

# 1.A.3.b i - Road transport: Passenger cars

## Short description

In sub-category *1.A.3.b i - Road transport: Passenger cars* emissions from fuel combustion in passenger cars (PCs) are reported.

| Category Code | Method          |                 |                 |        |     | AD    |                  |                   |     |     | EF       |     |      |     |     |
|---------------|-----------------|-----------------|-----------------|--------|-----|-------|------------------|-------------------|-----|-----|----------|-----|------|-----|-----|
| 1.A.3.b i     | T1, T3          |                 |                 |        |     | NS, M |                  |                   |     |     | CS, M, D |     |      |     |     |
| Key Category  | SO <sub>2</sub> | NO <sub>x</sub> | NH <sub>3</sub> | NM VOC | CO  | TSP   | PM <sub>10</sub> | PM <sub>2.5</sub> | BC  | Pb  | Hg       | Cd  | Diox | PAH | HCB |
| 1.A.3.b i     | -/-             | L/T             | -/-             | L/T    | L/T | -/-   | L/T              | L/T               | L/T | L/T | -/-      | -/- | L/-  | -/- | -   |

## Methodology

Detailed information on the methods applied is provided in the [superordinate chapter](#).

## Activity data

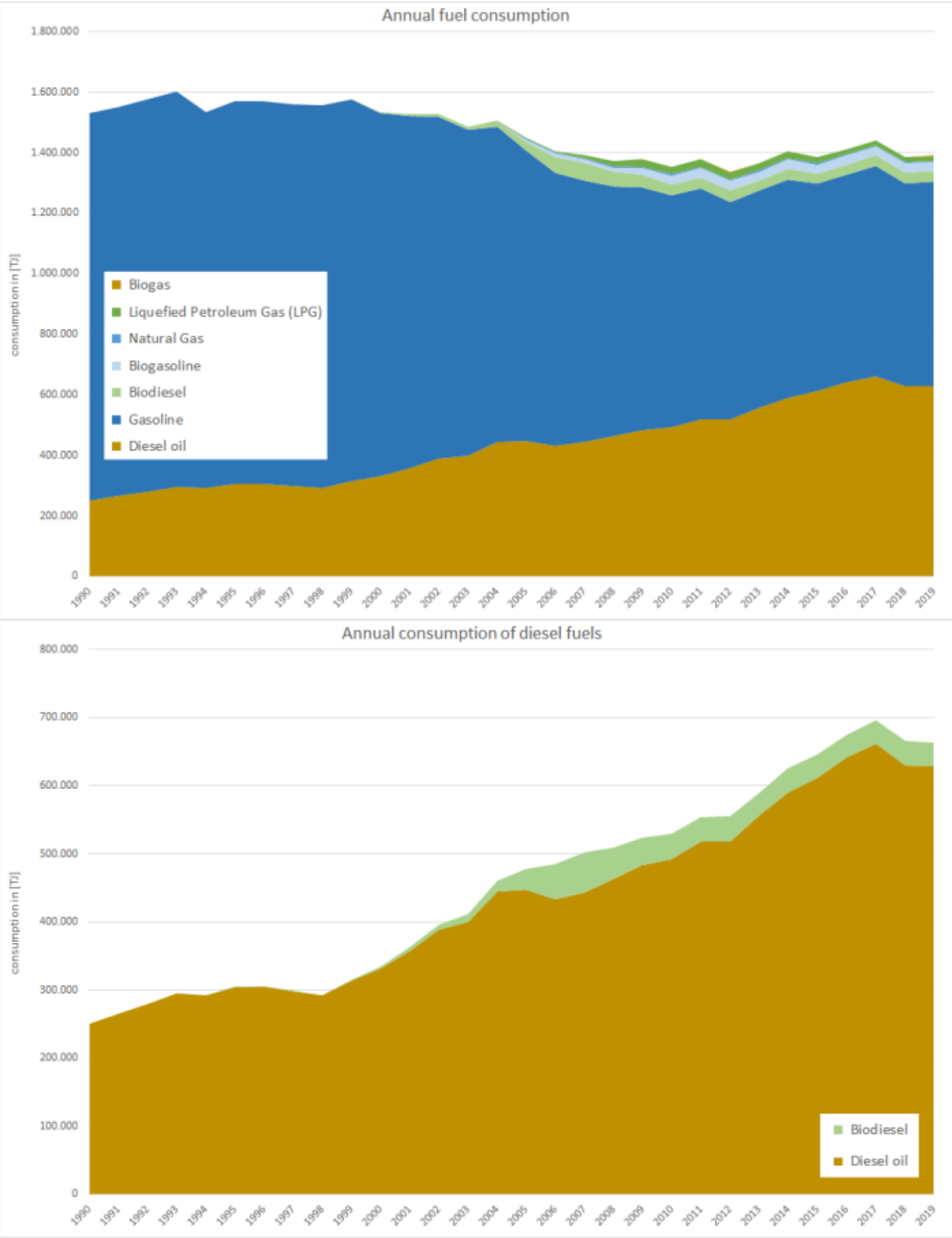
Specific consumption data for passenger cars is generated within TREMOD <sup>1)</sup>.

