Nordic Council of Ministers
Nordic Environmental Footprint

Report

Review of recommendation from the Agriculture Working Group on emissions related to manure management at farm level

Nordic Environmental Footprint Group

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Nordic Environmental Footprint Group
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1. Foreword

This is a review of the document "Environmental Footprint Initiative Agricultural Working Group 2022-2025, Milestone 3: Land based farmed animals – flows/direct emissions related to feed digestion and manure management at the facility" dated November 8th 2023. The goal of milestone 3 is to provide recommendations to improve the modelling in the Environmental Footprint (EF) method of emissions related to feed digestion and manure management from land-based animals. The recommendations in the TAB-document include models for housing, storage, and grazing and aim to take into account animal species, production system, farm management strategies, and implementation of future technology.

The review was financed by Nordic Environmental Footprint and carried out in the first half of January 2024 and thus has important time constraints. The viewpoints are based on a Nordic perspective.

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With the present paper, the NEF-group would like to contribute to Milestone 3, manure management at the facility.

The discussion paper has been drafted on a consultant basis by NORSUS

The NEF Group hopes the discussion paper may contribute to a dialogue among European stakeholders.

2. Summary of the TAB-document for Milestone 3: Land based farmed animals – flows/direct emissions related to feed digestion and manure management at the facility

Milestone 3 is based on the IPCC (2019) refinement and the LEAP guidelines (FAO 2020) as well as the PEFCR for dairy products (IDF 2022), PEFCR on feed for food-producing animals, and the PEFCR for red meat (under development). The goal of Milestone 3 is to provide recommendations to improve the modelling in EF of emissions related to feed digestion and manure management from land-based animals. The recommendations include models for housing, storage, and grazing and aim to take into account animal species, production system, farm management strategies, and implementation of future technology. The emissions generated while using manure as fertiliser is out the scope of Milestone 3 and are addressed by Milestone 2. This review of the recommendation will only consider manure management (housing, storage, pasture). Thus, enteric methane (CH_4) emissions related to feed digestion and spreading of manure is not considered in this review of the recommendation.

The specific emissions addressed in the TAB-document for Milestone 3 are the following:

1. Enteric methane (CH_4) emissions related to feed digestion (not considered in this memo)
2. Methane emissions related to animal manure management
3. Nitrogenous emissions (i.e. ammonia (NH_3) and nitrous oxide (NO)) related to animal manure management
4. Particulate matter (PM2.5) and non-methane volatile solids (NMVOCs) emitted to air
5. Flows of minerals and trace elements in manure at husbandry (i.e. excluding manure application).

2.1. Methane (CH_4) from manure (storage and pasture)

The TAB-document recommended the default method for manure CH_4 is an IPCC (2019) Tier 2 approach using case specific estimation of volatile solid (VS), maximum CH_4 production capacity by species (Table 10.16; IPCC (2019)) and CH_4 conversion factors (MCF) by manure management system and climatic zone (Table 10.17; IPCC (2019)). Where relevant, an advanced Tier 2 methodology can be used to estimate MCF. Pros and cons are listed in Table 1.

Table 1 Pros and cons recommended approach for estimating methane (CH_4) from manure (storage, and pasture)

	Pros	Cons
Default IPCC (2019) Tier 2 approach	• Take diet composition into account when estimating volatile solids • Take the maximum CH_4 production capacity of the species into account • Take the manure management system into account • Take the climatic zone into account	• Does not take the specific temperature into account
Advanced Tier 2 for MCF	• Take the specific temperature into account	• Require reliable data of 5 year average temperature

2.2. Direct nitrous oxide (N_2O) from manure (storage and pasture)

The recommended default method in the TAB-document for manure N_2O is an IPCC (2006) Tier 1 approach by estimating case-specific total amount of N in manure (following mass balance principle) and using updated default emission factors by manure systems (Table 10.21; IPCC (2019)). Pros and cons are listed in Table 2.

Table 2 Pros and cons recommended approach for estimating direct nitrous oxide (N_2O) from manure (storage, and pasture)

	Pros	Cons
Default Tier 1	• Easy to calculate	• An IPCC (2019) Tier 1 approach means that default nitrogen excretion data and default manure management system data can be used. • Not consistent to use Tier 1 compared to recommended approach for

		estimating manure CH_4 or manure NH_3 and NO which is Tier 2.
IPCC (2019) Tier 2 (not described in the TAB-document, but added as a recommendation, see comment #5)	• Take into account country-specific/case-specific nitrogen excretion rates for livestock categories. • Take into account country-specific/case-specific manure management system data can be used.	

