

# 1.A.4.a ii - Commercial / Institutional: Mobile

## Short description

In *NFR 1.A.4.a ii - Commercial/institutional: Mobile* fuel combustion activities and emissions from non-road diesel and LPG-driven (forklifters) vehicles used in the commercial and institutional sector are taken into account.

| Method | AD    | EF       | Key Category Analysis |
|--------|-------|----------|-----------------------|
| T1, T2 | NS, M | CS, D, M | no key category       |

## Methodology

### Activity data

Sector-specific **diesel** consumption data are included in the primary fuel-delivery data available from NEB line 67: 'Commercial, trade, services and other consumers' (AGEB, 2019) <sup>1)</sup>.

Table 1: Sources for primary fuel-deliveries data

|              |                                                                |
|--------------|----------------------------------------------------------------|
| through 1994 | NEB line 79: 'Households and small consumers'                  |
| as of 1995   | NEB line 67: 'Commercial, trade, services and other consumers' |

Following the deduction of diesel oil inputs for military vehicles as provided in (BAFA, 2019) <sup>2)</sup>, the remaining amounts of diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and off-road vehicles in commercial/institutional use (1.A.4.a ii) as well as agriculture and forestry (1.A.4.c ii) based upon annual shares derived from (Knörr et al. (2019b)) <sup>3)</sup> (cf. [NFR 1.A.4 - mobile](#) ).

Table 2: Annual contribution of NFR 1.A.4.a ii to the over-all amounts of diesel oil provided in NEB line 67

| 1990  | 1995  | 2000  | 2005  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  | 2019  |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 7,01% | 6,65% | 6,99% | 7,18% | 6,52% | 6,36% | 6,21% | 5,96% | 5,82% | 5,73% | 5,83% | 5,78% | 5,68% | 5,59% |

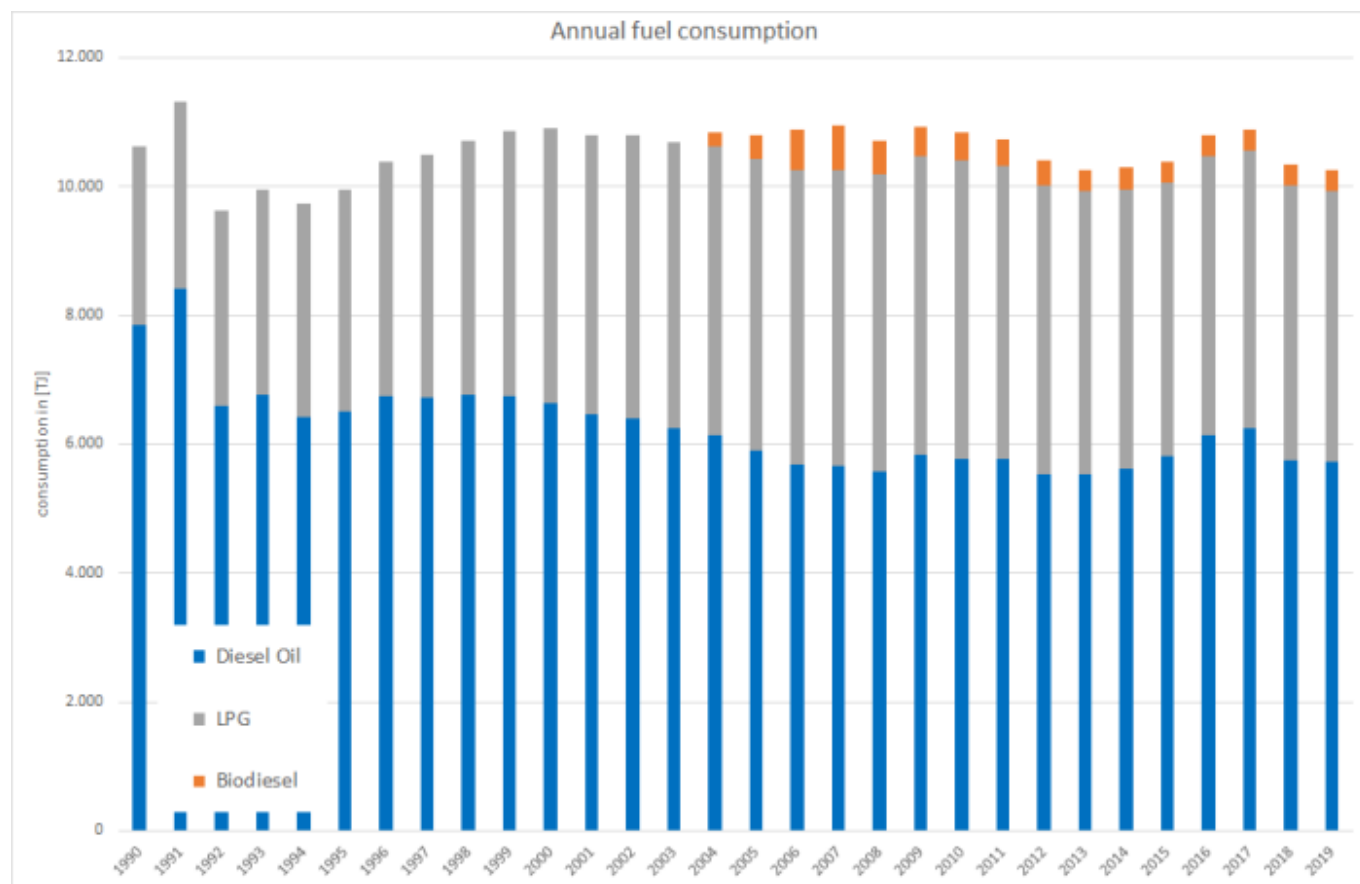
source: (Knörr et al. (2019b)) <sup>4)</sup>