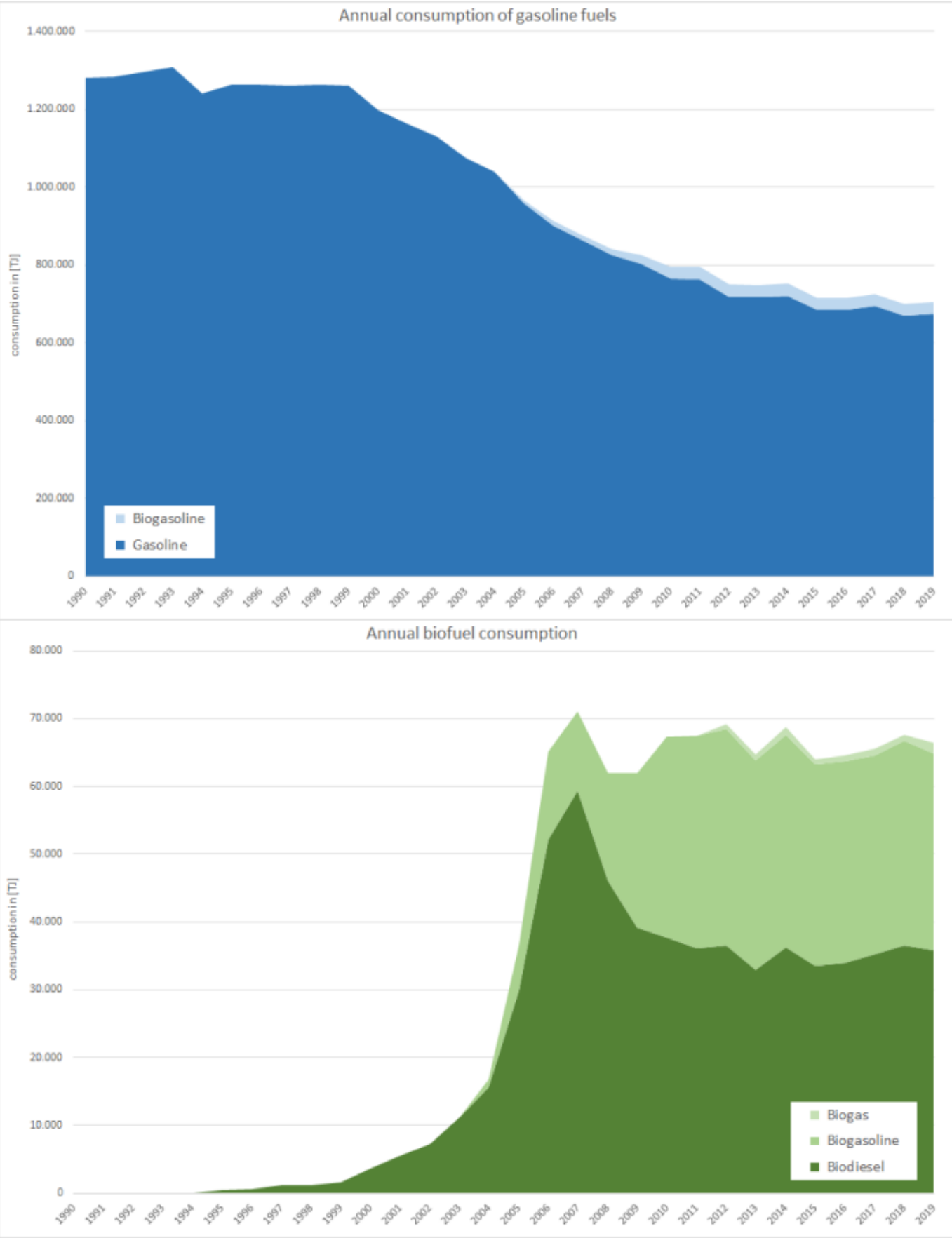
The following table gives an overview of annual amounts of the fuels consumed by passenger cars in Germany.

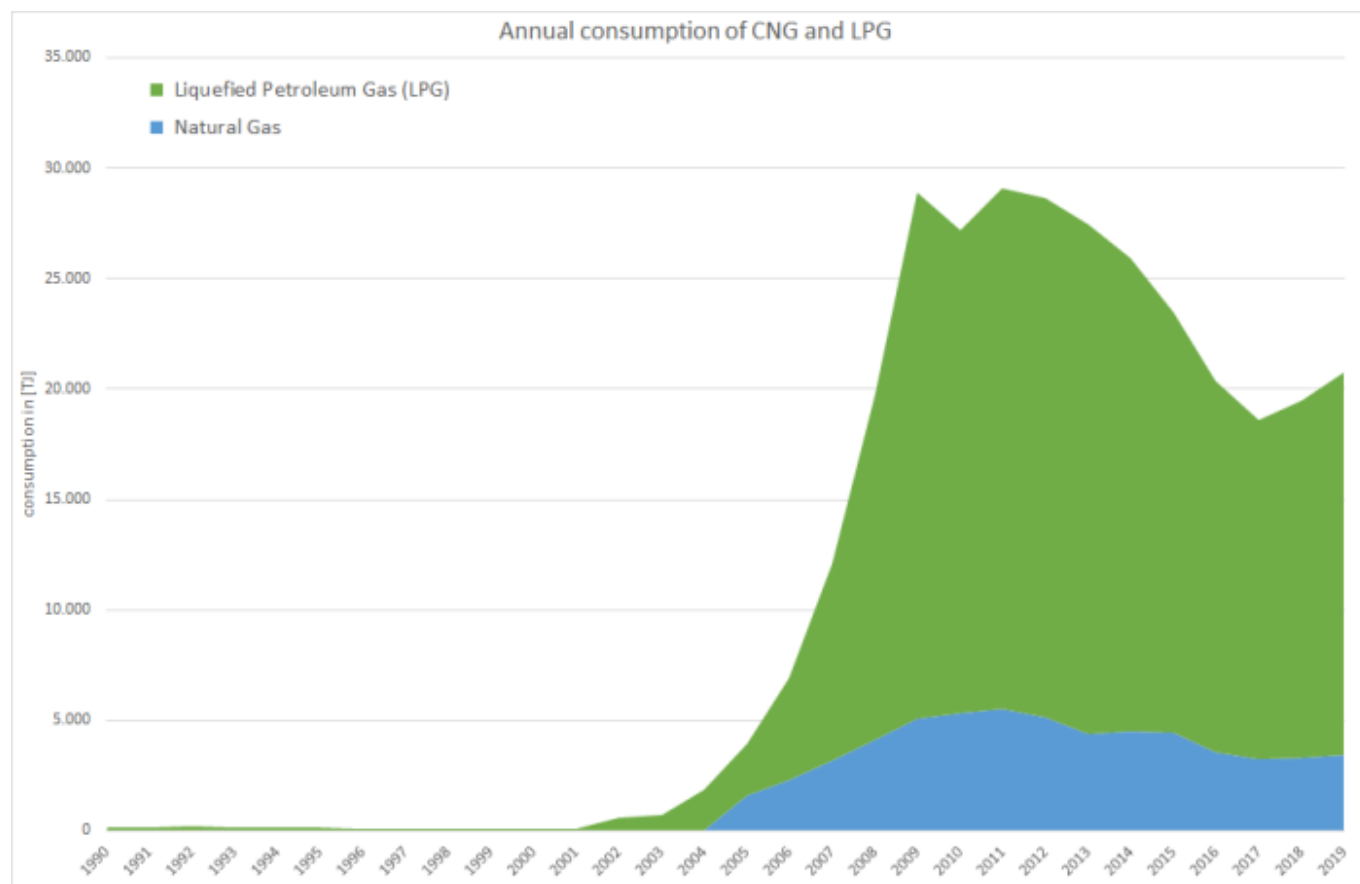
Table 1: Annual passenger car fuel consumption, in terajoule

