

## **Issues to consider for nitrogen in relation to review of the Gothenburg Protocol.**

Input to the Gothenburg Protocol Review Group from the Task Force on Reactive Nitrogen

Note submitted by the co-chairs of the Task Force on Reactive Nitrogen<sup>1</sup>

### **Summary**

1. This note provides interim responses from the Task Force on Reactive Nitrogen (TFRN) to the questions identified in Annex I of “Preparations for the review of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone as amended in 2012” (ECE/EB.AIR/WG.5/2020/3).
2. The answers have been prepared following two consultations with the TFRN members, firstly during the 15<sup>th</sup> Annual Meeting of TFRN (4 February 2021) and secondly in a specific TFRN workshop to prepare input for the Gothenburg Protocol Review (19 March 2021).
3. The present document includes issues related to ammonia and the wider nitrogen cycle, including relevant interactions with nitrogen oxides, especially those arising from anthropogenically influenced soils. The document complements and extends the Inf. Doc. presented to the 58<sup>th</sup> Session of the WGSR “Considerations for ammonia relevant to future review of the Gothenburg Protocol”.

### **General considerations**

4. The answers here focus on aspects where TFRN is providing lead input. It is noted that there are other nitrogen-related issues in the responses provided by the TF on Technical and Economic Issues, the TF on Integrated Assessment Modelling and from the Task Forces and programmes under EMEP and Working Group on Effects. It is anticipated to comment further on those other aspects once a full draft of the Gothenburg Protocol Review Group report is available.

### **Questions and Responses**

The following numbering in Table 1 is given in accordance with the Annex I questions.

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<sup>1</sup> Prepared with the support of the Global Environment Facility (GEF) and the United Nations Environment Programme (UNEP) through the International Nitrogen Management System (INMS), with inputs from the United Kingdom, Denmark and Portugal, and experts from the Task Force on Reactive Nitrogen.

**Table 1:** Responses to the Gothenburg Review questions from TFRN.

1	<b>Review of obligations in relation to emission reductions</b>	Timing
1.5	<p><b>a. To what extent have best available techniques and emission limit values and other technical provisions in annexes IV, V, VI, VIII, IX, X and XI been implemented by the Parties?</b></p> <p>See Answers to 5.1 concerning Annex IX.</p> <p><b>d. What barriers have been identified by Parties and non-Parties to implement the obligations in the technical annexes?</b></p> <p>See Answers to 5.1 concerning Annex IX.</p>	Spring 2022
1.6	<p><b>a. Which emission limit values and other technical requirements in the technical annexes are not up to date anymore?</b></p> <p><b>Annex IX is over 20 years old and can no longer be considered up to date. Based on substantial progress in technical capability, availability of cost-effective measures, and recognition that measures are needed to achieve ammonia emission ceilings, a comprehensive revision of Annex IX is overdue</b></p> <p><b>b. Which technical annexes should be adapted to better address key sectors in Eastern, South-Eastern Europe and Turkey, the Caucasus and Central Asia?</b></p> <p>See answer for Question 5.1.</p> <p><b>c. Where are the current technical annexes too detailed, complex and/or demanding?</b></p> <p>Annex IX is extremely short and contains little that is mandatory. There are many opportunities to revise Annex IX, as already considered during the Gothenburg Protocol review/revision of 2008-2012.<sup>2</sup></p>	Spring 2022

<sup>2</sup> The Working Group may wish to note the following documents related to revision of Annex IX:

