste' (i.e. emissions and losses of NH_3, N_2O, N_2, NO_x, NO_3^- etc) lead to a low 'nitrogen use efficiency' (NUE) in agriculture and across the wider economy. This means that emissions of N_2 (as one of the largest terms) also contribute indirectly to pollution, because more freshly manufactured inputs are needed to achieve the same food and energy goals, which ultimately increases emissions of the N_r pollution forms.
4. Global society typically operates a linear system for nitrogen flows. We make nitrogen compounds intentionally (as well as unintentionally in the form of NO_x), but only a small fraction

[1] 'Nitrogen waste' is seen as the loss of reactive nitrogen resources, from all activities in all sectors, including emissions of NH_3, NO_x, N_2O, leaching of NO_3^- and other N_r compounds, and wasteful denitrification (and other 'unfixing') of N_r compounds to N_2 where the stored energy is not recovered (see ECE/EB.AIR/149).

is used gainfully. Globally, around 80% is wasted to the environment.[2] One of the core challenges going forward is to transform to a more circular nitrogen economy, where losses are reduced and organic residues containing nitrogen are recovered and reused. This means that existing N_r production (whether from industrial production or biological nitrogen fixation) can go further, meaning that less new inputs are needed, reducing pollution and benefiting the economy. It shows how reducing N_r pollution is good for food security, as N_r resources are used more effectively, in addition to the benefits of reducing crop loss due to tropospheric ozone pollution caused by NO_x emissions.

5. The scale of the wasted nitrogen resource is huge. At 2022 prices (c. €2.8/kg N), nitrogen wasted from the agri-food chain alone was worth around €60 billion across the EU.[3] This is similar to the total annual cost of the EU Common Agricultural Policy. Although fertilizer prices have now decreased to less than half of this, the illustration shows how smart nitrogen management is good for farmers and the wider economy. This becomes even more clear when the societal costs of nitrogen pollution are considered, which are even larger (estimated by the '*European Nitrogen Assessment'* at €70-320 billion per year).[4]
6. The International Nitrogen Management System (INMS) is currently working to extend such estimates as part of the first '*International Nitrogen Assessment*',[5] which is showing how integrated sustainable nitrogen management can reduce NH_3, N_2O, N_2, NO_x, NO_3^- losses, giving multiple benefits, for human health, while helping to protect terrestrial and aquatic systems from degradation and biodiversity loss. As emphasised by the '*Nitrous Oxide Assessment*' published in 2024, [6] such an approach also offers long-term climate benefits, at the same time as safeguarding against a future where growing N_2O emissions would otherwise reverse progress made by the Montreal Protocol in protecting the stratospheric ozone layer.

Changing societal perceptions about reducing ammonia emissions

7. When the Gothenburg Protocol was signed in 1999, the challenge to abate ammonia emissions seemed new to many Parties. As a consequence, the emission ceilings agreed were rather unambitious compared with other pollutants, while Annex IX represented a basic 'first step'. Even at that time, however, mitigation of ammonia was not actually new. Ammonia mitigation research in leading countries such as the Netherlands had been ongoing since the 1980s.
8. During 2008-2012, in preparing for revision of the Gothenburg Protocol in 2012, engagement by the Task Force on Reactive Nitrogen (TFRN) showed how ammonia mitigation techniques had matured substantially. This led to a full revision of the UNECE '*Guidance document on preventing and abating ammonia emissions from agricultural sources*' (ECE/EB.AIR/120), as well as a detailed update of costs estimates.[7,8] In 2012, it proved not possible for Parties to update Annex IX as part of the revised Gothenburg Protocol, which can be clearly attributed to political barriers. The message from the scientific community represented by TFRN was clear: many

