Calculation documentation

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 the draft NAPCP 2023 the ‘Projektionsbericht 2021 für Deutschland’[1] published at the end of 2021 and reported according to art. 18 of regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action. Meanwhile the main reporting obligations of the National Energy and Climate Progress Report (NECPR) were submitted in August 2023 and of the draft updated National Energy and Climate Plan (NECP) in November 2023, both in line with the ‘Projektionsbericht 2023 für Deutschland’ published in August 2023, that could therefore not be reflected for the draft NAPCP 2023.

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 measures scenario (MMS) of the ‘Projektionsbericht 2021 für Deutschland’. The MMS of the 2021 projection report for Germany includes all climate protection-relevant measures and instruments adopted by August 31, 2020.

Deviating from this comprehensive projection of activity data, the transport emissions are calculated with the aid of the TREMOD model (“Transport Emission Model”, see Allekotte et al. 2020[2]). For estimating the future development of transport-related energy consumption and emissions a TREMOD trend scenario to 2050 has been developed, which is updated each year. For the draft NAPCP 2023 version 6.21 of TREMOD built the basis of the emission projections (Allekotte et al., 2023[3]). However, a few modifications seemed necessary during updating the emission projections for the draft NAPCP 2023. The traffic situations that are also included in the release of HBEFA 4.2 for Germany were not taken into account, to avoid errors in the allocation of traffic situations. Instead, former traffic situations (from HBEFA 4.1) were retained and combined with the updated emission factors (from HBEFA 4.2). In addition, based on current findings from measurements on various Euro 6/VI vehicles, the emission factors for these were updated compared to HBEFA 4.2 and abrasion emissions from electrically driven mileage were adjusted according to EMEP/EEA air pollutant emission inventory guidebook 2019[4].

The projection for the agricultural sector (NFR 3) was created by the Thünen Institute (TI) using the py-GAS-EM reporting model. The most recently published activity data projections of the Thünen Baseline 2022-2032 (2022)[5] for numbers of cattle and pigs were not used for the projections, as some of the animal population declines of the Thünen-Baseline assumed for 2032 compared to the reference period 2018 to 2020 were already achieved in 2022, for example a reduction in the number of dairy cows by 2 %. Instead, taking into account the development of the latest years, it was accepted as plausible to assume that the numbers of pigs and cattle will continue to decline by 2030. This assumption is also supported by the report “EU Agricultural Outlook for markets, income and environment 2022-2032”, published in 2023[6]. For the other animal categories, the animal numbers were taken from the Thünen baseline 2022-2032. The projection of the Thünen baseline 2022-2032 was also corrected downwards for the amount of mineral fertiliser used in 2030 and a value corresponding to the mean value of the reference period 2018 to 2020 was assumed.

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) was assumed. 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 2021. An increase in the amount of slurry in biogas plants is part of the WAM scenario. The use of energy crops in biogas plants was assumed to be declining, as described in the Thünen Baseline 2022-2032. The quantities of the Thünen baseline reported for the year 2032 are transferred to the year 2030 using linear interpolation. This corresponds to a reduction in the amount of energy crops used compared to 2020 of around 59 % based on the nitrogen contained.

With the assumptions described above, a significant reduction of ammonia emissions compared to the emissions reported for 2020 will be achieved by 2030. 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)[7], which came into force on December 1st, 2021, were evaluated. In total, this results in a buffer of 7.4 kt in the WM scenario for complying with the reduction obligation for ammonia in 2030. 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, containing emissions from solvent and solvent-containing product use and their manufacturing, are not calculated from activity rates and emission factors within the emission inventory database. For their calculation a separate model run by the Institute for Environmental Strategies (Ökopol GmbH) is used and resulting emissions are imported into the inventory database. This model also contains an emission projection based on economic projections for specific branches of industry. These economic projections were updated using Prognos (2019) “Deutschland Report 2025 | 2035 | 2045“[8]). Methodology of updating the NMVOC inventory as well as the projections is described in Zimmermann and Memelink (2023)[9]. The projection for the years 2025, 2030 and 2035 was then extrapolated for the year 2040.

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 and 2040. 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. The following documentation shows the calculation of emission projections in detail.

Data basis of the emission projections calculation is the inventory submission 2022 with the processing of the emission data. The calculations of the emission values are based on the NEC directive EU 2016/2284 as well as the German regulations for the implementation of the Federal Immission Control Act (BImSchV), which define plant-specific limit values.

Because the limit values in the BImSchVs and in the BAT conclusions are usually given in mg/Nm^3, a conversion into kg/TJ is necessary. Table 1 shows an example of the conversion factors for NO_x (Rentz et al., 2002)[10] which are used to convert mg/Nm^3 into kg/TJ for the reduction measures under consideration. For each relevant pollutant, a fuel-specific conversion factor is given, taking into account the reference oxygen content in percent.

Table 1: 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

Furthermore, the calculations of the emission factors for particulate matter ($PM_{2.5}$ and PM_{10}) as well as for Black Carbon (BC) usually result as shares from the TSP emission factors. In most cases a constant ratio between TSP and $PM_{2.5}$, PM_{10} or BC is assumed for the years 2025 to 2040 as in the reference year from the 2022 submission. This may lead to a slight underestimation of PM or BC mass, if measures to reduce TSP emissions are reducing coarse particles more than smaller particles, especially ultrafine particles, that would be more relevant looking on particle number.

1) https://dip.bundestag.de/vorgang/projektionsbericht-2021-f%C3%BCr-deutschland/282715

2) https://www.umweltbundesamt.de/en/publikationen/aktualisierung-tremod-2019

3) https://www.umweltbundesamt.de/publikationen/bewertung-von-emissionsminderungspotenzialen

4) https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-vi/at_download/file

5) https://www.thuenen.de/media/publikationen/thuenen-report/Thuenen_Report_100.pdf

6) https://agriculture.ec.europa.eu/document/download/1492c9fa-7336-4542-8d3b-04443d4ac0ab_en?filename=agricultural-outlook-2022-report_en.pdf

7) http://www.verwaltungsvorschriften-im-internet.de/bsvwvbund_18082021_IGI25025005.htm

8) Prognos Deutschland Report 2025 | 2035 | 2045 (2019

9) https://www.umweltbundesamt.de/publikationen/aktualisierung-des-deutschen-inventars-fuer-nmvoc-0

10) 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.