- **ECE/EB.AIR/WG.5/2008/10** (Paragraphs 31-32).
- **ECE/EB.AIR/WG.5/2009/12** (Annex: Report on work in progress on Annex IX).
- **ECE/EB.AIR/WG.5/2010/4** (Paragraphs 5-74, including High (A), Middle (B) and Low (C) ambition options, plus Annex I: Information on possible farm-size thresholds in relation to mandatory measures for land application of manures.
- **ECE/EB.AIR/WG.5/2010/5** Options for revising the Gothenburg Protocol. Draft Revised Technical Annex IX (bracketed options for revision of the protocol) (Note prepared by TFRN co-chairs).
- **ECE/EB.AIR/WG.5/2010/13** (Paragraphs 9-16, 33 and Annex: Explanation of amendments to the options for revision of the Gothenburg Protocol, Annex IX).
- **ECE/EB.AIR/WG.5/2010/14** Draft revised Annex IX.
- WGSR-47<sup>th</sup> Session, Informal Document 2. Draft revised technical Annex IX – with annotation and explanation.
- **ECE/EB.AIR/WG.5/2011/3**: Draft revised Annex IX – updated annotated draft and clean copy including revised options A, B, C.

	<p><b>d. Which gaps or redundancies in technical annexes can be identified?</b></p> <p>Although Annex IX briefly notes that “<i>Each Party shall take due account of the need to reduce losses from the whole nitrogen cycle</i>”, no further details or requirements are provided related to <b>the wider nitrogen cycle</b>. <b>This can be considered as a critical gap given the last decade of activity in developing joined-up perspectives and solutions across the nitrogen cycle.</b><sup>3</sup></p> <p>There is currently no annex to the Gothenburg Protocol describing measures and requirements for the control of emissions of <b>nitrogen oxides from soils</b>. Such emissions result from both agricultural soils and anthropogenic change to natural soils (e.g. from increased atmospheric nitrogen deposition). <b>Controlling emissions of NO<sub>x</sub> from soils offers an opportunity to go further in reducing total NO<sub>x</sub> emissions, and should be seen as part of strategies to reduce total amounts of wasted nitrogen resources, with co-benefits for climate, stratospheric ozone and water quality (through simultaneous mitigation of nitrous oxide, di-nitrogen, nitrate and other nitrogen losses).</b><sup>4</sup> Emissions of NO<sub>x</sub> from soils are specifically excluded from the revised Gothenburg Protocol, which represents a barrier to progress in further reducing total NO<sub>x</sub> emissions, while not giving credit for progress with such measures.</p>	
5	<b>Evaluation of ammonia control measures and consideration of the need to revise annex IX</b>	
5.1	<p><b>What are the main barriers to effectively reduce ammonia emissions and implement annex IX or existing Guidance Documents?</b></p> <p><b>Many parties appear not to have fully implemented the requirements of Annex IX. This annex is no longer state-of-the-art being over 20 years old (prior to 1999).</b> It is not technically demanding, as has been demonstrated by actions taken by a few parties. This appears to suggest that lack of full implementation of Annex IX is linked to social/political barriers, where Parties have not prioritized measures on ammonia. The following excerpt of Annex IX is illustrative: “<i>Within one year from the date of entry into force of the present Protocol for it, a Party shall establish, publish and disseminate an advisory code of good agricultural practice to control ammonia emissions</i>”.</p>	Spring 2021

- ECE/EB.AIR/WG.5/2011/13: (Paragraphs 23-32 on explanation of draft Annex IX).
- ECE/EB.AIR/WG.5/106: Report of WGSR-49 (Paragraphs 35-38).
- ECE/EB.AIR/2012/11: Draft revised Annex IX. The proposed text was not supported by TFRN.
- ECE/EB.AIR/WG.5/2012/3: (Paragraph 9).

