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Support to the improvement of national air pollutant emissions inventories for the agricultural sector in Europe

Administrative Arrangement
DG JRC Air and Climate (C5)
DG Environment Clean Air and Urban Policy (C3)

Banja M., Crippa M., Pagani F., Pisoni E.

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Joint Research Centre

EUR 31015 EN

Contact information
Name: Manjola Banja
Address: Joint Research Centre, EC, Via Enrico Fermi 2749, Ispra 21027, Italy
Email: Manjola.Banja@ec.europa.eu
Tel.: +390332786253

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Authors

Manjola Banja
Monica Crippa
Federico Pagani
Enrico Pisoni

Abstract

To improve the estimates of air pollutant and greenhouse gas (GHG) emissions from agricultural activities we need transparent and harmonised emission inventories; also, we need to know how these estimates from such activities are performed and reported. This is important not only in relation to the direct impact of these activities, but also to understand their contribution in relation to other sectors such as energy, industrial processes, waste etc…

The aim of this report is to provide an overview of the work done in supporting EU Member States (MS) to improve their national air pollutant emissions from agricultural activities. The work has started from the identification of methodologies and parameters needed to estimate air pollutant and GHG emissions from all agricultural sub-sectors, following the EMEP/EEA Guidebook and IPCC Guidelines. On the basis of this analysis, a database of agriculture air pollutant emission factors has been created together with a user-friendly web tool to estimate the emissions.

The work done aims at providing to the EU Member States the knowledge and the actual tool necessary to improve their reporting moving towards higher tiers methodologies. Moreover the methodology and the tool proposed will allow MS to develop air pollutant and GHG emission inventories in a consistent way using them for their reporting the template set under the Air Convention and referred to in the National Emission reduction Commitments Directive (NECD).

1 Introduction

Air pollution and climate policies of the European Union are pursuing high ambitions on their way towards 2030 and 2050. The European Union (EU) adopted in 2013 a Clean Air Policy Package containing a new Clean Air Programme for Europe, setting new air quality objectives up to 2030 (EC, 2013).

The new National Emissions reduction Commitments Directive (NECD) (EC, Directive 2016/2284, 2016), in particular, is the main legislative instrument to achieve the 2030 objectives of the Clean Air Programme for Europe, setting emission reduction commitments for five main pollutants.

In December 2019 the European Commission presented its European Green Deal – a multi-sectoral roadmap for green and just transition, including the political ambition of climate neutrality by 2050. A year later the European Council endorsed a target of at least 55% reduction of net emissions by 2030. In June 2021 the European Climate Law (EC, 2021a) came into force and both 2030 and 2050 targets became legally binding (EC, 2021b).

In terms of air pollutant emissions, the EU Member States (MS) are required to report on the level of air pollutant emissions (yearly inventories and Informative Inventory Reports - IIRs), policies, measures and projections including existing/additional measures (obligations under the NECD).

The European Commission has the role of reviewing the reported national emission inventories and verify their transparency, accuracy, consistency, comparability, and completeness. Starting from February 2022, the EU Member States will report emissions with the purpose of complying with the NECD emission reduction commitments for 2020-2029; followed by reporting towards complying with the emission reduction commitments for 2030 onwards

Being parties of the United Nations Framework Convention on Climate Change, Kyoto Protocol and Paris Agreement the EU Member States are also required to report on their annually greenhouse gas (GHG) emissions (National Inventory Reports – NIRs; Common Reporting Format Tables - CRF) and their climate policies, measures, and their progress towards targets (biennial reports and national communications).

Commitments towards lowering air pollutants and greenhouse gas emissions are very important, to improve air quality and fight global warming, and the accurate monitoring of emissions across all countries is crucial for meeting the established targets. Countries may either under-estimate or over-estimate their emissions, with a gap between actual emissions into the atmosphere and what has been reported. For facts-based policy making and to identify relevant policy priorities, it is important to know accurately what is emitted in the atmosphere.

Emission inventories are a quantitative expression of the pollution load in a defined area, region, or country at a certain time. These inventories are the starting point to monitor the progress of each country in reducing emissions and to assess the collective effort for climate change mitigation. Emission inventories are prepared using methods provided in the EMEP/EEA Guidebook and IPCC Guidelines which have evolved over time improving the methodologies and covering more emissions sources.

Among all anthropogenic sources, agricultural activities such as enteric fermentation, manure management, fertiliser application, cultivation of crops, farm level operations, field burning of agricultural residues etc, included in the EU Effort Sharing System and under the NEC Directive, are sources for mainly emissions of methane (CH_4) and ammonia (NH_3).

In 2019 overall ammonia emissions in the EU were nearly 8% lower than in 2005 (lowest reduction for any of the NECD pollutants). Moreover, when 2019 MS ammonia emissions are compared with national ceilings (that applied for the period 2010-19), four MS were still found to exceed their national ceiling in 2019 (EEA Brief, 2021).

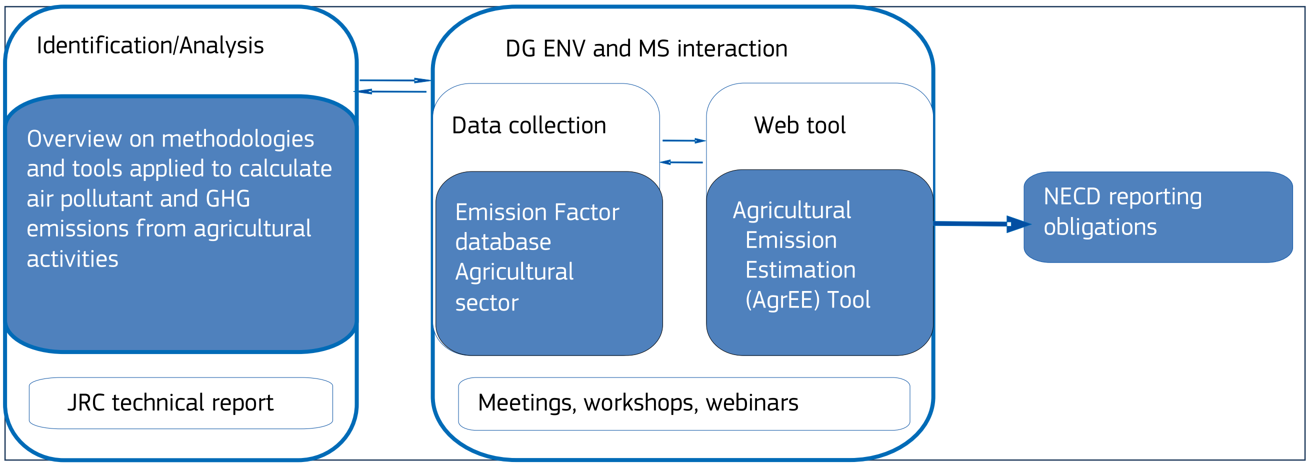
This report presents the work done under the Administrative Arrangement between Directorate General for Environment - Clean Air & Urban Policy (ENV.C.3) / JRC-C.5 related to the "Support to the improvement of national emission inventories for the agricultural sector in Europe".

The report is structured as follows: ***chapter 2*** provides an overview of the project including tasks and deliverables followed by the discussion on some of the challenges in the EU agricultural sector and some information on emission inventories, their reporting and available quantifying tool. An update on the state of methodologies applied to estimate the air pollutant emissions is also described here. Moreover in this chapter detailed information on how the EU Member States include the abatement measures/techniques in the estimation of ammonia emissions from agricultural activities is included. ***Chapter 3*** deals with the air pollutant emission factors database for agricultural sector developed under this Administrative Arrangement based on the EU Member States Inventory Reports submitted under the NECD. The description of the main deliverable of this work (the AgrEE tool) is provided in ***chapter 4***. Some examples of the application of the web tool in the estimations of air pollutants and methane emissions in some EU Member States as well as the comparison between current reporting and results obtained using the web tool is shown in ***chapter 5***. The agriculture sectors, categories, air pollutants, greenhouse gases included in the web tool, structure of inputs for methods applied in the tool are shown in the Annexes of this report.

2 Project overview

The project is developed under the Administrative Agreement between Directorate General for Environment - Clean Air and Urban Policy (ENV.C.3) and the Air and Climate Unit (C.5) of the Joint Research Centre. The general objective of this Administrative Arrangement is to support the development of robust agricultural air pollutants emissions inventory data at EU Member State[1] level as requested by the National Emissions reduction Commitments Directive (EC, Directive 2016/2284, 2016). Figure 1 illustrates the main objectives of this project.

Figure 1. Schematic view of the project and deliverables under the Administrative Arrangement



The work supports the European Commission environmental and climate ambitions. The NECD (2016/2284/EU) established emission reduction obligations (comparing with baseline year 2005) for the periods 2020-29 and 2030-onward, for five main air pollutants NOx, NMVOCs, SO_2, NH_3 and $PM_{2.5}$ (see Figure 2) that can lead to adverse effects on both human health and ecosystems. The NECD requires yearly reporting by EU Member States of air pollutant emission inventories, to assess the progress of air pollution reduction in the EU and to identify whether Member States are compliant with their commitments.

Figure 2. Air pollutants covered by NECD corresponding EU level reduction to be achieved as of 2030 (vs 2005)

Source: (EC, Directive 2016/2284)

This project supports the Commission priorities from the EU Green Deal, implemented in particular through the EU Action Plan “Towards Zero Pollution for Air, Water and Soil” (EC, COM (2021) 400 final) and is in line with the “EU Methane Strategy” (EC, COM (2020) 663 final) aiming at improving the emission reporting from the agricultural sector through better data collection. This project has been developed through the following tasks and deliverables during the period 2020-2022 (see Figure 1):

Task 1 - Preparation of the information needed to develop the inventory web tool. Deliverables under this task are:

- JRC technical report on methodologies applied in the EU Member States to estimate air pollutant and greenhouse gas emissions from agricultural activities (see Section 2.3),
- Development of an emission factors and activity data database (see section 3).

Task 2 - Supporting the dialogue with Member States in collaboration with DG ENV and collecting detailed information. This has been done through a series of dedicated meetings listed below:

(1) Hereafter EU Member States refers to EU27

- Ambient air quality expert group relating to the implementation of the directive on the reduction of national emissions of certain atmospheric pollutants - DG ENV (June 2020, February, and December 2021)
- UNECE Task Force on Emission Inventories and Projections (TFEIP), Agriculture and Nature Expert Panel meetings (UNECE, TFEIP) (May 2020 and 2021),
- Workshops on inventory capacity building – Ricardo Energy & Environment, Citepa, Aether-UK, DG ENV (November 2020 and September 2021),
- Meeting of the expert group for sustainability and quality of agriculture and rural development, Sub-group on methane emissions in agriculture – DG AGRI (28 June 2021),
- Workshop on Ammonia reducing technology & measures: how to include the reduction effect in the national emission inventory and projections – TAIEX EIR Peer 2 Peer European Commission programme[2] (16 November 2021).

Task 3 - Development of a tool to compute air pollutant and greenhouse gas emissions from agricultural sector. More in details:

- The purpose of developing a tool for the calculation of air pollutant and GHG emissions from agricultural activities is to provide the user/inventory compiler with the possibility to improve consistency between air and GHG emission reporting and to move to a Tier 2 methodology for their reporting following the template set under the Air Convention and referred to in the NECD (EC, Directive 2016/2284, 2016).
- Detailed description of the deliverable under this task is provided in chapters 4 and 5. A user guide is provided to the MS inventory compilers describing all the steps needed to apply when using the Agricultural Emission Estimation (AgrEE) tool.
- Two webinars were also organised in collaboration with DG Environment on 12th and 19th October 2021 providing guidance to the MS on how to use the AgrEE tool.

The tool and related documents are available at https://edgar.jrc.ec.europa.eu/agree_tool/

(2) https://webgate.ec.europa.eu/TMSWebRestrict/resources/js/app/#/library/detail/81159

2.1 Challenges linked to reporting air pollutant emissions from agriculture

The agricultural sector covers plenty of processes (e.g. livestock production, decomposition of manure, agricultural soil management etc.) that include activities emission-producing activities such as enteric fermentation, manure management, fertiliser use, burning agricultural residues etc. resulting in emissions of different air pollutants (ammonia (NH_3), nitrogen oxides (NOx expressed as NO_2), particulate matter (PM_{10}, $PM_{2.5}$, TSP), non-methane organic volatile compounds (NMVOC), sulfur dioxide (SO_2), carbon monoxide (CO), heavy metals) and greenhouse gases (GHG), such as methane (CH_4), and nitrous oxide (N_2O).

Cows are responsible for nearly 60% of air pollution from the EU livestock sector

Adobe Stock #170071737

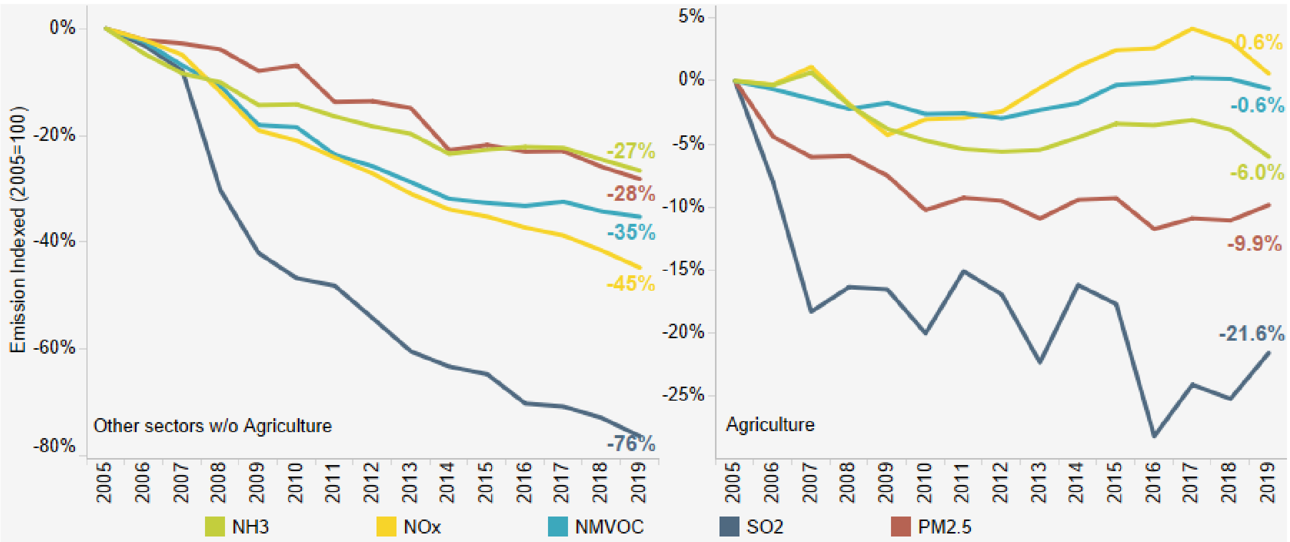
In particular ammonia emissions from the agricultural sector represents 93% of total EU NH_3 emissions in 2019, half of which derives from agriculture soils.
Agriculture also represents the largest contribution in the anthropogenic CH_4 emission sources in the EU, with a share of 45% of all GHG emissions from the EU agricultural sector, of which 80% sourced from enteric fermentation.

Advanced and proven techniques (BAT) are available for large poultry and pig facilities, being regulated through the Industrial Emissions Directive (IED).

Moreover, the NECD (EC, Directive 2016/2284, 2016) refers to several measures aiming at reducing emissions from agriculture

Overall ammonia emissions decreased by nearly 8% since 2005 reaching 3526 kt in 2019, but the decrease within the EU agricultural sector was by only 6% in comparison with 26% drop in other sectors (see Figure 3). Agricultural ammonia emissions reached 3299 kt in 2019 with manure management being the main contributor in this decrease as its ammonia emissions were nearly 11% lower in 2019 comparing with 2005. The main source of ammonia emissions within the EU agricultural sector remained the agricultural soil activities, which contributed with a limited decrease by only 2% in 2019 compared with 1827 kt in 2005.

Figure 3. Relative change of the EU air pollutant emissions covered by NECD versus baseline year, 2005-2019

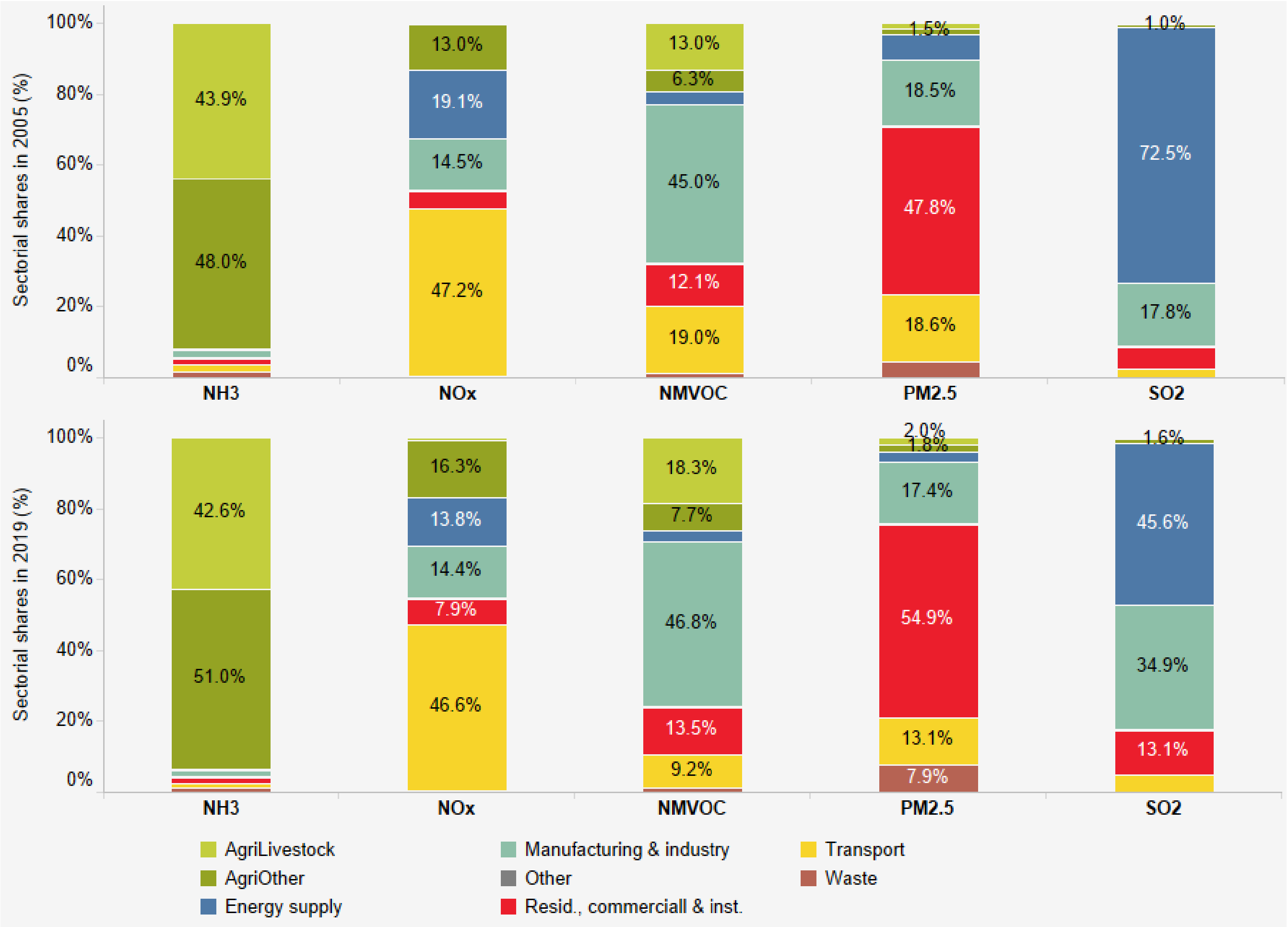


Source: (EEA, NECD Emission Inventory Data Viewer, s.d.), JRC elaboration

The share of agriculture emissions in the overall EU emissions has also changed in the latest decades, depending on the pollutants considered.

Figure 4 illustrates the sectorial breakdown of the EU emissions of air pollutants covered by NECD in years 2005 and 2019. The contribution of NH_3 from agricultural activities increased from 91.6% in 2005 to 93.6% in 2019. In overall the NH3 and NOx emissions increased linked this with the significant decrease of SO_2 emissions in other sectors and limited decrease of NOx and NH_3 emissions in agricultural sector. It is worth to notice for instance that the relative drop of SO_2 emissions from agricultural activities was more than 3 times lower than the decrease in other sectors (see Figure 3).

Figure 4. Sectoral shares of air pollutant emissions covered by NECD in EU, 2005 & 2019



Source: (EEA, NECD Emission Inventory Data Viewer, s.d.), JRC elaboration

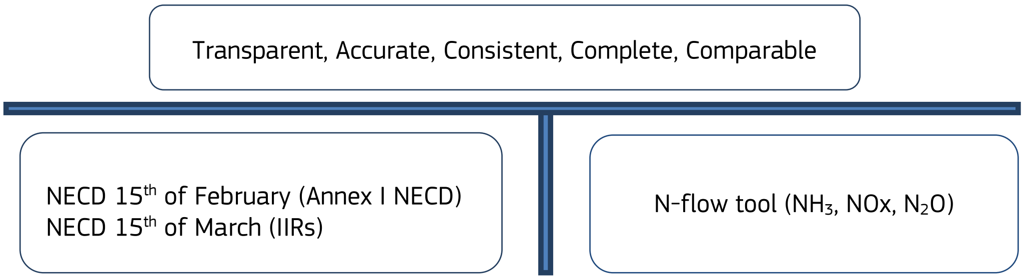
In 2019 NOx emissions from the EU agricultural activities were 0.6% above the level in 2005 whereas, on the contrary, the respective emissions in other sectors dropped by 45%. The main contribution to this increase came from emissions of agricultural soils activities: their share reached 16.3% in 2019 comparing with 2005, from 5.8% to 10.1%, mainly due to the increase of fertilisers use.

The share of NMVOC emissions from the EU agricultural activities increased from nearly 19% in 2005 to nearly 26% in 2019, whereas the share of PM2.5 emissions slightly moved up from 3% to 3.8%.

2.2 Emission Inventories, reporting and quantifying tools

Emission inventories are at the basis of EU legislation towards reducing those emissions and play a major role in assessing the environmental impact of those emissions in developing emission control strategies and air quality management decisions and in assessing the progress or changes over time towards achieving the goal of cleaner air. Air pollutant emission inventories are compiled for emissions from different sectors being so an important input to the atmospheric models. Considering abatement measures, emission inventories enable the evaluation of their effects within different sectors that can be assessed and compared, investigating the costs of the different options and enabling the identification of most cost-effective emission reduction measures.

