Calculation documentation

In general, data basis of the emission projections calculation was the inventory submission 2024 with all the included processing of the emission data. Only for ammonia also a calculation based on inventory submission 2025 under otherwise identical assumptions was carried out.

For its national emission projections, Germany takes into account projected activity data for GHG projections and category-specific reports on air pollution emission factor development in the future. For all sectors, emission scenarios were developed in the greatest possible consistency with the latest available energy and greenhouse gas emission scenario for Germany, which was at the time of preparation of the emission projections for reporting in 2025 the MMS (WEM, with existing measures scenario) of 'Treibhausgas-Projektionen 2024 für Deutschland'[1)] published in mid-2024. This is also consistent with the current NECPR-reporting according to art. 17 of regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action. However, reporting of updated GHG emission projections in 2025 according to art. 18 of regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action could not be reflected for the current air pollutant emission projections, except for ammonia (reported in a separate file).

In the scenario "with measures" (WM), for the majority of the emission sources in the sectors 1.A.1 (energy industry), 1.A.2 (manufacturing industry), 1.A.4 (other combustion systems), 1.A.5 (military), 1.B (diffuse emissions from fuels), 2 (industrial processes) and 5 (waste and wastewater treatment) projected development of the activity rates is based on the with existing measures scenario (MMS=WEM) of the 'Treibhausgas-Projektion 2024 für Deutschland'. The MMS of the 2024 GHG emission projections for Germany includes all climate protection-relevant measures and instruments adopted by July 31, 2023.

In contrast to this comprehensive projection of activity data, transport emissions are calculated using the TREMOD model ("Transport Emission Model"). To estimate the future development of transport-related energy consumption and emissions, a trend scenario up to 2050 was developed, which is updated annually. Version 6.53 of TREMOD formed the basis for the current emission projections (see Allekotte et al., 2024[2)]). Therefore, road transport measures from the WAM scenario of the German NAPCP 2023[3)], including the expansion of the truck toll system and a package of measures to promote electromobility, which have since been implemented, become part of the trend scenario. Beyond the trend scenario, findings from ongoing work for the upcoming HBEFA 5.1 update (Handbook of Emission Factors for Road Transport[4)]), such as an increase in the implied emission factors for trucks and coaches with Euro V and VI due to defective or manipulated exhaust aftertreatment systems were considered[5)] in the current WM scenario. In addition, the introduction of Euro 7 on the basis of Regulation (EU) 2024/1257 was considered in the WM scenario, leading to further decline of implied emission factors of the fleet, especially beyond 2030. Those additional assumptions are documented in Allekotte et al. (2025)[6)]). Furthermore, assumptions about emissions from road abrasion as well as tyre and brake wear from electrically driven mileage were included according to EMEP/EEA air pollutant emission inventory guidebook 2023[7)]. In order to reflect the Euro 7 Regulation also regarding particle emissions from tyre and brake wear the emission factors of the historical emissions were further adjusted for the emission projections.

The projection for the agricultural sector (NFR 3) was created by the Thünen Institute (TI) using the py-GAS-EM reporting model twofold, once based on the inventory submission 2024 and the MMS (WEM, with existing measures) of the "Treibhausgas-Projektionen 2024 für Deutschland" and once based on the current inventory submission 2025 and the MMS (WEM, with existing measures) of the "Treibhausgas-Projektionen 2025 für Deutschland"[8)]. For both projections, the most important input data for the calculation of the agricultural emissions (animal numbers, animal performance, mineral fertilizer use) were derived for the first time using the CAPRI model, based on the current Thünen-Baseline 2024-2034 (2024)[9)]. Further assumptions for the sector agriculture were assumed as in the WM scenario of the German NAPCP 2023 and are described below for the year 2030.

For dairy cows, the proportion of cows kept in tied housing systems was reduced by 50 % compared to 2020 (weakened trend projection). In the past, the decline in tied housing systems has not had the same impact on the decline in the number of dairy cows in Germany. It is assumed that this will not be the case in the future either. For other cattle, tied housing systems will also be reduced by 50 % compared to 2020.

Due to the further implementation of the German Fertiliser Ordinance, strip application on cultivated fields (since 2020) and grassland (from 2025) as well as immediate incorporation on uncultivated farmland after no more than one hour (from 2025) is becoming mandatory. On cultivated fields, the current proportions of broadcast application were redistributed to trailing hose application. On grassland, 80 % of the current proportions of broadcast application were redistributed to trailing shoe application and 20 % to trailing hose application. This roughly corresponds to today's ratio of trailing hose and trailing shoe on grassland.

The proportion of the share of liquid manure spread using injection and slot technology was extrapolated based on the increasing trend between 2010 and 2020.

The use of manure in biogas plants is statically updated based on the year 2023. The use of energy crops in biogas plants was assumed to be declining, as described in the Thünen Baseline 2024-2034. This corresponds to a reduction in the amount of energy crops used in 2030 compared to 2023 of around 61 % based on the nitrogen contained (and to a reduction of 80 % for the projection year 2035).