As the NEB does not distinguish into specific biofuels, consumption data for biodiesel are calculated by applying Germany's official annual shares of biodiesel blended to fossil diesel oil.

In contrast, for **LPG**-driven forklifters, specific consumption data is modelled in TREMOD-MM. These amounts are then subtracted from the over-all amount available from NEB line 67 to estimate the amount of LPG used in stationary combustion.

Table 3: Annual fuel consumption, in terajoules

|                     | 1990          | 1995         | 2000          | 2005          | 2010          | 2011          | 2012          | 2013          | 2014          | 2015          | 2016          | 2017          | 2018          | 2019          |
|---------------------|---------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>Diesel Oil</b>   | 7.847         | 6.508        | 6.646         | 5.894         | 5.773         | 5.770         | 5.533         | 5.524         | 5.629         | 5.810         | 6.145         | 6.257         | 5.749         | 5.726         |
| <b>Biodiesel</b>    | 0.00          | 0.00         | 0.00          | 377           | 443           | 403           | 390           | 328           | 346           | 318           | 326           | 334           | 334           | 326           |
| <b>LPG</b>          | 2.787         | 3.450        | 4.261         | 4.533         | 4.629         | 4.557         | 4.484         | 4.409         | 4.333         | 4.256         | 4.336         | 4.301         | 4.264         | 4.213         |
| <b>Σ 1.A.4.a ii</b> | <b>10.634</b> | <b>9.958</b> | <b>10.907</b> | <b>10.803</b> | <b>10.844</b> | <b>10.729</b> | <b>10.407</b> | <b>10.261</b> | <b>10.307</b> | <b>10.383</b> | <b>10.807</b> | <b>10.892</b> | <b>10.347</b> | <b>10.347</b> |



## Emission factors

The emission factors used here are of rather different quality: Basically, for all **main pollutants, carbon monoxide** and **particulate matter**, annual IEF modelled within <sup>5)</sup> are used, representing the sector's vehicle-fleet composition, the development of mitigation technologies and the effect of fuel-quality legislation.

As no such specific EF are available for biofuels, the values used for diesel oil are applied to biodiesel, too.