|                    | 1990             | 1995             | 2000             | 2005             | 2010             | 2011             | 2012             | 2013             | 2014             | 2015             | 2016             | 2017             | 2018             | 2019             |
|--------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| <b>Diesel oil</b>  | 251,081          | 304,573          | 330,544          | 447,843          | 491,684          | 517,460          | 518,642          | 556,149          | 589,801          | 612,084          | 641,130          | 661,289          | 629,483          | 628,079          |
| <b>Gasoline</b>    | 1,280,592        | 1,263,563        | 1,198,941        | 960,365          | 766,348          | 763,397          | 719,091          | 718,322          | 721,165          | 685,429          | 685,497          | 695,259          | 668,949          | 675,555          |
| <b>LPG</b>         | 138              | 138              | 94               | 2,357            | 21,823           | 23,613           | 23,532           | 23,077           | 21,464           | 18,963           | 16,799           | 15,377           | 16,153           | 17,332           |
| <b>CNG</b>         | 0                | 0                | 0                | 1,604            | 5,351            | 5,494            | 5,140            | 4,380            | 4,483            | 4,476            | 3,590            | 3,247            | 3,332            | 3,412            |
| <b>Biodiesel</b>   | 0                | 475              | 3,662            | 29,928           | 37,696           | 36,105           | 36,603           | 32,982           | 36,244           | 33,481           | 33,989           | 35,303           | 36,591           | 35,762           |
| <b>Biogasoline</b> | 0                | 0                | 0                | 6,597            | 29,609           | 31,292           | 31,866           | 30,792           | 31,361           | 29,728           | 29,775           | 29,312           | 30,078           | 29,136           |
| <b>Biogas</b>      | 0                | 0                | 0                | 0                | 0                | 0                | 734              | 867              | 1,130            | 755              | 844              | 1,009            | 897              | 1,561            |
| <b>Σ 1.A.3.b i</b> | <b>1,531,811</b> | <b>1,568,749</b> | <b>1,533,241</b> | <b>1,448,694</b> | <b>1,352,511</b> | <b>1,377,360</b> | <b>1,335,609</b> | <b>1,366,568</b> | <b>1,405,647</b> | <b>1,384,915</b> | <b>1,411,625</b> | <b>1,440,795</b> | <b>1,385,484</b> | <b>1,390,837</b> |

Here, the following charts underline the ongoing shift from gasoline to diesel-powered passenger cars, that started around 1999/2000.







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>2)</sup> where they are provided on a tier3 level mostly and processed within the TREMOD software used by the party <sup>3)</sup>.

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

For heavy-metal (other than lead from leaded gasoline) and PAH exhaust-emissions, default emission factors from (EMEP/EEA, 2019) <sup>4)</sup> have been applied. Regarding PCDD/F, a tier1 EF from (Rentz et al., 2008) <sup>5)</sup> is used.

Table 3: tier1 emission factors

|                                                 | Pb    | Cd    | Hg    | As    | Cr    | Cu    | Ni    | Se    | Zn    | B[a]P  | B[b]F | B[k]F | I[1,2,3-c,d]p | PAH 1-4 | PCDD/F   |
|-------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|-------|-------|---------------|---------|----------|
|                                                 | [g/T] |       |       |       |       |       |       |       |       | [mg/T] |       |       |               | [µg/km] |          |
| <b>Diesel oil</b>                               | 0.012 | 0.001 | 0.123 | 0.002 | 0.198 | 0.133 | 0.005 | 0.002 | 0.419 | 498    | 521   | 275   | 493           | 1.788   |          |
| <b>Biodiesel<sup>1</sup></b>                    | 0.013 | 0.001 | 0.142 | 0.003 | 0.228 | 0.153 | 0.005 | 0.003 | 0.483 | 575    | 601   | 317   | 569           | 2.062   |          |
| <b>Gasoline fuels</b>                           | 0.037 | 0.005 | 0.200 | 0.007 | 0.145 | 0.103 | 0.053 | 0.005 | 0.758 | 96     | 140   | 69    | 158           | 464     |          |
| <b>CNG<sup>2</sup> &amp; biogas<sup>3</sup></b> | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE     | NE    | NE    | NE            | NE      |          |
| <b>LPG<sup>4</sup></b>                          | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    | 4.35   | 0.00  | 4.35  | 4.35          | 13.0    |          |
| <b>all fuels</b>                                |       |       |       |       |       |       |       |       |       |        |       |       |               |         | 0.000006 |