[2] UN Environment Assembly Resolution 4/14.
[3] Based on estimates from Chapter 16 of the *European Nitrogen Assessment*.
[4] *'European Nitrogen Assessment'*. Sutton et al. (2011). Cambridge University Press: http://www.nine-esf.org/node/360/ENA-Book.html Annual costs were updated to €75-485 billion by van Grinsven et al. (2013) https://pubs.acs.org/doi/10.1021/es303804g
[5] https://www.inms.international/international-nitrogen-assessment. For publication later in 2025.
[6] INMS cooperated with the Climate and Clean Air Coalition (CCAC) to produce the joint '*Nitrous Oxide Assessment*' as a fast-track appetizer to the full *International Nitrogen Assessment*. See: https://www.unep.org/resources/report/global-nitrous-oxide-assessment
[7] Published as '*Options for Ammonia Mitigation*' (Bittman et al., 2014) https://www.clrtap-tfrn.org/content/options-ammonia-abatement-guidance-unece-task-force-reactive-nitrogen
[8] Reis et al. (2015) 'Costs of ammonia abatement and the climate co-benefits'. https://link.springer.com/book/10.1007/978-94-017-9722-1

cost-effective methods for ammonia emission abatement are available and are well justified. However, it was understood that there were fears expressed by some agricultural stakeholders that action on ammonia might represent a burden to that sector.

9. Building on the early mitigation efforts of the 1980s, substantial progress has been made in building confidence in ammonia mitigation methods, especially over the last 20 years. There is now a mature body of experience in applying ammonia mitigation methods at scale that range from improved animal feeding strategies and animal housing, to covered manure storage, low-emission manure spreading and low-emission fertilizers. The costs of such methods are typically low, and investment can often offer profit opportunities for farmers (where the cost of investment is paid back by the value of nitrogen savings), in addition to the health, ecosystem and wider environmental benefits. Cost-curves show a clear distinction between the most obvious immediate actions and the most ambitious measures that do come with significant costs (e.g., re-building of animal housing with low emission systems). A comprehensive global analysis prepared by INMS showed how ammonia mitigation is more cost-effective than further mitigation of nitrogen oxides, when considering the health benefits.[9]
10. The activities of TFRN have also highlighted that many citizens in Europe are eating more meat and dairy than is needed for a healthy diet. Two Special Reports of the European Nitrogen Assessment, prepared by TFRN, have quantified how healthy diet scenarios would reduce ammonia and other forms of nitrogen pollution simultaneously. The '*Nitrogen on the Table*' report showed that a 'demitarian' approach across Europe (half meat & dairy scenario) could reduce ammonia emissions by 40% even without including any technical measures.[10] More recently, the '*Appetite for Change*' report has outlined pathways and options that could help achieve such changes, estimating that the most acceptable way to an ambitious mitigation to 'halve nitrogen waste' by 2030 (consistent with the Kunming-Montreal Global Biodiversity Framework, Target 7) would be to share actions across society, between farmers, consumers and other actors.[11]
11. Through 2015-2020, the Air Convention has pioneered new ground with development of the UNECE 'Guidance Document on Integrated Sustainable Nitrogen Management' (ECE/EB.AIR.149).[12] This outlines the principles of sustainable nitrogen management, describes over 75 measures (with a focus on agriculture and land management) and then shows how to develop coherent 'measures packages' according to context. The core philosophy is that ammonia mitigation is seen as part of this wider approach, so that cost-effective measures can improve nitrogen use efficiency, reduce nitrogen waste and pollution (and its adverse effects), and contribute to improved farm profitability at the same time.
12. After around 40 years of research, application and testing, ammonia emission mitigation is thus very well established. With upscaling, mitigation costs have tended to decrease, while price spikes in the cost of nitrogen fertilizers, have encouraged leading farmers to invest in adopting low-emission technologies, as part of integrated sustainable nitrogen management.

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[9] Gu et al. (2021) *Science*: https://www.science.org/doi/10.1126/science.abf8623

[10] '*Nitrogen on the Table*' (Westhoek et al., 2015): https://www.inms.international/nitrogen-table-influence-food-choices-nitrogen-emissions-and-european-environment A central assumption of the scenarios was that reduction European meat and dairy intake would not be offset by increasing international exports. The resulting reduction in animal numbers implies less need for arable land to produce livestock feed, which was considered in two sub-scenarios focused on using freed-up arable land either to a) increase crop exports or b) promote greening and bioenergy opportunities.