Table 4: Annual country-specific emission factors from TREMOD MM, in kg/TJ

|                                 | 1990   | 1995   | 2000   | 2005   | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019 |
|---------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|------|
| <b>Diesel fuels<sup>1</sup></b> |        |        |        |        |        |        |        |        |        |        |        |        |        |      |
| <b>NH<sub>3</sub></b>           | 0.089  | 0.092  | 0.093  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  |      |
| <b>NM VOC</b>                   | 77.8   | 74.8   | 82.3   | 101    | 106    | 106    | 106    | 106    | 106    | 106    | 106    | 106    | 106    |      |
| <b>NO<sub>x</sub></b>           | 54.0   | 68.3   | 75.9   | 76.8   | 76.9   | 76.9   | 77.0   | 77.0   | 77.0   | 77.0   | 77.0   | 77.0   | 77.0   |      |
| <b>SO<sub>x</sub></b>           | 10.1   | 8.3    | 3.2    | 0.4    | 0.4    | 0.4    | 0.4    | 0.4    | 0.4    | 0.4    | 0.4    | 0.4    | 0.4    |      |
| <b>BC<sup>3</sup></b>           | 0.302  | 0.271  | 0.241  | 0.236  | 0.236  | 0.236  | 0.236  | 0.236  | 0.235  | 0.235  | 0.235  | 0.235  | 0.235  |      |
| <b>PM<sup>2</sup></b>           | 6.03   | 5.43   | 4.83   | 4.72   | 4.71   | 4.71   | 4.71   | 4.71   | 4.71   | 4.71   | 4.71   | 4.71   | 4.71   |      |
| <b>CO</b>                       | 38,459 | 35,290 | 32,423 | 32,108 | 34,681 | 35,250 | 35,791 | 36,289 | 36,661 | 36,840 | 36,918 | 36,973 | 37,010 |      |
| <b>LPG</b>                      |        |        |        |        |        |        |        |        |        |        |        |        |        |      |
| <b>NH<sub>3</sub></b>           | 0.161  | 0.164  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  |      |
| <b>NM VOC</b>                   | 185    | 157    | 134    | 90     | 59     | 55     | 52     | 48     | 44     | 41     | 38     | 35     | 32     |      |
| <b>NO<sub>x</sub></b>           | 1,047  | 1,012  | 970    | 757    | 523    | 484    | 449    | 417    | 386    | 357    | 325    | 292    | 263    |      |
| <b>SO<sub>x</sub></b>           | 79.6   | 60.5   | 14.0   | 0.4    | 0.4    | 0.4    | 0.4    | 0.4    | 0.4    | 0.4    | 0.4    | 0.4    | 0.4    |      |
| <b>BC<sup>3</sup></b>           | 78.5   | 64.1   | 51.1   | 36.4   | 27.6   | 26.5   | 25.3   | 23.8   | 22.1   | 20.5   | 18.8   | 17.2   | 15.7   |      |
| <b>PM<sup>2</sup></b>           | 149    | 121    | 94     | 60     | 39     | 36     | 34     | 32     | 29     | 27     | 25     | 22     | 20     |      |
| <b>CO</b>                       | 585    | 579    | 552    | 421    | 324    | 313    | 304    | 296    | 289    | 283    | 278    | 272    | 267    |      |

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

<sup>2</sup> EF(PM<sub>2.5</sub>) also applied for PM<sub>10</sub> and TSP (assumption: > 99% of TSP consists of PM<sub>2.5</sub>)

<sup>3</sup> estimated via a f-BCs as provided in <sup>6)</sup>, Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1

## emission factors for off-road machinery



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>1)</sup>

For lead (Pb) from leaded gasoline and corresponding TSP emissions, additional emissions are calculated from 1990 to 1997 based upon country-specific emission factors from <sup>7)</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](#) ].

## Discussion of emission trends

**NFR 1.A.4.a ii** is no key source.

++ Unregulated pollutants (NH<sub>3</sub>, HMs, POPs, ...)

[gallery size="medium" : 1A4aii\\_EM\\_NH3.PNG : 1A4aii\\_EM\\_Cd.PNG gallery](#)

For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.