2.3. Ammonia (NH_3) and nitric oxide (NO) from manure (housing, storage, and pasture)

For cattle and poultry the default method recommended in the TAB-document is the IPCC (2019) Tier 2 approach to calculate N excretion using the equations 10.33 (a,b,c,d,e) and 10.20 (a,b). Pros and cons are listed in Table 3. Be aware that the equation numbers in the recommendations should be corrected (see comment #9 and 10 in Table 6) and that the recommendations as it is written at this point does not include method for NH_3 and NO from cattle and poultry manure (see comment #11 and 12 in Table 6). For fattening pigs, TAN in manure is recommended to be calculated based on the formula by Cappelaere, van Milgen et al. (2021). For other mammals, TAN is recommended to be modelled based on Dämmgen and Hutchings (2008) and default values given by EMEP/EEA (2019) are recommended to be used for other livestock. Pros and cons for the different approaches are listed in Table 4. The default method recommended for NH_3 and NO in the TAB-document for other livestock types is the EMEP/EEA (2019) Tier 2 approach based on total N excretion in manure and the share of ammonium nitrogen (TAN) by manure type (e.g. slurry or solid) and emission factors for TAN by manure type and type of storage (Table 3.9; EMEP/EEA (2019)). Pros and cons are listed in Table 4.

Table 3 Pros and cons recommended approach for estimating N excretion.

	Pros	**Cons**
Cattle and poultry: IPCC (2019) Tier 2	• Reflect nitrogen in the diet and nitrogen retention by the animals	• Require information about diet composition (N-content)
Other species: IPCC (2019) Tier 2 (not described in the TAB-document but	• Reflect nitrogen in the diet and nitrogen retention by the animals	• Require information about diet composition (N-content)

added as a recommendation)		

Table 4 Pros and cons recommended approach for estimating ammonium nitrogen (TAN).

	Pros	**Cons**
Nitrogen excretion (cattle and poultry), IPCC (2019) Tier 2	• Reflect nitrogen in the diet and nitrogen retention by the animals	• Require information about diet composition (N-content) which might not be available
TAN, fattening pigs, Cappelaere, van Milgen et al. (2021).	• Robust estimation of TAN based on N-retention and N intake	• Methodology described in French and therefore not easily available. • Different methodology across species might cause methodological differences in addition to true differences
TAN, other mammals, Dämmgen and Hutchings (2008)	• Take diet into account	• Complex • Not proposed as recommended method by EMEP/EEA (2019) • Different methodology across species might cause methodological differences beyond actual differences
TAN, other livestock, EMEP/EEA (2019) default values	• Easily available in Table 3.9 • Recommended approach by EMEP/EEA (2019) as an alternative to detailed national procedures for deriving N excretion rates that provide the proportion of N excreted as TAN	• Does not reflect diet • Different methodology across species might cause methodological differences in addition to true differences
TAN, National procedures for deriving N excretion rates that provide the proportion of	• Recommended approach by EMEP/EEA (2019)	

N excreted as TAN (not described in the TAB-document but added as a recommendation, see comment 15)		

Table 5 Pros and cons recommended approach for estimating ammonia (NH_3) and nitric oxide (NO) from manure (housing, storage, and pasture)

	Pros	**Cons**
Cattle and poultry are not included in the TAB-document as it written at this point	• Consistent methodology across species • Takes type of manure and manure management system into account.	
Other livestock, EMEP/EEA (2019) Tier 2	• Takes type of manure and manure management system into account.	

2.4. Feed ingredients/additives with direct effect on nitrogenous emissions

To take reductions of emissions into account, the recommended approach in the TAB-document is to document the robustness and the magnitude of the impact according to the LEAP Guidelines (FAO 2020). The baseline emissions calculated based on the Tier 2 approach by EMEP/EEA (2019) can be modified proportionally to the documented effect.

2.5. Particular matter (PM 2.5) and non-methane volatile organic compounds (NMVOCs) emitted to air

The recommended approach in the TAB-document is to estimate PM 2.5 and NMVOCs using an EMEP/EEA (2019) Tier 1 approach.

Flows of minerals and trace elements in manure at husbandry (excl. manure application)
The recommended approach in the TAB-document is that substances in manure is modelled using the mass balance principle.