[11] '*Appetite for Change*' (Leip et al., 2023): https://www.clrtap-tfrn.org/content/appetite-change-food-system-options-nitrogen-environment-health-2nd-european-nitrogen

[12] Guidance Document on Integrated Sustainable Nitrogen Management (Sutton et al., 2022) https://unece.org/environment-policy/publications/guidance-document-integrated-sustainable-nitrogen-management

13. It is nevertheless realised that farming systems are diverse. While innovation in farm practice can move quickly, adoption of well-established improved practices does not always happen as fast as it might. Given that agriculture is typically a subsidized sector, this means that policy changes, including regulations and economic incentives have an essential role to play. An example is government support for capital investment, which can often ultimately pay for itself.

Distinguishing national perspectives on ammonia

14. Recent discussion, including at the Air Convention's Leuven Meeting (23-25 October 2024), has emphasized how there are major differences between country experiences that need to be recognized if effective progress is to be made. In simple terms, we may identify three broad groups of Parties:
    a) **International leaders** who have already reduced ammonia emissions substantially,
    b) **Emerging actors** in ammonia emission reduction, now implementing recent decisions,
    c) **Parties yet to start** substantial actions to reduce their ammonia emissions.
15. Parties in these groups face different issues, where engagement across the Air Convention can improve mutual understanding of challenges and opportunities, as a basis to mobilize change.

International Leaders

16. Possibly the first Party to agree substantial policy actions to reduce ammonia emissions was the Netherlands, where requirements for low-emission actions were already established in the early 1990s. They were followed shortly thereafter by Denmark, with policies to achieve major reductions in ammonia emissions since around 2000. These countries thus have over two decades of experience in ammonia emission reduction technologies, including a clear understanding of the most cost-effective measures and those that are more expensive.
17. National analysis by the Netherlands has shown that by far the most important single action to reduce ammonia emissions has been the requirement to use low-emission approaches to spreading manure on fields. The UNECE Ammonia Guidance Document distinguishes between: a) trailing hose (circa 30% abatement), b) trailing shoe (circa 50% abatement), c) shallow injection (circa 70% abatement) and d) deep, closed slot injection (circa 90% abatement).[13] The Netherlands required methods b), c) or d) to be used, while method a) was considered insufficiently ambitious to meet its national goals. Together with packages of support to its farmers, and ongoing improvements in technologies (e.g., manure storage, animal housing), the Netherlands was able to reduce its NH_3 emissions by 55% between 1990 and 2005.[14] As part of these activities, experts suggest that the actions were accomplished cost effectively, and achieved at the same time as other constructive activities to modernise agriculture (e.g., embracing improved animal welfare standards).
18. Subsequently, the Netherlands made much smaller progress to reduce its ammonia emissions over 2005 to 2020.[15] The message was that the easy actions had already been taken, and now more ambitious (or costly or innovative) actions were needed. A ruling by the Dutch Council of State (informed by a decision of the European Court of Justice) declared the Dutch Programmatic Approach to Nitrogen to be insufficiently precautionary to meet the

[13] These number are currently being updated as part of ongoing revision of the Ammonia Guidance Document
[14] Van Zanten et al. (2017) *Atmospheric Environment*, **148**, 352-360.
[15] Van Zanten et al. (2017), cited above. Cf. CBS (2024): Emissies van luchtverontreinigende stoffen volgens NEC-richtlijnen [Air pollutant emissions according to NEC guidelines]. https://opendata.cbs.nl/statline/#/CBS/nl/dataset/85670NED Centraal Bureau voor Statistiek, Statistics Netherlands (CBS). The Hague.

requirements of the EU Habitats Directive.[16] The Dutch government set itself a goal equivalent to roughly halving ammonia emissions again between 2020 and 2035 (i.e., 82% reduction compared with 1990, see Figure 1).[17] This has proved hard, leading to resentment in the agricultural sector. With the available and most cost-effective measures already adopted, to go further has led to discussions in reducing animal numbers across the country. In recent years, the Dutch government has made more €3 billion available for buyout-schemes to reduce animal numbers.

