# 1.A.3.b iii - Transport: Road Transport: Heavy Duty Vehicles and Buses

## Short description

In sub-category *1.A.3.b iii - Road Transport: Heavy Duty Vehicles and Buses* emissions from fuel combustion in trucks, lorries, buses etc. are reported.

| **Category Code** | **Method** | | | | | **AD** | | | | | **EF** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.3.b iii | T1, T3 | | | | | NS, M | | | | | CS, M, D | | | | |
| | **$NO_x$** | **NMVOC** | **$SO_2$** | **$NH_3$** | **$PM_{2.5}$** | **$PM_{10}$** | **TSP** | **BC** | **CO** | **PB** | **Cd** | **Hg** | **Diox** | **PAH** | **HCB** |
| Key Category: | L/T | -/- | -/- | -/- | L/T | L/T | -/- | L/T | -/- | -/- | -/- | -/- | -/- | -/- | - |

**T** = key source by Trend **L** = key source by Level

| **Methods** | |
|---|---|
| **D** | Default |
| **T1** | Tier 1 / Simple Methodology * |
| **T2** | Tier 2* |
| **T3** | Tier 3 / Detailed Methodology * |
| **C** | CORINAIR |
| **CS** | Country Specific |
| **M** | Model |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in the group specific chapters. | |

| **AD - Data Source for Activity Data** | |
|---|---|
| **NS** | National Statistics |
| **RS** | Regional Statistics |
| **IS** | International Statistics |
| **PS** | Plant Specific data |
| **As** | Associations, business organisations |
| **Q** | specific Questionnaires (or surveys) |
| **M** | Model / Modelled |
| **C** | Confidential |

| **EF - Emission Factors** | |
|---|---|
| **D** | Default (EMEP Guidebook) |
| **C** | Confidential |
| **CS** | Country Specific |
| **PS** | Plant Specific data |
| **M** | Model / Modelled |

## Methodology

### Activity data

Specific consumption data for heavy-duty vehicles (trucks and lorries) and buses are generated within TREMOD [1]. - The following tables provide an overview of annual amounts of fuels consumed by these vehicles in Germany.

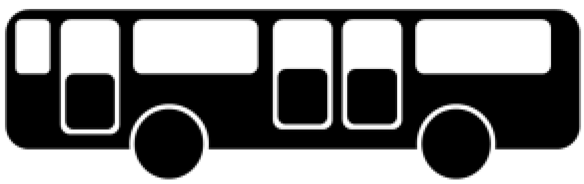


Table 1: Annual fuel consumption of trucks and lorries, in terajoules

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **thereof: Buses** | | | | | | | | | | | | | | | | |
| **Diesel oil** | 54,449 | 46,071 | 46,040 | 37,582 | 43,949 | 43,549 | 46,516 | 47,685 | 44,800 | 47,766 | 49,068 | 47,777 | 45,841 | 47,939 | 31,448 | 29,736 |
| **Biodiesel** | | 72 | 510 | 2,511 | 3,369 | 3,039 | 3,283 | 2,828 | 2,753 | 2,613 | 2,601 | 2,551 | 2,665 | 2,730 | 2,612 | 2,066 |
| **CNG** | | | | 1,147 | 2,141 | 1,962 | 2,152 | 1,737 | 1,667 | 1,576 | 1,213 | 1,155 | 956 | 1,004 | 983 | 983 |
| **Biogas** | | | | | | | 307 | 344 | 420 | 266 | 285 | 319 | 257 | 408 | 529 | 470 |
| **Petroleum** | | 610 | 414 | | | | | | | | | | | | | |
| **Σ Buses** | **54,449** | **46,143** | **46,550** | **41,240** | **49,459** | **48,550** | **52,258** | **52,594** | **49,640** | **52,221** | **53,167** | **51,802** | **49,720** | **52,082** | **35,572** | **33,255** |
| **thereof: Trucks & Lorries** | | | | | | | | | | | | | | | | |
| **Diesel oil** | 382,330 | 507,334 | 590,322 | 455,044 | 509,974 | 510,920 | 535,523 | 550,889 | 523,710 | 543,429 | 549,899 | 555,099 | 542,086 | 552,663 | 535,871 | 523,678 |
| **Biodiesel** | | 792 | 6,540 | 30,409 | 39,098 | 35,648 | 37,795 | 32,670 | 32,182 | 29,726 | 29,153 | 29,634 | 31,511 | 31,478 | 44,513 | 36,381 |
| **CNG** | | | | | | | 393 | 336 | 320 | 272 | 190 | 182 | 164 | 206 | 276 | 444 |
| **Biogas** | | | | | | | 56,2 | 66,6 | 80,5 | 45,8 | 44,7 | 50 | 44 | 84 | 148 | 212 |
| **LNG** | | | | | | | 36,1 | 41,1 | 46,7 | 52,2 | 63,0 | 104 | 192 | 830 | 2.511 | 5.045 |
| **Σ Trucks & Lorries** | **382,330** | **508,125** | **596,862** | **485,453** | **549,072** | **546,569** | **573,767** | **583,962** | **556,292** | **573,472** | **579,287** | **584,964** | **573,805** | **584,432** | **580,807** | **560,715** |
| **HDVs over-all** | | | | | | | | | | | | | | | | |
| **Diesel oil** | 436,779 | 553,405 | 636,362 | 492,626 | 553,922 | 554,469 | 582,039 | 598,574 | 568,510 | 591,195 | 598,967 | 602,876 | 587,927 | 600,602 | 567,318 | 553,414 |
| **Biodiesel** | | 863 | 7,050 | 32,920 | 42,467 | 38,687 | 41,078 | 35,498 | 34,935 | 32,339 | 31,754 | 32,184 | 34,175 | 34,209 | 47,125 | 38,446 |
| **CNG** | | | | 1,147 | 2,141 | 1,962 | 2,545 | 2,074 | 1,986 | 1,848 | 1,403 | 1,337 | 1,120 | 1,211 | 1,259 | 1,428 |
| **Biogas** | | | | | | | 364 | 410 | 501 | 312 | 330 | 369 | 301 | 492 | 677 | 682 |
| **Petroleum** | | 610 | 414 | | | | | | | | | | | | | |
| **LNG** | | | | | | | 36,1 | 41,1 | 46,7 | 52,2 | 63,0 | 104 | 192 | 830 | 2.511 | 5.045 |
| **Σ 1.A.3.b iii** | **436,779** | **554,878** | **643,825** | **526,693** | **598,531** | **595,118** | **626,061** | **636,598** | **605,979** | **625,745** | **632,517** | **636,870** | **623,716** | **637,344** | **618,890** | **599,016** |