Figure 5. Information on emission inventories, reporting times for air pollutants and main quantifying tools



Currently, the EU Member States compute air pollutant emissions from their agricultural activities based on the EMEP/EEA Guidebooks 2013, 2016 and 2019, and GHG emissions based on the IPCC Guidelines (1997, 2006 and 2019) and the IPCC Good Practice Guidance (IPCC, 2000).

Consistency exists among methodologies applied to compile the agricultural emission inventories under the United Nations Framework Convention on Climate Change (UNFCCC) and the UNECE Air Convention through integrated databases, preparation of inventories and reporting. However, since in some cases Member States use older versions of the EMEP/EEA Guidebooks the consistency between inventories is not always achieved.

Every year, before 15 February, Member States must report their national air pollutant emissions to the European Commission up to the year (t-2). The Informative Inventory Reports (IIRs) shall be submitted before 15 March. In February 2022 and every year after, Member States will report emissions for the purpose of complying with the emission reduction commitments for 2020-2029; followed by reporting towards complying with the emission reduction commitments for 2030 onwards. Under the NECD the European Commission reviews national emission inventories and verifies their transparency, accuracy, consistency, comparability, and completeness.

Among the existing tools developed in support to official emission reporting there are the IPCC Inventory software and EMEP/EEA N-flow tool shortly described hereafter.

The ***IPCC Inventory software***[3] implements a Tier 1 method for all anthropogenic emitting sectors and a Tier 2 method for most of the categories including those of agriculture. The IPCC 2006 methodology can be applied to calculate with the same activity data (such as the number of livestock, animal weight, feeding situation and animal waste management system (AWMS)) the CH_4 emissions from enteric fermentation (3A) and manure management (3B) and N_2O emissions from manure management (3B).

The ***N-flow tool*** is part of EEA/EMEP Guidebook 2019 and is available for download[4]. The tool provides a Tier 2 approach to calculate NH_3, NOx, N_2O and N_2 emissions from manure management (3B), manure applied to soils (3Da2a), urine and dung deposited by grazing animals (3Da3), and biological treatment of waste (5B2).

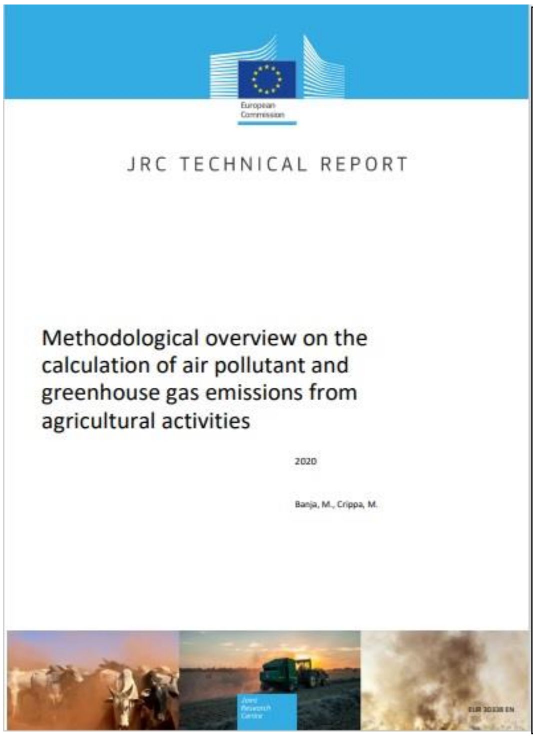
Application of these tools do not provide however a unique place where all air pollutant emissions from agricultural activities can be calculated in a consistent way with the guidelines in place, which brought to the development and implementation of a new web tool described in detail in Chapter 4.

(3) https://www.ipcc-nggip.iges.or.jp/software/index.html
(4) https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

2.3 Methodological overview

An overview on the methodologies reported by EU MS in their IIRs to estimate air pollutant and greenhouse gas emissions from agricultural activities, has been provided in the recently published JRC technical report (Banja et.al., 2020).

Figure 6. Task 1 deliverable Administrative Arrangement



Region of interest: EU Member States

Period covered: 1990-2018

Air pollutants: NH_3, NOx (as NO_2), NMVOC, PM_{10}, $PM_{2.5}$

Greenhouse gases: CH_4, N_2O

Methodological overview by sector, country, air pollutant, greenhouse gas

Approaches for the improvement of agricultural emission estimates

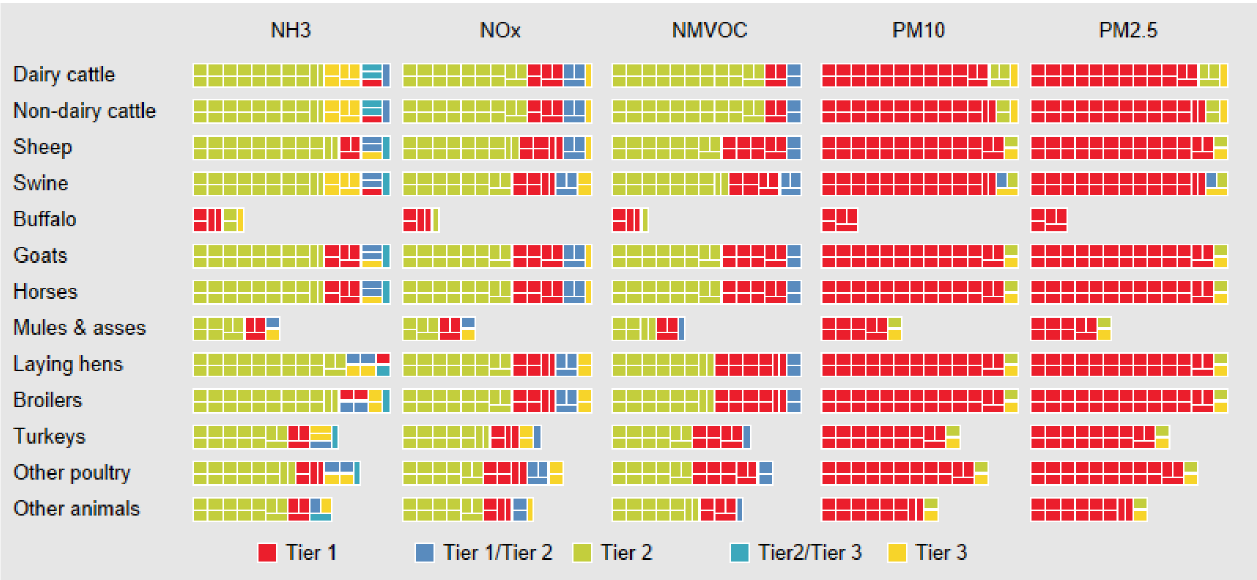
Other sources (EDGAR, CAPRI) to quantify air pollutant emissions

Best inventory practices in compilation and reporting

Example of questionnaires for farms

An update of the findings of this report are presented in Figures 7, 8 and 9[5]. The report shows that according to the MS IIRs the Tier 2 is the main method applied to estimate emissions of NH_3, NOx and NMVOC from cattle and that a combination of Tier 2 & Tier 3 methods is applied for livestock categories as cattle, swine, and poultry. According to these reports the Tier 1 is the main method for estimation of particulate matter emissions from livestock.

Figure 7. Methods reported by EU Member States to estimate air pollutant emissions from livestock

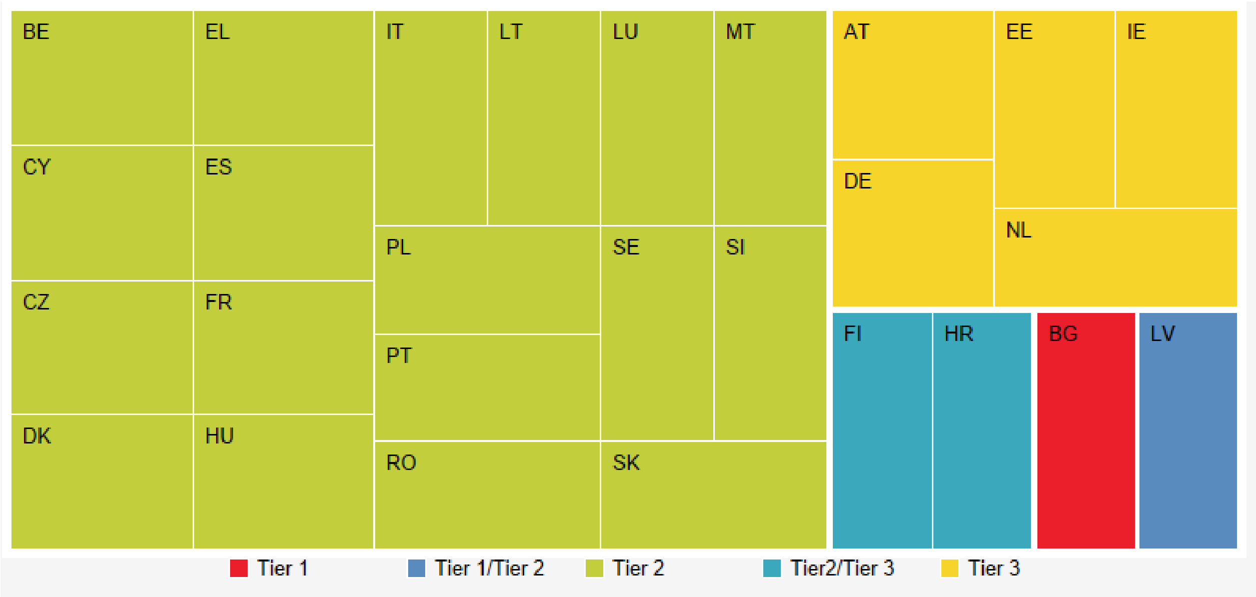


Source: (EU MS IIRs, Eionet, 2021), JRC elaboration

([5]) In Figures 7 and 9 each square represents one MS. The length of a rectangle is linked with the number of MS that calculate air pollutant emissions from the selected category. The largest rectangle contains 27 squares.

Figure 8 illustrates methods reported by EU MS in their IIRs to estimate NH_3 emissions from cattle (dairy and non-dairy). Tier 2 method is reported as being applied in more than half of EU countries. Advanced Tier 3 method is reported as applied in some of the countries related mainly to the extended application of country specific activity data and emission factors as well as in the application of several abatement measures for NH_3 emissions.

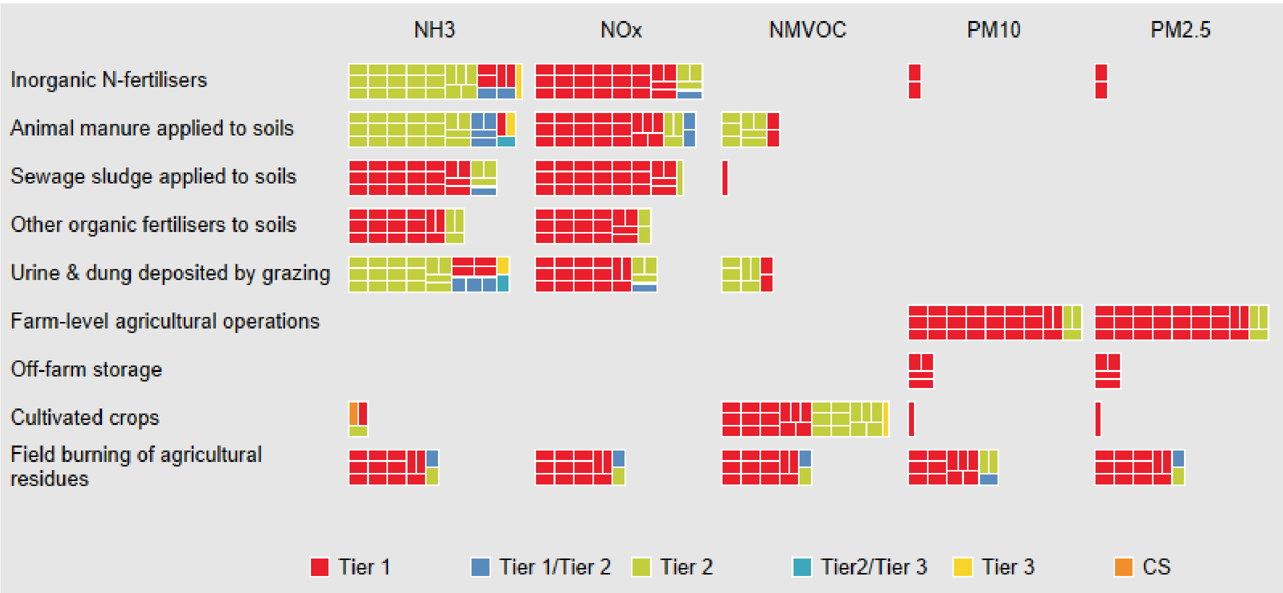
Figure 8. Methods reported as applied in EU countries to calculate NH_3 emissions from cattle[6]



Source: (EU MS IIRs, Eionet, 2021), JRC elaboration

Based on EU MS reporting Tier 1 is the main method applied for estimating NOx and particulate matter emissions from agricultural soils categories. Tier 2 method is reported to be mainly applied for NH_3 emissions from inorganic N-fertilisers and manure applied to soils (related with estimation in manure management). Tier 1 method is reported as applied in several MS to estimate NMVOC emissions from cultivated crops manure applied to soils, sewage sludge, farm level agricultural operations and urine and dung deposited by grazing.

Figure 9. Methods reported as applied in EU countries to calculate air pollutant emissions from agriculture soils



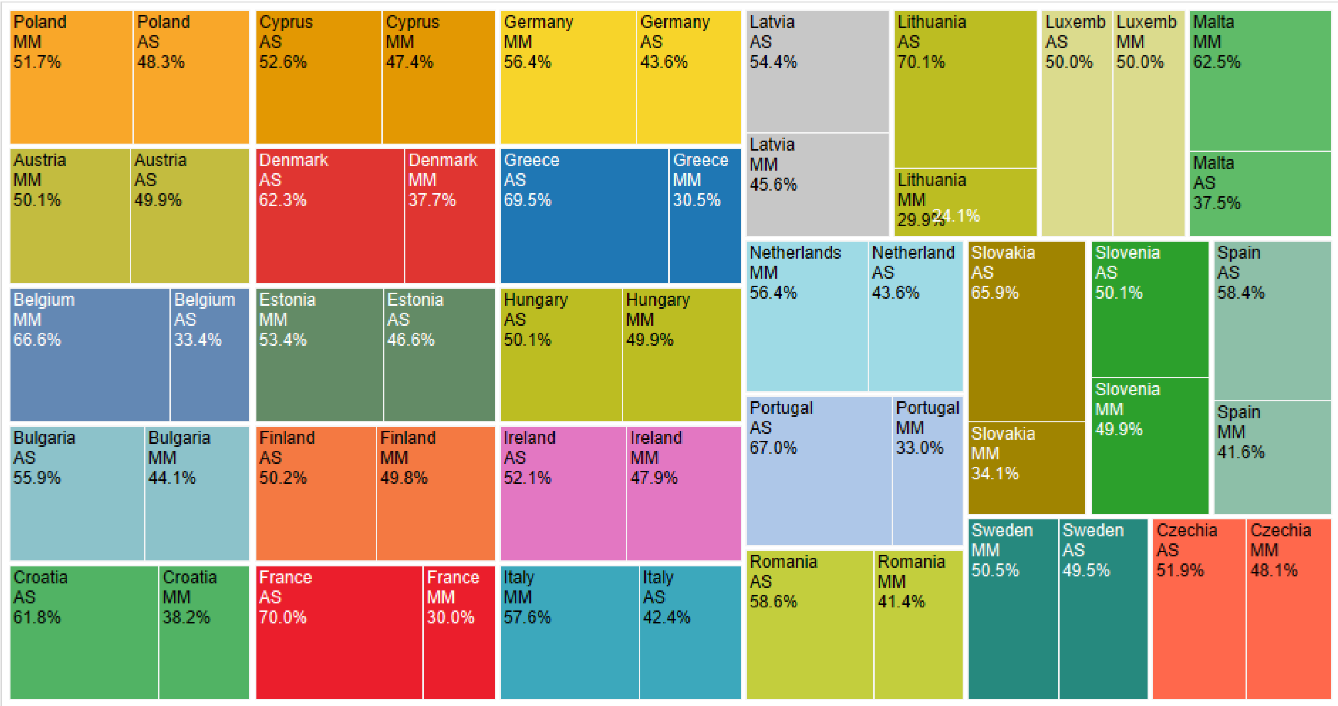
Source: (EU MS IIRs, Eionet, 2021) , JRC elaboration

(6) A combination of methods is applied to estimate the emissions of air pollutants from manure management and agricultural soils activities. This includes not only the emission factors applied but also the activity data used. For example, one country might apply country specific activity data (that can be considered as Tier 2) and default emission factors (that can be Tier 1 or Tier 2). Or it can use default activity data (Tier 1 or Tier 2) applying country specific emission factors (Tier 2). The definition “T1/T2” or “T2/T3” shows only that a combination of two methods has been applied for a certain category.

2.4 Abatement measures for ammonia in the EU agricultural sector

As already reminded ammonia is mainly sourced from agricultural activities which accounted for 93% (3301 kt) of total EU ammonia released in atmosphere. As shown in Figure 10 the majority of NH_3 emissions from agriculture derives from manure management ("MM") in 6 EU MS (Italy, Malta, Finland, Bulgaria, Netherlands, and Estonia), whereas the agricultural soils("AS") slightly dominate in the rest of the countries.

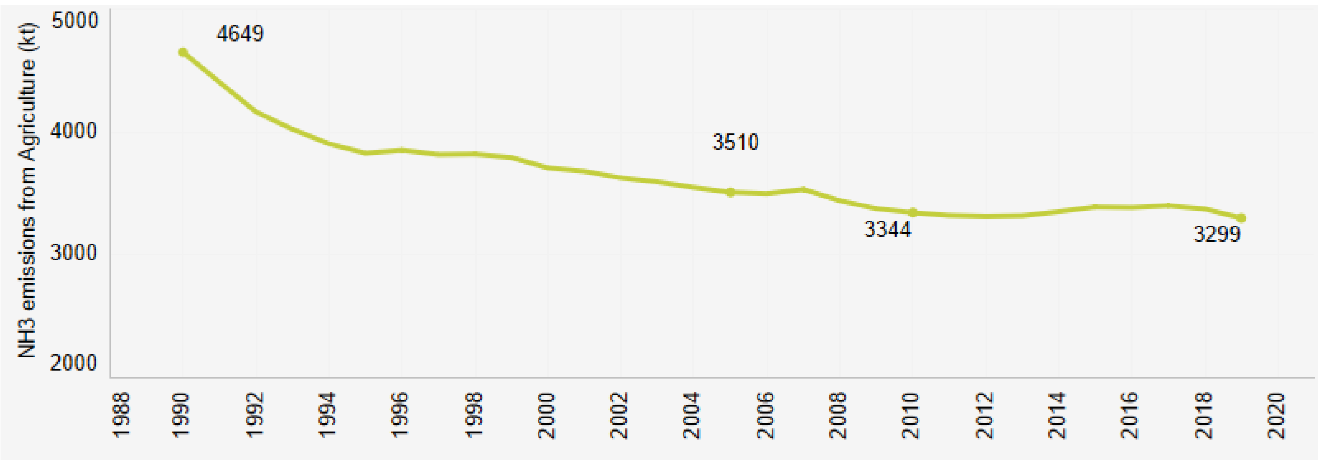
Figure 10. Breakdown by source of NH_3 emissions in each EU Member State agricultural sector, 2019



Source: (EEA, NECD Emission Inventory Data Viewer, s.d.) JRC elaboration

Ammonia emissions sourced from the EU manure management decreased by nearly 11% between 2005 and 2019, reaching nearly 1501 kt. During the same period ammonia emissions from agricultural soils activities decreased by only 2% (1798 kt in 2019). Figure 11 illustrates historic trend of ammonia emissions from the EU agricultural sector over period 1990-2019 (EEA, NECD Emission Inventory Data Viewer, s.d.).

Figure 11. Trend of NH_3 emissions in the EU agricultural sector, 1990-2019



Source: (EEA, NECD Emission Inventory Data Viewer, s.d.), JRC elaboration

A more accurate estimation of emissions of air pollutant and greenhouse gas emission can be reached using a Tier 2 method with activity data and emission factors originating from experiments or models. Tier 3 methodology can also be used to report the effect of abatement measuresm taken to reduce the emissions following guides such as those listed in the UNECE Ammonia Guidance and UNECE Framework Code for Good Agricultural Practice under the Air Convention. The UNECE framework code measures are also referred to in NECD Annex III, part 2.

Measures to reduce ammonia emissions in the agricultural sector can be applied to several stages of the nitrogen cycle from housing, storage, manure application, feeding process to the application of fertilisers. Several measures that can be applied in these stages are described in the UNECE Guidance document on preventing and abating ammonia emissions from agricultural sources. It is worth noticing that the reduction options for NH_3 at the various stages of livestock manure production and handling are interdependent, and combinations of measures are not simply additive in terms of their combined emission reduction (UNECE ECE, 2014).

Measures that can be applied to reduce NH_3 emissions in the agricultural sector are related with the floor area (fully or partly slatted), the way manure is removed, conditions in housing (temperature and pH), drying manure, air scrubbing, grazing time, covering manure, injection of slurry manure, direct incorporation of solid manure etc, (see Table 1).

Table 1. Some NH_3 abatement measures/techniques that can be applied in different stages of nitrogen cycle in livestock sector

Housing	Reduction (%)	Manure Storage	Reduction (%)	Manure Application	Reduction (%)
Housed floor	25-75	Tight lid	80	Injection	>60
Air scrubbing	70-90	Floating/Plastic cover	60	Band application	>30
New house	0-90	Natural crust cover	40	Direct incorporation	30 - 55
		Other low technology cover	40	Dilution	>30

Source: (UNECE ECE, 2014)

A description of NH_3 abatement measures reported by several EU MS up to 2019 is provided below. Some information related to manure in house can be used in the new JRC web tool (see Chapter 4 for more detailed information on the tool and its features) when estimating the NH_3 emissions from livestock.

In **Austria** abatement measures to reduce ammonia emission are reported as applied in housing, storage (see Table 2), application of manure and fertilisers. Categories for which these measures are applied in the livestock sector are cattle, swine, laying hens, and broilers. Solid cover dominates among other types of covers applied (straw, plastic foil, natural crust) whereas houses are equipped with grooved and partially slatted floor. Combination of new and highly efficient urease and nitrification inhibitors corresponds to a reduction potential of 70% for solid urea (IIR AT, 2021)..