19. The experience from Denmark to some extent mirrors the Netherlands. Ambitious measures at first delivered a cost-effective reduction in ammonia emissions from 1990 and onwards. It is estimated that emissions were reduced by 54% between 1990 and 2022 (see Figure 2).[18] However, it becomes more costly to achieve major additional reductions.
20. It should be noted that while 'international leaders' have achieved most with regard to reducing ammonia emissions (in terms of percentage reductions), these Parties were also among those with the highest emission densities, and with greatest excess of nitrogen use.

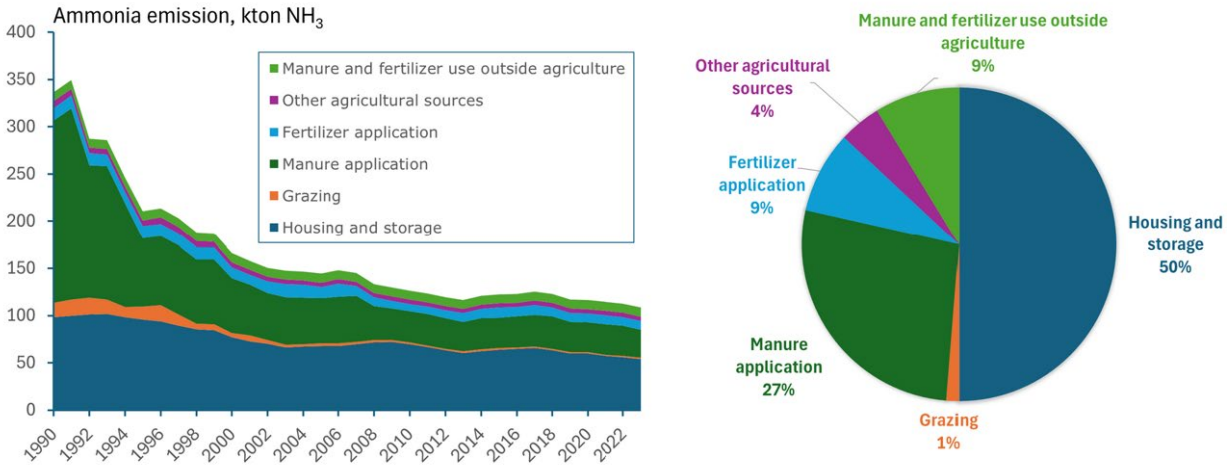

Figure 1: Contribution of different source sectors to ammonia emissions in the Netherlands in 2023 (left) together with time series from 1990 to 2023 (Van Bruggen et al., 2024, with results for 2023 added). Ammonia emission from other sources, such as Industry, Transport, Energy and Waste are not included. These sources contribute to about 6% of the total ammonia emission in 2023 (right) (van Bruggen, C., Bannink, A., Bleeker, A., Bussink, D. W., Dooren, H. J. C., Groenestein, C. M., Huijsmans, J. F. M., Kros, J., Oltmer, K., Ros, M. B. H., van Schijndel, M. W., Schulte-Uebbing, L., Velthof, G. L., & van der Zee, T. C. (2024). *Atmospheric emissions from agricultural activities in 1990–2022 calculated with NEMA*; No. 264. https://doi.org/10.18174/672550

[16] Since the ruling derived from a conclusion of the European Court of Justice with regard to interpretation of 'plans and project', this also has ramifications across all EU Member States concerning the effects of ammonia and other nitrogen emissions on European nature conservation sites (See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A62017CA0293 ; https://eur-lex.europa.eu/legal-content/en/TXT/PDF/?uri=uriserv%3AOJ.C_.2017.293.01.0014.01.ENG)

[17] Technically, the goal defined in the Dutch law is to achieve at least 74% of nature area without critical load exceedance in 2035. It has been estimated that this would require roughly halving ammonia emissions (but the spatial distribution is important, with different spatial configurations achieving the same goal with lower or higher national emission reductions) (reference).