With the assumptions described above, a significant reduction of ammonia emissions compared to the current annual emissions will be achieved by 2030. For the WM projection based on inventory submission 2025 a buffer of roughly 16 kt results for 2030 (for the current WM projection based on inventory submission 2024 there would be no buffer without the further assumptions described below).

In addition, potential emission reductions as a result of the new version of the first general administrative regulation for the Federal Immission Control Act (Technical Instructions for Air Pollution Control - TA Luft)[10)], which came into force on December 1st, 2021, were evaluated. These bring about a reduction effect of a further 11.8 kt of ammonia in 2030. In total, this results in a buffer of roughly 28 kt in the current WM scenario based on inventory submission 2025 for complying with the reduction obligation for ammonia in 2030 (or roughly 11 kt in the current WM projection based on inventory submission 2024). The assumed reduction effects through the TA-Luft are divided into three sub-areas.

- For farms falling in the category ‚G‘ (according to Annex 1 of the 4th BImSchV for keeping or rearing of sows, fattening pigs, piglets, laying hens, pullets and broilers) it was assumed that the current status of air scrubber systems for pigs remains constant (with a reduction performance of 80 %) and that the current status for poultry increases slightly (with a reduction performance of 70 %). For almost the entire remaining stock of the respective animal category in G-systems, it was assumed that 40 % of the emissions in the barn are reduced by further system-integrated measures. This can be achieved, for example, with a less effective air scrubber system or other technical measures in animal housing. These assumptions are conservative since they only reflect the minimum requirements with regard to emission reductions according to the current legal situation and implementation practice. The TA Luft prescribes the cleaning of the exhaust air as state of the art for new systems. This also applies to existing systems – with various transitional periods – unless retrofitting is not proportionate or technically possible. In this case, other mitigation measures must be implemented. Alternatively, the TA Luft enables the use of quality-assured housing facilities that demonstrably serve animal welfare and, if designed appropriately (e.g. animal-friendly, emission-optimized outdoor climate stable), at the same time achieve relevant emission reductions that are quantitatively specified in the TA Luft. It is currently not possible to reliably estimate what proportion of the existing systems can be retrofitted with air scrubbing systems and what proportion of the new construction or replacement construction will take the form of quality-assured, animal-friendly and emission-optimized husbandry systems. Therefore, for the entire (heterogeneous) group, only the minimum achievable reductions when implementing the legal requirements were initially assumed in the sense of a conservative total analysis.
- For 30 % of the animal stocks falling into the category ‚V‘ (according to Annex 1 of the 4th BImSchV for keeping or rearing of sows, fattening pigs, piglets, laying hens, pullets and broilers), it was assumed that these reduce emissions by 40 % through system-integrated measures in animal housing. As explained above, this is also a conservative assumption (e.g. with regard to retrofitting and the new construction of animal-friendly husbandry systems) in order not to overestimate the emission reduction.
- For 80 % of the slurry from G and V systems, it was assumed that in 2030 they would be stored covered at least with foil or comparable technology.

The NMVOC emissions from NFR sector 2.D.3, which includes emissions resulting from the use of solvents and solvent-containing products, as well as their manufacturing, are not calculated using activity rates and emission factors within the inventory. Instead, a separate model developed and expanded steadily over the past 15 years primarily by the Institute for Environmental Strategies (Ökopol GmbH) is utilized to calculate these emissions, and the results are imported into the inventory database. This model also provides emission projections based on economic forecasts specific to certain branches of industry. These economic projections were last updated for the emissions projections reported in 2023 using the Prognos report (2019) titled “Deutschland Report 2025 | 2035 | 2045”. The methodology for updating the NMVOC inventory and projections is detailed in Zimmermann and Memelink (2023[11)]).

In a more recent project, Zimmermann et al. (2025[12)]) conducted a comprehensive review of the previous methods used for projecting NMVOC emissions in the sectors of printing (NFR 2.D.3.h) and coating applications (NFR 2.D.3.d). They developed new projection methods for the years 2025 to 2050. The updates made for the individual SNAP codes can be summarised as follows:

SNAP 60101 demonstrated a clear correlation with automobile production. A forecast for production in Germany has been established based on EU production forecasts and used in the emission projections. For SNAP 60102, emissions showed a correlation with vehicle fleet size from 2015 onward. Forecast data on the vehicle population was taken from the study (Adolf et al., 2014[13)]) and used for the projection. SNAP 60103 showed that employee numbers and annual construction output correlated with emissions from 2018 on. Projections have been implemented using data from BMAS (2021[14)]) and the

Prognos report (2019). For SNAP 60104, a correction factor to the “population development” indicator has been applied to update projections. SNAP 60105 showed a significant correlation with the completion of commercial buildings. Due to the lack of specific forecasts for this indicator, automotive production data (from SNAP 60101) has been used as an alternative. SNAP 60106 faced challenges in identifying suitable indices for emissions. A weak correlation with boat and shipbuilding turnover has been noted and additional corrections to enhance projection accuracy have been applied. In the case of SNAP 60107, no meaningful correlations were established, prompting to create emission projections based on trend extrapolations. Future investigations into specific SNAP areas will yield better methodologies. SNAP 60108 required careful analysis of several sub-areas. No correlation of the emissions to economic (or other) variables could be determined for several sub-areas, which is why some of the emissions were updated using trend progression. In the future, it may be useful to take a closer look at the individual areas of the SNAP code that are particularly relevant to emissions and the developments taking place in these areas to identify suitable alternative approaches for creating projections. No correlation could be established between SNAP 60109 and the indices used to date. However, with the “Other expenditure, inflation-adjusted” index, an alternative suitable forecast index could be used for the projection.

