



|                        |          |          |          |          |          |          |          |          |          |          |          |          |          |  |  |  |  |
|------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--|--|--|--|
| ~ Biodiesel            | > 0      | > 0      | > 0      | > 397    | > 949    | > 966    | > 882    | > 798    | > 745    | > 720    | > 724    | > 602    | > 633    |  |  |  |  |
| ~ <b>Liquids TOTAL</b> | > 38,458 | > 31,054 | > 25,410 | > 18,539 | > 15,575 | > 15,696 | > 14,396 | > 14,569 | > 13,028 | > 14,041 | > 14,499 | > 11,946 | > 11,594 |  |  |  |  |
| ~ Lignite Briquettes   | > 0.00   | > 0.00   | > 431.00 | > 0.00   | > 0.00   | > 0.00   | > 0.00   | > 0.00   | > 0.00   | > 0.00   | > 0.00   | > 0.00   | > 0.00   |  |  |  |  |
| ~ Raw Lignite          | > 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   |  |  |  |  |
| ~ Hard Coal            | > 576    | > 250    | > 250    | > 255    | > 314    | > 345    | > 357    | > 352    | > 341    | > 339    | > 340    | > 340    | > 340    |  |  |  |  |
| ~ Hard Coal Coke       | > 0      | > 86     | > 1      | > 1      | > 1      | > 1      | > 1      | > 1      | > 1      | > 1      | > 1      | > 1      | > 1      |  |  |  |  |
| <b>Solids TOTAL</b>    | > 576    | > 336    | > 682    | > 256    | > 315    | > 346    | > 357    | > 353    | > 342    | > 340    | > 341    | > 341    | > 341    |  |  |  |  |
| <b>Σ 1.A.3.c</b>       | ~ 39,034 | ~ 31,390 | ~ 26,092 | ~ 18,795 | ~ 15,890 | ~ 16,041 | ~ 14,754 | ~ 14,921 | ~ 13,370 | ~ 14,381 | ~ 14,839 | ~ 12,287 | ~ 11,934 |  |  |  |  |

The use of other fuels – such as vegetable oils or gas – in private narrow-gauge railway vehicles has not been included to date and may still be considered negligible.

Table 3: Annual transport performance, in Mio tkm (ton-kilometers)

| =                   | = 1990    | = 1995    | = 2000    | = 2005    | = 2010    | = 2011    | = 2012    | = 2013    | = 2014    | = 2015    | = 2016    | = 2017    | = 2018    |  |  |  |  |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|--|--|--|--|
| ~ Electric Traction | > 361,515 | > 337,853 | > 361,633 | > 356,605 | > 344,546 | > 342,701 | > 350,085 | > 335,298 | > 331,235 | > 323,387 | > 295,798 | > 296,280 | > 288,336 |  |  |  |  |
| ~ Diesel Traction   | > 98,812  | > 58,805  | > 37,237  | > 26,540  | > 26,702  | > 27,403  | > 26,791  | > 23,768  | > 23,734  | > 21,397  | > 21,484  | > 21,365  | > 19,580  |  |  |  |  |
| <b>Σ 1.A.3.c</b>    | ~ 460,326 | ~ 396,658 | ~ 398,870 | ~ 383,145 | ~ 371,248 | ~ 370,104 | ~ 376,876 | ~ 359,065 | ~ 354,970 | ~ 344,785 | ~ 317,282 | ~ 317,645 | ~ 307,916 |  |  |  |  |

gallery size="medium" : 1A3c\_AD(TJ).png : 1A3c\_AD(km).png gallery

Regarding particulate-matter and heavy-metal emissions from **abrasion and wear of contact line, braking systems, tyres on rails**, annual transport performances of railway vehicles with electrical and Diesel traction derived from Knörr et al. (2019a) <sup>5)</sup> are applied as activity data.

+ Emission factors

The (implied) emission factors used here for estimating **emissions from diesel fuel combustion** of very different quality: For main pollutants, CO and PM, annual tier2 IEF computed within the TREMOD model are used, representing the development of German railway fleet, fuel quality and mitigation technologies <sup>6)</sup>. On the other hand, constant default values from (EMEP/EEA, 2019) <sup>7)</sup> are used for all reported PAHs and heavy metals and from Rentz et al. (2008) <sup>8)</sup> regarding PCDD/F. As no emission factors are available for HCB and PCBs, no such emissions have been calculated yet.

Regarding **emissions from solid fuels** used in historic steam engines, all emission factors displayed below have been adopted from small-scale stationary combustion.

Furthermore, regarding **emissions from abrasion and wear**, emission factors are calculated from PM<sub>10</sub>, emission estimates directly provided by the German railroad company Deutsche Bahn AG. As these original emissions are only available as of 2013, implied EF(PM<sub>10</sub>) were calculated from the emission estimates extrapolated backwards from 2013 to 1990 and the transport performance data available from TREMOD. Regarding PM<sub>2.5</sub>, and TSP, due to lack of better information, a fractional distribution of 0.5 : 1 : 1 (PM<sub>2.5</sub> : PM<sub>10</sub> : TSP) is assumed for now. Emission factors for emissions of copper, nickel and chrome are calculated via typical shares of the named metals in the contact line (copper) and in the braking systems (Ni and Cr). Other heavy metals contained in alloys used for the contact line (silver, magnesium, tin) are not taken into account here. Furthermore, emissions from other wear parts (e.g. the current collector) are not estimated. However, these components are not supposed to contain any of the nine heavy metals to be reported here (current collectors are made of aluminium alloys and coal).

Table 3: Annual country-specific emission factors for diesel fuels<sup>1</sup>, in kg/TJ

Table 4: Emission factors applied for solid fuels, in kg/TJ

Table 4: Country-specific emission factors for abrasive emissions, in g/km

**NOTE:** With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly.<sup>footnote</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. <sup>footnote</sup>

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to [Appendix 2.3 - Heavy Metal \(HM\) exhaust emissions from mobile sources](#) and [Appendix 2.4 - Persistent Organic Pollutant \(POP\) exhaust emissions from mobile sources](#)].

Table 5: Tier1 emission factors for heavy-metal and POP exhaust emissions

[illegible]

- + Discussion of emission trends

Basically, for all unregulated pollutants, emission trends directly follow the trend in over-all fuel consumption.

gallery size="medium" : 1A3c EM NH3.png : 1A3c EM NOx.png gallery

gallery size="medium" : 1A3c EM PM.png : 1A3c EM PM10.png gallery

gallery size="medium" : 1A3c EM SO2.png gallery

gallery size="medium" : 1A3c EM Cu.png : 1A3c EM Cd.png gallery

+ Recalculations

## Activity data

Given the revised NEB 2017, both the activity data for diesel oil and the annual amounts of blended biodiesel were revised accordingly.

Table 5: Revised 2017 fuel consumption, in terajoule

| >                 | > Diesel Oil | > Biodiesel |
|-------------------|--------------|-------------|
| ~ Submission 2020 | > 11,344     | > 602       |
| ~ Submission 2019 | > 13,690     | > 726       |
| ~ absolute change | > -2,346     | > -124      |
| ~ relative change | > -17.1%     | > -17.1%    |

## Emission factors

Due to the routine revision of the TREMOD model<sup>10)</sup>, tier2 emission factors changed for recent years. Here, the revision results mainly from the consideration of revised NCVs for diesel oil as provided by the AGEb.

Table 6: Revised country-specific emission factors for diesel fuels, in kg/TJ

|                                     |        |        |        |        |        |        |        |        |        |        |        |        |        |
|-------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| =                                   | = 2005 | = 2006 | = 2007 | = 2008 | = 2009 | = 2010 | = 2011 | = 2012 | = 2013 | = 2014 | = 2015 | = 2016 | = 2017 |
| < Nitrogen oxides - NO <sub>x</sub> |        |        |        |        |        |        |        |        |        |        |        |        |        |

|  |          |          |          |          |          |          |          |          |          |          |          |           |          |
|--|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|----------|
| ~ Submission 2020  | > 1,111  | > 1,058  | > 1,028  | > 1,010  | > 991    | > 970    | > 990    | > 919    | > 899    | > 886    | > 826    | > 801     | > 775    |
| ~ Submission 2019  | > 1,111  | > 1,058  | > 1,029  | > 1,011  | > 1,001  | > 986    | > 1,010  | > 921    | > 882    | > 897    | > 851    | > 836     | > 814    |
| ~ absolute change  | > 0.00   | > -0.75  | > -0.44  | > -1.81  | > -9.91  | > -15.63 | > -19.97 | > -2.05  | > 16.27  | > -10.45 | > -25.27 | > -34.82  | > -38.70 |
| ~ relative change  | > 0.00 % | > -0.07% | > -0.04% | > -0.18% | > -0.99% | > -1.59% | > -1.98% | > -0.22% | > 1.84%  | > -1.16% | > -2.97% | > -4.16%  | > -4.75% |
| <b>&lt; Non-methane volatile organic compounds - NMVOC</b>                       |          |          |          |          |          |          |          |          |          |          |          |           |          |
| ~ Submission 2020  | > 64.8   | > 61.8   | > 57.3   | > 55.6   | > 51.2   | > 52.0   | > 54.3   | > 44.8   | > 42.2   | > 41.2   | > 38.5   | > 38.2    | > 37.2   |
| ~ Submission 2019  | > 64.8   | > 62.1   | > 57.8   | > 56.7   | > 53.8   | > 55.7   | > 59.2   | > 46.9   | > 43.5   | > 43.1   | > 41.4   | > 40.9    | > 39.3   |
| ~ absolute change  | > -0.04  | > -0.33  | > -0.48  | > -1.05  | > -2.60  | > -3.79  | > -4.84  | > -2.09  | > -1.33  | > -1.95  | > -2.87  | > -2.66   | > -2.08  |
| ~ relative change  | > -0.06% | > -0.52% | > -0.83% | > -1.85% | > -4.85% | > -6.80% | > -8.18% | > -4.46% | > -3.06% | > -4.52% | > -6.93% | > -6.50%  | > -5.30% |
| <b>&lt; Particulate matter - PM (PM<sub>2.5</sub>, = PM<sub>10</sub>, = TSP)</b> |          |          |          |          |          |          |          |          |          |          |          |           |          |
| ~ Submission 2020  | > 23.4   | > 22.4   | > 20.9   | > 19.5   | > 17.6   | > 17.7   | > 18.5   | > 16.0   | > 14.7   | > 14.3   | > 13.3   | > 13.1    | > 12.4   |
| ~ Submission 2019  | > 23.4   | > 22.5   | > 21.1   | > 19.9   | > 18.2   | > 18.6   | > 19.8   | > 16.6   | > 14.8   | > 15.4   | > 14.7   | > 14.6    | > 13.7   |
| ~ absolute change  | > -0.02  | > -0.14  | > -0.21  | > -0.40  | > -0.68  | > -0.95  | > -1.33  | > -0.58  | > -0.14  | > -1.12  | > -1.37  | > -1.58   | > -1.33  |
| ~ relative change  | > -0.08% | > -0.62% | > -1.01% | > -2.03% | > -3.75% | > -5.07% | > -6.72% | > -3.48% | > -0.95% | > -7.25% | > -9.31% | > -10.79% | > -9.73% |
| <b>&lt; Black carbon - BC</b>  |          |          |          |          |          |          |          |          |          |          |          |           |          |
| ~ Submission 2020  | > 15.2   | > 14.5   | > 13.6   | > 12.7   | > 11.4   | > 11.5   | > 12.0   | > 10.4   | > 9.5    | > 9.3    | > 8.6    | > 8.5     | > 8.0    |
| ~ Submission 2019  | > 15.2   | > 14.6   | > 13.7   | > 12.9   | > 11.9   | > 12.1   | > 12.9   | > 10.8   | > 9.6    | > 10.0   | > 9.5    | > 9.5     | > 8.9    |
| ~ absolute change  | > -0.01  | > -0.09  | > -0.14  | > -0.26  | > -0.45  | > -0.61  | > -0.87  | > -0.38  | > -0.09  | > -0.73  | > -0.89  | > -1.03   | > -0.87  |
| ~ relative change  | > -0.08% | > -0.62% | > -1.01% | > -2.03% | > -3.75% | > -5.07% | > -6.72% | > -3.48% | > -0.95% | > -7.25% | > -9.31% | > -10.79% | > -9.73% |
| <b>&lt; Carbon monoxide - CO</b>   |          |          |          |          |          |          |          |          |          |          |          |           |          |
| ~ Submission 2020  | > 162    | > 152    | > 141    | > 134    | > 123    | > 121    | > 121    | > 105    | > 101    | > 98.9   | > 94.7   | > 93.3    | > 92.6   |
| ~ Submission 2019  | > 162    | > 153    | > 142    | > 136    | > 129    | > 129    | > 129    | > 109    | > 104    | > 104    | > 101    | > 98.1    | > 94.8   |
| ~ absolute change  | > -0.09  | > -0.73  | > -1.08  | > -2.26  | > -6.12  | > -8.14  | > -8.30  | > -3.77  | > -2.33  | > -4.92  | > -5.81  | > -4.83   | > -2.26  |

|                   |          |          |          |          |          |          |          |          |          |          |          |          |          |
|-------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| ~ relative change | > -0.05% | > -0.48% | > -0.76% | > -1.66% | > -4.75% | > -6.31% | > -6.42% | > -3.46% | > -2.24% | > -4.74% | > -5.78% | > -4.93% | > -2.38% |
|-------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|

For more information on **recalculated emission estimates for Base Year and 2017**, please see the pollutant-specific recalculation tables following chapter [8.1 - Recalculations](#).

#### + Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023 (title: "Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland") carried out by Knörr et al. (2009)<sup>11)</sup>.

#### + Planned improvements

Besides the scheduled **routine revision** of TREMOD, no further improvements are planned for the next annual submission.

#### + FAQs

#### **Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?**

The EF provided in <sup>12)</sup> represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metals contained in the biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to biodiesel.

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<sup>2)</sup> (bibcite 2)

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