Table 2. Austria's abatement factors for NH_3 emissions from manure storage

Manure Storage	Abatement Factor
Composted solid manure	1.21
Solid cover – liquid system	0.2
Aerated open tank – liquid system	1.1
Straw cover – liquid system	0.6
Plastic foil cover – liquid system	0.4
Natural crus – liquid system	0.6

Source: (IIR AT, 2021)

In **Belgium** it is reported that the integration of solid manure within 24 hours is mandatory in Walloon region since 2002. The (UNECE ECE, 2014) abatement factor of 30% is used for this practice. The abatement factors are applied on the emissions from field application. In the Walloon region less than 10% of swine is in houses with air scrubbers (70% of efficiency) or biofilters. In Flanders low emission housing (ammonia-emission poor stables) are mandatory for the new stables. This is applied mainly for swine and poultry. Also, since 2007 the manure must be incorporated within 2 hours or injected on arable land.

Table 3. Abatement techniques in manure application system in Belgium

Spreading system (slurry)	Distribution (%)	Reduction (%)
In surface	65	
Near the soil	19	39
In the soil (injection)	16	75

Source: (IIR BE, 2021)

Croatia reports to apply a Tier 2 method with abatement measures to estimate NH_3 emissions from swine and poultry in all stages of nitrogen cycle in livestock sector (IIR HR, 2021). Table 4 shows abatement techniques applied in manure storage and application processes in the ammonia emission calculations.

Table 4. Abatement measures for NH_3 in Croatia manure storage and application systems

Manure storage technique	Reduction (%)
Tight lid, roof, or tent structure	80
Plastic sheeting (floating cover)	60
Natural crust (floating cover)	40
Plastic sheeting (floating cover)	40
Manure application technique	
Incorporation of surface applied slurry (within 4 h)	55
Injecting slurry (closed slot) - deep injection (> 15cm)	85
Incorporation of surface applied slurry (within 24 h)	30

Source: (IIR HR, 2021)

In **Czechia,** it is reported that low ammonia application techniques (provide a faster incorporation of manure into soils since 2011; it concerns 83% of manure with a reduction of at least 30% . Abatement factors used are those of (UNECE ECE, 2014). Techniques applied in manure application are listed in Table 5. In housing 44 % of rearing pigs in intensive pig farms were housed in the system with partly slated floor with reduced slurry channel, 32 % in the system with partly slatted floor with vacuum system and 22 % in the system with partly slatted floor with scraper (IIR CZ, 2021).

Table 5. Abatement techniques and factors applied in Czechia for NH_3 emissions from manure application

Manure application techniques		Share of manure (%)	Abatement effect (%)
Broadcast	Incorporation within 4hr	10	45-65
	Incorporation between 4 and 24hr	55	30
Brand-spread	Trailing hose	14	30
	Trailing shoe	1	
Injection	Shallow / open slot	2	80-90
	Deep / closed slot	1	

Source: (IIR CZ, 2021)

Denmark reports to apply housing systems with acidification of manure for cattle and swine, housing systems with cooling of manure for swine, and housing systems with heat exchanger for broilers (IIR DK, 2021).

Table 6. Share of livestock in housing with NH_3 reduction technology of acidification and reduction factor (%) applied, 2019

Housing	Reduction Factor acidification (%)	Share livestock	Reduction Factor cooling (%)	Share livestock
Dairy cattle	50	3.4		
Non-Dairy	50	1		
Fattening pigs	64	1.7	20	3.4
Weaners	64	1.4	20	5.3
Sows	64	2.5	20	7.4

Source: (IIR DK, 2021)

In **Estonia** the replacement of lagoons[7] with tall open tank or tight lid roof is reported as applied for cattle and swine slurry manure storage are shown in Table 7. Tie stall housing technology with its solid storage is used for mature non-dairy cattle (IIR EE, 2021).

Table 7. Share of animals in selected abatement techniques in Estonia's manure storage process and the reduction coefficients

2015	Replacement of lagoon with tall open tank (%)	Tight lid roof (%)	Low tech floating cover
Dairy cattle	35.8	0.8	-
Bovine animals	31.9	1	-
Calves	40	0.8	-
Mature females	32	-	-
Mature males	31.9	0.9	-
Swine (Fattening)	82.3	4.8	12.9
Swine (sows)	85.7	0.9	-
NH_3 reduction coefficient (%)	45	80	45

Source: (IIR EE, 2021)

Finland reports to apply several abatement measures/techniques for ammonia in housing, manure storage and manure application. Table 8 shows abatement measures applied as well as their reduction potential.

(7) It should be emphasised that it is recommended to phase out slurry lagoons even if covered with floating or crust, due to high leakage risk.

Table 8. NH_3 abatement measures/techniques in Finland manure management system

System	Livestock	Fuel	Abatement measure	Reduction (%)
Housing	Cattle, Swine	slurry	Flushing	60
	Cattle, Swine, Poultry, Sheep, Goats, Horses	slurry	Improved cleaning	10
	Cattle, Swine, Poultry, Sheep, Goats, Horses	slurry	Increased manure removal frequency	10, 25
	Cattle, Swine, Poultry, Sheep, Goats, Horses	slurry	Biological or chemical air scrubbers	85
	Cattle, Swine	slurry	Cooling of slurry channels	30
	Poultry	slurry	Rapid urine separation	60
Storage	Cattle, Swine, Poultry	slurry	Tight roof	95
	Cattle, Swine, Poultry	slurry	Floating cover	60
	Cattle, Swine, Poultry	slurry	Natural crust	40
	Cattle, Swine, Poultry	slurry	Tent roof	80
Application	Cattle, Swine, Poultry, Sheep, Goats, Horses	slurry	Incorporation with ploughing <4hr	70
	Cattle, Swine, Poultry, Sheep, Goats, Horses	slurry	Incorporation with ploughing <12hr	45, 50
	Cattle, Swine, Poultry, Sheep, Goats, Horses	slurry	Incorporation with harrowing <4hr	60, 50
	Cattle, Swine, Poultry, Sheep, Goats, Horses	slurry	Incorporation with harrowing <12hr	35, 25
	Cattle, Swine, Poultry, Sheep, Goats, Horses	slurry	Incorporation with harrowing >12hr	15
	Cattle, Swine, Poultry	slurry	Injection	78
	Cattle, Swine, Poultry	slurry	Band spreading	30

Source: (IIR FI, 2021)

Germany reports to apply air scrubbing as abatement measure in housing systems for the reduction of NH_3 emissions. The estimation assumes that the N removed by air scrubber systems is to be regarded as Total Ammoniacal Nitrogen (TAN) and is applied to the field without storage losses in liquid form like liquid manure (IIR DE, 2021).

In **Greece** urease inhibitors are reported to be used for some types of nitrogen fertilizer to decrease the nitrogen emissions. For 2019, it is estimated that for nearly 45% of the total annual urea consumption, urease inhibitors are used resulting in a reduction of approximately 80% of ammonia emissions (IIR EL, 2021).

Hungary reports to apply since 2016 different manure application technologies (band spreading with trailing hose, band spreading with trailing show, injection deep, injection shallow, incorporation of surface applied slurry, immediately and within 24 hours) for cattle (80% of manure) and swine (89% of manure) with an average reduction efficiency respectively 44% and 52% in 2019 (IIR HU, 2021).

It is reported that low emissions techniques used in **Ireland** for manure application include trailing hose application (30% reduction potential), trailing shoe application (60% reduction potential) and injection (70% reduction potential) (IIR IE, 2021).

Italy reports to take in consideration the effect of different abatement technologies in the calculation of country specific emission factors used in the estimation of NH_3 emissions from cattle, swine, poultry in housing, manure storage and land spreading systems and from fertiliser use. The country specific NH_3 emission factors are calculated considering the relevant reduction potential of the abatement measures/technologies (IIR IT, 2021).

In **Latvia** it is reported that all animal housings must have slurry storages with at least natural coverage. The reduction potential for storage of slurry with natural crust or cover with straw is set at 40%. All solid manure must be incorporated within 24 hours, and reduction rate by this activity is set to be 30% (IIR LV, 2021).

Luxembourg reports that it uses environmentally friendly techniques on grassland areas as trailing shoe (59% of farms), trailing hose (29% of farms) and injecting technique for manure spreading (12% of farms). For arable land with vegetation cover these shares are respectively 66%, 26% and 9%. For arable land without vegetation cover the shares are 40% for trailing shoe, 18% trailing hose, 8% injection technique, 31% slurry cultivator and 4% broadcast technique (IIR LU, 2021).

Spain reports to apply reduction measures for NH_3 emissions from white swine in all stages of nitrogen cycle in livestock sector. The practice of incorporating urea into soil is used for cereals and beans while for rice both the close-slot injection of urea and the incorporation of all fertilisers is applied (IIR ES, 2021).

Table 9. Good Agricultural Practices ((UNECE, 2015) for NH_3 emission reduction in Spain livestock sector (white swine), 2019

System	Best Available Technique (BAT)	Reduction (%)
Housing	Partly slatted floor with slanted walls (shallow V-shaped gutters)	52.5
	Frequent slurry removal (number of times a month ≥ 8)	25
	Partly slatted floor and Flushing Gutters	40
	Combined manure-canal and water-canal system	45
	Acid filters additionally to shallow V-shaped gutters	60
	Air scrubbing systems	80
Storage	Tight lid (over slurry store)	80
	Floating cover (over the slurry store)	60
	Slurry store covered by inert materials	50
	Slurry store covered by natural materials	40
Application	Soil incorporation by ploughing (with inversion) < 4h after application	55
	Soil incorporation by ploughing (non-inversion) < 4h after application	55
	Soil incorporation by ploughing (with inversion) 4 - 12 h after application	55
	Soil incorporation by ploughing (non-inversion) 4 - 12 h after application	55
	Soil incorporation by ploughing (inversion) 12 - 24 h after application	30
	Soil incorporation by ploughing (non-inversion) 12 - 24 h after	30

Source: (IIR ES, 2021)

Netherlands reports to apply reduction of ammonia EFs due to the use of various types of techniques in housing, manure spreading, storage and inorganic fertilisers. Average applied emission factors applied are calculated based on the shares of various housing, application, and storage systems. In houses system with air scrubbers, heated and cooled flooring and ventilation, and/or drying of litter and multiple storeys are applied (IIR NL, 2021). The reduction depends on the type of the reduction system applied e.g the type of air scrubber:

- Chemical air scrubber – 35% reduction
- Biological air scrubber with short rotation time – 60% reduction
- Biological air scrubber with long rotation time – 75% reduction
- Combined air scrubber – 80% reduction

In **Poland** it is reported that the estimation of NH_3 emissions from manure management using Tier 2 method considers the effect of some abatement measures (see Table 10) as manure cover during storage, partially slated floor use or multiphase feeding. The obligation of a 100% coverage with solid covers on liquid manure tanks is considered in calculations since 2019 (IIR PL, 2021).

Table 10. Abatement techniques for NH_3 emissions in Polish manure management system, (2005-2019)

Abatement in manure storage	Share of livestock covered (%)			NH_3 emission reduction [%]
	2005	2010	2014-2019	
Swine partially slated floor	0.0	11.9	15.6	20
Laying hens manure fast removal	0.6	28.0	32.3	32
Laying hens manure ventilation	0.0	12.1	14.3	32
Cattle manure cover	0.5	2.3	2.8	80
Swine manure cover	0.9	12.7	15.3	80
Laying hens manure cover	0.0	1.14	1.34	80
Broilers manure cover	0.2	0.5	0.7	80
Cattle slurry cover	0.0	43.5	44.8	80
Swine slurry cover	0.0	61.8	67.2	80
Dairy cattle protein feeding	0.0	14.2	17.6	15
Laying hens 3-phase feeding	0.0	23.3	27.4	20
Broilers 5-phase feeding	0.0	38.5	42.1	20
Fattening pigs 4-phase feeding	0.0	14.7	18.5	30
Piglets 3-phase feeding	0.0	10.2	14.7	30

Source: (IIR PL, 2021)

Emission factors reported from **Slovenia** are reduced based on the abatement techniques applied. For manure application it is assumed that 20 % of animal manures used on arable land were incorporated into the soil within about 12 to 24 hours after application. For this practice the emission factors are reduced by 40% (the average value for incorporation within 12 hours and within 24 hours). Reduction also considers the application of "low emissions techniques" assuming these techniques are distributed into trailing hoses (70%) and trailing shoe (30%). Several types of floors are used in the housing system: floor system on bedding, combined floor system, battery-cage system. For manure storage it is assumed that 50% the manure is removed daily and stored in tanks (liquid system) while the rest is collected under the batteries (e.g. poultry manure without bedding). In the agriculture soils sector, the fertilisers which are characterised by high emission factors are not in use. Since 2016 it is considered that low emission application techniques are used on arable land with the incorporation of urea a practice with a potential of 65% in NH_3 reduction.

Table 11. Abatement measures for NH_3 emissions from livestock and inorganic fertilisers and N excretion calculation as reported in the EU MS Informative Inventory Reports 2021.

	Housing	Storage	Application	Fertilisers	N excretion	Reference for abatement potential & Nex
Belgium	x	-	x	-	x	National; (UNECE, 2015)
Bulgaria	-	-	-	-	-	
Czechia	x	-	x	-	x	(JRC107189), National (Nex)
Denmark	x	x	x	-	x	National
Germany	x	-	-	x	x	National
Estonia	-	x	x	-	x	(UNECE ECE, 2014), National (Nex)
Ireland	-	-	x	-	x	(UNECE ECE, 2014), IPCC 2006 (Nex)
Greece	-	-	-	x	x	National
Spain	x	x	x	x	x	(UNECE, 2014), (JRC107189), National (Nex)
France	-	-	x		x	(UNECE, 2014), National (also Nex)
Italy	x	x	x	x	x	(UNECE, 2014), (JRC107189), National (Nex)
Cyprus	-	-	x	-	-	Default EMEP/EEA 2019 (Nex)
Latvia	-	x	x	-	x	(UNECE ECE, 2014), National
Lithuania	-	-	-	-	-	Default EMEP/EEA 2019 (Nex)
Luxembourg	-	-	x	-	x	National
Croatia	x	x	x	-	x	(UNECE ECE, 2014), National (Nex)
Hungary	-	-	x	-	x	(UNECE ECE, 2014), IPCC 2006 (Nex)
Malta	-	-	-	-	-	Default 2019 IPCC Refinement for Nex
Netherlands	x	x	ìx	x	x	National
Austria	x	x	x	x	x	National, (UNECE, 2015)
Poland	x	x	-	-	x	National
Portugal	-	-	-	-	x	National (Nex)
Romania	-	-	-	-	-	Default EMEP/EEA 2019 (Nex)
Slovenia	x	x	x	x	x	(UNECE, 2015), National (Nex (DC))
Slovakia	x	x			-	Default EMEP/EEA 2019 (Nex)
Finland	x	x	x	x	x	National
Sweden	-	x	-	-	x	National

Source: (EU MS IIRs, Eionet, 2021)
DC – Dairy cattle

As shown in Table 11 almost all EU Member States have reported to apply their methods for the calculation Nitrogen excretion (Nex)[8]. Only eight EU MS (Denmark, Spain, Italy, Croatia, Austria, Netherlands, Slovenia, and Finland) report to apply at the same time measures for the reduction of NH_3 in housing, manure storage and manure application. Thirteen EU MS report to apply measures to reduce NH_3 emissions in housing and in manure storage whereas seventeen EU MS report they have already abatement measures for the NH_3 reduction in manure application. Eight EU MS report to apply measures for NH_3 reduction from the use of fertilisers.

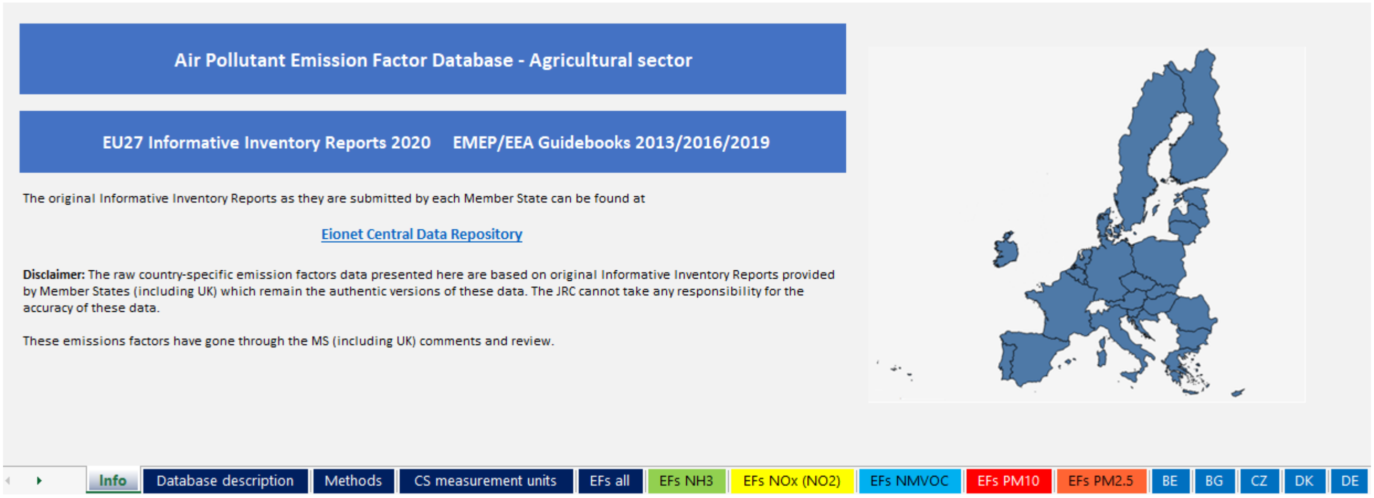
(8) Feeding situation is mainly related with the average nitrogen excretion (Nex) for each livestock. The EMEP/EEA Guidebook 2019 provides the default values for Nex which derives from the Tier 1 equation (10.30) of the IPCC 2006 Guidelines and 2019 Refinement.

3 Air Pollutant Emission Factors Database for Agriculture

Emission factors quantity the amount of a certain pollutant emitted by a given activity level. Emission factors are frequently the best or only method available for estimating emissions, despite their limitations and are usually derived from calculations based on measured data and supposed being representative values of a given process resulting in emissions.

To assist the EU Member States in improving their air pollutant emission inventories for the agricultural sector, the Air and Climate Unit of the Joint Research Centre has developed an emission factor database[9] based on available EU Member States Informative Inventory Reports and (EMEP/EEA Guidebook, 2013, 2016, 2019).

Figure 12. Established Air Pollutant Emission Factor Database for the EU Agricultural Sector



The procedure of checking and completing the emission factors database by each EU Member State, was launched in December 2020 by DG Environment (ENV-C3) and the revised values received so far are included in the current emission factors database. The database has 2018 as the reference year as IIRs 2020 are used as a source for the compilation of the EU air pollutant EFs database for agricultural sector.

The database keeps the same structure of EMEP/EEA Emission Factor Database (default EFs)[10]. The database has been developed in Excel format where it has been easy to store the data, perform numerical calculation and generate outputs.

The established emission factor database is organised in one single file to avoid the update of multiple files. Clear and harmonised descriptive names are used allowing multiple ways of use, for example by categories, methods, fuels, technologies, or systems.

To assure that the emission factors database provides reliable data internal consistency checks using Tableau 2020 v.3 software are performed on:

- Empty and zero values – default zero values are kept in the database as they are in the Guidebooks.
- Data ambiguity – the same table in different guidebooks
- Duplicates
- Reference table
- NFR category
- Measurement unit
- Category/Technology/Pollutant

The air pollutant emission factors database for the agricultural sector is organized by:

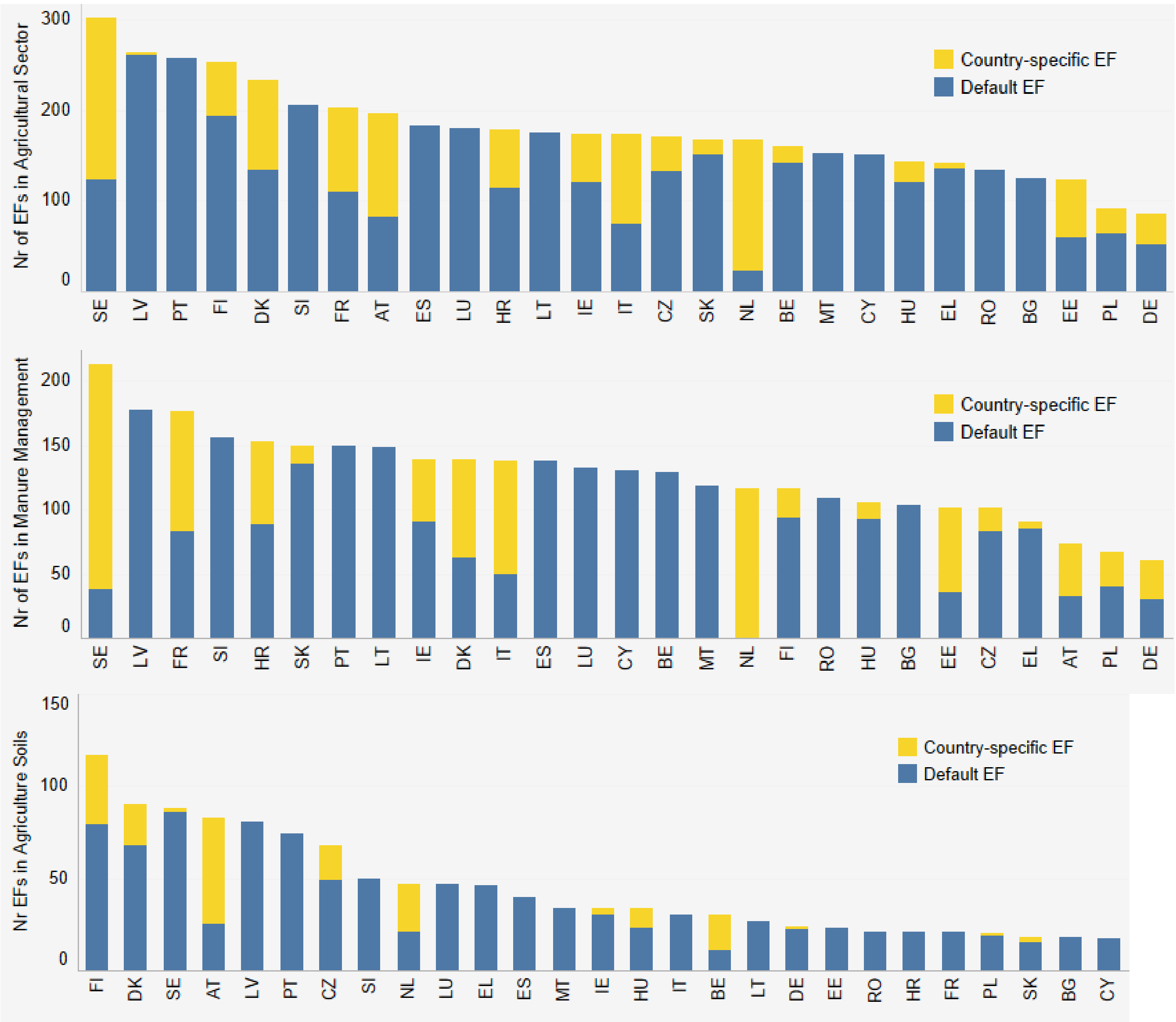
([9]) Disclaimer: The raw country-specific emission factors data based on original Informative Inventory Reports (http://cdr.eionet.europa.eu/) and on reviewing process by each EU Member State, remain the authentic versions of these data. The JRC cannot take any responsibility for the accuracy of these data.