[18] Nielsen O.-K. et al. (2024) Annual Danish Informative Inventory Report to UNECE. Emission inventories from the base year of the protocols to year 2022. Aarhus University, Danish Centre for Environment and Energy, 628 pp. Scientific Report No. 595. https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Videnskabelige_rapporter_500-599/SR595.pdf

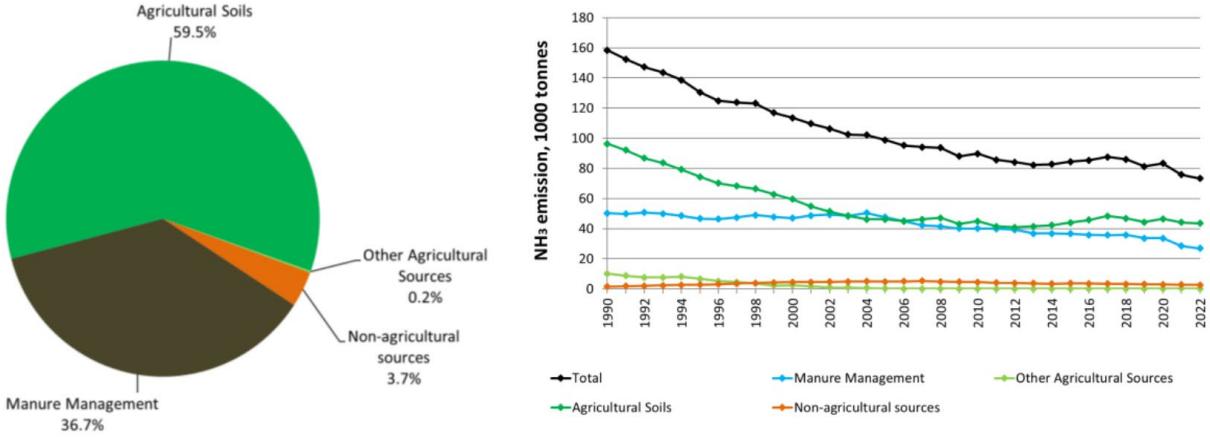

Figure 2: Contribution of different source sectors to ammonia emissions in Denmark (left) together with time series from 1990 to 2022, indicating an overall reduction over the period of 54% (right).[17]

Emerging actors

21. It is important to distinguish the experience of leading countries who already halved their ammonia emissions from those countries who have only recently started. The agreement of the revised Gothenburg Protocol, backed up by the revised National Emissions Reductions Commitments (NERC) directive of the EU, has seen many member states embracing solid actions to reduce ammonia emissions over the last decade. Germany has shown innovation in this regard by emphasizing the need for immediate incorporation of solid manure when this is applied to arable land, and by including the first international regulations prohibiting the free surface spreading of urea fertilizer (a measure not apparently adopted by either the Netherlands or Denmark). In Germany, urea fertilizer must either be immediately incorporated, or used with a urease inhibitor (that slows the decomposition to release ammonia), or another nitrogen fertilizer used instead (such as ammonium nitrate or calcium ammonium nitrate). In practice, this regulation has been implemented cost-effectively by a manufacturer changing to produce urea including a urease inhibitor with no increase in the market price.[19] Nevertheless, there are still many options available to achieve further emissions reductions.
22. Many of the countries in the emerging group are also giving an increased role for the trailing hose (method a, noted above). Although the emission reduction (circa 30%) is less than other low-emission techniques, a requirement for this method as minimum sets farmers on a path towards precision application of slurries, which sees slurry spread evenly, also with benefits to reducing water pollution (as compared with the old 'splash-plate' spreader that was previously used). Experience in Switzerland shows that the trailing hose can be used on slopes up to 18%, while it has long been argued internationally that application on steeply sloping land should be anyway avoided, to limit nitrogen pollution run-off from slurries.
23. Ireland and Belgium have also been active in starting to implement measures to reduce ammonia emissions. Ireland has also published its 'National Code of Good Agricultural Practice to Reduce Ammonia Emissions'. [20] In the UK, there are yet few national requirements to reduce ammonia emissions (apart from large pig and poultry farms as part of industrial emissions

[19] This situation is different to most companies international, which typically charge a significant price premium for fertilizers including a urease inhibitor. The German example, leads to questions over whether such price increases are necessary.