<sup>1</sup> values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel

<sup>2</sup> no specific default available from <sup>6)</sup>; value derived from CNG powered busses

<sup>3</sup> no specific default available from <sup>7)</sup>; values available for CNG also applied for biogas

<sup>4</sup> no specific default available from <sup>8)</sup>; value derived from LPG powered passenger cars

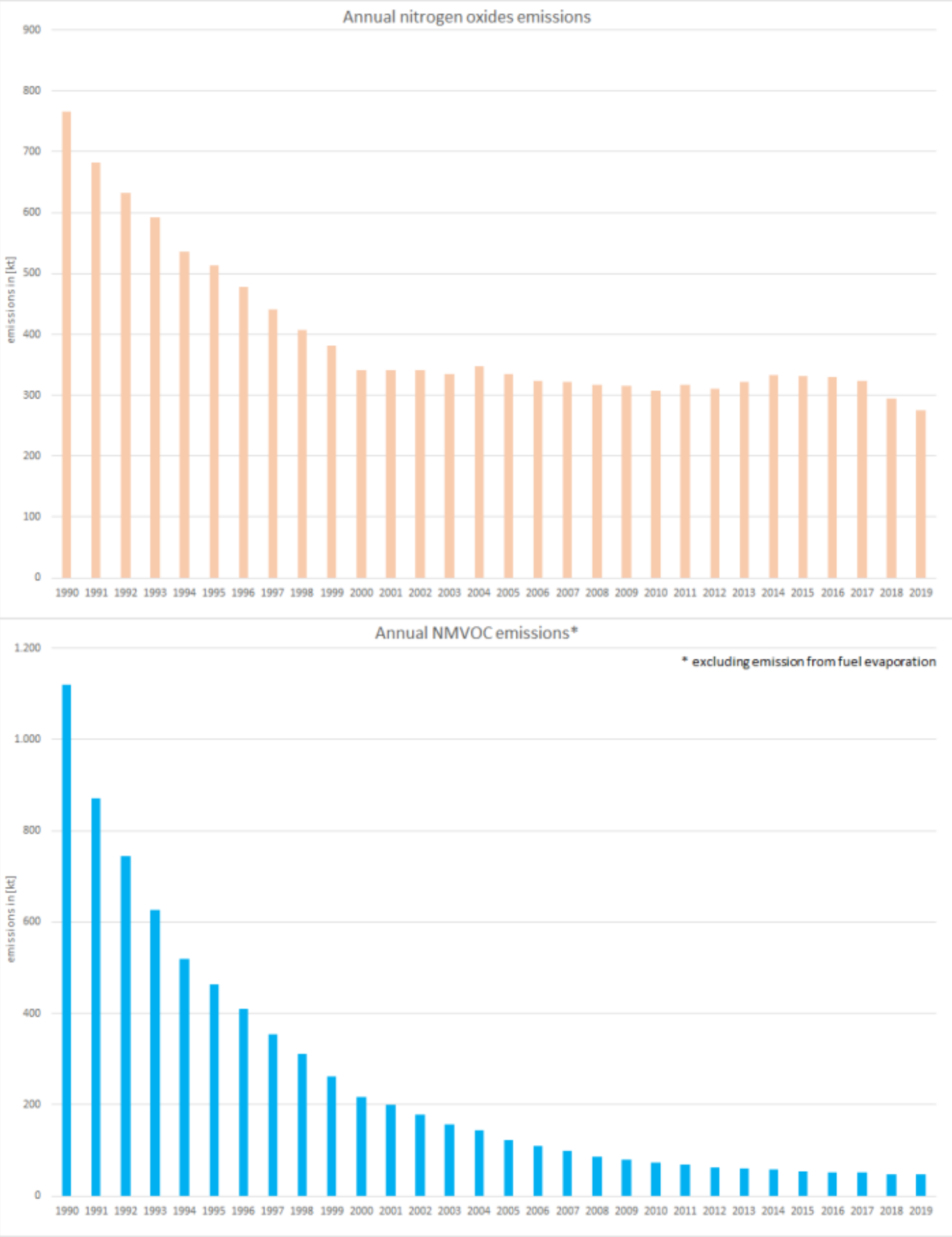
## Discussion of emission trends

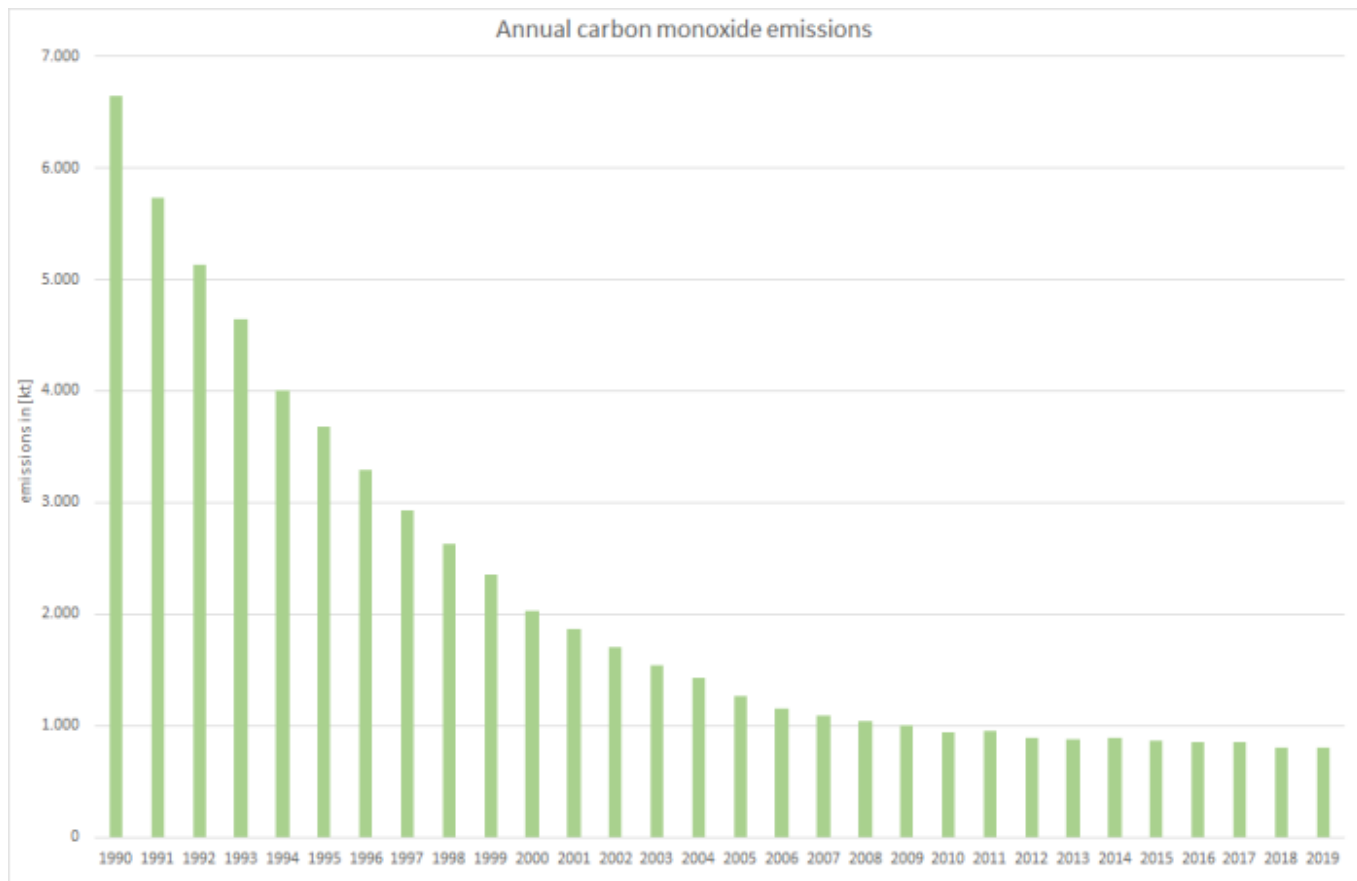
Table: Outcome of Key Category Analysis

|             |                       |              |           |                        |                         |           |           |             |
|-------------|-----------------------|--------------|-----------|------------------------|-------------------------|-----------|-----------|-------------|
| <b>for:</b> | <b>NO<sub>x</sub></b> | <b>NMVOC</b> | <b>CO</b> | <b>PM<sub>10</sub></b> | <b>PM<sub>2.5</sub></b> | <b>BC</b> | <b>Pb</b> | <b>Diox</b> |
| <b>by:</b>  | L/T                   | L/T          | L/T       | L/T                    | L/T                     | L/T       | L/T       | L/-         |

### Non-methane volatile organic compounds, nitrogen oxides, and carbon monoxide

Since 1990, exhaust emissions of **nitrogen oxides**, **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.