<sup>3</sup> e.g., **The European Nitrogen Assessment: Sources, effects and policy perspectives** (eds. Sutton et al., 2011, Cambridge University Press). Includes spatial analysis of threats, damage costs and examination of solutions. <http://www.nine-esf.org/node/360/ENA-Book.html>

<sup>4</sup> **Guidance Document on Integrated Sustainable Nitrogen Management** ECE/EB.AIR/2020/6-ECE/EB.AIR/WG.5/2020/5. See also: *The European Nitrogen Assessment 6 years after: What was the outcome and what are the future research challenges?* In: *Innovative Solutions for Sustainable Management of Nitrogen*, Aarhus, Denmark (25-28 June 2017), pp 40-49. Aarhus. <https://static1.squarespace.com/static/58cff61c414fb598d9e947ca/t/5abb898faa4a99a0ab4e71d9/1522239888660/The+European+Nitrogen+Assessment+-+Prof+Mark+Sutton+%28003%29.pdf>

Although this became a requirement on 17 May 2006, engagement by the Task Force with the support of the Secretariat has shown that, even by 2020, most parties to the Protocol had not yet met this requirement.<sup>5</sup>

Future review of progress on ammonia measures would benefit from annual questionnaires of the actions taken by Parties in relation to all the requirements of Annex IX.

Considering '**best available techniques**' (Question 1.5a), there are many measures available for abatement of ammonia emissions<sup>6</sup> that have not so far been implemented by Parties. Analysis by TFRN<sup>7</sup> has shown that dietary change to reduce excess intake of meat and dairy offers a key **non-technical measure**, with co-benefits for health and climate. **The report 'Nitrogen on the Table' showed that halving meat and dairy intake in Europe (demitarian scenario) would reduce ammonia emissions by around 40% (without any technical measures)** (See Question 5.4). It appears that Parties have not yet applied policies related to food choice as part of their ammonia emission reduction plans, although co-benefits with ambitious climate-related policies may see this change in future.

The **main barrier to ammonia reduction** by Parties and non-Parties appears to be a lack of political willingness. A wide range of co-effective abatement methods and non-technical measures are available. **The last 3 years has seen a significant change in political willingness as Parties realise that implementation of measures is needed to reach emission reduction commitments of the amended Gothenburg Protocol and/or additional EU legislation<sup>8</sup>.**

Annex IX was not updated in the amended Gothenburg Protocol of 2012. Although many options were discussed (see footnote 2), it was not possible for the parties to agree on an amended text (hence the inclusion of Article 10.4 in the amended protocol).

With notable exceptions, there has **been only limited uptake of National Nitrogen Budgets, which was introduced as an optional element of the revised Gothenburg Protocol. The main barriers appear to be the lack of any mandatory requirement, resources to provide demonstration national budgets, and resources for awareness**

<sup>5</sup> Concerning establishment of 'National Ammonia Codes' (NACs), as required by Annex IX, paragraph 3. Although the original protocol entered into force in 2005, analysis by the Task Force on Reactive Nitrogen in 2010 (ECE/EB.AIR/WG.5/2010/13, paragraph 33) found that very few parties had established clearly identified National Ammonia Codes, subsequent review has seen the number slowly increasing, but overall, many Parties appear to have largely neglected this requirement of the protocol.

<sup>6</sup> See the **Guidance Document on preventing and abating ammonia emissions from agricultural sources**, originally Guidance Document V (decision 1999/1) as referred in Annex IX of the Gothenburg Protocol, which has since been revised as ECE/EB.AIR.120, adopted in 2012. Published for wider dissemination as "Options for Ammonia Mitigation: Guidance from the UNECE Task Force on Reactive Nitrogen" (eds. Bittman et al., 2014, CEH). [http://www.clrtap-tfrn.org/sites/clrtap-tfrn.org/files/documents/AGD\\_final\\_file.pdf](http://www.clrtap-tfrn.org/sites/clrtap-tfrn.org/files/documents/AGD_final_file.pdf)

<sup>7</sup> **Nitrogen on the Table**: The influence of food choices on nitrogen emissions and the European environment. (European Nitrogen Assessment Special Report on Nitrogen and Food.) (Westhoek et al., 2015, CEH) [http://www.clrtap-tfrn.org/sites/clrtap-tfrn.org/files/documents/EPNF%20Documents/Nitrogen\\_on\\_the\\_Table\\_Report\\_WEB.pdf](http://www.clrtap-tfrn.org/sites/clrtap-tfrn.org/files/documents/EPNF%20Documents/Nitrogen_on_the_Table_Report_WEB.pdf)