[20] Ireland, national ammonia code: https://assets.gov.ie/118669/f7c87e4c-3153-412d-b196-0f9c936a1da9.pdf

legislation). However, legislative requirements to avoid splash plate spreading of liquid manure are already in place in devolved administrations (Northern Ireland and Scotland).

24. Experience from Canada notes that ammonia emission reduction itself can also be a co-benefit of other objectives, for example, injection of liquid manure may be done to reduce odour or reduce the runoff of phosphorus. However, whichever motivation comes first, this further illustrates the multiple win-wins associated with reducing ammonia emission.

Parties yet to start

25. The third group of Parties are those who have yet to take substantial action in reducing ammonia emissions. Such countries lack specific requirements to reduce ammonia emissions from animal houses, manure storage and manure spreading, as well as from the application of nitrogen fertilizers to land.
26. This group is also likely to include Parties to the original 1999 and revised Gothenburg Protocol (2012) who have unambitious targets reduce ammonia emissions, but who are still subject to Annex IX. For example, analysis by the TFRN has shown that several Parties of the protocol have yet to implement the measures required under Annex IX, such as establishing a (voluntary) national code of practice to reduce ammonia emissions.

The importance of different perspectives

27. The three country groups highlight the need to consider the opportunities, barriers and necessary actions in a way that takes account of the major differences.
28. For countries in the first group (international leaders), further ammonia abatement may seem tough, even though needed to meet existing laws (e.g., Habitats Directive). Recognizing the pressing concerns at a national level, such countries become innovators, offering opportunities to market their technologies internationally. However, for these parties domestically (unless new innovation can bit identified), the most cost-effective measures will have already been adopted over a decade ago.
29. By contrast, for the other two groups (Emerging actors; Parties yet to start), ammonia emission reduction represents a practical opportunity to reduce nitrogen waste, improve economic performance and protect the environment at the same time (for air, land, water, climate).
30. It is essential that the opportunities for the 'Emerging actors' and 'Parties yet to start' are not coloured by the later experience of the International Leaders, who having already halved ammonia emissions, are now looking to halve them again. While legal requirements may necessitate 'going the extra mile' for the international leaders, for those Parties who have not yet started, there are a wide range of cost-effective options that (with appropriate investment) can help improve farm profitability.

Policy options for Gothenburg Protocol revision

31. In considering the policy options, we should recognize that progress ultimately will depend on a willingness by the agricultural sector to embrace necessary changes. This applies for all of the options considered below. It is therefore important to emphasise that:
    a. For those parties who have so far taken little action on ammonia, low-hanging fruit are available where investment can lead to significant cost savings for farmers.
    b. Ammonia mitigation should be seen as part of sustainable nitrogen management, and the transition to a circular nitrogen economy, which is simultaneously needed to meet existing goals for biodiversity, climate, health and economy (e.g. the Kunming-Montreal Global Biodiversity Framework, Target 7).

c. Substantial ammonia mitigation is possible (circa 50%), as has already been delivered in leading countries. Ammonia mitigation with even higher level of ambition can represent a cost to farmers but is well-justified by the environmental and health benefits.
d. While additional actions, such as non-technical measures to promote dietary change or to reduce animal numbers may be embraced by some parties, these might be considered as optional, e.g., where Parties recognize that they need to go further than their existing actions. This suggestion must be subject to hearing the views of Parties, and simply reflects an anticipated caution concerning such actions from some Parties.

32. A further issue is the ongoing development of ammonia as a carbon-free fuel, which is expected to see the share of ammonia emissions from industrial and transport sources increase in future. Alongside existing analyses that integrate nitrogen across the agri-food chain (see '*Appetite for Change*' already cited), this emphasizes that ammonia abatement is a multi-sectoral challenge requiring cooperation across the whole of society.