source: TREMOD [2]

For information on mileage, please refer to sub-chapters on emissions from tyre & brake wear and road abrasion.

## Emission factors

The majority of emission factors for exhaust emissions from road transport are taken from the 'Handbook Emission Factors for Road Transport' (HBEFA, version 4.1) [3] where they are provided on a tier3 level mostly and processed within the TREMOD software used by the party [4].

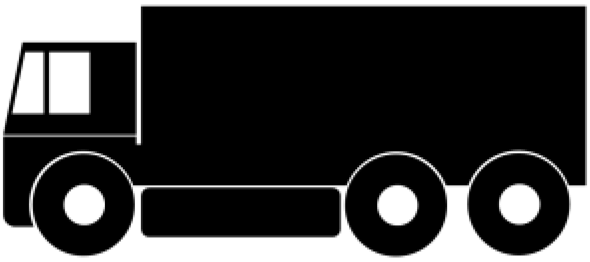
However, it is not possible to present these tier3 values in a comprehendible way here.

With respect to the country-specific emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. [1]

For heavy-metal (other then lead from leaded gasoline) and PAH exhaust-emissions, default emission factors from the 2019 EMEP Guidebook (EMEP/EEA, 2019) [5] have been applied. Regarding PCDD/F, tier1 EF from (Rentz et al., 2008) [6] are used instead.

Table 2: tier1 EF derived from default values

| | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | B[a]P | B[b]F | B[k]F | I[...]P | PAH 1-4 | PCDD/F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | [g/TJ] | | | | | | | | | [mg/TJ] | | | | | [µg/km] |
| **Diesel oil** | 0.012 | 0.001 | 0.123 | 0.002 | 0.198 | 0.133 | 0.005 | 0.002 | 0.419 | 498 | 521 | 275 | 493 | 1,788 | |
| **Biodiesel** | 0.013 | 0.001 | 0.142 | 0.003 | 0.228 | 0.153 | 0.005 | 0.003 | 0.483 | 575 | 601 | 317 | 569 | 2,062 | |
| **CNG & Biogas** | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | |
| **Petroleum** | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | |
| **all fuels: buses** | | | | | | | | | | | | | | | 0.000019 |
| **all fuels: trucks & lorries** | | | | | | | | | | | | | | | 0.000016 |



