

# 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 <sub>2</sub> | NO <sub>x</sub> | NH <sub>3</sub> | NM VOC | CO  | BC    | Pb  | Hg  | Cd  | Diox | PAH      | HCB | TSP | PM <sub>10</sub> | PM <sub>2.5</sub> |
| 1.A.3.b iv    | -/-             | -/-             | -/-             | -/-    | -/- | -/-   | -/- | -/- | -/- | -/-  | -/-      | -   | -/- | -/-              | -/-               |

## Methodology

### Activity data

Specific consumption data for mopeds and motorcycles is generated within the TREMOD model (Knörr, 2020a) <sup>1)</sup>.



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 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|-------------------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <b>MOPEDS</b>                                         |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Gasoline                                              |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Biogasoline                                           |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>Σ Mopeds</b>                                       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>MOTORCYCLES</b>                                    |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Gasoline                                              |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Biogasoline                                           |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>Σ Motorcycles</b>                                  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>MOTORIZED 2-WHEELERS: Mopeds &amp; Motorcycles</b> |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Gasoline                                              |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Biogasoline                                           |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>Σ 1.A.3.b iv</b>                                   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

source: TREMOD 6.02 <sup>2)</sup>





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) <sup>3)</sup> where they are provided on a tier3 level mostly and processed within TREMOD <sup>4)</sup>.

However, it is not possible to present these highly specific tier3 values in a comprehensible 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<sup>1</sup>, in kg/TJ

|                     | 1990   | 1995   | 2000   | 2005   | 2006   | 2007  | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018 | 2019 |
|---------------------|--------|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|
| NH <sub>3</sub>     | 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  |      |      |
| NM VOC <sup>2</sup> | 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 <sub>x</sub>     | 183    | 198    | 186    | 175    | 171    | 179   | 173   | 167   | 163   | 159   | 155   | 151   | 148   | 146   | 143   | 140   |      |      |
| SO <sub>2</sub>     | 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 <sub>2.5</sub>   | 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 <sub>10</sub>    | 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 <sup>3</sup>    | 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  |      |      |

<sup>1</sup> due to lack of better information: similar EF are applied for fossil and biofuels

<sup>2</sup> from fuel combustion only!

<sup>3</sup> from 1990 to 1997: also including additional dust from leaded gasoline

-]



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. <sup>1)</sup>

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

Table: Outcome of Key Category Analysis

| Key Category | SO <sub>2</sub> | NO <sub>x</sub> | NH <sub>3</sub> | NM VOC | CO  | BC  | Pb  | Hg  | Cd  | Diox | PAH | HCB | TSP | PM <sub>10</sub> | PM <sub>2.5</sub> |
|--------------|-----------------|-----------------|-----------------|--------|-----|-----|-----|-----|-----|------|-----|-----|-----|------------------|-------------------|
| 1.A.3.b iv   | -/-             | -/-             | -/-             | -/-    | -/- | -/- | -/- | -/- | -/- | -/-  | -/- | -   | -/- | -/-              | -/-               |

## 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 characteristics very different from those shown above: Here, the strong dependence on increasing fuel qualities (sulphur content) leads to an cascaded downward trend of SO<sub>2</sub> emissions, influenced only slightly by increases in fuel consumption and mileage.



### ++ Particulate Matter (PM)

Particle emissions result from the combustion of gasoline and bioethanol. Here, due to the assumption that nearly all TSP emitted is formed by particles in the PM<sub>2.5</sub> 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 |
|-------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|------|
| <b>GASOLINE</b>               |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |      |
| 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% |      |
| <b>BIOGASOLINE</b>            |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |      |
| 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% |      |
| <b>TOTAL FUEL CONSUMPTION</b> |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |      |
| 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 |      |

|                        |       |       |       |       |       |       |       |       |       |       |        |        |        |        |        |        |  |
|------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--|
| <b>absolute change</b> | 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   |  |
| <b>relative change</b> | 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 comprehensible 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

<sup>1), 2), 4)</sup> 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.

<sup>3)</sup> 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.

<sup>5)</sup> 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.

<sup>6)</sup> 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>

<sup>1)</sup> During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (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.