A. Opportunities for more ambitious emissions ceilings / reduction commitments

33. The central pillar of the Gothenburg Protocol is the emissions ceilings, where the emission reduction commitments are compared with 2005 according to the revised protocol of 2012.
34. For most countries the emission reduction commitments are rather modest for ammonia, and much less than the maximum technically feasible reduction (MTFR). As noted, changes in European food systems to promote healthy diets would allow further reductions.
35. It is evident that agreement on more ambitious emission reduction commitments provides a feasible and obvious way to reduce the adverse effects of ammonia emissions on health and ecosystems.
36. Such emission reductions (for both NO_x and NH_3) will contribute towards meeting the existing commitment of the Kunming-Montreal Global Biodiversity Framework (Target 7) to reduce pollution from excess nutrients by at least 50% between 2011-2020 and 2030.

B. Ambition of Annex IX

37. As it stands, the initial 1999 approach that is outlined in Annex IX is both rather light and now dated. It is light in that the measures (framed as 'shall') are often framed in vague terms, allowing wide interpretation, as well as some ambiguity. This means that some parties have interpreted its provisions as mandatory, while other parties have emphasized the flexibility, thereby avoiding taking action. A range of options for explicit requirements were outlined by the TFRN over 2008-2012,[21] and there is merit in revisiting these in the light of the additional 15 years of experience. These include:
    a. options to focus on medium and large farms (e.g., farms with more than 50 livestock units), which in the case of cattle in Europe account for over 70% of the animals, but only 13% of the farms[22];
    b. Options to exclude requirements when spreading manure using hand systems (based on tanker/truck capacity, thereby excluding the smallest farms);
    c. Options to extend sector coverage, including actions related to anaerobic digestion and other operations processing organic matter;

[21] Considerations for ammonia relevant to future review of the Gothenburg Protocol. Inf. Doc. to WGSR-58 2022. https://unece.org/environment/documents/2022/07/session-documents/considerations-ammonia-relevant-future-review

[22] See ECE/EB.AIR/WG.5/2010/4 (Paragraphs 5-74, which considers High (A), Middle (B) and Low (C) ambition options), including Annex I: Information on possible farm-size thresholds in relation to mandatory measures for land application of manures.

d. Options to update requirements for animal housing, in the light of revised industrial emissions legislation across the UNECE region.

38. Meanwhile, Parties are reminded of the requirement already agreed in 1999 under Annex IX, paragraph 3: "*a Party shall establish, publish and disseminate an advisory code of good agricultural practice to control ammonia emissions*," according to further provisions defined therein. Revision of the Gothenburg Protocol provides an opportunity to update the required list of topics to be addressed in National Ammonia Codes, including from anaerobic digestion.

C. National Nitrogen Budgets

39. The revised Gothenburg Protocol already includes provision for the Executive Body to request reports on National Nitrogen Budgets, which benefits from the Guidance Document on National Nitrogen Budgets agreed in 2012 (ECE/EB.AIR/119), and for which a draft revision has now been forwarded by the Working Group on Strategies and Review to the Executive Body for adoption.
40. Parties may wish to consider strengthening the requirements on establishing national nitrogen budgets, especially given the benefits for guiding towards priority actions on sustainable nitrogen management with a holistic benefit that can also help reduce adverse effects on health, biodiversity, climate and water.

D. Financing actions to reduce ammonia emissions

41. One of the key messages of this document is that actions to reduce ammonia emissions can be seen as part of transforming towards a nitrogen circular economy, which means a reduced need for fresh inputs of reactive nitrogen compounds. Under this approach, a larger role is played by reducing nitrogen losses in the first place, and by recovering nitrogen from organic residues from all sources (livestock, crops, human excreta etc). This means that, done well, many such measures can pay for themselves, or could do so with appropriate investment.
42. This points to the opportunity for accelerated change by clear statements in a revised Gothenburg Protocol that encourage the development of financing actions to reduce nitrogen waste. These are being framed by the *International Nitrogen Assessment* under the concept of 'Nitro-Finance' (i.e., financing related to *nitrogen* mitigation, and related to *accelerating* action).
43. As many parts of agriculture are subsidized in many countries, it is essential to see the legislative requirements in relation to possible implications on eligibility for government financial support.
    a. It is often said that an actor may not be eligible for a grant to implement that which is already required by legislation. This issue is sometimes handled by transition periods: e.g., 5 year of grant aid to transition, followed by making of an approach a requirement.
    b. Another approach is to set the benchmark for mandatory action at a medium level. For example, if a mandatory requirement is set to reduce emissions by at least 30%, this means that a measure which achieves this might not be eligible for a grant (e.g. trailing hose). By contrast, a measure that goes beyond that would be eligible for a grant (e.g., trailing shoe).
    c. A further approach would be to use farm-size indicators as a benchmark for requirements. Thus, a large farm might not be eligible for support (as the emission standard is set as mandatory for medium and large farms), but a small farm could still be eligible for support (as the standard is voluntary for small farms).
44. The ambition of mandatory actions thus needs to be seen in relation to providing the opportunity to catalyze change through financial support.