Crediting methane production from anaerobic digestion of manure to the livestock system
The TAB-document recommended to consider manure as a co-product and use economic allocation when manure is exported and has an economic value at the farm gate. It is recommended to use the relative economic value of manure compared to other livestock products to allocate the upstream burden. When manure is treated as waste, the circular footprint formula (CFF) should be used. The manure shall be treated as residual if manure is treated in an

anaerobic digester on farm. Emissions of the anaerobic digestion shall be allocated to the electricity and heat produced. If digestate is used at the farm, it shall be considered as residual. However, if the digestate is exported for other uses, the recommended approach is to use economic allocation, using the relative economic value to allocate the upstream burden.

2.6. Our recommendations

The bullet points below summarize our recommendations based on the review of the recommendation from the Agricultural Working Group on manure management. The bullet points somewhat overlap with the specific comments in Table 6.

2.6.1. General recommendations

- The data quality requirements should apply for the method to be used for the modelling of manure management.
- It should be possible to use primary/specific data for agricultural modelling. A kind of order of priority ladder could be established, first specific data, then regional or national, and then more global data but considering, for example, geographical conditions such as precipitation and temperature.
- The methods developed under AWG must live up to the intention of PEF, i.e. when an environmental impact is significant, then data must reflect the specific situation as far as possible. Thus, the recommendations should state whether a specific diet for calculation of N excretion and TAN should be considered or if it is sufficient with typical diets.
- The recommendations should also state whether a typical manure management system should be assumed or if the proportion of different management systems should be considered (i.e. national average).
- Ensure that the same approach for estimating N excretion and TAN is the basis for all emissions (N2O, NH3 and NO) and that the description of how to estimate N excretion and TAN is given before the description of how to estimate emissions.
- Methods should be consistent and cover all animal species.
- The recommendations should state what should be the alternative approach if the recommended approach (i.e. Tier 2) is not possible.

2.6.2. Recommendations methane (CH_4)

- Add references to relevant equations and tables in IPCC (2019).

2.6.3. Recommendations direct nitrous oxide (N_2O):

- Move the description of estimating N excretion so it comes before the recommendation on estimating manure N2O.
- Change the recommendation from an IPCC (2006) Tier 1 approach to an IPCC (2019) Tier 2 approach for direct N2O emissions from manure storage. Methods should mirror the actual environmental impact from the farming system. If a Tier 1 approach is accepted, it will have the effect that most food will have more or less the same footprint independent of origin.
- Add references to relevant equations and tables in IPCC (2019).

- Include description of recommendation for direct N_2O from pasture.

2.6.4. Recommendations ammonia (NH_3) and nitric oxide (NO):

- Suggest to follow the approach described in EMEP/EEA (2019) where it is recommended to use detailed national procedures for deriving N excretion rates that provide the proportion of N excreted as TAN. If that is not available, the default values (proportion TAN) in Table 3.9 (EMEP/EEA 2019) is recommended, which is the recommended approach for other livestock in the TAB-document.
- Rewrite the section and make sure it is clear which approach is recommended for which species. At this point the recommended approaches is somewhat overlapping
- Make sure that the approach for estimating emissions for all species is actually included in the section. At this point, cattle and poultry are excluded.
- Make sure that the references is to the correct equations in IPCC (2019), now the TAB-document refer to wrong equation (see comment #9, 10, and 16 in Table 6)
- In the National Inventory Report of e.g. Norway and Finland, a temperature correction factor is applied for both housing, storage, and grazing to reflect the difference in climatic conditions between Norway/Finland and central European countries. Such approach should also be described in the recommendations (see comment #19 in Table 6).

2.6.5. Recommendations indirect nitrous oxide (N_2O):

- Recommendations on the estimation of indirect N_2O from manure storage and pasture should be added.

2.6.6. Recommendations feed ingredients/additives with direct effect on nitrogenous emissions

- No comments

2.6.7. Recommendations particular matter (PM 2.5) and non-methane volatile organic compounds (NMVOCs) emitted to air

- No comments

2.6.8. Recommendations flows of minerals and trace elements in manure at husbandry (excl. manure application)

- No comments

2.6.9. Recommendations crediting methane production from anaerobic digestion of manure to the livestock system

- Applying economic allocation for manure exported off farm in animal extensive areas or areas with no horticulture will give a distorted picture of the environmental impact or the utilization rate. In many cases in Denmark manure can be transferred for

a no-cost to biogas plants who utilizes the manure (see former Nordic input concerning this issue).