<sup>8</sup> NEC Directive (EU) 2016/2284 for 2005-2030

	<p>raising on the benefits of such an approach. It is currently planned that the International Nitrogen Management System supported by UNEP/GEF will provide a future repository for national nitrogen budgets, including in the UNECE region. The TFRN Expert Panel on Nitrogen Budgets currently lacks resources with work conducted on a voluntary basis.</p> <p><b>What barriers exist for non-Parties?</b></p> <p>The requirements of Annex IX are <b>similar across the entire UNECE region</b>, even though preferences for specific ammonia abatement solutions may vary across the region.</p> <p>The Guidance Document on Integrated Sustainable Nitrogen Management includes <b>source related measures</b> (animal housing, manure storage and spreading, nutrient recovery methods and field application of organic and inorganic resources) and <b>land use/landscape related measures</b> (for example placement of buffer strips or wetlands, and changed crops or crop rotations, catch crops, agroforestry, afforestation, set aside of land etc.) Such measures are used to optimize how measures are placed in the landscape and/or how land use can be changed to reduce effects of N-losses. Parties appear to vary in their preference for source oriented or landscape oriented measures. Potential trade-offs of certain landscape measures (e.g. impact on priority nature areas) can limit their applicability in some areas while in other contexts they can be seen as complementing source oriented measures to maximize environmental benefits.</p> <p>Article 8 of the Gothenburg Protocol makes clear that Annex IX and ammonia measures do not apply <b>outside the geographical area of EMEP. The Protocol therefore specifies no measures for ammonia for Parties in North America.</b> There is no evidence for a past assertion that “ammonia is not a transboundary pollutant”. Ammonia emissions contribute to transboundary effects and waste of nitrogen resources on local to global scales, amplifying adverse effects on health, climate and ecosystems.</p>	
5.2	<p><b>a. What are best available control measures to further reduce ammonia emissions?</b></p> <p><b>A wide range of measures is available to Parties to achieve their national emissions reduction commitments for ammonia.</b> These include: measures on animal housing, storage of manure, spreading of solid and liquid manures and of urea and other inorganic fertilizers to land, together with measures to promote recovery and re-use of nitrogen and other resources, <b>with an emphasis on reducing pollution and developing the circular economy with innovation opportunities.</b></p> <p><b>The confidence in measures to control ammonia emissions has increased greatly since these were first discussed by the Convention in the 1990s.</b> Early uncertainty</p>	Spring 2021

has been largely replaced with a wide recognition that measures for ammonia abatement are available, cost effective and reliable.

**Control of ammonia emissions is now seen as part of a wider strategy to reduce the huge amount of valuable reactive nitrogen resource that is wasted. Activities linked to the International Nitrogen Management System (INMS) have drawn attention to a global loss of reactive nitrogen worth US\$200 billion per year, pointing to the opportunity to “halve nitrogen waste”<sup>9</sup> by 2030, saving US\$100 billion per year globally<sup>10</sup>, as embraced as part of national action plans under the Colombo Declaration<sup>11</sup>.**

Since the adoption of Annex IX, new knowledge on the wider N-cycle has shown the importance of **win-win opportunities** for ammonia emissions reduction by addressing it in an integrated manner with nitrogen oxides.<sup>12</sup> Although **NO<sub>x</sub> emissions from soils** are currently excluded from the Gothenburg Protocol as amended (Annex II, Table 3), with ongoing reductions in NO<sub>x</sub> emissions from combustion, soil NO<sub>x</sub> may account for up to 25% of total emissions for some parties by 2030. This highlights the need for coordinated reduction of NH<sub>3</sub> and NO<sub>x</sub> emissions from agricultural soils, especially, since this could facilitate simultaneous reduction of nitrous oxide (N<sub>2</sub>O) emissions, di-nitrogen (N<sub>2</sub>) emissions, and nitrate (NO<sub>3</sub><sup>-</sup>) and other reactive nitrogen leaching within the context of more efficient management of the nitrogen cycle.