([10]) http://efdb.apps.eea.europa.eu/

- Country - (EU Member States)
- Air pollutant[11] - NH_3, NOx as NO_2, NMVOC, PM_{10} and $PM_{2.5}$
- Method - Tier 1, Tier 2, Tier 3
- Emission Factor type - Default (D), Country Specific (CS)
- Agricultural subsectors
  - Manure management (3B)
  - Agriculture soils (3D)
  - Field burning of agriculture residues (3F)
  - Agriculture Other (3I)
- Agricultural systems
- Housing, Storage, Yard, Pasture, Spreading, Grazing
- Fuel types
- Solid, Slurry, Litter, Composting, Digestate, Straw

As shown in Figure 13 almost all countries have reported to apply a combination of default and country specific emission factors. The largest number of country specific emission factors are those in manure management.

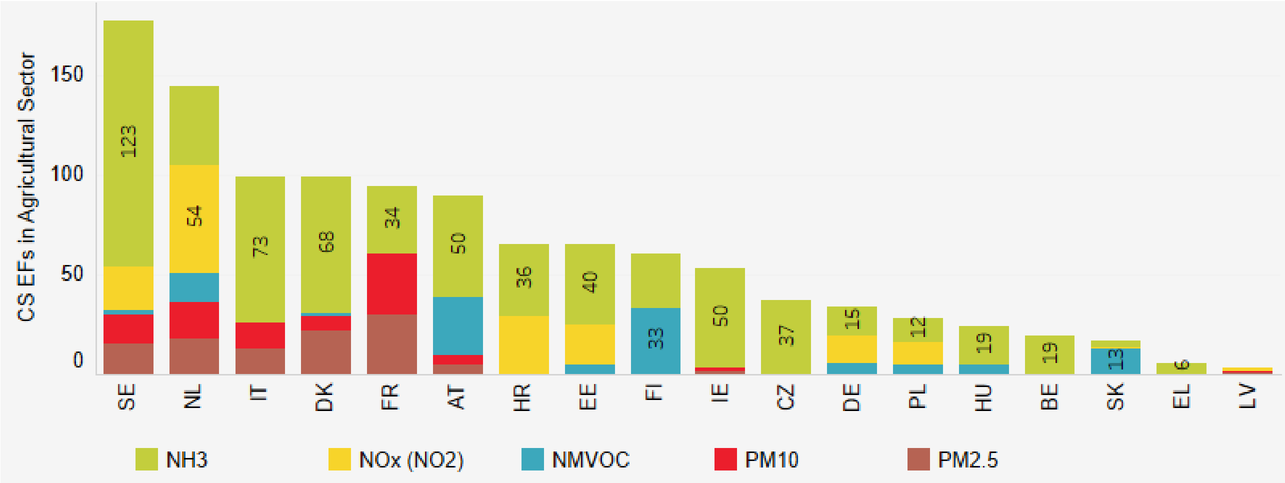
Figure 13. Distribution of default and country specific emission factors in each EU MS agricultural sector, 2018



Source: (Air Pollutant Emission Factors Database - Agricultural Sector, 2020)

([11]) EU MS apply default EFs to estimate SO_2 emissions from field burning of agricultural activities which are not included in the EFs database.

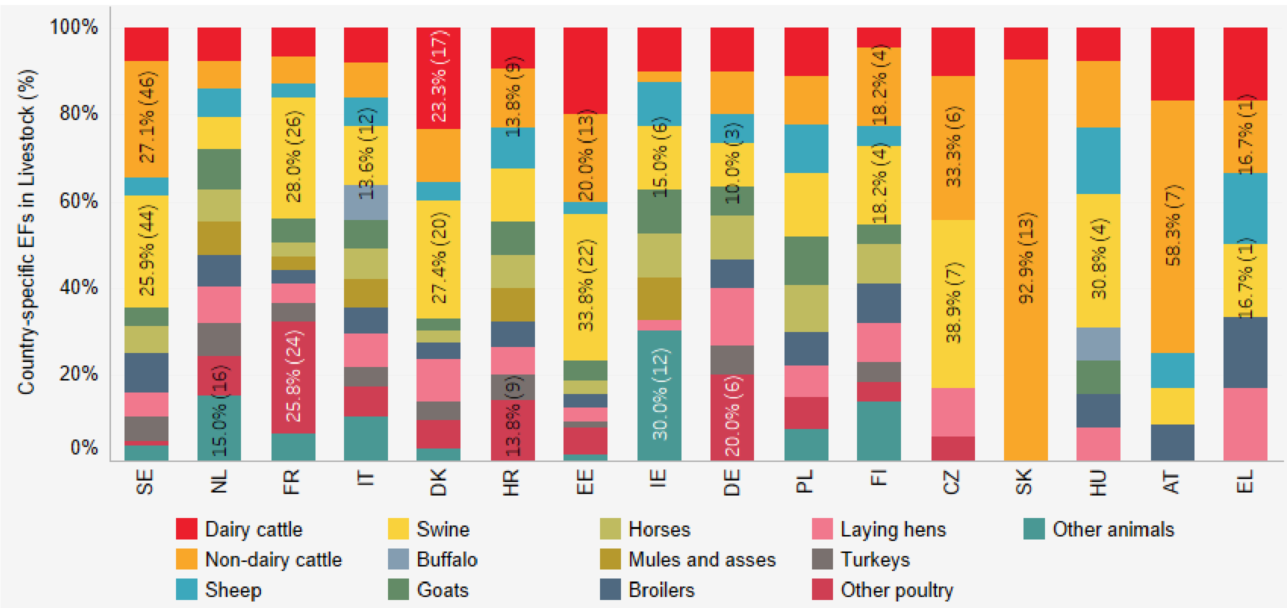
Figure 14. Number of CS EFs by pollutant in the agricultural sector of the EU MS that use this type of EFs, 2018



Source: (Air Pollutant Emission Factors Database - Agricultural Sector, 2020)

The largest number of country specific emission factors is used for the estimation of ammonia emissions (see Figure 14), with sixteen MS having developed country specific EFs for the estimation of emissions from manure management system, in particular from cattle and swine. On the other hand, only half of EU MS which have developed country specific EFs have done so for the estimation of air pollutant emissions from agricultural soils activities (see Figure 15).

Figure 15. Breakdown of CS EFs in each EU MS Manure Management System[12] for NH_3, NOX, NMVOC, PM_{10} and $PM_{2.5}$



Source: (Air Pollutant Emission Factors Database - Agricultural Sector, 2020)

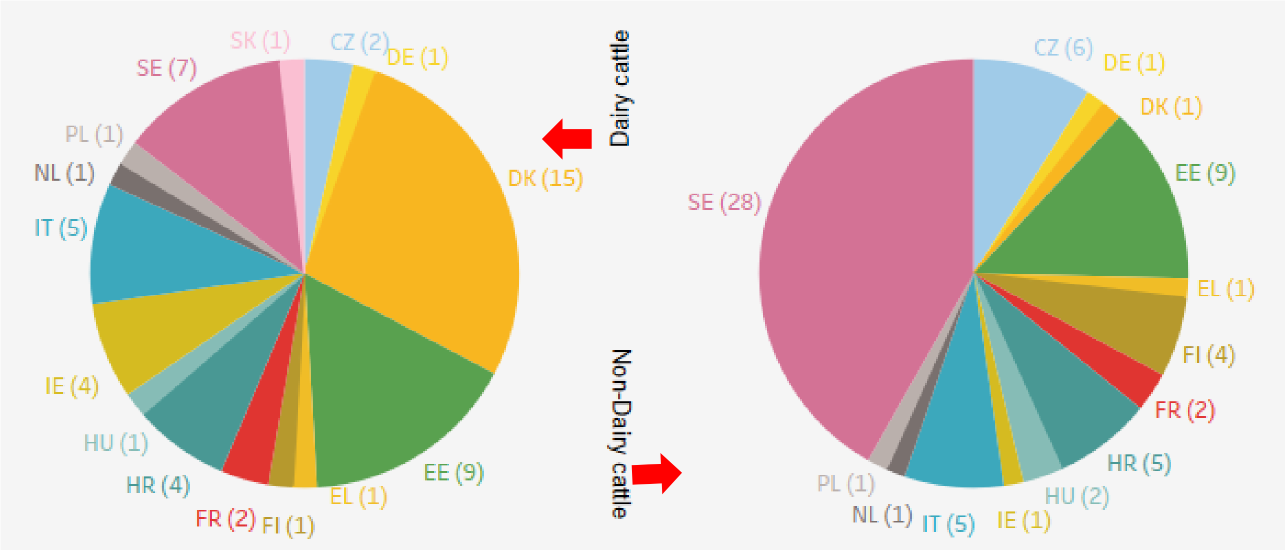
Within the livestock sector country specific emission factors have been developed for manure in house (with full slatted floor, partially slatted floor, solid floor, tied system, loose houses liquid slurry, loose houses solid storage, stable ventilation, deep pit, cages with belt clearing), for manure storage (covered, uncovered, weeping wall, lagoon, ground tank above, ground tank below) and for manure application. Nevertheless, several EU MS report country specific emission factors for the overall manure management system (MMS) without splitting in different systems (house, storage, application, grazing).

Within the cattle category several country specific emission factors have been developed for dairy cattle and non-dairy cattle livestock. Figure 16 shows country specific emission factors developed in each EU MS manure management system for the estimation of NH_3 emissions. Sweden has the largest number of country specific

(12) Here all country specific emissions are counted despite their measurement unit (EU MS report their emission factors in different measurement units as percent of TAN, percent of N, kg pollutant/head etc)

emission factors due to the application of its country specific model (similar with the EMEP/EEA Guidebook 2019 Tier 2 method). The elevated number of emission factors for non-dairy cattle is also linked to the largest number of subdivisions this livestock is characterised (heifers, calves, bulls, young).

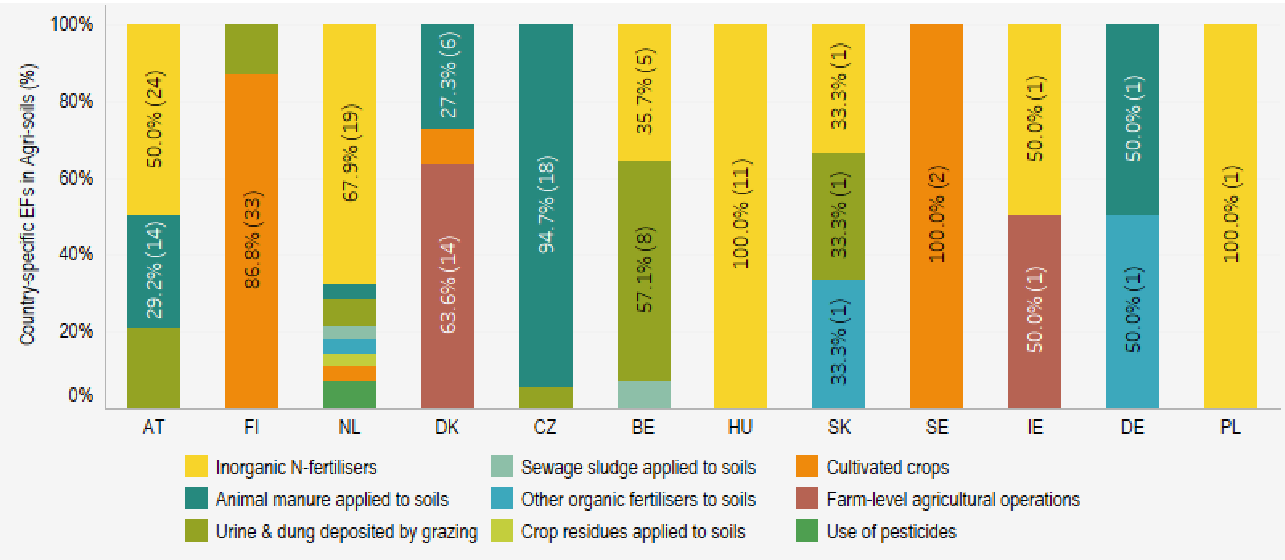
Figure 16. NH_3 country specific EFs for Dairy cattle and Non-Dairy cattle in each EU country MMS, 2018[13]



Source: (Air Pollutant Emission Factors Database - Agricultural Sector, 2020)

In the agricultural soils sector country specific emission factors have been mainly developed for NH_3 emission estimation from inorganic fertilisers. These country specific emissions factors are based on EMEP/EEA Guidebook 2019 default values that are then recalculated/weighted considering the amount of fertiliser applied in a certain combination of climatic conditions and soil pH. For example, Austria reports to apply country specific emission factors for NH_3 emissions from inorganic fertilisers for cold climate conditions and both normal and high pH situation and for a combination of 65% normal pH and 35% high pH conditions.

Figure 17. Breakdown of CS EFs by Agricultural Soils categories in the EU MS that use this type of EFs, 2018



Source: (Air Pollutant Emission Factors Database - Agricultural Sector, 2020)

(13) The number of country specific emission factors in manure management system might be even higher since several EU MS reports only the total value of an emissions factor without splitting into different systems.

4 Agricultural Emission Estimation (AgrEE) Tool

The Agricultural Emission Estimation (AgrEE) tool for the calculation of air pollutant and GHG emissions from agricultural activities is a publicly available and user-friendly web tool designed to support inventory compilers to calculate these emissions using the EMEP/EEA and IPCC Tier 2 method. The tool can be used in the preparation of national inventories for air pollutant emissions from livestock, agricultural soils activities and field burning of agriculture residues.

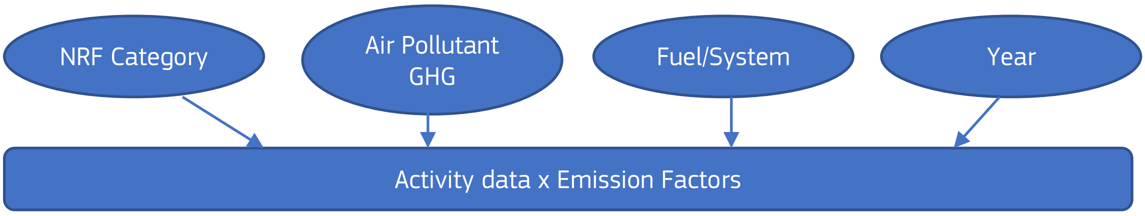
The AgrEE tool has been developed to support the compilation of robust agricultural air pollutant emissions inventory data at EU Member State level as requested by the National Emission reduction Commitments Directive [2]. In line with the requirements of international conventions and protocols and EU legislation, the calculation of air pollutant and greenhouse gas (GHG) emissions from agricultural activities should be transparent, consistent, comparable, complete, and accurate as regards the data collection and emission reporting.

Currently, the EU Member States compute air pollutant emissions from their agricultural activities based on the EMEP/EEA Guidebooks 2013, 2016 and 2019 versions, the IPCC Guidelines (1996, 2006 and 2019) and the IPCC Good Practice Guidance (IPCC, 2000). Consistency exists among methodologies applied to compile the agricultural emission inventories under the United Nations Framework Convention on Climate Change (UNFCCC) and the UNECE Air Convention through integrated databases, preparation of inventories and reporting. However, since in some cases the Member States use older versions of the EMEP/EEA Guidebooks the consistency between inventories is not always guaranteed.

4.1 The AgrEE tool concept

The basic approach of the tool (see Figure 18) enables the user/inventory compiler to fill out the templates with the activity data and emission factors. The user can change the activity data and emission factors online in the tool, in cases where country-specific data (both activity data and emission factors) are available for the inventory.

Figure 18. Basic approach of the tool

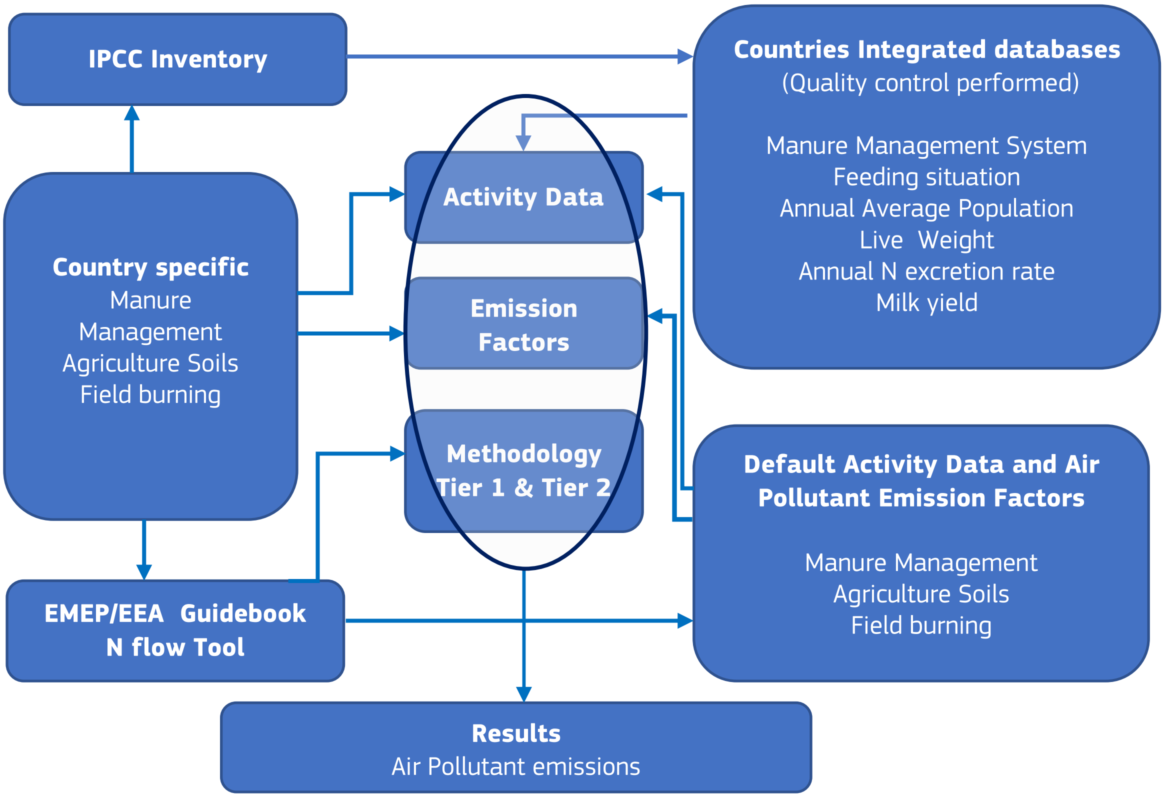


The tool includes functions related to the database administration (e.g. keeping the default activity data and emission factors database up to date), quality control (completeness, value check), data import/export and data reporting. The tool provides as outputs both air pollutant and GHG emissions from all categories (when only Tier 2 method is used in the calculations) and for separate categories (when Tier 1 and Tier 2 are both used in the calculations).

A schematic view of the basic idea for tool development is shown in Figure 19. The tool can be used by Member States to calculate their air pollutant emissions from agricultural activities applying a Tier 1 or Tier 2 method combining:

- Countries Integrated Databases prepared for the IPCC inventory. These databases are used to calculate CH_4 and N_2O emissions from agricultural activities (among other activities) that contain activity data on manure management system (allocation of slurry/solid), livestock population, livestock live weight, feeding situation, milk yield, annual N excreted rate etc. Being part of countries reporting process under the UNFCCC, the quality control of these databases is considered as already performed.
- Default parameters as in the EMEP/EEA Guidebook 2019.
- The N-flow approach tool (developed by the EMEP/EEA) already available for N_2O, NH_3, NO and N_2 emissions from manure management (3B), manure applied to soils (3Da2a), urine and dung deposited by grazing animals (3Da3) and biological treatment of waste (5B2). The JRC tool builds on this N-flow tool and complements it with information on NMVOC and PM (Total Suspended Particulates (TSP), PM_{10}, $PM_{2.5}$) emissions from manure management and NH_3, NOx, NMVOC and PM (TSP, PM_{10}, $PM_{2.5}$) emissions from agricultural soils. Air pollutant emissions from field burning of agricultural residues are also included.
- Country specific activity data and emission factors (that include the effect of abatement measures/techniques) that can replace the respective default values.

Figure 19. Schematic representation of the basic idea of the tool for the calculation of air pollutant emissions from agricultural activities



4.2 Methodology of the AgrEE tool

To estimate air pollutant emissions from Manure Management, Agriculture Soils and Field Burning of Agriculture Residues the AgrEE tool applies the methodology defined in the EMEP/EEA Guidebook 2019. Methodologies applied to calculate air pollutant and GHG emissions from agricultural activities are discussed in detail in the JRC report (Banja et.al., 2020) [1]. Here below a short description of methodologies available in AgrEE tool follows:

The **Tier 1 method (T1)** assumes a simple linear relation between emissions and activity data and emission factors. The default Tier 1 emission factors are chosen to represent 'typical' or 'averaged' process conditions and they tend to be technology independent. For example, the following equation is applied for manure management:

$$E_{pollutant\_animal} = AAP_{animal} * EF_{pollutant\_animal} \qquad [1]$$

where:

$E_{pollutant\_animal}$ - is the emission of a certain pollutant from a certain livestock category,
AAP_{animal} – is the number of animals of a livestock category on average within the year (annual average population),
$EF_{pollutant\_animal}$ – is the emission factor for a certain pollutant emitted from a certain livestock category (kg/AAP/year)[14]

Tier 2 method (T2) applies a similar methodological approach as the Tier 1 method, but with country-specific emission factors and more refined activity data. A Tier 2 method better reflects he management practices and animal productivity (quality and quantity of production during a specific period), allowing to catch the effects on the corresponding emissions and to shape mitigation policies. This method should be used especially when large livestock populations are present. However, emission calculations in accordance with this method require more detailed data. For example, to calculate NH_3 emissions from livestock (see Box 1), detailed data are required on animal waste management system (AWMS), for which default values may not be available such as for manure fractions (slurry or solid), ratio slurry/solid stored on farms and used for biogas production (for each livestock), proportion of slurry manure deposited in houses (for each livestock) etc.