++ Regulated pollutants

+++ Nitrogen oxides (NO<sub>x</sub>), Sulphur dioxide (SO<sub>2</sub>)

For all regulated pollutants, emission trends follow not only the trend in fuel consumption but also reflect the impact of fuel-quality and exhaust-emission legislation.

[gallery size="medium" : 1A4aii\\_EM\\_NOx.PNG : 1A4aii\\_EM\\_SOx.PNG gallery](#)

+++ Particulate matter (BC, PM<sub>2.5</sub>, PM<sub>10</sub>, and TSP)

Over-all PM emissions are by far dominated by emissions from diesel oil combustion with the falling trend basically following the decline in fuel consumption between 2000 and 2005. Nonetheless, the decrease of the over-all emission trend was and still is amplified by the expanding use of particle filters especially to eliminate soot emissions.

Additional contributors such as the impact of TSP emissions from the use of leaded gasoline (until 1997) have no significant effect onto over-all emission estimates.

Here, as the EF(BC) are estimated via fractions provided in <sup>8)</sup>, black carbon emissions follow the corresponding emissions of PM<sub>2.5</sub>.

[gallery size="medium" : 1A4aii\\_EM\\_PM.PNG gallery](#)

## Recalculations

**Activity data** have been revised according to revised annual NEB line 67 shares and the finalized data from the National Energy Balance 2019.

Table 5: Revised annual contribution of 1.A.4.a ii to over-all diesel oil deliveries provided in NEB line 67

|                        | 1990  | 1995  | 2000  | 2005  | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   |
|------------------------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>Submission 2021</b> | 0,070 | 0,067 | 0,070 | 0,072 | 0,065  | 0,064  | 0,062  | 0,060  | 0,058  | 0,057  | 0,058  | 0,058  | 0,057  |
| <b>Submission 2020</b> | 0,069 | 0,066 | 0,066 | 0,071 | 0,070  | 0,070  | 0,069  | 0,068  | 0,068  | 0,068  | 0,068  | 0,068  | 0,068  |
| <b>absolute change</b> | 0,001 | 0,001 | 0,003 | 0,000 | -0,005 | -0,006 | -0,007 | -0,009 | -0,010 | -0,011 | -0,010 | -0,010 | -0,011 |
| <b>relative change</b> | 0,94% | 1,48% | 5,23% | 0,54% | -7,09% | -8,62% | -10,2% | -13,0% | -14,2% | -15,6% | -14,1% | -14,8% | -15,9% |