## Discussion of emission trends

Table 3: Outcome of Key Category Analysis

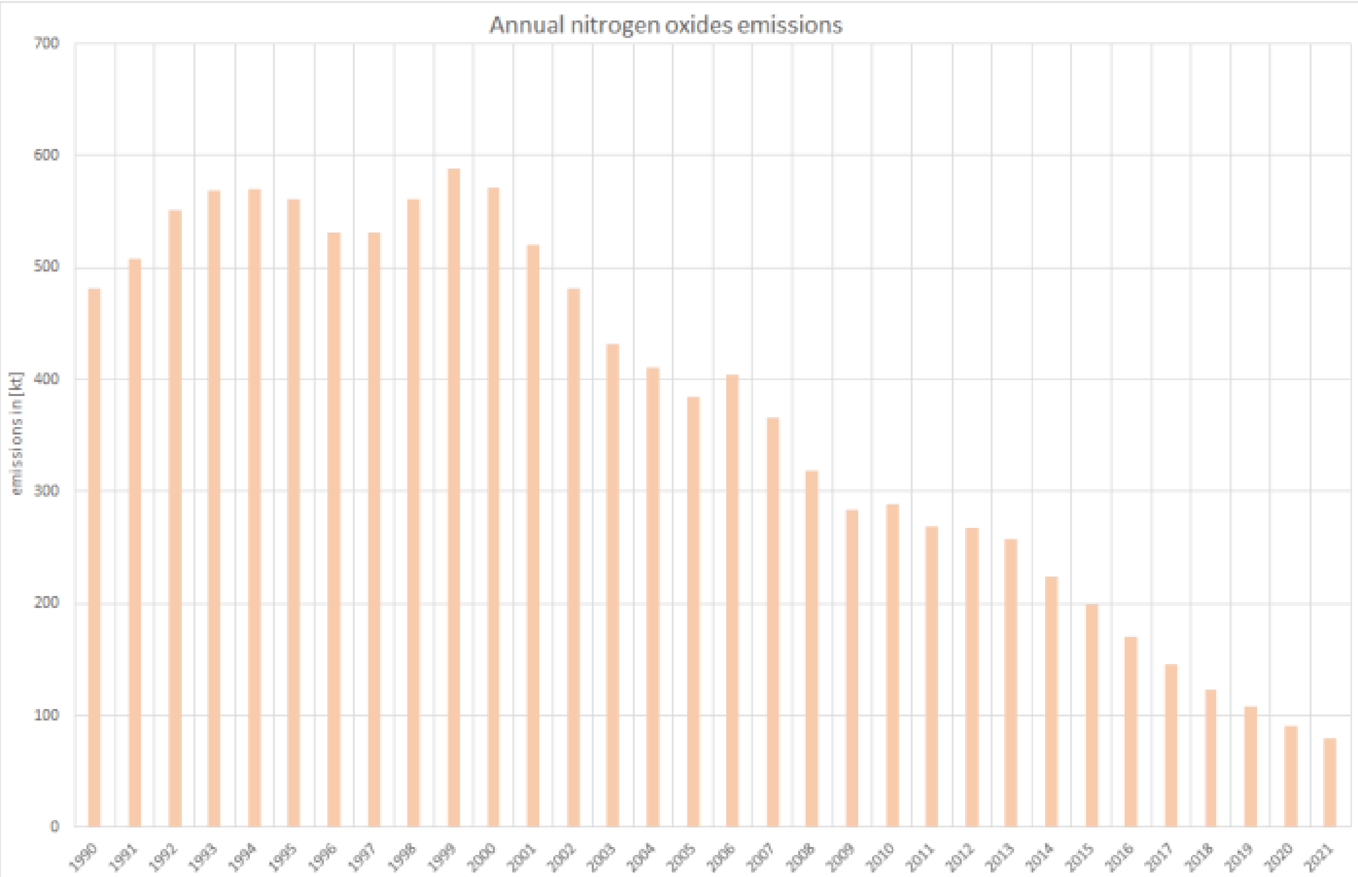
| for: | **$NO_x$** | **BC** | **$PM_{10}$** | **$PM_{2.5}$** |
|---|---|---|---|---|
| by: | L/T | L/T | L/T | L/T |

### Nitrogen oxides

Until 2005, $NO_x$ emissions followed mileage and fuel consumption. Since 2006, in contrast to nearly unchanged fuel consumption, emissions have decreased due to controlled catalytic-converter use and engine improvements resulting from continual tightening of emissions laws.