([14]) The emission factor is expressed as the weight of pollutant divided by the unit of animal annual average population that emits the pollutant.

4.3 The AgrEE tool system

Figure 20 illustrates the AgrEE tool system which is composed by three main modules: Livestock, Agriculture soils and Field burning of agricultural residues. The livestock module is divided in two sub-modules: Manure Management and Enteric Fermentation. The tool is designed to calculate the air pollutant and GHG emissions from the subsectors and categories (see Annex 1, 2 and 3 for more information).

Within the Tier 1 selection
the Livestock module covers the estimation of emissions for:

- NH_3 from House, Storage, Yard (3B), Manure Application (3Da2a), Excreta Deposited by Grazing (3Da3)
- NOx from Manure Storage (3B)
- NMVOC from Manure Management (3B)
- PM_{10}, $PM_{2.5}$, TSP from House (3B)
- CH_4 from Enteric Fermentation (3A1)

and the agriculture soils module covers the estimation of emissions for:

- NH_3 from inorganic fertilisers (3Da1), sewage sludge (3Da2b) and other organic fertilisers (3Da2c),
- NOx from inorganic fertilisers (3Da1), manure applied to soils (3Da2a), sewage sludge (3Da2b), other organic fertilisers (3Da2c) and urine dung deposited in grazing (3Da3),
- NMVOC from cultivated crops (3De)
- Particulate matter (PM_{10}, $PM_{2.5}$, TSP) from farm agricultural operations (3Dc)

Within the Tier 2 selection
the Livestock module covers the estimation of emissions for

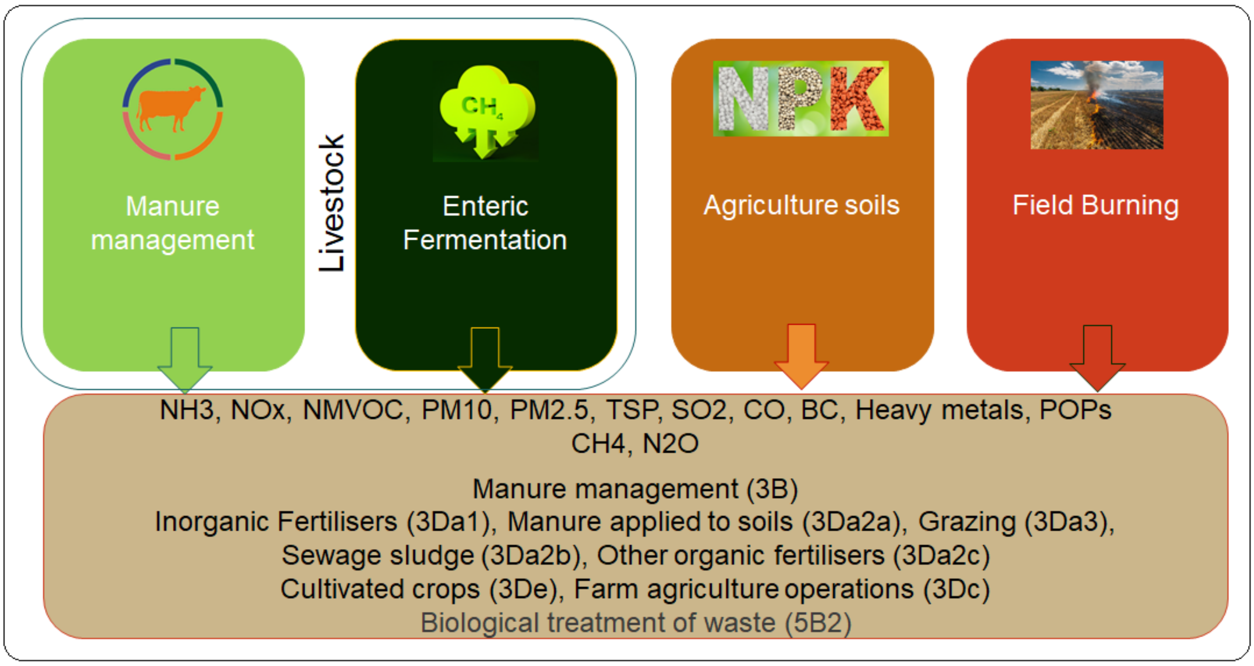
- NH_3, NOx, NMVOC, PM_{10}, $PM_{2.5}$, TSP, CH_4, N_2O from Manure Management (3B),
- CH_4 from Enteric Fermentation (3A1)
- NH_3, NOx, NMVOC, PM_{10}, $PM_{2.5}$, TSP, N_2O from Manure Applied to Soils (3Da2a),
- NH_3, NOx, NMVOC, PM_{10}, $PM_{2.5}$, TSP, N_2O from Urine and Dung Deposited by Grazing (3Da3)
- NH_3 from Biological treatment of waste (5B2)

and the agriculture soils module covers the estimation of emissions for:

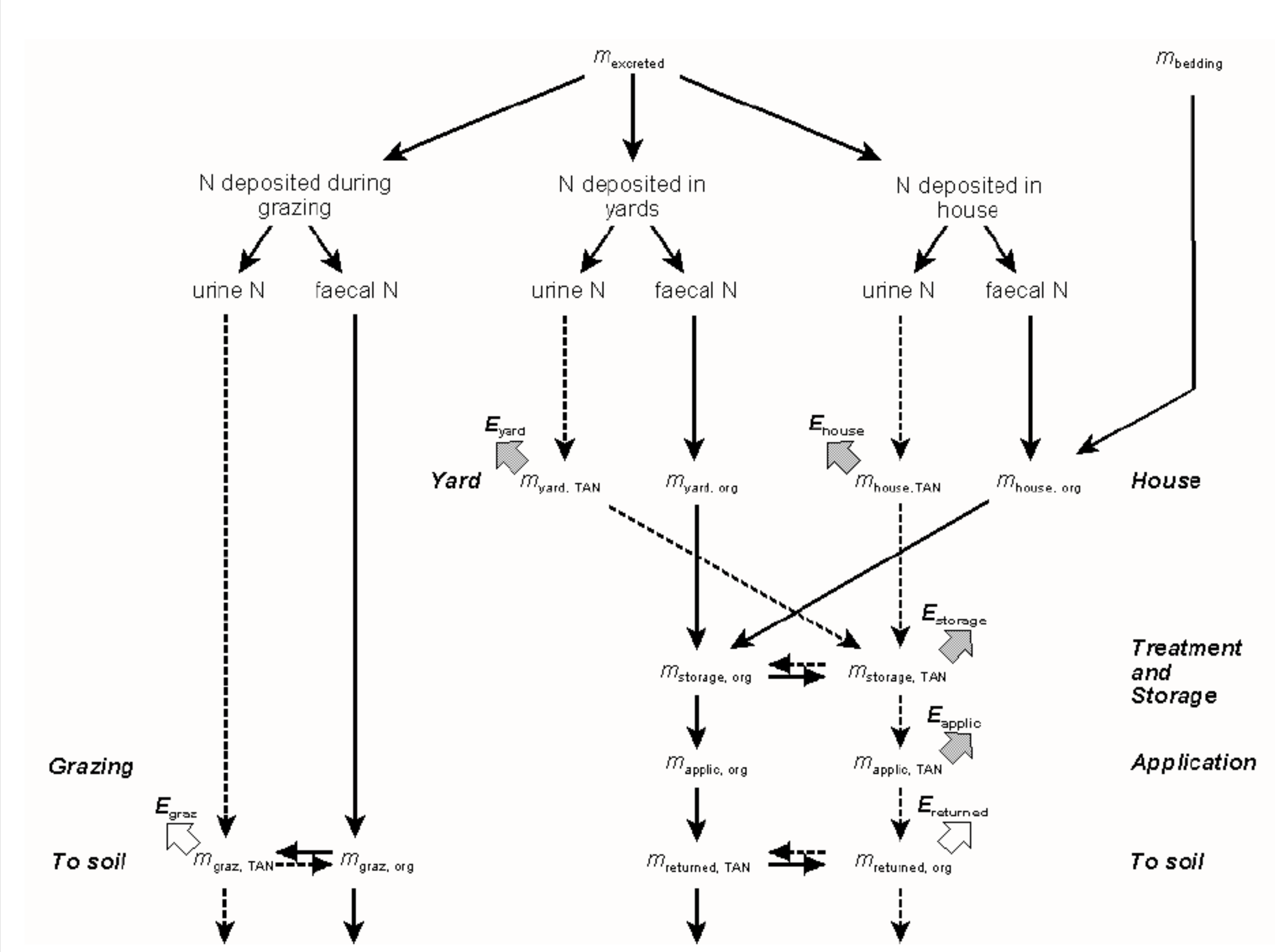
- NH_3 from Inorganic Fertilisers (3Da1),
- NMVOC from Cultivated Crops (3De)
- Particulate Matter (PM_{10}, $PM_{2.5}$, TSP) from farm agricultural operations (3Dc)

The field burning module covers all air pollutants shown in Figure 20 both in Tier 1 and Tier 2 methods.

Figure 20. Agricultural Emission Estimation (AgrEE) Tool system



Box. 1. Nitrogen flow in the Animal Waste Management System



Source: EMEP/EEA Guidebook, 2019

m - mass from which emissions may occur.
E – emissions

Based on this scheme the Animal Waste Management System (AWMS) required for the calculation of air pollutant emissions is composed as the following:

1. Fraction in which livestock spent time in
- House (Xhouse)
- Yard (Xyard)
- Grazing (Xgrazing)

2. Fraction of livestock manure handled as
- Slurry (Xslurry)
- Solid (Xsolid)

3. Livestock slurry manure
- Spread directly to soil (Xspread_slurry)
- Stored before application (Xstore_slurry)
- Feedstock in biogas facilities (Xbiogas_slurry)

4. Livestock solid manure
- Spread directly to soil (Xspread_solid)
- Stored before application (Xstore_solid)
- Feedstock in biogas facilities (Xbiogas_sloid)

Box. 2. Tier 2 inputs for the calculation of NH_3 emission estimation from livestock – AgrEE tool

The calculation of NH_3 emissions from livestock is done applying Eq. 2:

(Ehouse_slurry + Ehouse_solid + Estorage_slurry + Estorage_solid + Eappl_slurry + Eappl_solid + Eyard + Egraz) × 17/14 [2]

Data type	Description	System	Fuel	Unit
Livestock / Dairy cattle / Dairy cattle (3B1a)				
AD	Animal Weight	All types	All types	kg
AD	AWMS	Biogas	slurry	Fraction
AD	AWMS	Biogas	solid	Fraction
AD	AWMS	House	slurry	Fraction
AD	AWMS	Storage	slurry	Fraction
AD	AWMS	Storage	solid	Fraction
AD	AWMS	Storage	without natural crust	Fraction
AD	AWMS	Storage	with natural crust	Fraction
AD	AWMS	Tied Housing	All types	Fraction
AD	AWMS	Yard	waste	Fraction
AD	fimm	All types	All types	kg N/kg straw
AD	fmin	All types	All types	kg N/kg
AD	fmin biogas	All types	All types	kg N/kg
AD	Housed period	House	All types	Days
AD	Nex	All types	All types	kg N/1000 kg animal mass day-1
AD	Nex as TAN	All types	All types	Fraction
AD	Number livestock	All types	All types	head
AD	N added in straw	All types	All types	kg/animal/year
AD	Straw	All types	All types	kg/year
EF	EF N2	Storage	slurry	Fraction_TAN
EF	EF N2	Storage	solid	Fraction_TAN
EF	EF N2O	Storage	slurry without natural crust	Fraction_TAN
EF	EF N2O	Storage	slurry with natural crust	Fraction_TAN
EF	EF N2O	Storage	solid	Fraction_TAN
EF	EF NH3	Grazing (3Da3)	All types	Fraction_TAN
EF	EF NH3	House	slurry	Fraction_TAN
EF	EF NH3	House	solid	Fraction_TAN
EF	EF NH3	Manure application (3Da2a)	slurry	Fraction_TAN
EF	EF NH3	Manure application (3Da2a)	solid	Fraction_TAN
EF	EF NH3	Pre-storage	All types	kg NH3-N/kg N in feedstock
EF	EF NH3	Storage	slurry	Fraction_TAN
EF	EF NH3	Storage	solid	Fraction_TAN
EF	EF NH3	Storage of digestate	All types	kg NH3-N/kg N in feedstock
EF	EF NH3	Tied Housing	slurry	Fraction_TAN
EF	EF NH3	Tied Housing	solid	Fraction_TAN
EF	EF NH3	Yard	All types	Fraction_TAN
EF	EF NO	Storage	slurry	Fraction_TAN
EF	EF NO	Storage	solid	Fraction_TAN

Source: AgrEE Tool Guidebook

4.4 AgrEE tool testing phase, launch and webinars

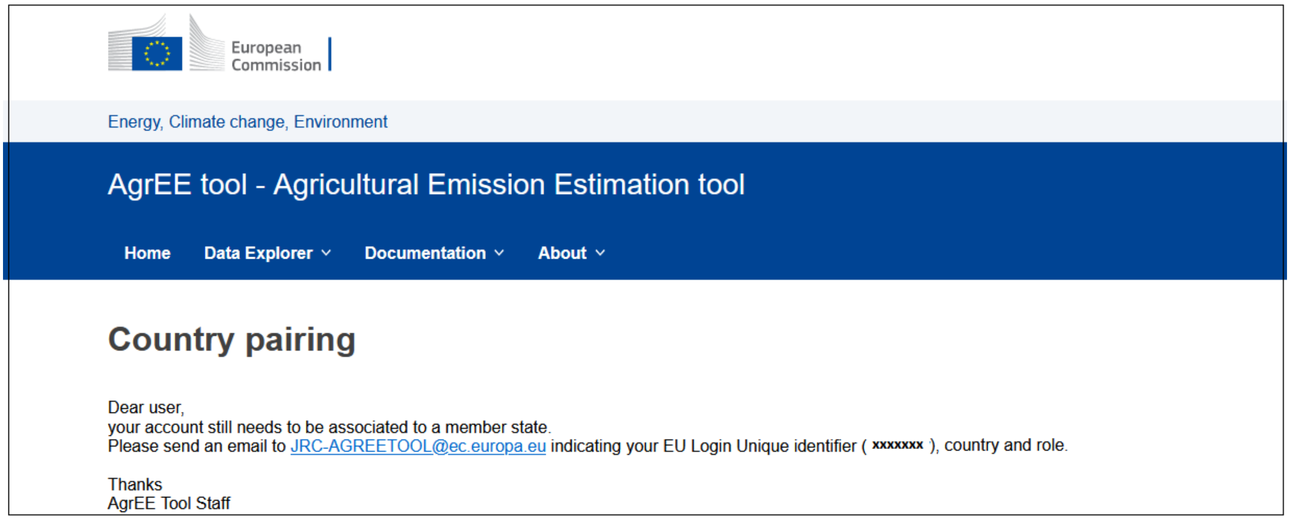
The testing phase of the AgrEE tool was performed in June 2021. Feedback from eight EU Member States (Bulgaria, Czechia, Germany, Italy, Luxembourg, Netherlands, Romania, and Poland) were received. This helped improving many features of the tool as the download/upload of input template in excel format, navigation, copy/paste, transferring results in the Annex I reporting template etc. The first launch of AgrEE tool took place on 8th of October 2021 followed by two webinars on 12th and 19th of October 2021 in which representatives of several EU Member States participated.

Figure 21. Presentation on "How to use the AgrEE tool" at the webinar of 19th October 2021

4.5 Working with the AgrEE tool

The AgrEE Tool can be accessed from https://edgar.jrc.ec.europa.eu/agree_tool. The access to the tool is possible through the EU login. The user should register on ECAS[15] (European Commission Authentication Service). After registering and accessing the tool link, instructions will be provided to the user on how to access the country of interest (the user should indicate the EU Login Unique identifier, country, and the role e.g inventory compiler/researcher/stakeholder). The user can consult the guide for navigating/working with AgrEE tool which is available for download under the "Documentation" command.

Figure 22. AgrEE tool login page

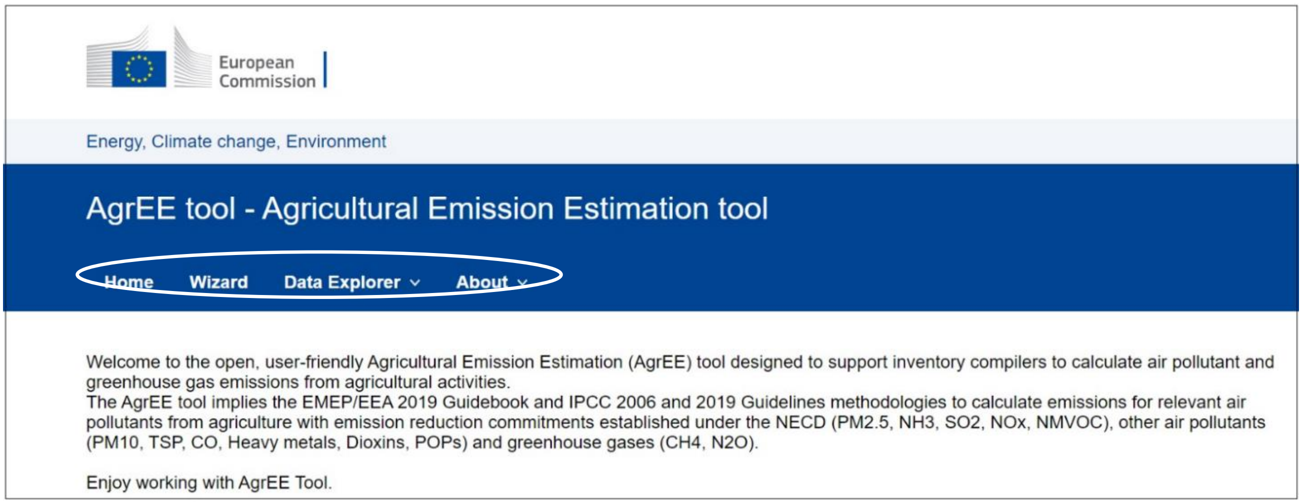


Source: JRC AgrEE Tool

(15) https://webgate.ec.europa.eu/cas/

After the user get access the home page of AgrEE tool appears. Here the user can start working with the tool using the "Wizard" command as shown in Figure 23. Here the user can make the selection of inventory year/inventory period, sector, methodology, pollutant, category, subcategory.

Figure 23. Home page of AgrEE tool



Source: JRC AgrEE Tool

4.6 Main features of AgrEE tool

- The tool main method is Tier 2 method (Tier 1 method is also available for comparison).
- The user has the possibility to save (export in excel or copy/paste in the tool) the input data for a certain year. The saved inputs can be used to compile the inventory for another year, e.g. the user can save the input data for 2019 and then use these data for the calculations of air pollutant emissions for the year 2020. In this case the user will apply modifications only for those inputs that have changed. The user can download the input template in excel format for all the period of interest, insert all data needed and upload it in the tool.
- The user may establish a baseline year and compare it with another year (e.g. emissions of NH_3 from a category/subcategory in 2018 compared with the respective emissions in 1990 and/or 2005).
- The tool incorporates the quality control checks related to the range of values, number formats (e.g. negative values), summing (e.g. checking the sum of shares of different manure management systems),
- The tool has a specific decimal format for each input.
- The tool includes the effect of abatement measures for NH_3 for manure in house.
- The tool enables the Member States to extract their emissions and data as requested in the template under the Air Convention, also referred to under NECD (see Figure 24).
- The tool helps Member States to analyse trends over years, compare results calculated using the tool and possible other national methods, view the consolidated results (final emissions for each pollutant and sector) of other Member States and compare them with national results. It will also provide an overall view for the EU in terms of time series, trends, relative contributions, and more refined analysis.
- Several types of charts are available in the tool: (i) Area; (ii) Line with values; (iii) Column with percentages; (iv) Pie with drill down and (v) Comparison with baseline.
- The user/inventory compiler has the possibility to visualise the results e.g. the trend of emissions from a certain category/subcategory or the relative contribution of categories/subcategories (see Figure 25).