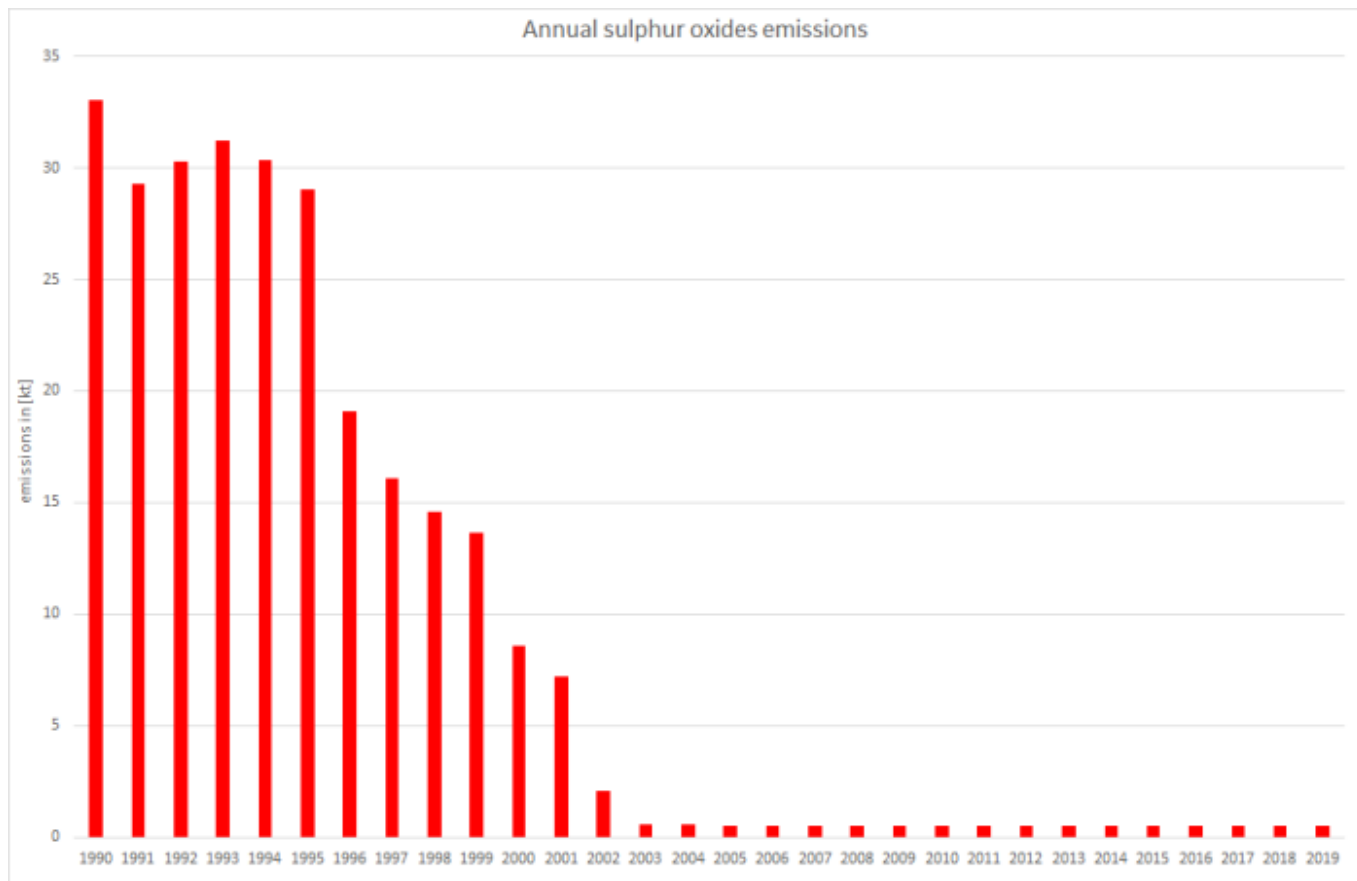




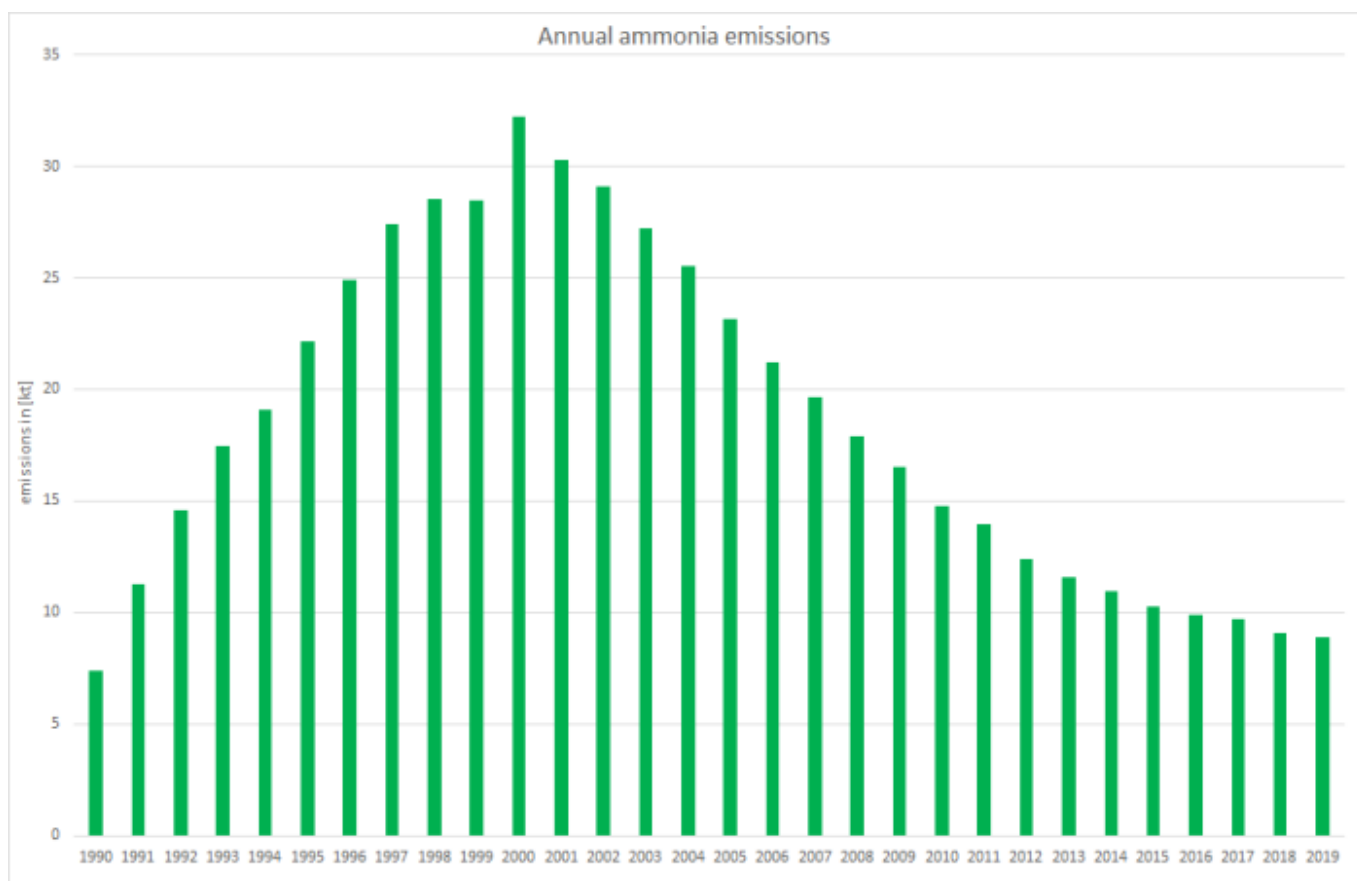
## Ammonia and sulphur dioxide

As for the entire road transport sector, the trends for **sulphur dioxide** and **ammonia** exhaust emissions from passenger cars show characteristics very different from those shown above.