Table 4: EURO norms and their effect on limit values of $NO_x$ emissions from passenger cars, in [mg/km]

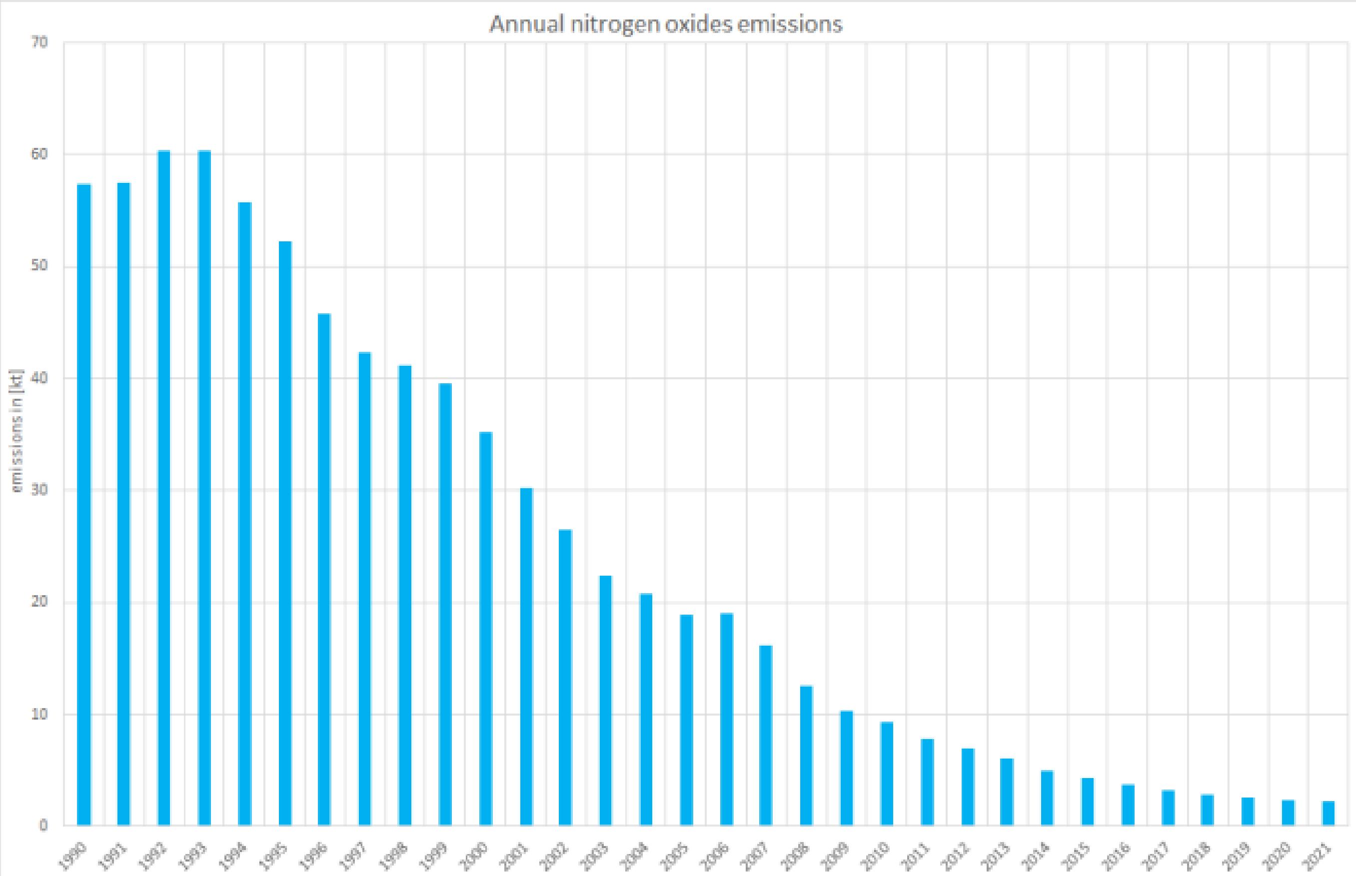
| exhaust emission standard (EURO norm) | **Euro I** | **Euro II** | **Euro III** | **Euro IV** | **Euro V** | **Euro 6a/b** | **Euro 6c** | **Euro 6d** |
|---|---|---|---|---|---|---|---|---|
| **Diesel** | - | - | 500 | 250 | 180 | 80 | | |