Figure 24. Example of NH_3 emissions from livestock (Tier 2) derived from the AgrEE tool saved in the Annex I template

ANNEX 1: National sector emissions: Main pollutants, particulate matter, heavy metals and persistent organic pollutants

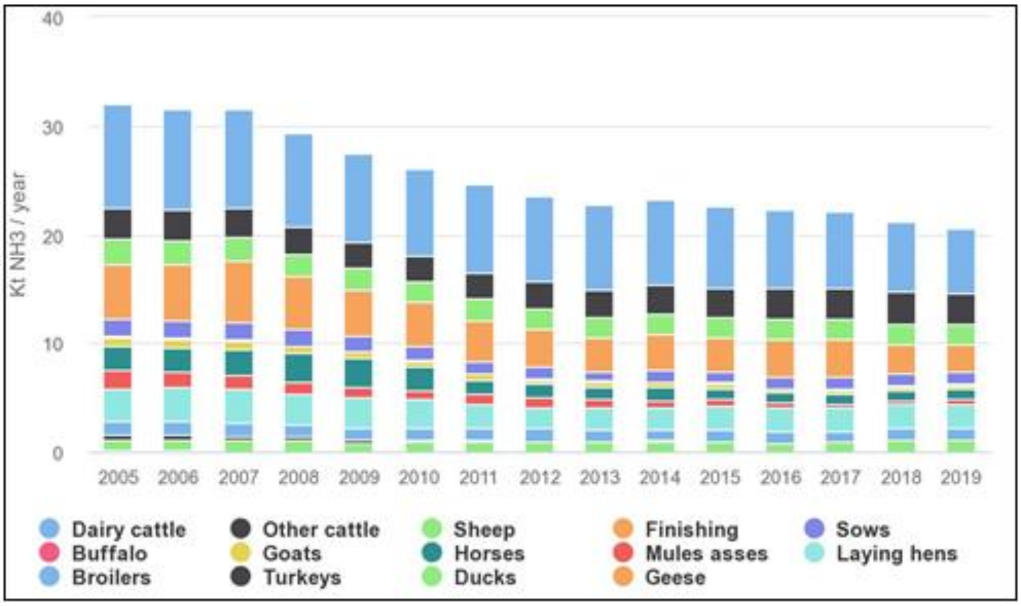
NFR 2019-1

COUNTRY:	AA	(as ISO2 code)
DATE:	DD.MM.YYYY	(as DD.MM.YYYY)
YEAR:	2018	(as YYYY, year of emissions and activity data)
Version:	v1.0	(as v1.0 for the initial submission)

AA: DD.MM.YYYY: 2018	NFR sectors to be reported			Main Pollutants (from 1990)			
				NOx (as NO_2)	NMVOC	SOx (as SO_2)	NH_3
NFR Aggregation for Gridding and LPS (GNFR)	NFR Code	Long name	Notes	kt	kt	kt	kt
K_AgriLivestock	3B1a	Manure management - Dairy cattle					11.573
K_AgriLivestock	3B1b	Manure management - Non-dairy cattle					12.73
K_AgriLivestock	3B2	Manure management - Sheep					0.427
K_AgriLivestock	3B3	Manure management - Swine					7.299
K_AgriLivestock	3B4a	Manure management - Buffalo					
K_AgriLivestock	3B4d	Manure management - Goats					0.07
K_AgriLivestock	3B4e	Manure management - Horses					0.303
K_AgriLivestock	3B4f	Manure management - Mules and asses					
K_AgriLivestock	3B4gi	Manure management - Laying hens					0.342
K_AgriLivestock	3B4gii	Manure management - Broilers					0.528
K_AgriLivestock	3B4giii	Manure management - Turkeys					0.131
K_AgriLivestock	3B4giv	Manure management - Other poultry					0.142
K_AgriLivestock	3B4h	Manure management - Other animals (please specify in the IIR)					
L_AgriOther	3Da1	Inorganic N-fertilizers (includes also urea application)					
L_AgriOther	3Da2a	Animal manure applied to soils					19.764
L_AgriOther	3Da2b	Sewage sludge applied to soils					
L_AgriOther	3Da2c	Other organic fertilisers applied to soils (including compost)					
L_AgriOther	3Da3	Urine and dung deposited by grazing animals					2.409
L_AgriOther	3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products					
L_AgriOther	3De	Cultivated crops					
L_AgriOther	3F	Field burning of agricultural residues					
L_AgriOther	3I	Agriculture other (please specify in the IIR)					

Source: JRC AgrEE Tool

Figure 25. Visualisation of NH_3 emissions from Livestock calculated through the tool with Tier 2 method, 2005-2019



Source: JRC AgrEE Tool

4.7 The added value of AgrEE tool

The development of AgrEE tool provides an added value to the work for the improvement of air pollutant emissions from the EU agricultural sector for the following reasons:

- The tool covers all categories of emissions in Manure Management, Agriculture Soils, Field Burning (one stop shop).
- Regular maintenance is guaranteed, and technical support is provided through the JRC_AGREETOOL@ec.europa.eu.
- The tool provides readily accessible and readable information on all relevant pollutants regulated under the NEC Directive (NOx, NMVOC, NH_3 and $PM_{2.5}$)[16] and information on CH_4 and N_2O which are co-emitted by the same sources in each EU Member State.
- The tool helps Member States to analyse trends over years, compare results calculated using the tool and possible other national methods, view the consolidated results (final emissions for each pollutant and sector) of other Member States and compare with national results. It provides an overall view for the EU in terms of time series, trends, relative contributions, and more refined analysis.
- The tool ensures consistency in how emissions are calculated across different EU Member States and consistency of emission calculation with the EMEP/EEA Guidebook 2019 (eventually to be used by Member States to cross check their own calculations), avoiding as such the application of different versions of the Guidebook since differences exist between these versions.
- The tool provides the possibility for the EU Member States to move towards higher tiers for those emission categories and air pollutants that were so far calculated applying Tier 1 method. The tool gathers, for each Member State, the information needed to apply Tier 2 methodology. In case some pieces of information are missing, assumptions/suggestions are provided based on other sources (models, literature, and data from related countries).
- The emission factors and activity data databases available in the tool incorporate all input data necessary to compute emissions. Member States can easily update and refine this information for their own inventory in a transparent way. The tool allows Member States to report for emissions categories that they possibly do not yet cover.
- It is a user-friendly tool with simple data manipulation and flexible entry of country specific activity data/emission factors.
- The default activity data and emission factors will be kept updated, which means less time consuming for the user/inventory compiler. The tool will be fed also by the activity data and emission factors sourced from EDGAR database and other sources/literature.
- The tool enables Member States to extract their emissions and data as requested under the Air Convention, also referred to under NECD reporting template.
- AgrEE tool can be used also for the calculation of CH_4 emissions from agricultural sector (enteric fermentation and manure management) applying the IPCC methodology as well as for the calculation of the N_2O emissions from livestock.

([16]) SO_2 is regulated under the NECD but not directly relevant for the agricultural sector

5 Application of the AgrEE tool to a country inventory – a comparison analysis

The sections below present some comparison between the air pollutant emissions from agricultural activities reported by MS and the emissions calculated using AgrEE tool.

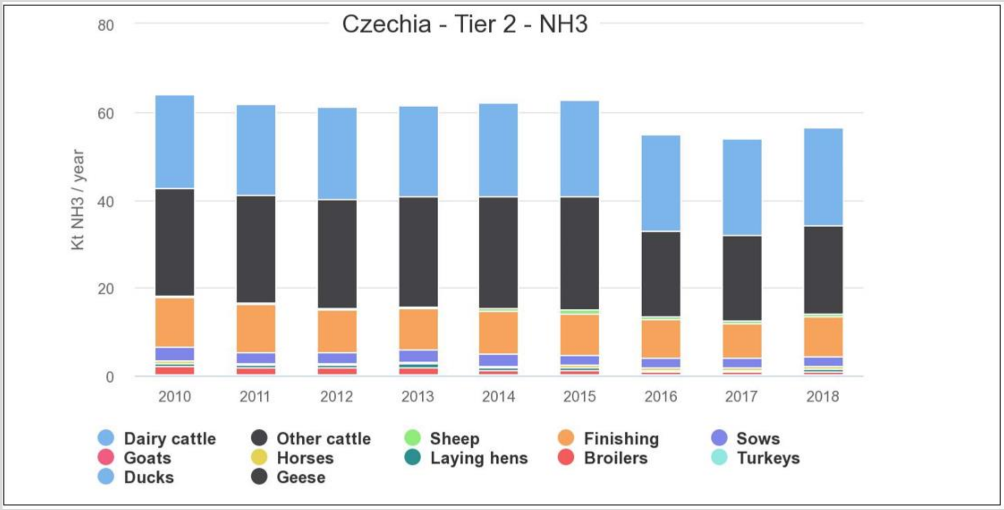
5.1 NH_3 emissions from livestock - Czechia

Czechia applies a Tier 2 method to estimate NH_3 emissions from livestock. The comparison of results obtained through the AgrEE tool with the data actually reported by CZ in past inventories for NH_3 emissions from dairy cattle over the period 2005-2018 is presented below. Data inserted in AgrEE tool are provided by the national inventory contact point.

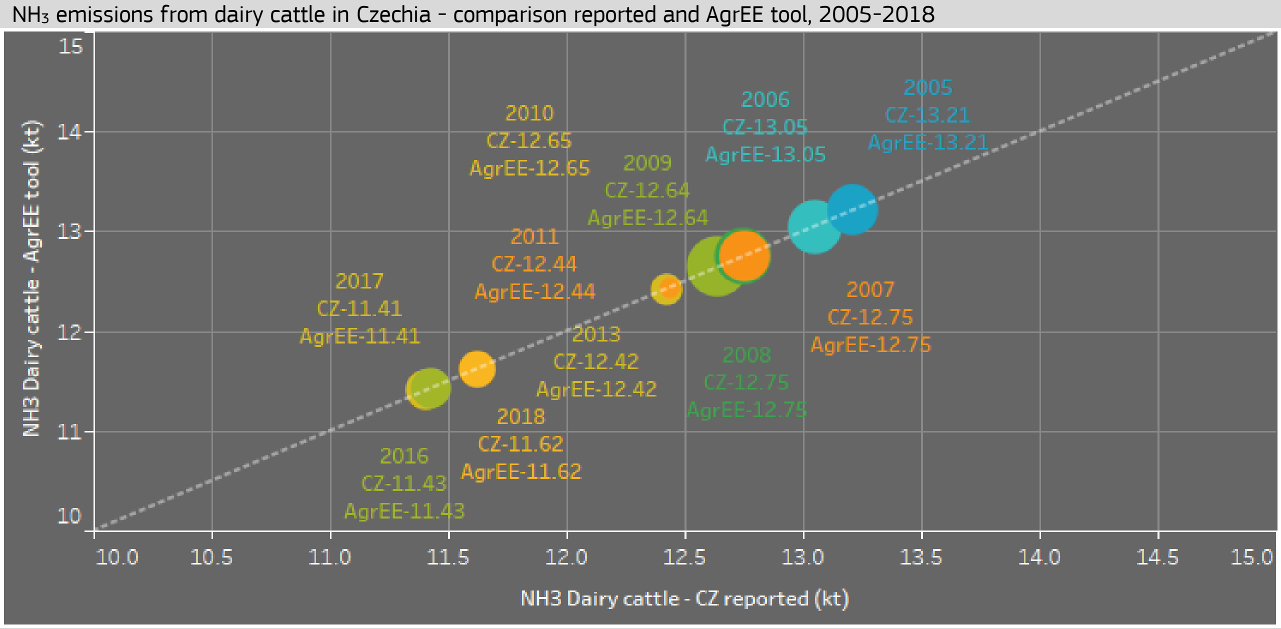
Box. 3. Calculation of NH_3 emissions from livestock in Czechia

Czechia applies country specific activity data for the animal waste management system (AWMS), nitrogen excretion, animal weight, housed period, and straw when estimating NH_3 emissions from livestock. Country specific emission factors are used for housing and manure application considering the effect of abatement measures.

The figures below show the total NH_3 emissions from livestock (manure management, manure applied to soils and urine and dung deposited by grazing) in Czechia over period 2010 – 2018 **calculated with AgrEE tool (up) and the comparison with reported NH_3 emissions from Dairy cattle over the same period (bottom)**. Changes between calculated and reported values stay below 0.5% in all years taken in consideration.



NH_3 emissions from dairy cattle in Czechia - comparison reported and AgrEE tool, 2005-2018



Source: (IIR CZ, 2021), JRC AgrEE Tool

5.2 NH_3 emissions from livestock - Bulgaria

Bulgaria is the only EU Member State that in its IIR 2021 have reported to apply the Tier 1 method to estimate the air pollutant emissions sourced from all its agricultural activities. Data inserted in the AgrEE tool are sourced from BG IIRs 2021 for period 2005 – 2019.

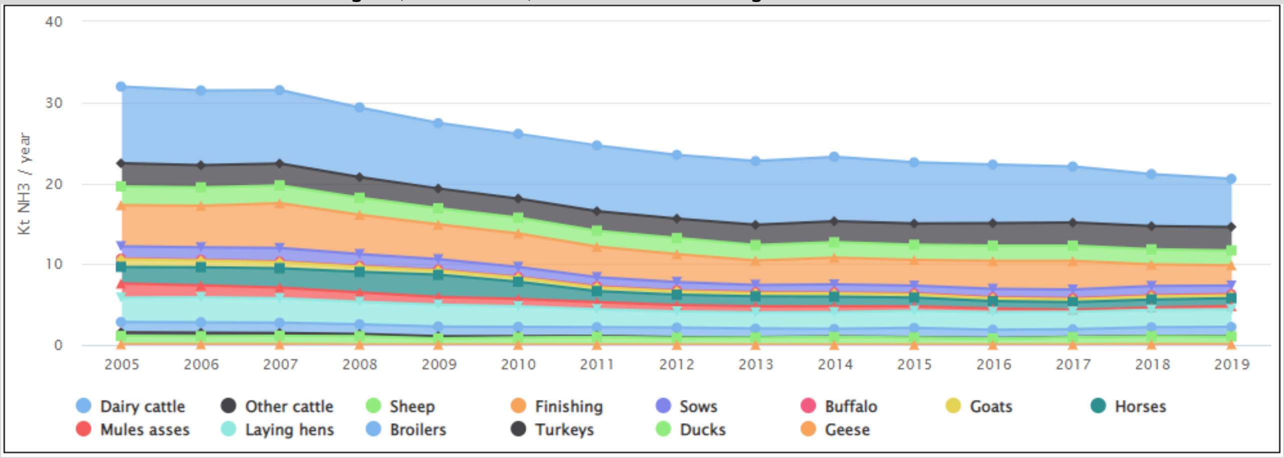
Box. 4. Calculation of NH_3 emissions from livestock in Bulgaria

To estimate NH_3 emissions from livestock over the period of interest the following activity data and emission factors are needed

- Livestock number
- Housed period
- Animal Waste Management System (slurry, solid)
- NH_3 emission factors (House, Storage, Yard; Manure application and Grazing).

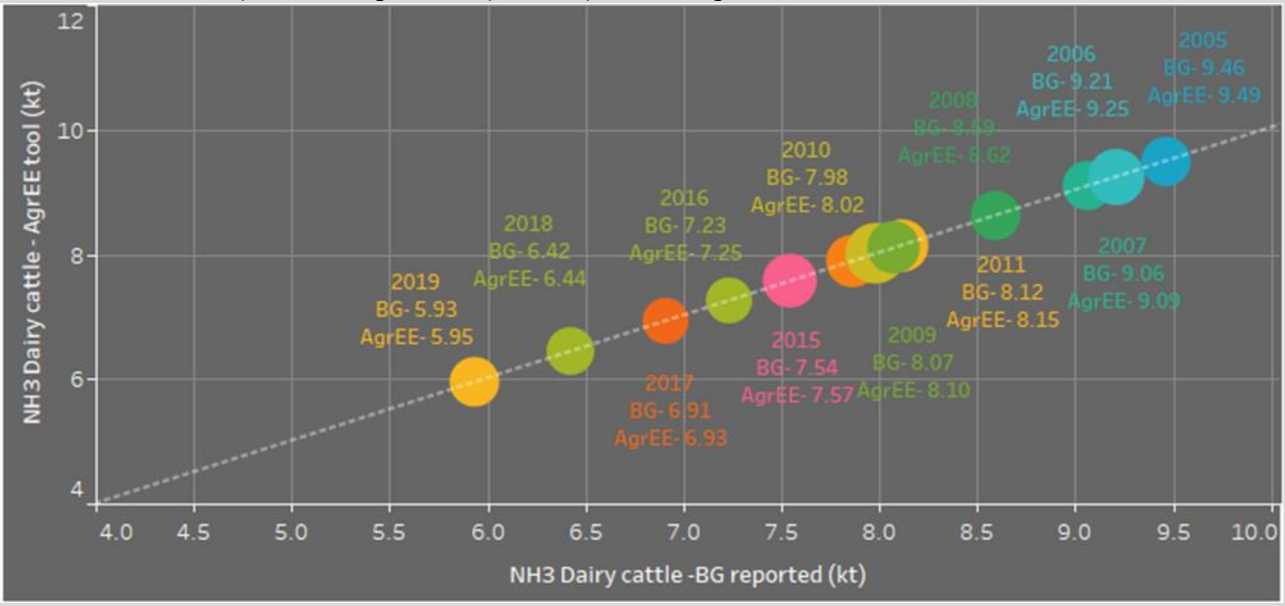
Bulgaria applies the total values of NH_3 default emission factors. So, the total NH_3 emissions from livestock is calculated and reported under category 3B (no split is applied between House, Storage, Yard (3B); Manure Application (3Da2a) and Grazing (3Da3)), whereas the AgrEE tool provides these results separately for categories 3B, 3Da2a and 3Da3

NH_3 emissions from livestock in Bulgaria, 2005-2019, as calculated in the AgrEE tool



NH_3 emissions calculated with AgrEE tool are compared with reported values at the Annex I under the NECD (BG IIR 2021). Changes between calculated and reported values stay below 0.5% in all years taken in consideration. The figure below illustrates the comparison between NH_3 emissions sourced from dairy cattle reported by BG under the NECD and calculated under the AgrEE tool (in both cases using Tier 1 method).

NH_3 emissions from dairy cattle in Bulgaria - comparison reported and AgrEE tool, 2005-2019



Source: (IIR BG, 2021), JRC AgrEE Tool

5.3 NMVOC emissions from cultivated crops – Finland

Finland applies Tier 2 method to calculate NMVOC emissions from cultivated crops. Data inserted in AgrEE tool are sourced from (IIR FI, 2020) and (IIR FI, 2021).

Box. 5. Calculation of NMVOC emissions from cultivated crops in Finland

To estimate NMVOC emissions from cultivated crops the following activity data and emission factors are needed

- Crop cultivated area (area crop)
- Crop yield (Y_crop)
- Crop dry matter yield (Y_dry_matter_crop) and Weighted EF NMVOC (calculated)
- Crop distribution (Frac_distribution)
- Crop fraction emitting (Frac_emitting)
- Mean dry matter (mDm) crop Y_crop * Y_dry_matter_crop
- Weighted EF NMVOC crop (annual) 8760 * Frac_emitting_crop * EF_NMVOC_crop * mDm_crop * Frac_distribution_crop
  Default weighted EF NMVOC is 0.86 kg NMVOC/ha/yr
- NMVOC emissions from cultivated crops Area_Crop_tot * SUM of Weight_EF_NMVOC_Crop * kg->kt

Example of inputs in the AgrEE tool to calculate NMVOC emissions from Wheat, 2018 & 2019

Finland - Tier 2 - NMVOC

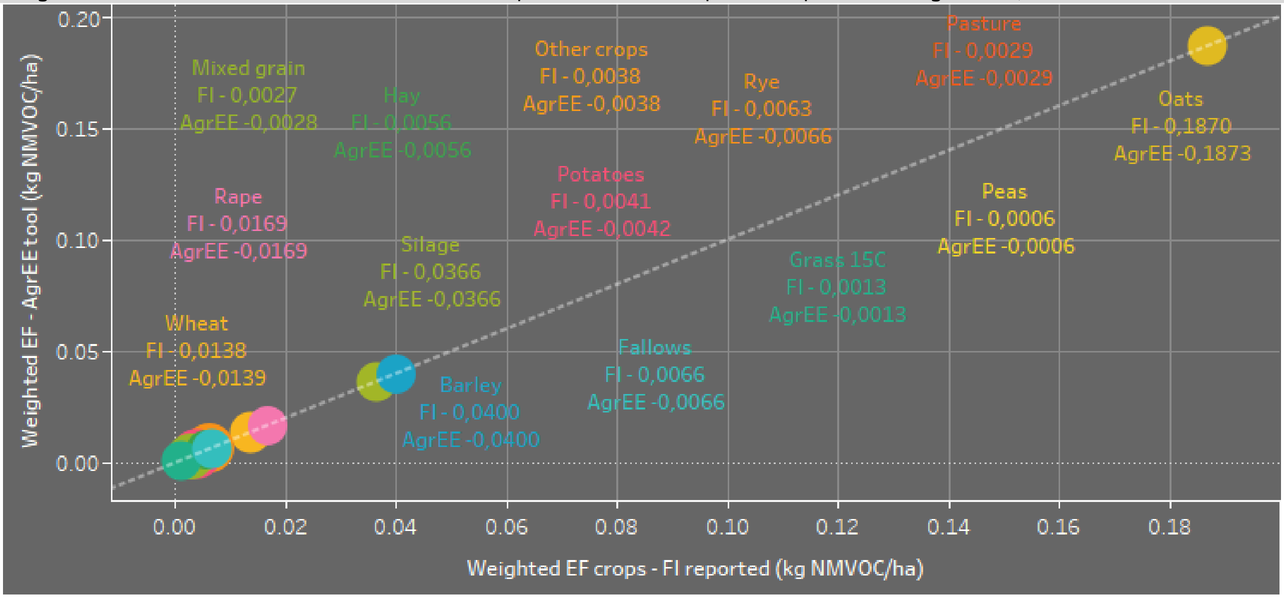
Agriculture soils

« Go back

Input fields legend: Changed by user Precompiled country-specific value Value copied from previous year Value changed by uploaded file Default value

Data type	Description	System	Fuel	Unit	2018	2019 >
Agriculture soils / Cultivated crops / Wheat (3De)						
AD	Crops distribution	All types	All types	Fraction	0.08500	0.09200
AD	Cultivated area	All types	All types	ha/year	190000.0	206000.0
AD	Year fraction emitting	All types	All types	Fraction	0.30000	0.30000
AD	Yield crop	All types	All types	kg/ha	2780.00	4560.00
AD	Yield dry matter crop	All types	All types	kg/kg	0.86	0.86
EF	EF NMVOC	All types	All types	kg NMVOC/kg dry matter/hour	0.000000026C	0.000000026C

Weighted NMVOC emission factors for cultivated crops in Finland – comparison reported and AgrEE tool, 2018



Source: (IIR FI, 2021), JRC AgrEE Tool

Weighted NMVOC emission factor for total cultivated crops in Finland calculated with AgrEE tool was 0.332 kg NMVOC/ha in 2018 and 0.449 kg NMVOC/ha in 2019. Respective reported values in (IIR FI, 2021) are 0.331 kg NMVOC/ha and 0.4485 kg NMVOC/ha.

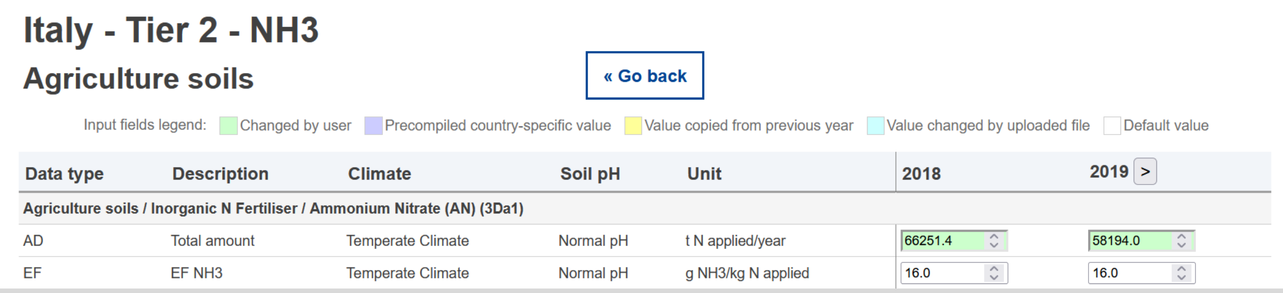
5.4 NH_3 emissions from inorganic fertilisers - Italy

Italy applies Tier 2 method to estimate NH_3 emissions from inorganic fertilisers. Data on inorganic fertilisers inserted in the AgrEE tool are sourced from Italy IIR 2021 for period 2010-2019 and checked by the national contact point.