Here, the strong dependence on increasing fuel qualities (sulphur content) leads to an cascaded downward trend of 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

*(from fuel combustion only; no wear/abrasion included)*

Starting in the middle of the 1990s, a so-called “diesel boom” began, leading to a switch from gasoline to diesel powered passenger cars. As the newly registered diesel cars had to meet the EURO2 standard (in force since 1996/'97) with a PM limit value less than half the EURO1 value, the growing diesel consumption was overcompensated quickly by the mitigation technologies implemented due to the new EURO norm. During the following years, new EURO norms came into force. With the still ongoing “diesel boom” those norms led to a stabilisation (EURO3, 2000/'01) of emissions and to another strong decrease of PM emissions (EURO4, 2005/'06), respectively. Over-all, the increased consumption of diesel in passenger cars was overestimated by the implemented mitigation technologies. The table below shows the evolution of the limit value for particle emissions from passenger cars with diesel engines.

With this submission, Black Carbon (BC) emissions are reported for the first time. Here, EF are estimated based on as fractions of PM as provided in <sup>9)</sup>. Due to this fuel-specific fractions, the trend of BC emissions reflects the ongoing shift from gasoline to diesel (“dieselisation”).

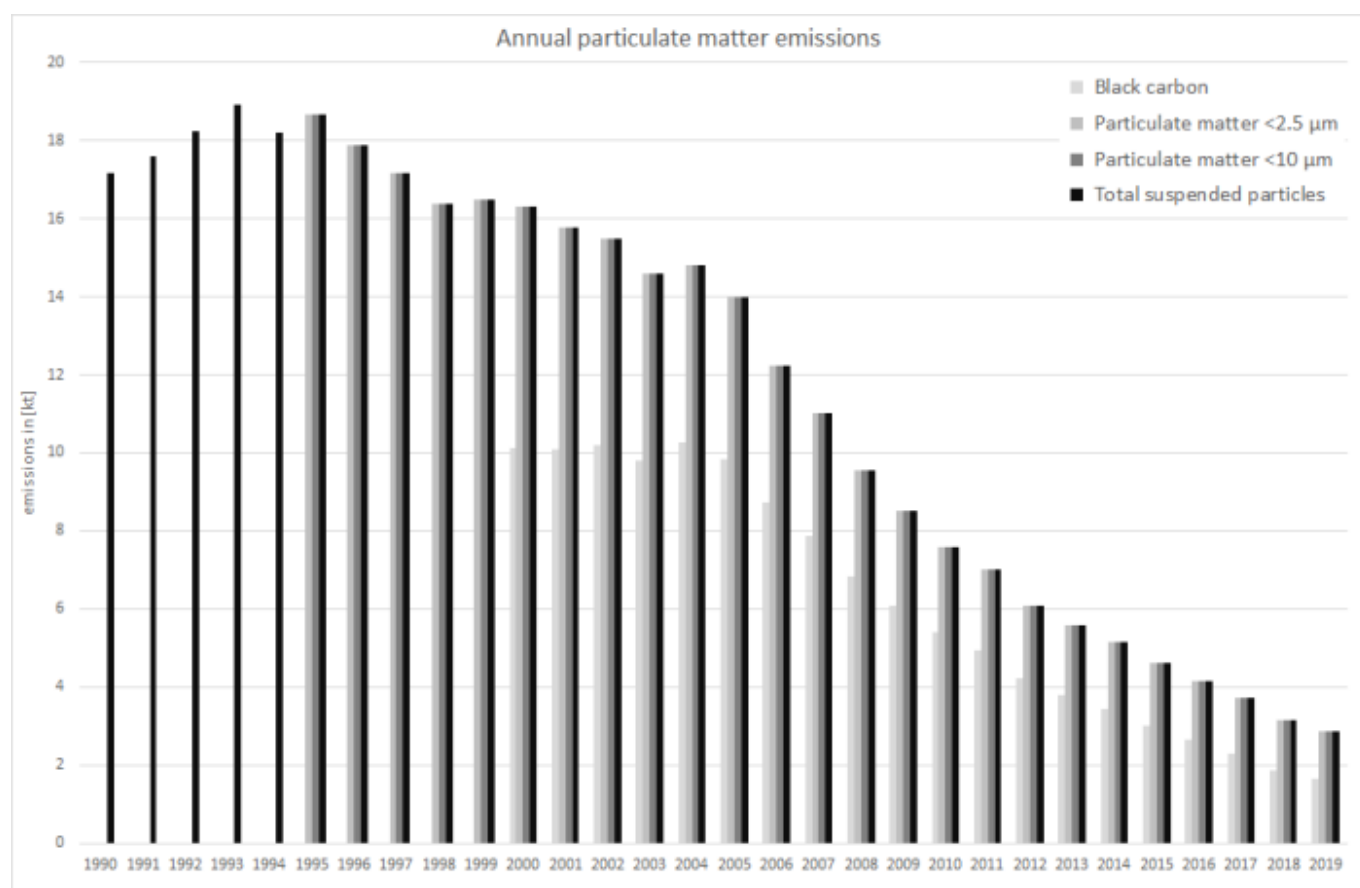


Table: EURO norms and their effect on limit values of PM emissions from diesel passenger cars