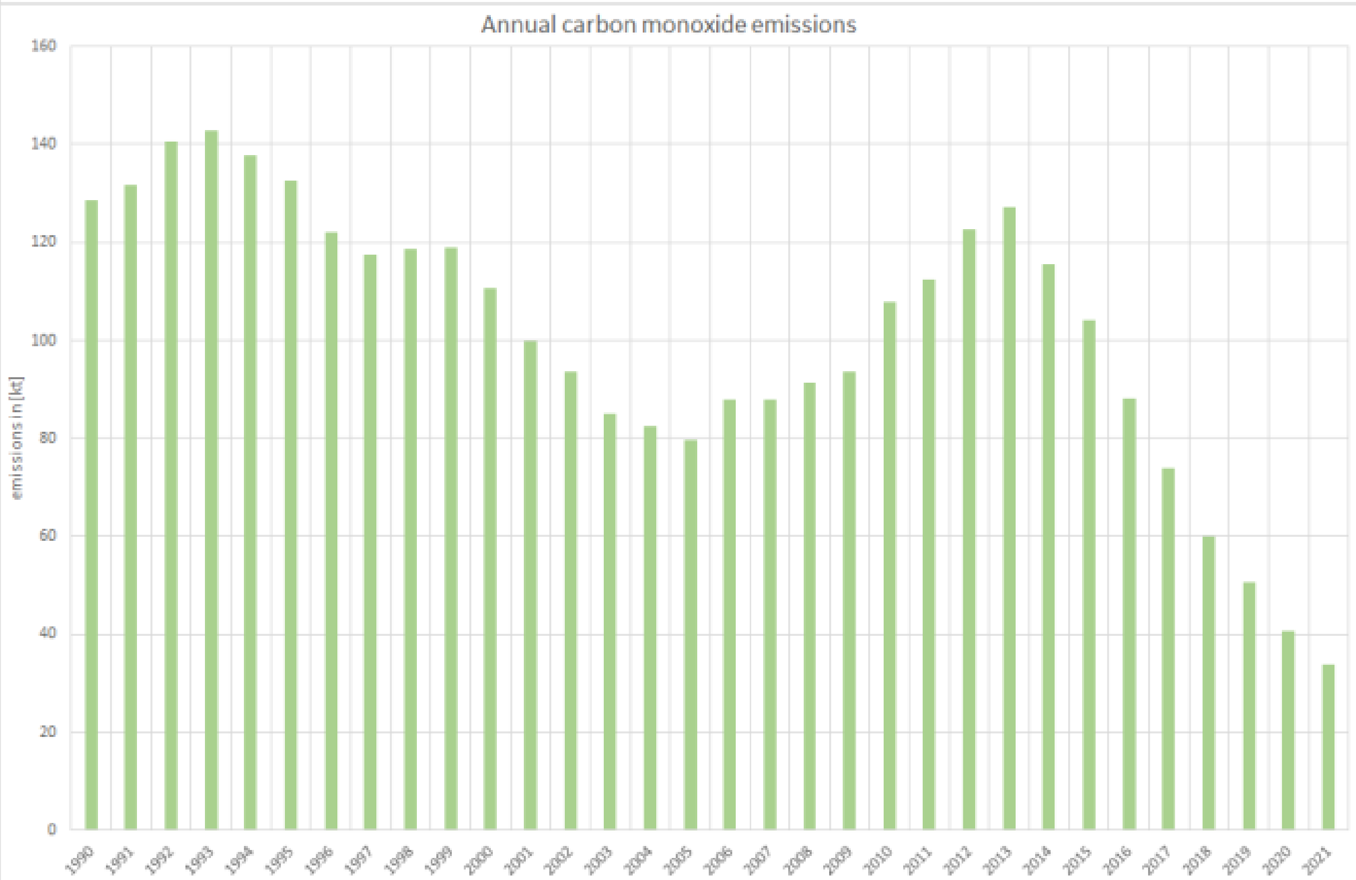



}}

## Non-methane volatile organic compounds (NMVOC) and carbon monoxide

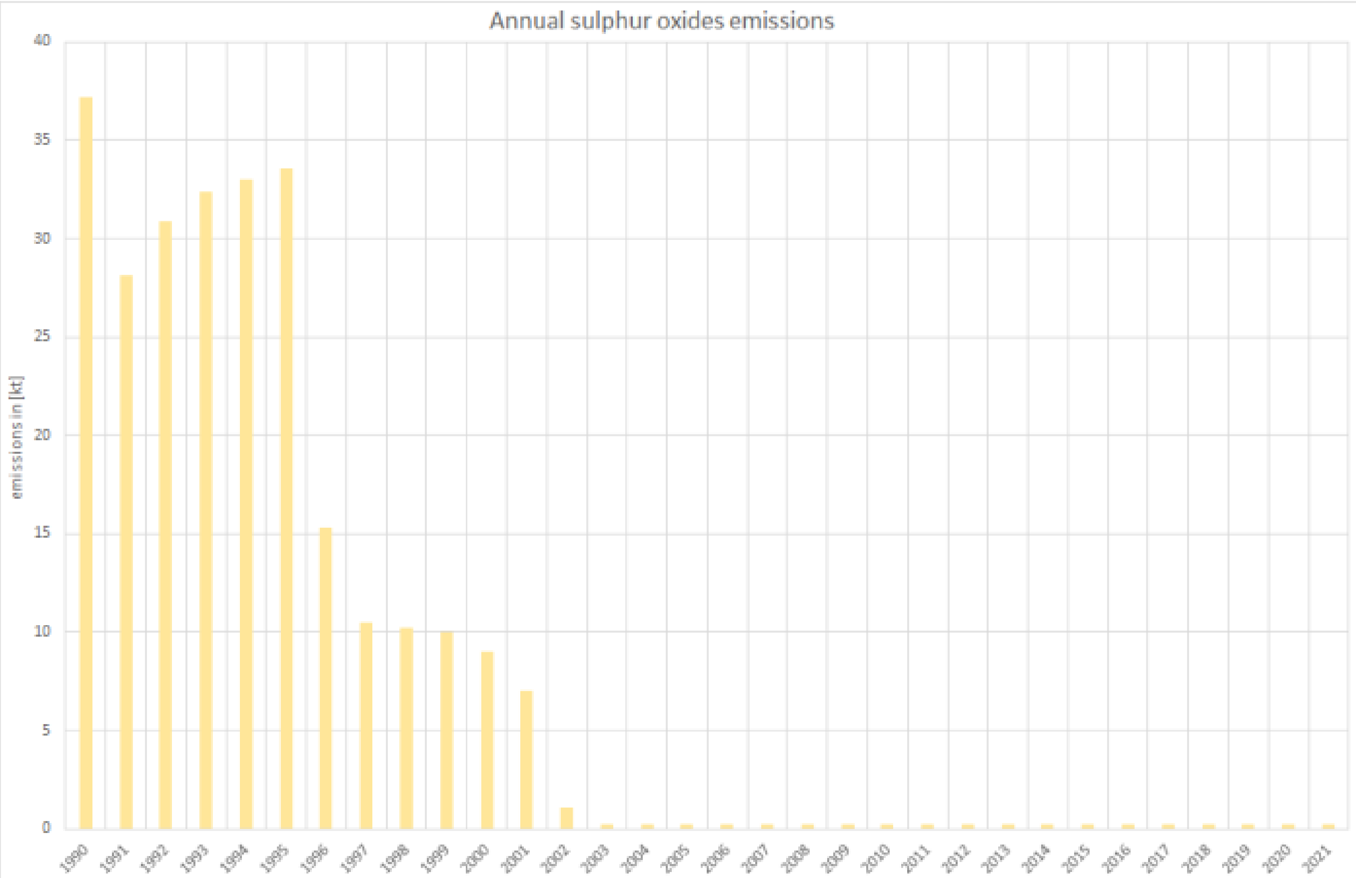
Since 1990, exhaust emissions of **NMVOC** and **carbon monoxide** have decreased sharply due to catalytic-converter use and engine improvements resulting from ongoing tightening of emissions laws and improved fuel quality.



