

Methodology for the Calculation of Nitrous Oxide (N₂O) Emissions in agricultural systems

The calculation of nitrous oxide (N₂O) emissions and carbon emissions associated with the use and production of nitrogen fertilizers is carried out in accordance with the IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 (Agriculture, Forestry and Other Land Use), Chapter 11: N₂O Emissions from Managed Soils, as well as reference industry data on fertilizer production from Fertilizers Europe. The calculations for direct and indirect emissions are entirely based on Chapter 11 of Volume 4 of the IPCC 2006 Guidelines (and their 2019 updates). The methodology divides soil emissions into three main flows, which are used for calculation or applies the so-called Default Factors.

N₂O emissions are calculated for the project and baseline scenarios using the IPCC 2006 Tier 1 methodology, with the results compared for each reporting year, and the reduction determined as the difference between baseline and project emissions in CO₂e. The reduction of N₂O emissions in the project scenario compared to the baseline scenario represents an improvement in the emission profile of the agro-system and is accounted for as part of the environmental contribution of the project. In case of higher project emissions, no reductions are generated.

The methodology follows the principles of:

- conservativeness;
- transparency;
- avoidance of underestimation of emissions;
- use of the IPCC Tier 1 approach for soil emissions

The methodology compares the values of the project year against the baseline and includes two main components:

I. EMISSIONS FROM PRODUCTION AND SUPPLY OF NITROGEN FERTILIZERS (CO₂e)¹:

Emissions associated with the production and supply of nitrogen fertilizers are calculated based on the applied quantity of nitrogen as active substance (kg N). For this purpose, the corresponding emission factor (kg CO₂e/kg N) is applied, reflecting emissions from the entire production cycle:

CO₂e emissions = applied quantity of nitrogen active substance (kg N/ha) × emission factor (kg CO₂e/kg N)

Emissions from the production of mineral nitrogen fertilizers are assessed using emission factors based on regional differences in technologies and energy sources. The emission factor used is determined according to the origin and production technology of the fertilizer.

Accepted emission factors (index):

- European production (standard), reflecting the reference value for production in the EU under typical industrial conditions and BAT level – index available in the calculation sheet;

¹ Fertilizers Europe

https://www.fertilizerseurope.com/wp-content/uploads/2020/01/The-carbon-footprint-of-fertilizer-production-Regional-reference-values.pdf?utm_source=chatgpt.com

- European production with low carbon footprint (premium) or (BAT + N₂O abatement) with proven implementation of best available techniques, including catalytic reduction of N₂O and optimized energy efficiency, with validated PCF/EPD data – index available in the calculation sheet);
- Production outside the EU (conservative scenario), reflecting an upper reference value for regions with more carbon-intensive technologies, lower energy efficiency and lack of BAT implementation – index available in the calculation sheet.

II. EMISSIONS FROM SOIL PROCESSES (N₂O):

1. Determination of the quantity of nitrogen (N) depending on the crop type (according to Table 11.2 of the IPCC 2006 Guidelines);
2. Soil N₂O emissions – IPCC defines three main pathways for N₂O formation:
 - Direct emissions – Nitrogen that is converted directly into N₂O in the soil:

$$N_2O = N \times 1\% \times 1.57 \times 273^2$$

IPCC method for converting nitrogen (N) into emissions of CO₂e through nitrous oxide (N₂O) and includes fertilizer, crop residues, organic sources. The formula uses the IPCC Tier 1 method, where 1% of the nitrogen is converted into N₂O-N, after which it is converted into N₂O through a molecular ratio (1.57) and into CO₂e through the global warming potential (273) according to IPCC (AR6).

- Indirect emissions from volatilization – Part of the nitrogen volatilizes as NH₃/NO_x and is subsequently redeposited:

$$N_2O = N \times 10\% \times 1\% \times 1.57 \times 273$$

IPCC assumes that approximately 10% of the applied nitrogen is lost through volatilization as NH₃ (ammonia) and NO_x and 1% is transformed into N₂O-N. The formula estimates indirect N₂O emissions from volatilization, assuming that 10% of nitrogen volatilizes as NH₃/NO_x, of which 1% is subsequently converted into N₂O-N, which is converted into N₂O (1.57) and CO₂e (GWP 273) according to the IPCC Tier 1 methodology.

- Indirect emissions from leaching/runoff – Nitrogen is leached into soil and water systems:

$$N_2O = N \times 30\% \times 0.75\% \times 1.57 \times 273$$

IPCC Tier 1 assumes that on average about 30% of the applied nitrogen can be leached from the soil into groundwater or surface water, and 0.75% is the fraction of the leached nitrogen that is converted into N₂O-N. The formula estimates indirect N₂O emissions from nitrogen leaching, assuming that 30% of nitrogen is leached, of which 0.75% is transformed into N₂O-N, which is converted into N₂O (1.57) and CO₂e (GWP 273) according to the IPCC Tier 1 methodology.

The applied methodology ensures a consistent and conservative approach for the assessment of greenhouse gas emissions, covering the entire nitrogen cycle – from the application of nitrogen fertilizers to its transformation into soil and indirect emissions of nitrous oxide (N₂O). The combination of the IPCC Tier 1 methodology for N₂O emissions from soil processes and emission

² IPCC Guidelines for National Greenhouse Gas Inventories приема, че: 1% от внесения азот се превръща директно в N₂O-N в почвата; 1.57 е превръщането от азот (N₂O-N) към молекула N₂O; 273 Global Warming Potential (GWP) това е коефициентът, който превръща N₂O в CO₂e

factors for nitrogen fertilizer production, differentiated according to origin and technological level (EU standard or premium production in the EU and non-EU scenarios), provides a more complete picture of the climate footprint of the agricultural system. In this way, both direct and indirect emissions from nitrogen in the agro-system are assessed, as well as emissions related to the life cycle of the applied fertilizers. The comparison between the baseline and project scenarios allows the determination of the net effect on greenhouse gas emissions in CO₂e, with the result reflecting the change in the environmental performance of the system under project implementation.