Table 6: Revised activity data, in terajoules

|                                  | 1990   | 1995  | 2000   | 2005   | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   |
|----------------------------------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>Diesel Oil</b>                |        |       |        |        |        |        |        |        |        |        |        |        |        |
| <b>Submission 2021</b>           | 7.847  | 6.508 | 6.646  | 5.894  | 5.773  | 5.770  | 5.533  | 5.524  | 5.629  | 5.810  | 6.145  | 6.257  | 5.749  |
| <b>Submission 2020</b>           | 7.774  | 6.413 | 6.316  | 5.851  | 6.213  | 6.314  | 6.158  | 6.348  | 6.562  | 6.885  | 7.153  | 7.343  | 6.816  |
| <b>absolute change</b>           | 73,2   | 94,7  | 330    | 43,2   | -440   | -544   | -625   | -824   | -933   | -1.075 | -1.008 | -1.085 | -1.067 |
| <b>relative change</b>           | 0,94%  | 1,48% | 5,23%  | 0,74%  | -7,08% | -8,61% | -10,1% | -13,0% | -14,2% | -15,6% | -14,1% | -14,8% | -15,7% |
| <b>Biodiesel</b>                 |        |       |        |        |        |        |        |        |        |        |        |        |        |
| <b>Submission 2021</b>           | 0.00   | 0.00  | 0.00   | 377    | 443    | 403    | 390    | 328    | 346    | 318    | 326    | 334    | 334    |
| <b>Submission 2020</b>           | 0.00   | 0.00  | 0.00   | 128    | 403    | 414    | 402    | 368    | 398    | 372    | 376    | 389    | 372    |
| <b>absolute change</b>           |        |       |        | 249    | 39,6   | -11,3  | -11,6  | -40,0  | -52,0  | -54,4  | -49,9  | -55,4  | -37,7  |
| <b>relative change</b>           |        |       |        | 194%   | 9,83%  | -2,72% | -2,88% | -10,9% | -13,1% | -14,6% | -13,3% | -14,2% | -10,1% |
| <b>LPG</b>                       |        |       |        |        |        |        |        |        |        |        |        |        |        |
| <b>Submission 2021</b>           | 2.787  | 3.450 | 4.261  | 4.533  | 4.629  | 4.557  | 4.484  | 4.409  | 4.333  | 4.256  | 4.336  | 4.301  | 4.264  |
| <b>Submission 2020</b>           | 2.787  | 3.450 | 4.261  | 4.894  | 5.431  | 5.441  | 5.449  | 5.456  | 5.462  | 5.467  | 5.471  | 5.474  | 5.477  |
| <b>absolute change</b>           | 0,000  | 0,000 | 0,006  | -361   | -802   | -884   | -966   | -1.048 | -1.130 | -1.211 | -1.135 | -1.174 | -1.214 |
| <b>relative change</b>           | 0,00%  | 0,00% | 0,00%  | -7,39% | -14,8% | -16,2% | -17,7% | -19,2% | -20,7% | -22,2% | -20,7% | -21,4% | -22,2% |
| <b>over-all fuel consumption</b> |        |       |        |        |        |        |        |        |        |        |        |        |        |
| <b>Submission 2021</b>           | 10.634 | 9.958 | 10.907 | 10.803 | 10.844 | 10.729 | 10.407 | 10.261 | 10.307 | 10.383 | 10.807 | 10.892 | 10.347 |
| <b>Submission 2020</b>           | 10.561 | 9.863 | 10.577 | 10.873 | 12.047 | 12.169 | 12.009 | 12.172 | 12.422 | 12.724 | 13.000 | 13.206 | 12.665 |
| <b>absolute change</b>           | 73,2   | 94,7  | 330    | -69,6  | -1.203 | -1.439 | -1.602 | -1.911 | -2.115 | -2.341 | -2.193 | -2.314 | -2.319 |
| <b>relative change</b>           | 0,69%  | 0,96% | 3,12%  | -0,64% | -9,98% | -11,8% | -13,3% | -15,7% | -17,0% | -18,4% | -16,9% | -17,5% | -18,3% |

With all **emission factors** remaining unrevised, emission values have only been recalculated for 2017 as shown in the following table for the main pollutants.

Table 8: Recalculated emission estimates 2017, in kilotonnes

| =                 | = NH <sub>3</sub> | = NMVOC | = NO <sub>x</sub> | = PM    | = BC    | = CO    |
|-------------------|-------------------|---------|-------------------|---------|---------|---------|
| ~ Submission 2020 | > 0.00203         | > 1.195 | > 10.3            | > 0.286 | > 0.217 | > 3.099 |
| ~ Submission 2019 | > 0.00202         | > 1.193 | > 10.3            | > 0.284 | > 0.216 | > 3.084 |
| ~ absolute change | > 0.00001         | > 0.002 | > 0.02            | > 0.002 | > 0.001 | > 0.014 |
| ~ relative change | > 0.37%           | > 0.19% | > 0.17%           | > 0.58% | > 0.58% | > 0.47% |



For pollutant-specific information on recalculated emission estimates for Base Year and 2018, 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: "Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland" by (Knörr et al. (2009)) <sup>9)</sup>.

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

## Planned improvements

Besides the annual **routine revision** of **TREMOD MM**, no specific improvements are planned.

## FAQs

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

The EF provided in <sup>10)</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 metal contained in 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 and bioethanol.

---

### bibliography

: 1 : AGEb (2019): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; URL: <https://ag-energiebilanzen.de/7-0-Bilanzen-1990-2017.html>, (Aufruf: 29.11.2019), Köln & