# 1.A.3.b iv - Road Transport: Mopeds & Motorcycles

## Short description

In sub-categories *1.A.3.b iv - Road Transport: Mopeds & Motorcycles* emissions from fuel combustion in motorised two-wheelers are reported.

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

## Methodology

### Activity data

Specific consumption data for mopeds and motorcycles is generated within the TREMOD model (Knörr, 2020a) [1].

The following table provides an overview of annual amounts of gasoline fuels consumed by motorized two-wheelers in Germany.

Table 1: Annual fuel consumption of mopeds and motorcycles, in terajoules

| | **1990** | **1995** | **2000** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MOPEDS** | | | | | | | | | | | | | | | | | | |
| **Gasoline** | 4.953 | 3.102 | 3.133 | 3.056 | 3.021 | 3.169 | 3.240 | 3.517 | 3.298 | 3.235 | 3.067 | 3.152 | 3.157 | 3.176 | 3.191 | 3.190 | 3.136 | 3.195 |
| **Biogasoline** | 0 | 0 | 0 | 21 | 44 | 43 | 62 | 100 | 127 | 133 | 136 | 135 | 137 | 138 | 139 | 134 | 141 | 138 |
| **Σ Mopeds** | **4.953** | **3.102** | **3.133** | **3.077** | **3.065** | **3.212** | **3.302** | **3.617** | **3.426** | **3.368** | **3.203** | **3.287** | **3.294** | **3.313** | **3.330** | **3.324** | **3.278** | **3.333** |
| **MOTORCYCLES** | | | | | | | | | | | | | | | | | | |
| **Gasoline** | 16.747 | 16.206 | 20.514 | 19.740 | 18.888 | 18.352 | 17.563 | 16.613 | 15.680 | 15.294 | 14.426 | 14.327 | 14.738 | 14.516 | 14.812 | 15.195 | 14.565 | 14.780 |
| **Biogasoline** | 0 | 0 | 0 | 21 | 44 | 43 | 62 | 100 | 127 | 133 | 136 | 135 | 137 | 138 | 139 | 134 | 141 | 138 |
| **Σ Motorcycles** | **16.747** | **16.206** | **20.514** | **19.761** | **18.932** | **18.395** | **17.625** | **16.714** | **15.807** | **15.427** | **14.561** | **14.463** | **14.875** | **14.654** | **14.950** | **15.330** | **14.706** | **14.917** |
| **MOTORIZED 2-WHEELERS: Mopeds & Motorcycles** | | | | | | | | | | | | | | | | | | |
| **Gasoline** | 21.700 | 19.308 | 23.648 | 22.796 | 21.909 | 21.521 | 20.803 | 20.130 | 18.978 | 18.530 | 17.492 | 17.480 | 17.894 | 17.691 | 18.003 | 18.385 | 17.702 | 17.974 |
| **Biogasoline** | 0 | 0 | 0 | 157 | 316 | 291 | 398 | 575 | 733 | 760 | 775 | 749 | 778 | 767 | 782 | 775 | 796 | 775 |
| **Σ 1.A.3.b iv** | **21.700** | **19.308** | **23.648** | **22.953** | **22.225** | **21.812** | **21.201** | **20.705** | **19.712** | **19.289** | **18.268** | **18.229** | **18.673** | **18.459** | **18.785** | **19.160** | **18.497** | **18.750** |

source: TREMOD 6.02 [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 TREMOD [4)].

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

[!– the following table provides a set of fuel-specific implied emission factors (ratio of total emissions per pollutant and total annual consumption.

Table 2: Annual country-specific implied emission factors[1], in kg/TJ

| | **1990** | **1995** | **2000** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $NH_3$ | 1.21 | 1.25 | 1.30 | 1.33 | 1.34 | 1.33 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | 1.34 | | |
| NMVOC[2] | 2,415 | 1,636 | 1,456 | 1,322 | 1,303 | 1,315 | 1,287 | 1,252 | 1,200 | 1,163 | 1,134 | 1,086 | 1,045 | 1,003 | 983 | 954 | | |
| $NO_x$ | 183 | 198 | 186 | 175 | 171 | 179 | 173 | 167 | 163 | 159 | 155 | 151 | 148 | 146 | 143 | 140 | | |
| $SO_2$ | 15.11 | 8.36 | 3.25 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | | |
| CO | 12,126 | 12,427 | 11,872 | 10,595 | 10,045 | 9,817 | 9,436 | 9,036 | 8,693 | 8,352 | 8,028 | 7,695 | 7,369 | 7,066 | 6,766 | 6,488 | | |
| $PM_{2.5}$ | NA | 63.7 | 42.7 | 39.9 | 38.8 | 40.0 | 38.1 | 36.3 | 34.2 | 33.0 | 32.3 | 30.7 | 29.3 | 27.8 | 27.0 | 25.4 | | |
| $PM_{10}$ | NA | 63.7 | 42.7 | 39.9 | 38.8 | 40.0 | 38.1 | 36.3 | 34.2 | 33.0 | 32.3 | 30.7 | 29.3 | 27.8 | 27.0 | 25.4 | | |
| TSP[3] | 71.0 | 64.5 | 42.7 | 39.9 | 38.8 | 40.0 | 38.1 | 36.3 | 34.2 | 33.0 | 32.3 | 30.7 | 29.3 | 27.8 | 27.0 | 25.4 | | |
| BC | NA | NA | 4.98 | 4.75 | 4.60 | 4.71 | 4.54 | 4.36 | 4.16 | 4.05 | 3.96 | 3.81 | 3.67 | 3.53 | 3.45 | 3.30 | | |

[1] due to lack of better information: similar EF are applied for fossil and biofuels
[2] from fuel combustion only!
[3] from 1990 to 1997: also including additional dust from leaded gasoline

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> 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 3: Overview of applied EMEP/EEA defaults and other tier1 EF

| As | Cd | Cr | Cu | Hg | Ni | Pb | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[...]P | PAH 1-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [g/TJ] | | | | | | | | | [µg/km] | [mg/TJ] | | | | |
| 0.007 | 0.005 | 0.145 | 0.103 | 0.200 | 0.053 | 0.037 | 0.005 | 0.758 | 0.0000027 | 192.91 | 215.88 | 156.17 | 234.25 | 799.21 |

# Discussion of emission trends

**NFR 1.A.3.b iv** is no key category.

## Carbon monoxide

## Non-methane volatile organic compounds

Since 1990, exhaust emissions of NMVOC have decreased due to technical improvements.

## Nitrogen oxides

## Sulphur dioxide

As for the entire road transport sector, the trends for **sulphur dioxide** exhaust emissions from two-wheelers shows charcteristics very 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.

## Particulate matter & Black carbon

Particle emissions result from the comusbtion of gasoline and bioethanol. Here, due to the assumption that nearly all TSP emitted is formed by particles in the PM,,2.5,, range, similar estimates are provided for all three fractions. (Exception: Until 1997, additional TSP emissions from use of leaded gasoline are included.)

# Recalculations

Compared to submission 2020, 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.

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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GASOLINE** | | | | | | | | | | | | | | | | | |
| **Submission 2020** | 23,131 | 19,972 | 24,124 | 23,030 | 21,811 | 21,678 | 20,902 | 20,202 | 19,039 | 18,591 | 17,555 | 17,548 | 17,996 | 17,777 | 18,080 | 18,456 | |
| **Submission 2019** | 22,049 | 16,628 | 19,184 | 20,151 | 20,306 | 17,167 | 17,492 | 17,657 | 17,384 | 18,033 | 17,840 | 18,540 | 19,289 | 18,641 | 18,609 | 18,809 | |
| **absolute change** | 1,082 | 3,344 | 4,940 | 2,878 | 1,505 | 4,511 | 3,410 | 2,544 | 1,655 | 558 | -285 | -992 | -1,293 | -863 | -529 | -352 | |
| **relative change** | 4,91% | 20,1% | 25,8% | 14,3% | 7,41% | 26,3% | 19,5% | 14,4% | 9,52% | 3,09% | -1,60% | -5,35% | -6,71% | -4,63% | -2,84% | -1,87% | |
| **BIOGASOLINE** | | | | | | | | | | | | | | | | | |
| **Submission 2020** | 0 | 0 | 0 | 158 | 314 | 293 | 400 | 577 | 736 | 762 | 778 | 752 | 783 | 771 | 785 | 778 | |
| **Submission 2019** | 0 | 0 | 0 | 138 | 293 | 232 | 334 | 504 | 672 | 739 | 791 | 795 | 839 | 808 | 808 | 801 | |
| **absolute change** | 0 | 0 | 0 | 20 | 22 | 61 | 65 | 73 | 64 | 23 | -13 | -43 | -56 | -37 | -23 | -23 | |
| **relative change** | 0.00 | 0.00 | 0.00 | 14,3% | 7,41% | 26,3% | 19,5% | 14,4% | 9,52% | 3,09% | -1,60% | -5,35% | -6,71% | -4,63% | -2,84% | -2,82% | |
| **TOTAL FUEL CONSUMPTION** | | | | | | | | | | | | | | | | | |
| **Submission 2020** | 23,131 | 19,972 | 24,124 | 23,188 | 22,125 | 21,971 | 21,302 | 20,779 | 19,775 | 19,354 | 18,336 | 18,304 | 18,783 | 18,554 | 18,871 | 19,242 | |
| **Submission 2019** | 22,049 | 16,628 | 19,184 | 20,290 | 20,598 | 17,399 | 17,827 | 18,162 | 18,056 | 18,773 | 18,631 | 19,335 | 20,128 | 19,449 | 19,417 | 19,609 | |
| **absolute change** | 1,082 | 3,344 | 4,940 | 2,898 | 1,527 | 4,572 | 3,475 | 2,617 | 1,719 | 581 | -295 | -1,030 | -1,345 | -895 | -545 | -368 | |
| **relative change** | 4.91% | 20.1% | 25.8% | 14.3% | 7.41% | 26.3% | 19.5% | 14.4% | 9.52% | 3.09% | -1.58% | -5.33% | -6.68% | -4.60% | -2.81% | -1.88% | |

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

For more information on recalculated emission estimates reported for Base Year and 2018, please see the pollutant-specific recalculation tables following chapter 8.1 - Recalculations.

# Planned improvements

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

# FAQs

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[1), 2), 4)] Knörr et al. (2020a): 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, 2020.

[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.