Box. 6. Calculation of NH_3 emissions from inorganic fertilisers in Italy

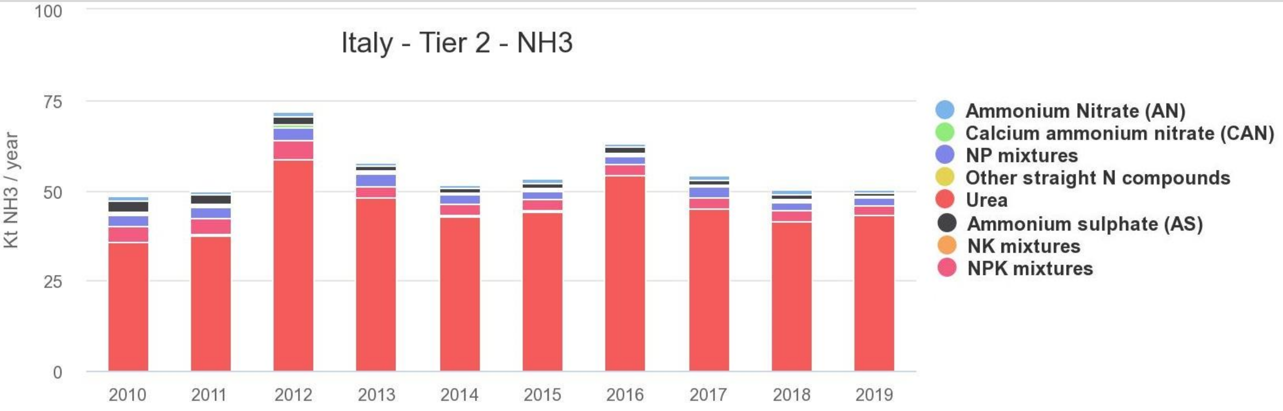
Italy applies Tier 2 method to estimate NH_3 emissions from inorganic fertilisers using EMEP/EEA Guidebook 2019 emission factors for temperate climate conditions and normal pH. The data inserted in the tool cover eight types of inorganic fertilisers meaning that the emission factor of a subcategory is also used for other types of fertiliser: in the Urea are included urea and other amidic nitrogenous data; in the Ammonium Nitrate (AN) are included Ammonium nitrate, Calcium cyanamide, Other nitric nitrogen, Other ammoniacal nitrogen, Organic mineral data; Calcium Nitrate is included in the Other Straight N compounds. The comparison with reporting under Annex I under NECD (IT IIR 2021) showed no differences between the calculated and reported values.

Example of inputs in the AgrEE tool to calculate NH_3 emissions from Ammonium Nitrate (AN) in Italy, 2018 & 2019

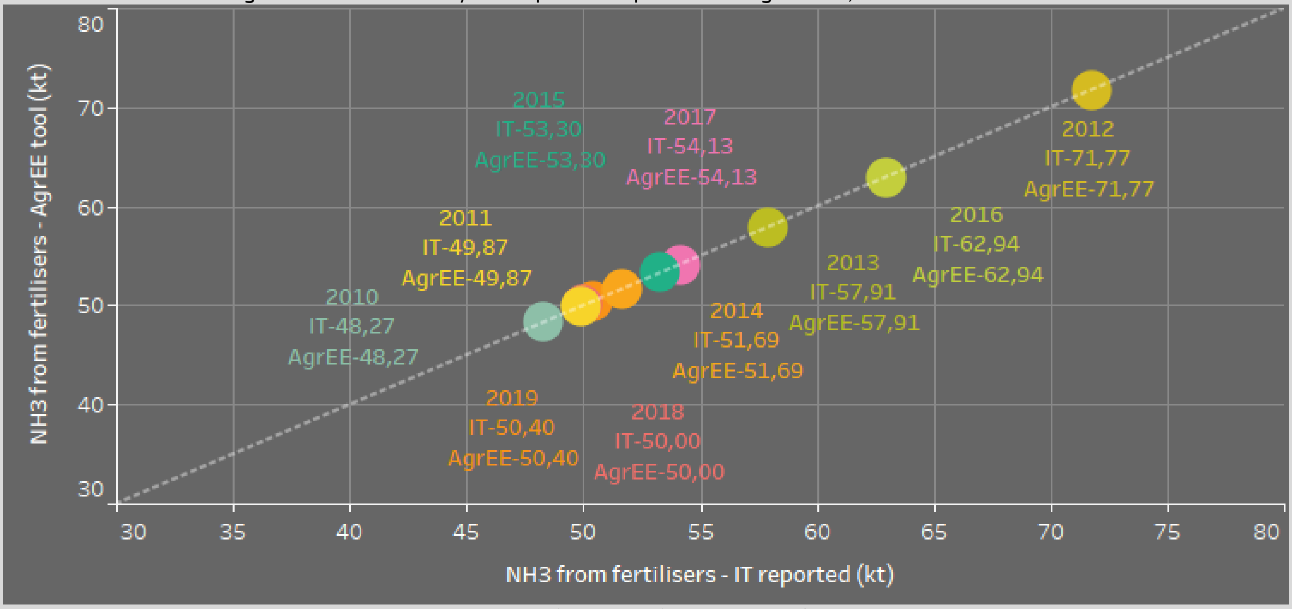


Data type	Description	Climate	Soil pH	Unit	2018	2019
Agriculture soils / Inorganic N Fertiliser / Ammonium Nitrate (AN) (3Da1)						
AD	Total amount	Temperate Climate	Normal pH	t N applied/year	66251.4	58194.0
EF	EF NH3	Temperate Climate	Normal pH	g NH3/kg N applied	16.0	16.0

NH_3 emissions from inorganic fertilisers in Italy, 2010-2019 – as calculated in the AgrEE Tool



NH_3 emissions from inorganic fertilisers in Italy – comparison reported and AgrEE tool, 2010-2019



Source: (IIR IT, 2021), JRC AgrEE Tool

5.5 Other application of AgrEE tool-CH_4 emissions from enteric fermentation in Italy

Italy applies Tier 2 IPCC method to calculate CH_4 emissions from enteric fermentation. Country specific activity data are implied in the calculation as the animal weight, weight gain per day, milk yield, milk fat content, digestible energy, methane conversion factor, proportion of animals pregnant and feeding situation. The comparison of results reported and calculated with AgrEE tool for CH_4 emissions in enteric fermentation for dairy cattle is presented below.

Box. 7. Calculation of CH_4 emissions from dairy cattle in enteric fermentation in Italy

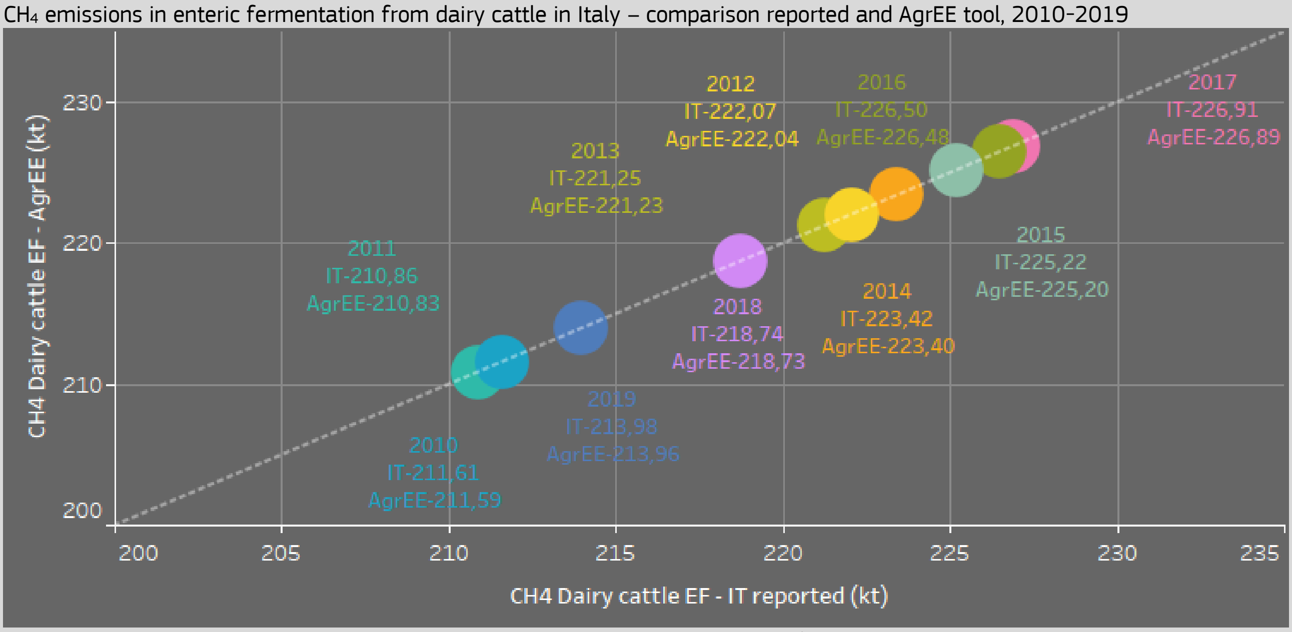
Italy applies country specific activity data to estimate CH_4 emissions from dairy cattle in enteric fermentation. Here below the country specific data inserted in AgrEE tool sourced from Italy reporting for period 2010-2019 in National Inventory Reports (NIR) and Common Reporting Format (CRF) Tables are presented. Housed period was 346.8 days all over the period under analysis. According to the Italian NIRs the feeding situation for dairy cattle is characterised by a mix of stall and pasture (5%). In this case to calculate the input for feeding situation the default value for pasture (0.17) has been multiplied by the ratio of "(365 - Housed_period)/365".

Year	Population	Ym (%)	DE (%)	Milk yield (kg/day)	Milk fat (%)	Pregnacy prop.	Weight gain/day (kg)	Feeding situation
2010	1746140	6.0090	67.68062	18.77661	3.720	0.90123	0.05	0.009
2011	1754981	6.0019	67.74496	18.52413	3.730	0.90347	0.05	0.009
2012	1857004	6.0450	67.23814	17.69426	3.750	0.88808	0.05	0.009
2013	1862127	6.0401	67.29255	17.45831	3.780	0.89242	0.05	0.009
2014	1830990	6.0248	67.46917	18.65303	3.770	0.89681	0.05	0.009
2015	1826484	6.0210	67.51178	19.12929	3.760	0.89024	0.05	0.009
2016	1821764	5.9962	67.77722	19.69560	3.790	0.90347	0.05	0.009
2017	1791120	5.9742	68.01724	20.67290	3.810	0.90796	0.05	0.009
2018	1693332	5.9467	68.33073	22.15936	3.710	0.90796	0.05	0.009
2019	1643117	5.9205	68.62774	22.87692	3.720	0.90796	0.05	0.009

CH_4 emissions, implied emission factors and gross energy calculated using AgrEE tool are compared with official eporting under UNFCCC (see table and figure below). The differences of calculated value with official reporting are less than 0.1%.

year	IEF CH4 CRF (kg CH4/head/yr)	IEF CH4 AgrEE (kg CH4/head/yr)	GE CRF (MJ/day)	GE AgrEE (MJ/day)
2010	121.19	121.18	307.49	307.46
2011	120.15	120.14	305.21	305.18
2012	119.58	119.57	301.61	301.58
2013	118.82	118.81	299.92	299.89
2014	122.02	122.01	308.79	308.76
2015	123.31	123.30	312.24	312.21
2016	124.33	124.32	316.14	316.11
2017	126.68	126.67	323.31	323.28
2018	129.18	129.17	331.20	331.17
2019	130.23	130.21	335.36	335.33

CH_4 emissions in enteric fermentation from dairy cattle in Italy – comparison reported and AgrEE tool, 2010-2019



Source: IT CRF 2021, JRC AgrEE Tool

6 Conclusions

The agricultural sector is an important source of air pollutant and greenhouse gas emissions; its activities emit both ammonia (also contributing to secondary particulate matter formation) and methane (both a powerful GHG and a precursor for ozone formation). The high contribution of agriculture to total ammonia and methane emissions reflects the importance this sector has in the reduction of these emissions. For this reason, agricultural sector is an important sector for which the quality of air pollutant emission inventory is important in order to define better the necessary mitigation measures

Air pollutant and greenhouse gas emissions from agricultural activities result from several natural and anthropic processes and their interactions. The accuracy of the estimation of these emissions requires detailed data on several processes such as animal waste management system (slurry, solid), feeding situation, agricultural operations, climatic condition, soil pH, etc.

This report summarised the work done on supporting the EU Member States to improve and harmonise their emission inventories, to improve the consistency among their air and greenhouse gas emission reporting. Such harmonisation was pursued by means of identification of methodologies, collection of data and finally the development of a user-friendly web tool.

The identification of methodologies as reported by the EU Member States to estimate air pollutant emissions from livestock show that they are more advanced for cattle and swine. For these livestock almost all EU countries report that they apply a Tier 2 method and in some countries a Tier 3 method. On the contrary, for the estimation of particulate matter ($PM_{2.5}$, PM_{10} and TSP) emissions from livestock Tier 1 is the method reported as applied in most of the EU Member States.

By the end of 2019 the use of Tier 2 method was broadly reported for the estimation of NH_3, NOx and NMVOC emissions from livestock, while less so for agricultural soils activities.

Almost all EU Member States report that they apply a combination between a default emission factor and a country specific one. The largest number of country specific emission factors are those applied in manure management and mainly for the calculation of NH_3 emissions. Within the livestock sector, country specific emission factors are developed for manure in house, for manure storage and for manure application. Only half of EU Member States have developed country specific emission factors for agricultural soils activities.

Several EU Member States have already developed and implemented in their national inventories a number of abatement measures for ammonia linked with manure in house, manure storage, manure application and use of fertilisers through the use of environmental technologies e.g. air scrubbing, slurry cooling, slurry acidification and other low emission technologies.

However, only eight EU MS report that they apply simultaneously measures for the reduction of ammonia in house, manure storage and manure application. Thirteen EU MS report that they apply measures to reduce ammonia emissions in house and in manure storage and seventeen have already abatement measures for the reduction in manure application. Only eight EU MS report applying measures for ammonia emissions reduction from the use of fertilisers.

Several web-tool/software/excel--based calculators are developed for the estimation of greenhouse gas emissions from agriculture, mainly based in the IPCC Guidelines. For air pollutant emissions from this sector the situation is not the same, even thought some EU MS have developed their tools/methods to perform calculations.

To help the EU Member States in better estimating emissions from their agricultural activities and in improving their national inventories and the consistency between air pollutant and greenhouse gas emission reporting, a user-friendly web tool has been developed – the **Agriculture Emission Estimation (AgrEE) tool**.

The Agriculture Emission Estimation (AgrEE) tool has been developed to support the compilation of robust agricultural air pollutant emissions inventories In line with the requirements of international conventions and protocols and EU legislation. The emission factors and activity data databases available in the tool incorporate all input data necessary to compute emissions. Tier 2 is the main method in the tool, which also provides the possibility for a comparison with Tier 1 method. The AgrEE tool can be applied for a region as well as for a country.

The AgrEE tool implements international methodologies to calculate emissions for relevant air pollutants from the agricultural sector. The calculations are performed for pollutants regulated under the NECD ($PM_{2.5}$, NH_3, SO_2, NOx, NMVOC); in addition, it also provides estimates in a consistent and harmonised way of emissions of other air pollutants (PM_{10}, TSP, CO, heavy metals, dioxins, POPs) and greenhouse gases (CH_4, N_2O) which are co-emitted by the same sources in each EU Member State.

The AgrEE tool provides to the EU Member States the possibility to move towards higher tiers for those emission categories and air pollutants that were so far calculated applying a Tier 1 method. The tool addresses data gaps for sources that have similar characteristics among EU Member States - a Tier 2 with "assumptions" is better than a Tier 1 method.

Possible next steps for the further improvement of the AgrEE tool are:

- Making the AgrEE tool more flexible with the possibility fpr the user to add categories within a sector/pollutant selection. This requires a significant modification of a core component of the tool. Under the current version, the inventory compilers are asked to contact JRC in case they want to add a category.
- Improvement and further development of the data visualisation and analysis section of the tool through the interaction with Member States
- Future updates of the EMEP/EEA Guidebook will be regularly included in the regular updates of AgrEE tool
- Inclusion of further abatement measures for NH_3 – enhancing the abatement measures for ammonia already in the tool to consider the interactions between different types of manure, calculation of average emission factors when more than one abatement measure is selected, including abatement measures also in agriculture soils (inorganic fertilisers).
- Inclusion of uncertainty estimates for agricultural emissions
- Consistency check across all variables (comparisons with CAPRI and other models?)
- Dedicated focus to the cattle category which is regulated under the Industrial Emission Directive
- Gridding emissions in AgrEE tool – reporting gridding emissions in required under NEC Directive every four years. EDGAR can offer a methodology for gridding emissions which can be linked with the results of AgrEE tool.

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List of abbreviations and definitions

AAP	Average annual population (Livestock)
AD	Activity Data
AS	Agriculture soils
CH_4	Methane
CRF	Common Reporting Format
EDGAR	Emissions Database for Global Atmospheric Research
EEA	European Environment Agency
EF	Emission Factor
EMEP	European Monitoring and Evaluation Programme
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse gas
IIR	Informative Inventory Report
IPCC	Intergovernmental Panel on Climate Change
MMS	Manure Management System
N	Nitrogen
N2	Dinitrogen
N_2O	Nitrous oxide
NECD	National Emission reduction Commitments Directive
NH_3	Ammonia
NIR	National Inventory Report
NFR	Nomenclature Format Reporting
NMVOC	Non methane volatile organic compounds
PM	Particulate Matter
TAN	Total Ammoniacal Nitrogen
TSP	Total Suspended Particulates
UNECE	United Nations Economic Commission for Europe
UNFCCC	UN Framework Convention on Climate Change

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Annexes

Annex 1. Agriculture Sectors and Categories in the AgrEE tool

Table 12. Sectors, categories, and pollutants included in the tool

NFR	Subsector	Category Name	Subcategory Name	Pollutant/GHG	Method
3B1a	Livestock	Dairy cattle	Dairy cattle	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B1b	Livestock	Non-dairy cattle	Other Cattle	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B1b	Livestock	Non-dairy cattle	Calves	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B2	Livestock	Sheep	Sheep	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B3	Livestock	Swine	Finishing	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B3	Livestock	Swine	Sows	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B3	Livestock	Swine	Weaners	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4a	Livestock	Buffalo	Buffalo	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4d	Livestock	Goats	Goats	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4e	Livestock	Horses	Horses	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4f	Livestock	Mules and asses	Mules and asses	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4gi	Livestock	Laying hens	Laying hens	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4gii	Livestock	Broilers	Broilers	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4giii	Livestock	Turkeys	Turkeys	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4giv	Livestock	Other poultry	Other poultry	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4giv	Livestock	Other poultry	Ducks	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4giv	Livestock	Other poultry	Geese	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4h	Livestock	Other animals	Fur animals	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4h	Livestock	Other animals	Rabbits	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4h	Livestock	Other animals	Reindeer	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, CH_4, N_2O	Tier 1 and Tier 2
3B4h	Livestock	Other animals	Camels	NH_3, NMVOC	Tier 1
3Da1	Agriculture Soils	Inorganic N-fertilisers	Inorganic N-fertilisers total	NH3, NOx	Tier 1
3Da1	Agriculture Soils	Inorganic N-fertilisers	Ammonium Nitrate (AN)	NH_3	Tier 2
3Da1	Agriculture Soils	Inorganic N-fertilisers	Ammonium phosphate (AP)	NH_3	Tier 2
3Da1	Agriculture Soils	Inorganic N-fertilisers	NK mixtures	NH_3	Tier 2
3Da1	Agriculture Soils	Inorganic N-fertilisers	NP mixtures	NH_3	Tier 2
3Da1	Agriculture Soils	Inorganic N-fertilisers	Other straight N compounds	NH_3	Tier 2
3Da1	Agriculture Soils	Inorganic N-fertilisers	Ammonium sulphate (AS)	NH_3	Tier 2
3Da1	Agriculture Soils	Inorganic N-fertilisers	Calcium ammonium nitrate (CAN)	NH_3	Tier 2
3Da1	Agriculture Soils	Inorganic N-fertilisers	NPK mixtures	NH_3	Tier 2
3Da1	Agriculture Soils	Inorganic N-fertilisers	N solutions	NH_3	Tier 2
3Da1	Agriculture Soils	Inorganic N-fertilisers	Anhydrous ammonia (AH)	NH_3	Tier 2
3Da1	Agriculture Soils	Inorganic N-fertilisers	Urea	NH_3	Tier 2
3Da2a	Agriculture Soils	Animal manure applied to soils	Animal manure applied to soils	NOx	Tier 1
3Da2b	Agriculture Soils	Sewage sludge applied to soils	Sewage sludge applied to soils	NH_3, NOx	Tier 1
3Da2c	Agriculture Soils	Other organic fertilisers	Other organic fertilisers	NH_3, NOx	Tier 1
3Da3	Agriculture Soils	Urine and dung deposited by	Urine and dung deposited by grazing	NOx	Tier 1
3Dc	Agriculture Soils	Farm-level agricultural operations	Farm-level agricultural operations	TSP, PM_{10}, $PM_{2.5}$	Tier 1 and Tier 2

3De	Agriculture Soils	Cultivated crops	Crops total	NMVOC	Tier 1 and Tier 2
3De	Agriculture Soils	Cultivated crops	Wheat	NMVOC	Tier 2
3De	Agriculture Soils	Cultivated crops	Barley	NMVOC	Tier 2
3De	Agriculture Soils	Cultivated crops	Grass (15^{0}C and 25^{0}C)	NMVOC	Tier 2
3De	Agriculture Soils	Cultivated crops	Oats	NMVOC	Tier 2
3De	Agriculture Soils	Cultivated crops	Other arable	NMVOC	Tier 2
3De	Agriculture Soils	Cultivated crops	Rye	NMVOC	Tier 2
3F	Field burning	Agricultural residues	Barley	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Beans	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Broad bean horse bean	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Cassava	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Cereals	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Chickpeas	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Cow peas	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Lentils	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Maize	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Millet	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Oats	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Other pulses	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Other roots and tubers	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Peas	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Potatoes	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Rice paddy	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Rye	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Sorghum	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Soybean	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Sugar beet	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Sugarcane	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Sweet potatoes	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Wheat	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Yams	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Cotton	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Feet beet	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Peanuts	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Sunflower	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Tobacco	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2
3F	Field burning	Agricultural residues	Alfalfa	NH_3, NOx, NMVOC, TSP, PM_{10}, $PM_{2.5}$, SOx, BC, CO, Heavy Metals, POPs	Tier 1 and Tier 2

Annex 2. Air Pollutants and Greenhouse Gases in AgrEE tool

Table 13. Air pollutants and greenhouse gases included in AgrEE tool

Air pollutants	Formula	Measurement unit
Main Air Pollutants		
Ammonia	NH_3	kt
Nitrogen Oxides	NOx (as NO_2)	kt
Non-Methane Volatile Organic Compounds	NMVOC	kt
Sulphur oxides	SOx (as SO_2)	kt
Particulate Matter		
Total Suspended Particulates	TSP	kt
Particulate Matter 10µm	PM_{10}	kt
Particulate Matter 2.5µm	$PM_{2.5}$	kt
Black Carbon	BC	kt
Other pollutant		
Carbon Monoxide	CO	kt
Priority Heavy Metals		
Lead	Pb	t
Cadmium	Cd	t
Mercury	Hg	t
Additional Heavy Metals		
Arsenic	As	t
Chromium	Cr	t
Cooper	Cu	t
Nickel	Ni	t
Selenium	Se	t
Zinc	Zn	t
Persistent Organic Pollutants	POPs	
Dioxin/Furans	PCDD/PCDF	g I-TEQ
Benzo(a)pyrene	$C_{20}H_{12}$	t
Benzo(b)fluoranthene	$C_{20}H_{12}$	t
Benzo(k)fluoranthene	$C_{20}H_{12}$	t
Indeno(1,2,3-cd)pyrene	$C_{22}H_{12}$	t
Greenhouse gases		
Methane	CH_4	kt
Nitrous oxide	N_2O	kt

Annex 3. Country specific livestock subdivision in AgrEE tool

AgrEE tool perform calculations for 13 livestock categories (see Annex 1) and 17 livestock subcategories. Only for Livestock sector AgrEE tool perform calculations even for country specific livestock subdivisions. Here below the example of Belgium livestock subdivisions included in the AgrEE tool.