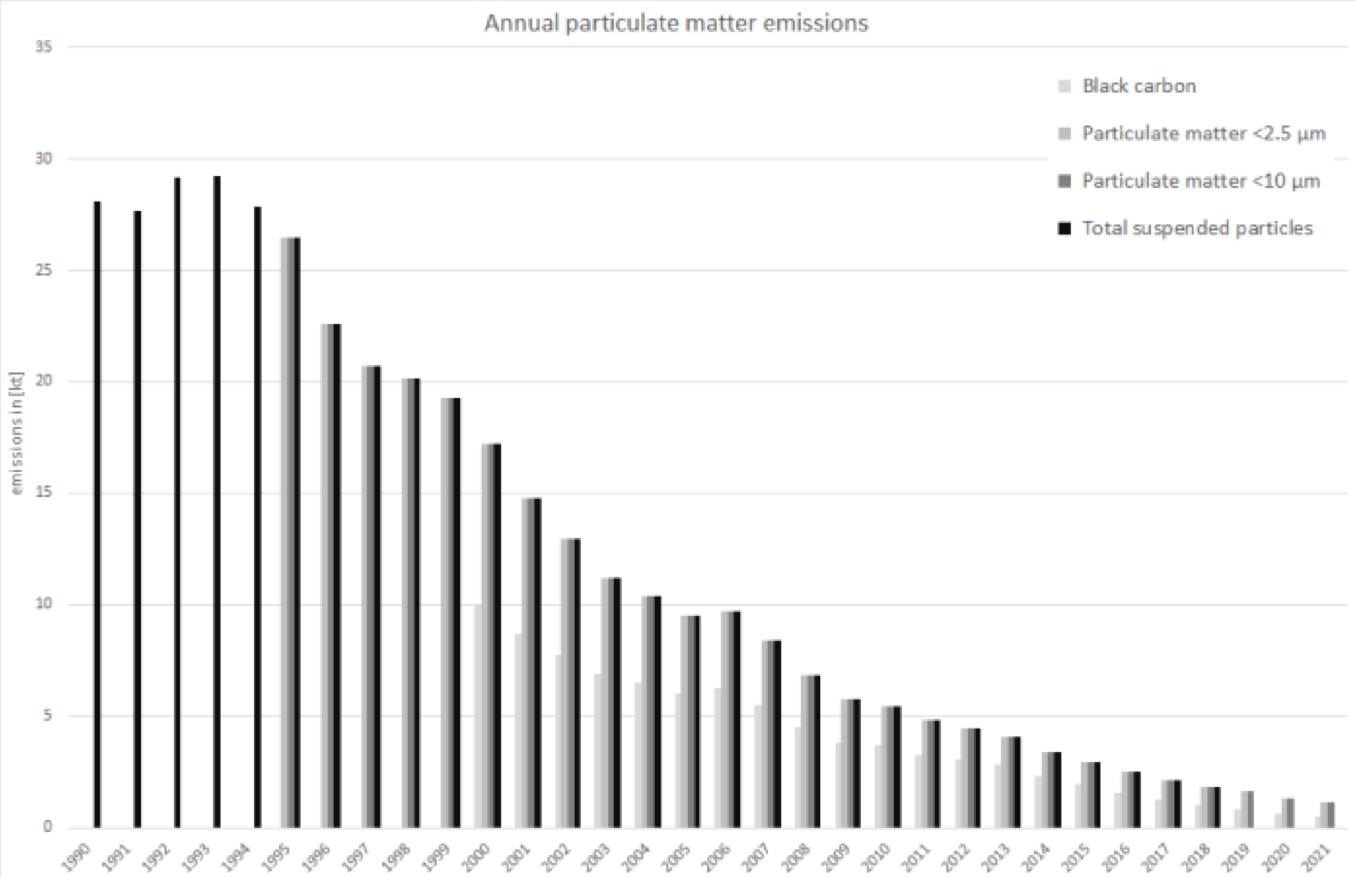
## Ammonia and sulphur dioxide

As for the entire road transport sector, the trends for **sulphur dioxide** ($SO_2$) and **ammonia** ($NH_3$) exhaust emissions from heavy duty vehicles show charcteristics different from those shown above: Here, the strong dependence on increasing fuel qualities (sulphur content) leads to an cascaded downward trend of $SO_2$ emissions , influenced only slightly by increases in fuel consumption and mileage. For **ammonia** emissions the increasing use of catalytic converters in gasoline driven cars in the 1990s lead to a steep increase whereas both the technical development of the converters and the ongoing shift from gasoline to diesel cars resulted in decreasing emissions in the following years.




## Particulate matter & Black carbon

As for all reported exhaust PM emissions from mobile diesel vehicles the Party assumes that nearly all particles emitted are within the $PM_{2.5}$ range, resulting in similar emission values for $PM_{2.5}$, $PM_{10}$, and TSP.




# Recalculations

Compared to submission 2022, recalculations were carried out due to a routine revision of the TREMOD software and the revision of several National Energy Balances (NEB).

Here, **activity data** were revised within TREMOD due to the provision of the final NEB 2020.

Furthermore, significant re-allocations of consumption shares between the different vehicle types and classes were conducted, effecting the entire time series but with the 1.A.3.b consumptipon totals remaining unaltered.