Table 6 Feedback on AWG Milestone 3

Commment nr	***Page***	***Comment (justification for change)***	***Proposed change***	***Reference if relevant***
#1	7	The reference providing the formulas for nitrogen emissions from finishing pings (or rather nitrogen excretion) is in French and therefore not available to use for everyone. An English version should be provided. The formulation "nitrogen emissions" is misleading if the intention is to use only the N excretion and formula for TAN from Cappelaere, van Milgen et al. (2021) and the approaches from IPCC (2019) and EMEP/EEA (2019) for estimating N_2O, NH_3, and NO.	An English version could be made available in the appendix. Rephrase if the intention is to use the formulas in Cappelaere, van Milgen et al. (2021) for estimating N excretion and TAN, rather than emissions.	Cappelaere, van Milgen et al. (2021)
#2	7	Nitrogen-based emissions from pigs may differ across regions and breeds due to e.g. different nitrogen/protein efficiency and there could also be diet-feed interactions which may underestimate using the equations from the meta-analysis. There might be other equations that are more accurate for certain production systems or breeds. Ammonia volatilization will depend on both excreted N, manure management system and temperature, which are accounted for in EMEP/EEA 2019 and IPCC (2019)	Should recommend to use specific equations or measurements if it exist such as measurements of N-excretion from a specific breed and diet. If the effect of specific manure management systems should be taken into account, EMEP/EAA and IPCC (2019) should be used for pigs as well as other species.	EMEP/EEA (2019) IPCC (2019)
#3	11	The effect of dietary manipulation on manure should be taken into account if the documentation is available	Some examples should be provided (e.g. effect of dietary supplementation of 3-NOP on manure methane and nitrous oxide emissions) and not just references. Should also be stated in paragraphs describing emissions from manure management	
#4	11	«The work also estimates the impact on the manure content..» probably means the content of VS and N?	What manure content is influenced by diet should be stated. There are equations used for e.g. national inventory for calculating N and VS in manure based on production, diet composition and protein percentage in concentrates	
#5	15	Recommending a Tier 1 approach for direct N_2O emissions seems inconsistent as a Tier 2 approach is used for manure CH_4 and manure NH_3. IPCC (2019) states that «The Tier 1 method is applied using IPCC	Change recommendation to a Tier 2 approach with case-specific estimated total amount of N.	IPCC (2019)

		default N_2O emission factors, default nitrogen excretion data, and default manure management system data (see Annex 10A.2, Tables 10A.5 to 10A.9 for default animal weights and manure management system allocations).» The Tier 2 approach follows the same calculation as Tier 1, but include country specific data for some or all variables, e.g. country specific nitrogen excretion rate, which in the case of the AWG recommendation already are recommended «..based on case-specific estimated total amount of N in manure».		
#6	15	Methodology for estimation of total N is not described other than «case-specific, following the mass balance principle» and should be based on the same diet as estimation of enteric CH_4 and manure volatile solids and influenced by both animal performance and diet composition. However, at page 16 a reference to equations in IPCC (2019) refinements are provided for estimating N excretion for cattle and poultry and EMEP/EEA (2019) for other livestock as a basis for estimating NH_3 and NO from manure. The same basis should be used for direct N_2O and the explanation on how to calculate N excretion should be given before all N-emissions.	Provide references to equation numbers in IPCC (2019) refinements	IPCC (2019)
#7	16	Link or reference to the spreadsheet for calculating mass balance for TAN in each step of manure handling should be provided	Add link	
#8	16	Description of NH_3 and NO from manure is a lot more detailed than other emissions (CH_4 and direct N_2O) with references to equations in IPCC (2019) refinements. Such details should be provided for all emissions to avoid confusion.	Provide details and references to equation numbers in IPCC (2019) refinements for manure CH_4 and direct N_2O from manure	IPCC (2019)
#9	16	Unprecise reference to equations for cattle «IPCC (2019 - equation 10.33 (a, b, c, d, e),». The N retention rates for cattle are given in equation 10.33. According to IPCC (2019), the amount of N excreted can be estimated as the difference in the total nitrogen taken in by the animal and the total nitrogen retained for growth and milk production. For cattle, N intake can be estimated using equation 10.32	Provide a better explanation on how to estimate N excretion with precise reference to N retention rate. The same diet should be used as the basis for estimating enteric CH_4, manure CH_4, manure N_2O, manure NH_3, and manure NO. Many countries have detailed procedures to derive N excretion rates for different livestock categories, which should be recommended if available	IPCC (2019)