Several Parties of the Convention have made further progress in commitments to reduce ammonia emissions, including in the revised National Emissions Reduction Commitments Directive of the European Union (Directive (EU) 2016/2284)<sup>13</sup>. That directive describes both emission reduction commitments for years between 2020-2030 and after 2030, relative to 2005 (Annex II, Table B) and a set of specific measures for ammonia emission reduction (Annex III, part 2).<sup>14</sup>

While the main sources of ammonia emissions in Europe are linked to livestock and crop activities, there are a very wide range of **additional ammonia sources** arising from human activities, including from internal combustion engines, biomass burning, anaerobic digestion and wastewater, offering further opportunities for emission reduction.

<sup>9</sup> Total nitrogen wasted has been defined as the sum of all forms of reactive nitrogen (N<sub>r</sub>) lost as pollution plus denitrification to N<sub>2</sub>, which is equally a waste of N<sub>r</sub> resources (see “The Nitrogen Decade: mobilizing global action on nitrogen to 2030 and beyond”, *One Earth* 4, 10-14. <https://doi.org/10.1016/j.oneear.2020.12.016>, where a baseline of 2020 has been used as a reference for halving wasted nitrogen globally).

<sup>10</sup> UNEP Frontiers Report: The Nitrogen Fix: <https://apo.org.au/sites/default/files/resource-files/2019-03/apo-nid224376.pdf>

<sup>11</sup> Colombo Declaration on Sustainable Nitrogen Management: <https://papersmart.unon.org/resolution/sustainable-nitrogen-management>

<sup>12</sup> Sutton M.A. et al. (2017) The European Nitrogen Assessment 6 years after: What was the outcome and what are the future research challenges? In: *Innovative Solutions for Sustainable Management of Nitrogen*. (Eds.: Dalgaard T. et al.). pp 40-49. Aarhus University and the dNmark Research Alliance.

<https://sustainablesoilsalliance.squarespace.com/s/The-European-Nitrogen-Assessment-Prof-Mark-Sutton-003.pdf>

<sup>13</sup> [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L\\_.2016.344.01.0001.01.ENG](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2016.344.01.0001.01.ENG)

<sup>14</sup> Such a technical annex on ammonia to some extent mirroring Annex IX of the Gothenburg Protocol was not included in the original National Emissions Ceilings Directive of 2001.

**Concerning revision of Annex IX, the “Top Five” priority areas for ammonia emission abatement were identified by TFRN (ECE/EB.AIR/WG.5/2011/16; considering availability across UNECE region, cost, contribution to emission reduction and capacity building):**

**1. Low-emission application of manures and fertilizers to land, including:**

(a) Low emission application of slurry and solid manure from cattle, pigs and poultry. Available measures included immediate or fast incorporation into the soil, trailing hose, trailing shoe and other band spreading and injection methods, and slurry dilution via irrigation;

(b) Low-emission application of urea fertilizers. Available measures included immediate or fast incorporation into the soil, coated pellets, urease inhibitors and fertilizer substitution;

**2. Animal feeding strategies to reduce nitrogen excretion.** Available measures included: (a) low-protein phase feeding on pig and poultry farms; and (b) low-protein supplement feeding of cattle during housing, and improved nitrogen and grazing management of grazed grassland targeted to improve nitrogen use efficiency;

**3. Low emission techniques for all new stores for cattle and pig slurries and poultry manure.** Available measures include covers on all new slurry tanks, use of floating covers or slurry bags, prohibition of the building of new open slurry lagoons and keeping stored poultry manure dry;

**4. Strategies to improve nitrogen use efficiencies and reduce nitrogen surpluses.** The priority target was to establish nitrogen balances on demonstration farms or through on-farm demonstration, as a basis to monitor improvements in nitrogen use efficiency. That priority would develop capacity across the UNECE region for wider use of nitrogen budgeting approaches after 2020;

**5. Low emission techniques in new and largely rebuilt pig and poultry housing.** Available measures included improved building designs, reducing the area of manure exposed to the air, keeping poultry litter dry and chemical scrubbing of exhaust air.