Table 4: Revised fuel consumption data, in terajoules

| | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DIESEL OIL** | | | | | | | | | | | | | | | | | | |
| **Submission 2022** | 459.124 | 590.259 | 680.299 | 526.071 | 547.742 | 529.429 | 535.158 | 525.222 | 571.016 | 571.405 | 598.290 | 615.392 | 585.865 | 608.497 | 615.976 | 619.134 | 602.053 | 612.992 |
| **Submission 2021** | 459.124 | 590.259 | 680.299 | 526.071 | 547.742 | 529.429 | 535.158 | 525.220 | 571.008 | 571.389 | 598.264 | 615.361 | 585.893 | 608.417 | 615.537 | 618.619 | 601.836 | 613.898 |
| **absolute change** | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 2,07 | 8,16 | 16,2 | 26,4 | 30,7 | -28,5 | 79,2 | 439 | 515 | 217 | -906 |
| **relative change** | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,01% | 0,07% | 0,08% | 0,04% | -0,15% |
| **BIODIESEL** | | | | | | | | | | | | | | | | | | |
| **Submission 2022** | | 921 | 7.537 | 35.155 | 66.042 | 70.833 | 53.317 | 42.432 | 43.778 | 39.869 | 42.225 | 36.496 | 36.002 | 33.285 | 32.656 | 33.052 | 34.996 | 34.915 |
| **Submission 2021** | | 921 | 7.537 | 35.155 | 66.042 | 70.833 | 53.317 | 42.432 | 43.777 | 39.867 | 42.223 | 36.494 | 36.004 | 33.281 | 32.633 | 33.025 | 34.984 | 34.954 |
| **absolute change** | | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,17 | 0,63 | 1,13 | 1,86 | 1,82 | -1,75 | 4,33 | 23,3 | 27,5 | 12,6 | -39,5 |
| **relative change** | | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,01% | 0,07% | 0,08% | 0,04% | -0,11% |
| **CNG** | | | | | | | | | | | | | | | | | | |
| **Submission 2022** | | | | 1.183 | 1.682 | 1.965 | 2.072 | 2.255 | 2.200 | 2.011 | 2.552 | 2.058 | 1.979 | 1.866 | 1.407 | 1.337 | 1.125 | 1.226 |
| **Submission 2021** | | | | 1.183 | 1.682 | 1.965 | 2.072 | 2.255 | 2.200 | 2.011 | 2.552 | 2.057 | 1.967 | 1.846 | 1.390 | 1.173 | 1.104 | 1.060 |
| **absolute change** | | | | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,02 | 1,10 | 12,0 | 20,3 | 17,1 | 165 | 21,4 | 166 |
| **relative change** | | | | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,05% | 0,61% | 1,10% | 1,23% | 14,04% | 1,94% | 15,7% |
| **BIOGAS** | | | | | | | | | | | | | | | | | | |

| | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Submission 2022** | | | | | | | | | | | 365 | 407 | 499 | 315 | 331 | 370 | 303 | 498 |
| **Submission 2021** | | | | | | | | | | | 365 | 407 | 496 | 311 | 327 | 365 | 297 | 485 |
| **absolute change** | | | | | | | | | | | 0,00 | 0,22 | 3,03 | 3,43 | 4,03 | 4,98 | 5,77 | 13,7 |
| **relative change** | | | | | | | | | | | 0,00% | 0,05% | 0,61% | 1,10% | 1,23% | 1,37% | 1,94% | 2,83% |
| **PETROLEUM** | | | | | | | | | | | | | | | | | | |
| **Submission 2022** | | 610 | 414 | | | | | | | | | | | | | | | |
| **Submission 2021** | | 610 | 414 | | | | | | | | | | | | | | | |
| **absolute change** | | 0,00 | 0,00 | | | | | | | | | | | | | | | |
| **relative change** | | 0,00% | 0,00% | | | | | | | | | | | | | | | |
| **TOTAL FUEL CONSUMPTION** | | | | | | | | | | | | | | | | | | |
| **Submission 2022** | 459.124 | 591.789 | 688.249 | 562.409 | 615.465 | 602.227 | 590.547 | 569.908 | 616.994 | 613.284 | 643.541 | 654.470 | 624.469 | 644.101 | 650.529 | 654.098 | 638.776 | 650.539 |
| **Submission 2021** | 459.124 | 591.789 | 688.249 | 562.409 | 615.465 | 602.227 | 590.547 | 569.906 | 616.985 | 613.267 | 643.403 | 654.319 | 624.360 | 643.855 | 649.887 | 653.181 | 638.221 | 650.396 |
| **absolute change** | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 2,24 | 8,79 | 17,4 | 138 | 151 | 110 | 245 | 642 | 916 | 556 | 143 |
| **relative change** | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,02% | 0,02% | 0,02% | 0,04% | 0,10% | 0,14% | 0,09% | 0,02% |

Due to the variety of highly specific tier3 **emission factors** applied, it is not possible to display any changes in these data sets in a comprehendible way.

For **pollutant-specific information on recalculated emission estimates for Base Year and 2020**, please see the recalculation tables following chapter 8.1 - Recalculations.

## Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

## FAQs

[1], [2], [4] Knörr et al. (2021a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg & Berlin, 2021.
[3] Keller et al. (2017): Keller, M., Hausberger, S., Matzer, C., Wüthrich, P., & Notter, B.: Handbook Emission Factors for Road Transport, version 4.1 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.1) URL: http://www.hbefa.net/e/index.html - Dokumentation, Bern, 2017.
[5] EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook 2019; https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/view; Copenhagen, 2019.
[6] Rentz et al., 2008: Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte | 01/2008, January 2008 - URL: http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer

[1]

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dillution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.