SNAP 60403 showed a high correlation with relevant economic indices and emissions. However, the available and previously used forecast for the “wood, paper and printing” sector is more highly aggregated and, in turn, hardly appears suitable for projections for the sub-sector. It was therefore decided to fall back on forecasts of employment trends. The employment figures also showed a high correlation with emissions in the retrospective analysis.

Despite the existing uncertainties and obstacles related to the creation of NMVOC emission projections, the quality of the projections for the SNAP codes mentioned above has been significantly improved by Zimmermann et al. (2025). In the past, indices were often used to create projections without a clear correlation to emissions. Now, more suitable parameters have been identified and utilized wherever possible. In other instances, trend extrapolations have been made based on historical emission data. Additionally, assumptions about technological developments have been incorporated. For future projections, an equally thorough review and update of the relevant NFR sectors that were not included in the current analysis is planned to ensure comprehensive coverage. In this regard, for the entire sector of 2.D.3 consultations with industry experts will be continued and deepened. The results of Zimmermann et al. (2025) will be regularly re-evaluated using new emission data and statistics to validate or adapt the projection preparation process.

Starting from these activity data set as a basis, future emission factors for air pollutants were modelled for each of the policies and measures individually. For each measure, the relevant emissions factors were identified and the existing historic time series in the database was extended to 2025, 2030, 2035, 2040, 2045 and 2050. Then, the future activity data for those years were multiplied with the modelled emission factors to derive projected emissions. This approach allows detailed calculations of mitigations attributable to each measure.

General assumptions

The emission inventory aims to record the true emissions of all German emission sources. For emission projections the future emission sources are often not yet existing and true emissions cannot be measured already. Emission projections for power plants, for example, are therefore estimated using regulatory limit values. Because emission limit values in the 13th BImSchV and in the accompanying BAT conclusions are usually given in mg/Nm³, a conversion into kg/TJ is necessary to multiply emission factors with activity rates (fuel use). Table 4 shows an example of the conversion factors for NO_x (Rentz et al., 2002)[15] which are used to convert mg/Nm³ into kg/TJ for the regulations under consideration. For each relevant pollutant, a fuel-specific conversion factor is given, taking into account the reference oxygen content in percent.

Table 4: Fuel-specific conversion factors for air pollutants according to Rentz et al. (2002)

Pollutant	Fuel	Reference oxygen content 3 %	Reference oxygen content 6 %	Reference oxygen content 11 %	Reference oxygen content 15 %
NO_x	Hard coal		2.75		
	Lignite	2.88	2.40	1.60	
	Heavy fuel oil	3.39			
	Light heating oil	3.49			
	Natural gas	3.57			
	Natural gas (gas turbines)	3.45		1.15	1.15
	Heavy fuel oil (gas turbines)	3.53		1.18	1.18

[1] https://www.umweltbundesamt.de/publikationen/technischer-anhang-der-treibhausgas-projektionen

[2] https://www.umweltbundesamt.de/publikationen/aktualisierung-tremodtremod-mm-ermittlung-der

[3] https://iir.umweltbundesamt.de/2023/general/projections/wam-scenario

[4] https://www.hbefa.net/

[5] https://ermes-group.eu/sites/default/files/2024-12/1.2_Hausberger.pdf

[6] not yet published, (Link will be added as soon as the report is published.

[7] https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023

[8] see chapter 6 for agriculture: https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/projektionen-2025-zentrale-annahmen.pdf

[9] https://literatur.thuenen.de/digbib_extern/dn068888.pdf

[10] http://www.verwaltungsvorschriften-im-internet.de/bsvwvbund_18082021_IGI25025005.htm

[11] https://www.umweltbundesamt.de/publikationen/aktualisierung-des-deutschen-inventars-fuer-nmvoc-0

[12] not yet published (Link will be added as soon as the report is published.)

[13] https://www.prognos.com/sites/default/files/2021-01/140900_prognos_shell_studie_pkw-szenarien2040.pdf

[14] https://www.bmas.de/SharedDocs/Downloads/DE/Publikationen/Forschungsberichte/fb526-3-aktualisierte-bmas-prognose-digitalisierte-arbeitswelt.pdf?__blob=publicationFile&v=2

[15] Rentz, O., Karl, U., Peter. H. (2002): Determination and evaluation of emission factors for combustion installations in Germany for the years 1995, 2000 and 2010, on behalf of the German Environment Agency (UBA), Project-Nr.299 43 142.