Since this list is now 10 years old, these priorities should be reviewed based on evolution of costs, innovation and policy experience.

**b. Which elements of annex IX and guidance documents need to be updated?**

**The main needs to update and extend Annex IX concern measures related to:**

- a) Feeding of livestock (currently not described),
- b) Housing of cattle and storage of cattle manure (currently not described),
- c) Housing of pigs, poultry and other livestock and their associated manure storage,
- d) Processing and recovery of organic nutrient resources (currently not described),
- e) Spreading to land of solid manure and liquid manure / slurries,
- f) Spreading to land of urea, ammonium nitrate and other nitrogen containing fertilizers,
- g) Grazing of livestock and other aspects of cropping, including from agricultural soils (currently not described),

	<p>h) Opportunities from sustainable nitrogen management including, reducing overall amounts of wasted nitrogen resources to air as ammonia, nitrogen oxides, nitrous oxide, di-nitrogen and to water as nitrate and other nitrogen forms, with a goal of progressing to more circular systems with higher system-wide nitrogen use efficiency (currently not described),</p> <p>i) Measures, including ‘nature based solutions’, related to landscape and landuse structure, so far as these reduce wasted nitrogen resources and do not compromise other objectives (currently not described),</p> <p>j) Dumping and disposal of organic and inorganic nitrogen containing resources (currently not described).</p> <p><b>The following guidance documents related to ammonia and the wider nitrogen cycle need to be updated as follows:</b></p> <p>a) The Ammonia Guidance Document (ECE/EB.AIR.120), last revised in 2012, should be updated by 2024</p> <p>b) Framework (advisory) code of good agricultural practice for reducing ammonia emissions (EB.AIR_WG.5_2001_7), last revised in 2015, should be updated by 2026</p> <p>c) The Guidance Document on National Nitrogen Budgets (ECE/EB.AIR/119), adopted by the Executive Body in 2012, should be revised by 2024.</p> <p>d) The Guidance Document on Integrated Sustainable Nitrogen Management (ECE/EB.AIR/2020/6-ECE/EB.AIR/WG.5/2020/5), having been adopted in 2020 is not currently a priority for revision.</p>	
5.3	<p><b>To what extent will new agricultural or integrated nutrient management policies (e.g. the European Union ‘Farm to Fork’ strategy and the reform of the European Union agricultural funding policies (CAP reform)) contribute to ammonia emission changes?</b></p> <p>Wider agricultural and integrated nutrient management policies offer great potential to reduce ammonia and wider nitrogen pollution. For example:</p> <p>a) Reform of agricultural funding (such as CAP) may influence ammonia and other nitrogen emissions by driving changes in the numbers of livestock and in setting requirements for the use of low-emission technologies, including financing schemes.</p> <p>b) The Farm-to-Fork and Biodiversity Strategies of the European Commission embrace a goal to “reduce nutrient pollution by 50% by 2030”, directly building on the Colombo Declaration.<sup>15</sup></p> <p>c) Nature policies can also have a major influence on nitrogen pollution, as illustrated by the ‘Nitrogen Crisis’ of the Netherlands, which has been driven by requirements of the EU Habitats Directive to avoid adverse effects of nitrogen on the Natura 2000 network, including Special Areas of Conservation.</p>	Spring 2022

<sup>15</sup> EU Farm-to-Fork Strategy: [https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/farm-fork\\_en](https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/farm-fork_en) Compared with the Colombo Declaration the EU Strategies include other nutrients (such as phosphorus), but by focusing only on ‘pollution’ do not include emissions of di-nitrogen (N<sub>2</sub>), which is not pollution as such but is a significant waste of reactive nitrogen resources.