E. Role of the UNECE Guidance Documents on ammonia, nitrogen budgets and integrated sustainable nitrogen management

45. The guidance documents on ammonia and nitrogen are not a part of the Gothenburg Protocol. Nevertheless, both the Ammonia Guidance Document (ECE/EB.AIR/120) and the Guidance Document on National Nitrogen Budgets (ECE/EB.AIR/119) are referred to in the protocol. These guidance documents represent informative collections of *options and established reference materials* for methodologies. They were not designed to set any particular level mitigation for ammonia emission or nitrogen management (which is the purpose of Annex IX).
46. The Guidance Document on Integrated Sustainable Nitrogen Management (ECE/EB.AIR/149) was adopted in 2020 and is therefore not referenced in the revised Gothenburg Protocol of 2012. There is the opportunity to refer to this guidance as part of a future protocol revision, emphasizing the opportunity of a 'full nitrogen approach' to achieve multiple benefits and to help mobilize change.

F. Role of the UNECE Ammonia Framework Code and National Ammonia Codes

47. The UNECE Ammonia Framework Code (ECE/EB.AIR/129) provides a template from which parties are encouraged to benefit as they prepare their own National Ammonia Codes (as required under paragraph 3 of Annex IX). Once the ongoing revision of the Ammonia Guidance Document is complete, attention is expected to turn to updating the Framework Code. This may also be informed by discussions to revise Annex IX as part of the revision of the Gothenburg Protocol, which could see new aspects emphasized in a future Framework Code.

Tools to support nitrogen management and ammonia emission reduction

48. Further thought should be given to a range of tools that can help mobilize change to reduce ammonia emissions and progress towards sustainable management of valuable nitrogen resources. These include:
    a. **Improving online guidance for the preparation of national nitrogen budgets** and further developing visualization tools to highlight the key messages from nitrogen budgets (e.g. to inform priorities for investment and action).
    b. **Further developing online tools** that can support local decision making that connect local and transboundary air pollution to support protection of biodiversity and other dimensions.[23]
    c. A core argument of this note is that, **done well, ammonia abatement can save farmers money.** This means that there is a need for further tools development to help farmers in their **decision making around the business case for investing** in low-emission technologies. A much wider international conversation on this topic is needed.

Conclusions

49. There is a wide range of options where a revised Gothenburg Protocol could further reduce ammonia emissions and their adverse effects. Technically, it is possible to go much further than most Parties have so far delivered. This is clearly demonstrated by international leaders who, having halved ammonia emissions, are currently working to halve them again.
50. Ambitious action across the UNECE region depends on building the consensus that ammonia emission reduction is technically possible, with has many low-hanging fruit that can contribute to improving farm economies (by reducing dependence on expensive bought in N inputs), especially in a world of fluctuating energy and nitrogen prices.

[23] An example is the SCAIL model (Simple Calculation of Ammonia Impact Limits), which is a simple online tool to support decision making related to emissions of ammonia and nitrogen oxides and the impacts on natural habitats. https://www.scail.ceh.ac.uk/

51. The transformation to a ‘nitrogen circular economy’ means embracing integrated sustainable nitrogen management, which further emphasizes the economic and environmental co-benefits for air and water quality, climate, health and biodiversity.