#10	16	Unprecise reference to equations for poultry «IPCC (2019 - equation 10.20 (a, b)» does not exist and equation 10.20 is for total emissions from livestock enteric fermentation (Tier 1). The reference should probably be equation 10.31 A, which is the annual N excretion rates, Tier 2, which use the N intake together with the N retention to estimate N excretion. For poultry, equation 10.32A give N intake rates. N retention rates for laying hens are given in equation 10.33D and for N retention rates for pullets or broilers are given in equation 10.33E.	Provide accurate description and references. Many countries have detailed procedures to derive N excretion rates for different livestock categories, which should be recommended if available	IPCC (2019)
#11	16	Unprecise description of default method for other livestock types as it refers to EMEP/EEA (2019) Tier 2 approach for estimating «these emissions», which in the previous sentences refer to N excretion. to EMEP/EEA (2019) give default values for Nex in Table 3.9 based on IPCC (2006) Table 10.19. Table 10.19 is also included in IPCC (2019) refinements and should be used instead of IPCC (2006). It is also described that N excretion should be estimated by mass balance – i.e. not by the default values in Table 3.9 in EMEP/EEA (2019).	Provide more accurate description and references	EMEP/EEA (2019) IPCC (2019)
#12	16	Description written «for other livestock types» is the only recommendation including methodology for estimating NH_3 and NO emission and should be rewritten as the recommendations as it is written now fail to give any recommendations for estimating NH_3 and NO emissions from cattle and poultry.	Provide more accurate description and references	EMEP/EEA (2019)
#13	17	Instead of giving the description of the methods for estimating TAN above in the background, it should be given in the recommendations	Move description from background to the recommendations	
#14	17	Not clear if the recommendation is to calculate NH_3 and NO from fattening pigs based on Cappelaere, van Milgen et al. (2021) or EMEP/EEA (2019) the approach for estimating TAN from Cappelaere, van Milgen et al. (2021)	Provide more accurate description	
#15	17	The approach described in Dämmgen and Hutchings (2008) is according to the statement in the abstract an Tier 3 approach. In EMEP/EEA (2019) Tier 2 approach there is recommended to use detailed national procedures for deriving N excretion rates that provide the proportion of N excreted as TAN. If that is not available, the default values (proportion TAN) in table 3.9 is recommended.	Suggest to follow the recommendation for estimating TAN by using either detailed national procedures for deriving TAN or using the default values (proportion TAN) from table 3.9	Dämmgen and Hutchings (2008) EMEP/EEA (2019)

#16	17	«When calculating N excretion by mass balance, the formulas for N-retention depending on actual milk and egg production as well as live-weight gain given in IPCC (2019 - equation 10.33 (a, b, c, d, e) and equation 10.20 (a,b)) are to be used for the respective livestock species and production.» is a repetition of the text on page 16. It is not clear which species is meant by "respective species" when the terms cattle, poultry, fattening pigs, other mammals, and other livestock have been used	Rewrite to avoid repetition and specify which species is meant as it is confusing and not easy to know which species are included in "other livestock" when many different terms are used (i.e. cattle, poultry, fattening pigs, other mammals, and other livestock)	IPCC (2019)
#17	16/17	The recommended approach for NH_3 and NO are mainly focusing on estimating TAN, which are overlapping for the different animal species and should be rewritten. The approach for estimating N and TAN should be described before both the recommendation for direct N_2O and NH_3/NO.	Move description	
#18	16/17	Calculating indirect N_2O from ammonia volatilization and run-off/leaching is not described in the recommendations	Add description	IPCC (2019)
#19	16/17	In the calculations for the National Inventory Report, some countries such as Norway and Finland use a temperature correction factor for both housing, storage, and grazing to reflect the difference in climatic conditions between Norway/Finland and central European countries. Such approach should also be described in the recommendations.	A description of the approach used by Norway is available in Carbon Limits (2020)	Carbon Limits (2020)
#20	17	Criteria for required documentation should be stated in the recommendations	Add criteria	(FAO 2020).

References

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NEF - Nordic Environmental Footprint

Nordic Environmental Footprint (NEF) was established in 2015 by the working group for Sustainable Consumption and Production under Nordic Council of Ministers (NMR).

The aim is to coordinate the Nordic countries authority work of common interest regarding Environmental Footprint work, Eco-Design for Sustainable Products Regulation and Green Claims and in common keep an up to date overview regarding the development in the EU PEF and OEF of special Nordic interest within these policy areas.

The participants of the group include national representatives and are organized in a Steering Committee and a Technical Advisory Board

The NEF group will initiate debate and analyses of issues of common Nordic interest. Activities of common interest are initiated by NEF who will disseminate knowledge regarding PEF to Nordic stakeholders. Information about the NEF conferences can be found under

https://www.nordic-pef.org/