	<p>d) As focus on Sustainable Nitrogen Management as part of climate negotiations under the UN Framework Convention on Climate Change offers the opportunity to mobilize co-benefits for climate, air pollution, water, biodiversity and economy, as illustrated by the #Nitrogen4NetZero initiative<sup>16</sup>.</p>	
5.4	<p><b>a. What is the potential for dietary change?</b></p> <p><b>Dietary change has huge potential to influence nitrogen losses to the environment, including ammonia, nitrous oxide, nitrogen oxides, nitrate and di-nitrogen. In Europe, meat and dairy consumption in excess of dietary needs is contributing substantially to pollution and waste of nitrogen resources.</b> The “Nitrogen on the Table” report showed that halving meat and dairy intake (demitarian scenario) would reduce ammonia emissions by 40%.<sup>17</sup> The scenarios also showed a doubling of food-chain nitrogen use efficiency from around 20% to 40%, while providing a major land opportunity for greening activities or increasing food crop export (since not so much agricultural land was needed to feed livestock). Feed imports and methane emissions were also reduced.</p> <p><b>b. What environmental and health benefits are associated with dietary change?</b></p> <p>Work conducted as part of the TFRN Expert Panel on Nitrogen and Food (EPNF), shows a rich interlinkage between nitrogen and food, including the potential for dietary change and health co-benefits. The results show that dietary change not only has a significant potential to reducing emissions of reactive nitrogen, but indeed it will be difficult if not impossible to reach ambitious climate, air and sustainability targets without a contribution from dietary change. An advance summary is provided as an Annex to the TFRN report to the 59th Session of WGSR (May 2021). The EPNF will continue finalizing the ENA Special Report in 2021 providing further details for Question 5.4.<sup>18</sup></p> <p>The EPNF work so far depended fully on in-kind contribution of the experts; for the contribution to the GP revision document, funds for a workshop might be necessary.</p> <p><b>c. What policy instruments are available to change diets?</b></p> <p>A large number of policies to shift food demand exist (i.e. Food Based Dietary Guidelines; public procurement; food labelling; school and other education programs;</p>	Spring 2022

<sup>16</sup> <https://www.inms.international/nitrogen4netzero>

<sup>17</sup> **Nitrogen on the Table:** The influence of food choices on nitrogen emissions and the European environment. (European Nitrogen Assessment Special Report on Nitrogen and Food.) (Westhoek et al., 2015, CEH) [http://www.clrtap-tfrn.org/sites/clrtap-tfrn.org/files/documents/EPNF%20Documents/Nitrogen\\_on\\_the\\_Table\\_Report\\_WEB.pdf](http://www.clrtap-tfrn.org/sites/clrtap-tfrn.org/files/documents/EPNF%20Documents/Nitrogen_on_the_Table_Report_WEB.pdf)

<sup>18</sup> See <http://www.clrtap-tfrn.org/content/epnf#Publications>

	marketing policies; food standards etc.), which, however, need to scale up to be more effective, and be integrated into comprehensive (food system) policy packages.	
<b>6</b>	<b>Additional inputs for the review</b>	
6.3	<p><b>a. What are the (best) available emission abatement techniques and measures for the reduction of methane emissions from key sources?</b></p> <p><b>Considering agricultural sources, several measures are available to reduce CH<sub>4</sub> emissions from enteric fermentation. These measures mostly are related to dietary change of ruminants</b> and comprise the following mitigating principles with a farm-specific approach: i) Improve feed quality and intake (Organic Matter digestibility, feeding value). ii) Less fibrous feeds of low digestibility. iii) Grass at early growth stage with high feeding value. iv) Feed crops/low-N feed to control N excretion/emissions. v) CH<sub>4</sub>-lowering supplements (starch, fat), vi) Implementation of biodiverse swards, and vii) supplementation of feed with additives, such as specific fatty acids/fat or methanogen inhibitors.</p> <p>Overall feeding a diet with more starch and less fibres not only produce less methane per kg feed Dry Matter, but also form a basis for higher feed intake and higher production per animal and hence will be the most efficient way to reduce the methane production per kg of meat or milk produced.<sup>19</sup></p> <p>Mitigation of CH<sub>4</sub> emissions from manure is also a tool that contributes to CH<sub>4</sub> emission mitigation. No single option appears to provide a simple and lasting solution so, a combination of different techniques seems to be the most appropriate and effective path. A summary of interactions between ammonia and methane mitigation has been provided previously by TFRN.<sup>20</sup></p> <p>Regarding <b>rice cultivation</b>, an extremely important crop in the world, changing water management has been identified as the most effective approach to consistently reducing CH<sub>4</sub> emissions from paddy rice fields. Midseason drainage and intermittent irrigation have proven to significantly reduce methane emissions.<sup>21</sup> The alternate wetting and drying water management technique has also been identified as one of the most promising options for mitigating CH<sub>4</sub> emissions from rice cultivation, but can reduce nitrogen use efficiency and increase nitrogen losses.<sup>22</sup></p> <p><b>b. What is the contribution of implemented and new climate measures on the reduction of methane emissions?</b></p>	<p>Spring 2021 (a and b)</p> <p>Spring 2022</p>

<sup>19</sup> Bannink et al. 2020. Applying a mechanistic fermentation and digestion model for dairy cows with emission and nutrient cycling inventory and accounting methodology. *Animal*. Vol. 14, Supplement 2, Pages 406-416

<sup>20</sup> <http://www.clrtap-tfrn.org/content/methane-and-ammonia-air-pollution>

<sup>21</sup> Wassmann et al., 2009. Chapter 2 Climate change affecting rice production: The physiological and agronomic basis for possible adaptation strategies. *Advances in Agronomy*, Vol. 101, Pages 59-122

<sup>22</sup> Cowan N., Bhatia A., Drewer J., Sutton M. et al. (under review).

	<p>There is potential for interaction between climate related measures on methane, nitrous oxide and ammonia. Examination of such relationships would require additional resources. For example, intensification of livestock management with indoor controlled ventilation systems may provide opportunities for feeding and environmental regimes that reduce methane emission and reduce nitrous oxide emissions (by limiting grazing). However, such practices risk substantially increasing ammonia levels unless a commitment is made to use ambitious technologies to control ammonia emission from housing, manure storage and land-spreading of manure.</p> <p><b>d. How could methane be addressed in a future instrument?</b></p> <p>It would be possible to specify emission limit values for methane and develop an annex of mandatory measures in agriculture. Resources would be needed to develop such an approach. All source sectors should be considered.<sup>23</sup></p>	
6.4	<p><b>Which guidance documents require an update in view of new available information, new emerged challenges and in view of further contributing to meet the long term environmental and health targets of the protocol? What new guidance documents are needed?</b></p> <p>Concerning updates to the ammonia and nitrogen guidance, see answer to Question 5.2b, including on national nitrogen budgets.</p>	Spring 2022

<sup>23</sup> Note the EU strategy on methane, which focuses on reducing methane emissions in the energy, agriculture and waste sectors (see <https://ec.europa.eu/energy/topics/oil-gas-and-coal/methane-gas-emissions-en> its roadmap and related documents ([https://ec.europa.eu/info/events/workshop-strategic-plan-reduce-methane-emissions-energy-sector-2020-mar-20\\_en](https://ec.europa.eu/info/events/workshop-strategic-plan-reduce-methane-emissions-energy-sector-2020-mar-20_en) )