| exhaust emission standard<br>(EURO norm) | Euro 1     | Euro 2     | Euro 3     | Euro 4     | Euro 5     | Euro 6     |
|------------------------------------------|------------|------------|------------|------------|------------|------------|
| in force <b>for type approval</b> since: | 1 Jul 1992 | 1 Jan 1996 | 1 Jan 2000 | 1 Jan 2005 | 1 Sep 2009 | 1 Sep 2014 |

|                                                   |               |                           |               |               |               |               |
|---------------------------------------------------|---------------|---------------------------|---------------|---------------|---------------|---------------|
| in force <b>for initial registration</b><br>since | 1 Jan<br>1993 | 1 Jan 1997                | 1 Jan<br>2001 | 1 Jan<br>2006 | 1 Jan<br>2011 | 1 Jan<br>2015 |
| <b>resulting PM limit value in<br/>[mg/km]</b>    | <b>180</b>    | <b>80/100<sup>1</sup></b> | <b>50</b>     | <b>25</b>     | <b>5</b>      | <b>5</b>      |

<sup>1</sup> for direct injection engines

## 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>DIESEL OIL</b>      |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |      |
| <b>Submission 2021</b> | 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 |      |
| <b>Submission 2020</b> | 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 |      |
| <b>absolute change</b> | 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   |      |
| <b>relative change</b> | 4,91%  | 20,1%  | 25,8%  | 14,3%  | 7,41%  | 26,3%  | 19,5%  | 14,4%  | 9,52%  | 3,09%  | -1,60% | -5,35% | -6,71% | -4,63% | -2,84% | -1,87% |      |
| <b>BIODIESEL</b>       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |      |
| <b>Submission 2021</b> | 0      | 0      | 0      | 158    | 314    | 293    | 400    | 577    | 736    | 762    | 778    | 752    | 783    | 771    | 785    | 778    |      |
| <b>Submission 2020</b> | 0      | 0      | 0      | 138    | 293    | 232    | 334    | 504    | 672    | 739    | 791    | 795    | 839    | 808    | 808    | 801    |      |
| <b>absolute change</b> | 0      | 0      | 0      | 20     | 22     | 61     | 65     | 73     | 64     | 23     | -13    | -43    | -56    | -37    | -23    | -23    |      |
| <b>relative change</b> | 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>GASOLINE</b>        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |      |
| <b>Submission 2021</b> | 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 |      |
| <b>Submission 2020</b> | 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 |      |
| <b>absolute change</b> | 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   |      |
| <b>relative change</b> | 4,91%  | 20,1%  | 25,8%  | 14,3%  | 7,41%  | 26,3%  | 19,5%  | 14,4%  | 9,52%  | 3,09%  | -1,60% | -5,35% | -6,71% | -4,63% | -2,84% | -1,87% |      |
| <b>BIOGASOLINE</b>     |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |      |
| <b>Submission 2021</b> | 0      | 0      | 0      | 158    | 314    | 293    | 400    | 577    | 736    | 762    | 778    | 752    | 783    | 771    | 785    | 778    |      |
| <b>Submission 2020</b> | 0      | 0      | 0      | 138    | 293    | 232    | 334    | 504    | 672    | 739    | 791    | 795    | 839    | 808    | 808    | 801    |      |
| <b>absolute change</b> | 0      | 0      | 0      | 20     | 22     | 61     | 65     | 73     | 64     | 23     | -13    | -43    | -56    | -37    | -23    | -23    |      |
| <b>relative change</b> | 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>CNG</b>             |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |      |
| <b>Submission 2021</b> | 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 |      |
| <b>Submission 2020</b> | 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 |      |
| <b>absolute change</b> | 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   |      |

|                               |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |  |
|-------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--|
| <b>relative change</b>        | 4,91%  | 20,1%  | 25,8%  | 14,3%  | 7,41%  | 26,3%  | 19,5%  | 14,4%  | 9,52%  | 3,09%  | -1,60% | -5,35% | -6,71% | -4,63% | -2,84% | -1,87% |  |
| <b>BIOGAS</b>                 |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |  |
| <b>Submission 2021</b>        | 0      | 0      | 0      | 158    | 314    | 293    | 400    | 577    | 736    | 762    | 778    | 752    | 783    | 771    | 785    | 778    |  |
| <b>Submission 2020</b>        | 0      | 0      | 0      | 138    | 293    | 232    | 334    | 504    | 672    | 739    | 791    | 795    | 839    | 808    | 808    | 801    |  |
| <b>absolute change</b>        | 0      | 0      | 0      | 20     | 22     | 61     | 65     | 73     | 64     | 23     | -13    | -43    | -56    | -37    | -23    | -23    |  |
| <b>relative change</b>        | 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>LPG</b>                    |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |  |
| <b>Submission 2021</b>        | 0      | 0      | 0      | 158    | 314    | 293    | 400    | 577    | 736    | 762    | 778    | 752    | 783    | 771    | 785    | 778    |  |
| <b>Submission 2020</b>        | 0      | 0      | 0      | 138    | 293    | 232    | 334    | 504    | 672    | 739    | 791    | 795    | 839    | 808    | 808    | 801    |  |
| <b>absolute change</b>        | 0      | 0      | 0      | 20     | 22     | 61     | 65     | 73     | 64     | 23     | -13    | -43    | -56    | -37    | -23    | -23    |  |
| <b>relative change</b>        | 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> |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |  |
| <b>Submission 2021</b>        | 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 |  |
| <b>Submission 2020</b>        | 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), 3)</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>2)</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>4), 6), 7), 8), 9)</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>5)</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.