Table 14. Livestock categories, subcategories, and subdivisions in Belgium inventory in AgrEE tool

country	NFR category code	Category name	Subcategory	Subdivision
BE	3B1a	Dairy_cattle	Dairy_cattle	Dairy_cattle
BE	3B1a	Dairy_cattle	Dairy_cattle	Brood_cows
BE	3B1b	Non dairy cattle	Other_cattle	Bovines<6month
BE	3B1b	Non dairy cattle	Other_cattle	Bovines_male_6month-1yr
BE	3B1b	Non dairy cattle	Other_cattle	Bovines_female_6month-1yr
BE	3B1b	Non dairy cattle	Other_cattle	Bovines_male_fattening >1yr
BE	3B1b	Non dairy cattle	Other_cattle	Bovines_male_reproduction>1yr
BE	3B1b	Non dairy cattle	Other_cattle	Bovines_female>1yr
BE	3B1b	Non dairy cattle	Other_cattle	Cattle<1yr
BE	3B1b	Non dairy cattle	Other_cattle	Cattle_1-2yr
BE	3B1b	Non dairy cattle	Other_cattle	Cattle>2yr
BE	3B1b	Non dairy cattle	Other_cattle	Other_cattle
BE	3B1b	Non dairy cattle	Calves	Slaughter calves
BE	3B1b	Non dairy cattle	Calves	Other_calves
BE	3B2	Sheep	Sheep	Breeding males
BE	3B2	Sheep	Sheep	Lamb
BE	3B2	Sheep	Sheep	Sheep
BE	3B3	Swine	Finishing	Pigs 20kg-110kg
BE	3B3	Swine	Finishing	Pigs >110kg
BE	3B3	Swine	Sows	Piglets <7kg
BE	3B3	Swine	Sows	Boars
BE	3B3	Swine	Sows	Sows
BE	3B3	Swine	Weaners	Weaners
BE	3B4a	Buffalo	Buffalo	Buffalo
BE	3B4d	Goats	Goats	Goats
BE	3B4d	Goats	Goats	Goats
BE	3B4e	Horses	Horses	Horses
BE	3B4f	Mules and asses	Mules and asses	Mules and asses
BE	3B4gi	Laying_hens	Laying_hens	Laying_hens
BE	3B4gi	Laying_hens	Laying_hens	Laying_hens for breeding
BE	3B4gii	Broilers	Broilers	Broilers for breeding
BE	3B4gii	Broilers	Broilers	Broilers for fattening
BE	3B4giii	Turkeys	Turkeys	Turkeys
BE	3B4giv	Other_poultry	Ducks	Ducks
BE	3B4giv	Other_poultry	Geese	Geese
BE	3B4h	Other_animals	Fur_animals	Fur_animals
BE	3B4h	Other_animals	Fur_animals	Rabbit
BE	3B4h	Other_animals	Fur_animals	Ostriches

Annex 4. AgrEE tool input structure for air pollutant emissions from Livestock – Tier 1 and Tier 2

Livestock – Tier 1 uniform structure

parameter_type	method	sector	system_type	fuel_type	activity_data_name	air_pollutant	category_name	subcategory_name	unit
activity_data	Tier_1	Livestock	All_types	All_types	Number_livestock	NH3, NO, NMVOC, PM	All_Livestock	All_Livestock	head
activity_data	Tier_1	Livestock	House	All_types	Housed_period	NH3, PM	All_Livestock	All_Livestock	Days
activity_data	Tier_1	Livestock	AWMS	solid	AWMS	NH3, NO	All except Broilers, Turkeys, Other poultry, Other animals	All except Broilers, Turkeys, Other poultry, Other animals	percentage
activity_data	Tier_1	Livestock	AWMS	slurry	AWMS	NH3, NO	Dairy cattle, Non Dairy cattle, Swine, Laying hens	DC, Other Cattle, Calves, Finishing, Sows, Weaners, Laying hens	percentage
activity_data	Tier_1	Livestock	AWMS	litter	AWMS	NH3, NO	All_Livestock	All_Livestock	percentage
activity_data	Tier_1	Livestock	AWMS	outdoor	AWMS	NH3, NO	Swine	Sows	percentage
activity_data	Tier_1	Livestock	With_silage_feeding	soild_slurry	Days	NMVOC	All_Livestock	All_Livestock	Days
emission_factor	Tier_1	Livestock	House_Storage_Yard	solid	EF_NH3_house_storage_yard_solid	NH3	All except Broilers, Turkeys, Other poultry, Other animals	All except Broilers, Turkeys, Other poultry, Other animals	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	House_Storage_Yard	slurry	EF_NH3_house_storage_yard_slurry	NH3	Dairy cattle, Non Dairy cattle, Swine, Laying hens	Dairy cattle, Non Dairy cattle, Swine, Laying hens	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	House_Storage_Yard	litter	EF_NH3_house_storage_yard_litter	NH3	Broilers, Turkeys, Other poultry	Broilers, Turkeys, Ducks, Geese	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	House_Storage_Yard	outdoor	EF_NH3_house_storage_yard_outdoor	NH3	Swine	Sows	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	Manure application	solid	EF_NH3_manure_application_solid	NH3	All except Broilers, Turkeys, Other poultry, Other animals	All except Broilers, Turkeys, Other poultry, Other animals	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	Manure application	slurry	EF_NH3_manure_application_slurry	NH3	Dairy cattle, Non Dairy cattle, Swine, Laying hens	Dairy cattle, Non Dairy cattle, Swine, Laying hens	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	Manure application	litter	EF_NH3_manure_application_litter	NH3	Broilers, Turkeys, Other poultry	Broilers, Turkeys, Ducks, Geese	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	Manure application	outdoor	EF_NH3_manure_application_outdoor	NH3	Swine	Sows	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	Grazing	solid	EF_NH3_grazing_solid	NH3	All except Broilers, Turkeys, Other poultry, Other animals	All except Broilers, Turkeys, Other poultry, Other animals	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	Grazing	slurry	EF_NH3_grazing_slurry	NH3	Dairy cattle, Non Dairy cattle, Swine, Laying hens	Dairy cattle, Non Dairy cattle, Swine, Laying hens	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	Grazing	litter	EF_NH3_grazing_litter	NH3	Broilers, Turkeys, Other poultry	Broilers, Turkeys, Ducks, Geese	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	Grazing	outdoor	EF_NH3_grazing_outdoor	NH3	Swine	Sows	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	Total	solid	EF_NH3_total_solid	NH3	All except Broilers, Turkeys, Other poultry, Other animals	All except Broilers, Turkeys, Other poultry, Other animals	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	Total	slurry	EF_NH3_total_slurry	NH3	Dairy cattle, Non Dairy cattle, Swine, Laying hens	Dairy cattle, Non Dairy cattle, Swine, Laying hens	kg NH3/AAP/year
emission_factor	Tier_1	Livestock	Storage	solid	EF_NO_storage_solid	NO	All except Broilers, Turkeys, Other poultry, Other animals	All except Broilers, Turkeys, Other poultry, Other animals	kg NO2/AAP/year
emission_factor	Tier_1	Livestock	Storage	slurry	EF_NO_storage_slurry	NO	Dairy cattle, Non Dairy cattle, Swine, Laying hens	Dairy cattle, Non Dairy cattle, Swine, Laying hens	kg NO2/AAP/year
emission_factor	Tier_1	Livestock	Storage	litter	EF_NO_storage_litter	NO	Broilers, Turkeys, Other poultry	Broilers, Turkeys, Ducks, Geese	kg NO2/AAP/year
emission_factor	Tier_1	Livestock	Storage	outdoor	EF_NO_storage_outdoor	NO	Swine	Sows	kg NO2/AAP/year
emission_factor	Tier_1	Livestock	With_silage_feeding	soild, slurry	EF_NMVOC_silage_feeding	NMVOC	All_Livestock	All_Livestock	kg NMVOC/AAP/year
emission_factor	Tier_1	Livestock	Without_silage_feeding	soild, slurry	EF_NMVOC_no_silage_feeding	NMVOC	All_Livestock	All_Livestock	kg NMVOC/AAP/year
emission_factor	Tier_1	Livestock	House	All_types	EF_PM10_house	PM10	All_Livestock	All_Livestock	kg PM10/AAP/year
emission_factor	Tier_1	Livestock	House	All_types	EF_PM2.5_house	PM2.5	All_Livestock	All_Livestock	kg PM2.5/AAP/year
emission_factor	Tier_1	Livestock	House	All_types	EF_TSP_house	TSP	All_Livestock	All_Livestock	kg TSP/AAP/year
activity_data	Tier_1	Agriculture soils	All_types	All_types	Total_N_fertilisers	NH3, NO	Inorganic_N _fertilisers	Inorganic_N _fertilisers	kg N/year
activity_data	Tier_1	Agriculture soils	All_types	All_types	Total_N_manure_applied	NO	Manure_applied_soils	Manure_applied_soils	kg N applied/year
activity_data	Tier_1	Agriculture soils	All_types	All_types	Total_N_sewage_sludge	NH3, NO	Sewage_sludge	Sewage_sludge	kg N/year
activity_data	Tier_1	Agriculture soils	All_types	All_types	Total_N_organic_wastes	NH3, NO	Organic_wastes	Organic_wastes	kg N/year
activity_data	Tier_1	Agriculture soils	All_types	All_types	Cultivated_crops_area	NMVOC	Cultivated_crops	Cultivated_crops	ha
activity_data	Tier_1	Agriculture soils	All_types	All_types	EF_NH3_fert	NH3	Inorganic_N _fertilisers	Inorganic_N _fertilisers	kg NH3/kg N fertiliser
activity_data	Tier_1	Agriculture soils	All_types	All_types	EF_NO_fert	NO	Inorganic_N _fertilisers	Inorganic_N _fertilisers	kg NO2/kg N fertiliser
activity_data	Tier_1	Agriculture soils	All_types	All_types	EF_NO_man_appl	NO	Manure_applied_soils	Manure_applied_soils	kg NO2/kg N applied
activity_data	Tier_1	Agriculture soils	All_types	All_types	EF_NO_graz	NO	Urine_dung_deposited_grazing	Urine_dung_deposited_grazing	kg NO2/kg N applied
activity_data	Tier_1	Agriculture soils	All_types	All_types	EF_NH3_sewage	NH3	Sewage_sludge	Sewage_sludge	kg NH3/kg N applied
activity_data	Tier_1	Agriculture soils	All_types	All_types	EF_NO_sewage	NO	Sewage_sludge	Sewage_sludge	kg NO2/kg N applied
activity_data	Tier_1	Agriculture soils	All_types	All_types	EF_NH3_org_wastes	NH3	Organic_wastes	Organic_wastes	kg NH3/kg waste N appli
activity_data	Tier_1	Agriculture soils	All_types	All_types	EF_NO_org_wastes	NO	Organic_wastes	Organic_wastes	kg NO2/kg waste N appli
activity_data	Tier_1	Agriculture soils	All_types	All_types	EF_NMVOC_cult_crops	NMVOC	Cultivated_crops	Cultivated_crops	kg NMVOC/ha
activity_data	Tier_1	Agriculture soils	All_types	All_types	EF_PM10_agri_op	PM10	Agricultural_operations	Agricultural_operations	kg PM10/ha
activity_data	Tier_1	Agriculture soils	All_types	All_types	EF_PM2.5_agri_op	PM2.5	Agricultural_operations	Agricultural_operations	kg PM2.5/ha
activity_data	Tier_1	Agriculture soils	All_types	All_types	EF_TSP_agri_op	TSP	Agricultural_operations	Agricultural_operations	kg TSP/ha

Livestock – Tier 2 uniform structure

parameter type	method	region	climate	soil pH	sector	Activity data	System type	fuel type	pollutant_equation	short_name	category name	subcategory name	unit
activity_data	Tier_2	All_regions	All	All	Livestock	Number_livestock	All_types	All	NH3, NO, N2O, NMVOC, PM	Num_	All livestock	All livestock	head
activity_data	Tier_2	All_regions	All	All	Livestock	Housed_period	All	All_types	NH3, NO, N2O, NMVOC, PM	Hou_	All livestock	All livestock	Days
activity_data	Tier_2	All_regions	All	All	Livestock	AWMS	Storage	slurry	NH3, NO, N2O	St_slurry_	All livestock	All livestock	Fraction
activity_data	Tier_2	All_regions	All	All	Livestock	AWMS	Storage	solid	NH3, NO, N2O	St_solid_	All livestock	All livestock	Fraction
activity_data	Tier_2	All_regions	All	All	Livestock	AWMS	Biogas	slurry	NH3, NO, N2O	Biog_slurry_	All livestock	All livestock	Fraction
activity_data	Tier_2	All_regions	All	All	Livestock	AWMS	Biogas	solid	NH3, NO, N2O	Biog_solid_	All livestock	All livestock	Fraction
activity_data	Tier_2	All_regions	All	All	Livestock	AWMS	House	slurry	NH3, NO, N2O, PM	Hou_slurry_	All livestock	All livestock	Fraction
activity_data	Tier_2	All_regions	All	All	Livestock	AWMS	Yard	waste	NH3, NO, N2O	Exc_Ya_	All livestock	All livestock	Fraction
activity_data	Tier_2	All_regions	All	All	Livestock	AWMS	Tied_Housi	All_types	NH3, NO, N2O	Tied_Hou_	All livestock	All livestock	Fraction
activity_data	Tier_2	All_regions	All	All	Livestock	AWMS	Storage	with_natur	NH3, NO, N2O	St_nat_crust_	All livestock	All livestock	Fraction
activity_data	Tier_2	All_regions	All	All	Livestock	AWMS	Storage	without_na	NH3, NO, N2O	St_without_nat_crust_	All livestock	All livestock	Fraction
activity_data	Tier_2	western_europe	All	All	Livestock	Animal_Weight	All_types	All	NH3, NO, N2O	Weight_	All livestock	All livestock	kg
activity_data	Tier_2	eastern_europe	All	All	Livestock	Animal_Weight	All_types	All	NH3, NO, N2O	Weight_	All livestock	All livestock	kg
activity_data	Tier_2	western_europe	All	All	Livestock	Nex	All_types	All	NH3, NO, N2O	Nex_	All livestock	All livestock	kg N/1000 kg animal mass /day
activity_data	Tier_2	eastern_europe	All	All	Livestock	Nex	All_types	All	NH3, NO, N2O	Nex_	All livestock	All livestock	kg N/1000 kg animal mass day-1
activity_data	Tier_2	All_regions	All	All	Livestock	Nex_as_TAN	All_types	All	NH3, NO, N2O	Nex_as_TAN_	All livestock	All livestock	Fraction
activity_data	Tier_2	All_regions	All	All	Livestock	Straw	All_types	All	NH3, NO, N2O	Straw_	All livestock	All livestock	kg/year
activity_data	Tier_2	All_regions	All	All	Livestock	N_added_in_straw	All_types	All	NH3, NO, N2O	N_add_straw_	All livestock	All livestock	kg/animal/year
activity_data	Tier_2	All_regions	All	All	Livestock	fimm	All_types	All	NH3, NO, N2O	fimm_	All livestock	All livestock	kg N/kg straw
activity_data	Tier_2	All_regions	All	All	Livestock	fmin	All_types	All	NH3, NO, N2O	fmin_	All livestock	All livestock	kg N/kg
activity_data	Tier_2	All_regions	All	All	Livestock	fmin_biogas	All_types	All	NH3, NO, N2O	fmin_biogas_	All livestock	All livestock	kg N/kg
activity_data	Tier_2	All_regions	All	All	Livestock	Gross_Feed_Intake	All_types	All	NMVOC	Gross_FI_	All livestock	All livestock	MJ/head/day
activity_data	Tier_2	All_regions	All	All	Livestock	VS_excreted	All_types	All	NMVOC	Vs_ex_	All livestock	All livestock	kg dm/head/day
activity_data	Tier_2	All_regions	All	All	Livestock	Fraction_silage	Silage	All	NMVOC	Frac_sil_	All livestock	All livestock	Fraction
activity_data	Tier_2	All_regions	All	All	Livestock	Fraction_silage_N	Silage	normal	NMVOC	Frac_sil_N_	All livestock	All livestock	Fraction
activity_data	Tier_2	All_regions	All	All	Livestock	Fraction_silage_D	Silage	dominant	NMVOC	Frac_sil_D_	All livestock	All livestock	Fraction
activity_data	Tier_2	All_regions	All	All	Livestock	Fraction_silage_storage	Silage	storage	NMVOC	Frac_sil_St_	All livestock	All livestock	Fraction
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NH3	House	slurry	NH3, NO, N2O	EF_NH3_Hou_slurry_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NH3	House	solid	NH3, NO, N2O	EF_NH3_Hou_solid_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NH3	Tied_Housi	slurry	NH3, NO, N2O	EF_NH3_Tied_Hou_slu	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NH3	Tied_Housi	solid	NH3, NO, N2O	EF_NH3_Tied_Hou_soli	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NH3	Yard	All	NH3, NO, N2O	EF_NH3_Ya_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NH3	Storage	slurry	NH3, NO, N2O	EF_NH3_St_slurry_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NH3	Storage	solid	NH3, NO, N2O	EF_NH3_St_solid_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NH3	Manure_ap	slurry	NH3, NO, N2O	EF_NH3_appl_slurry_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NH3	Manure_ap	solid	NH3, NO, N2O	EF_NH3_appl_solid_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NH3	Grazing	All	NH3, NO, N2O	EF_NH3_graz_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NH3	Pre-storage	All	NH3, NO, N2O	EF_NH3_Pre-st_	All livestock	All livestock	kg NH3-N/kg N in feedstock
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NH3	Storage of c	All	NH3, NO, N2O	EF_NH3_St_digestate_	All livestock	All livestock	kg NH3-N/kg N in feedstock
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NO	Storage	slurry	NH3, NO, N2O	EF_NO_St_slurry_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_N2	Storage	slurry	NH3, NO, N2O	EF_N2_St_slurry_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NO	Storage	solid	NH3, NO, N2O	EF_NO_St_solid_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_N2	Storage	solid	NH3, NO, N2O	EF_N2_St_solid_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NO	Managed_s	All	NH3, NO, N2O	EF_NO_Manag_soils_n	All livestock	All livestock	kg NO2/kg N input
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NO	Managed_s	All	NH3, NO, N2O	EF_NO_Manag_soils_e	All livestock	All livestock	kg NO2/kg N input
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_N2O	Manure_ap	All	NH3, NO, N2O	EF_N2O_appl_	All livestock	All livestock	kg N2O-N/kg N input
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_N2O	Storage	slurry_with	NH3, NO, N2O	EF_N2O_St_slurry_with	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_N2O	Storage	slurry_with	NH3, NO, N2O	EF_N2O_St_slurry_with	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_N2O	Storage	slurry	NH3, NO, N2O	EF_N2O_St_slurry_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_N2O	Storage	solid	NH3, NO, N2O	EF_N2O_St_solid_	All livestock	All livestock	Fraction_TAN
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_N2O	Grazing	All	NH3, NO, N2O	EF_N2O_graz_	All livestock	All livestock	kg N2O-N/kg N input
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NMVOC	House	feed_intake	NMVOC	EF_NMVOC_Hou_FI_	All livestock	All livestock	kg NMVOC/kg MJ feed intake
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NMVOC	Silage	feed_intake	NMVOC	EF_NMVOC_sil_FI_	All livestock	All livestock	kg NMVOC/kg MJ feed intake
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NMVOC	Grazing	feed_intake	NMVOC	EF_NMVOC_graz_FI_	All livestock	All livestock	kg NMVOC/kg MJ feed intake
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NMVOC	House	VS_excreted	NMVOC	EF_NMVOC_Hou_VS_	All livestock	All livestock	kg NMVOC/kg VS excreted
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NMVOC	Silage	VS_excreted	NMVOC	EF_NMVOC_sil_VS_	All livestock	All livestock	kg NMVOC/kg VS excreted
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_NMVOC	Grazing	VS_excreted	NMVOC	EF_NMVOC_graz_VS_	All livestock	All livestock	kg NMVOC/kg VS excreted
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_TSP	House	slurry	PM	EF_TSP_Hou_slurry_	All livestock	All livestock	kg TSP/AAP/year
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_TSP	House	solid	PM	EF_TSP_Hou_solid_	All livestock	All livestock	kg TSP/AAP/year
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_PM10	House	slurry	PM	EF_PM10_Hou_slurry_	All livestock	All livestock	kg PM10/AAP/year
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_PM10	House	solid	PM	EF_PM10_Hou_solid_	All livestock	All livestock	kg PM10/AAP/year
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_PM2.5	House	slurry	PM	EF_PM2.5_Hou_slurry_	All livestock	All livestock	kg PM2.5/AAP/year
emission_factor	Tier_2	All_regions	All	All	Livestock	EF_PM2.5	House	solid	PM	EF_PM2.5_Hou_solid_	All livestock	All livestock	kg PM2.5/AAP/year

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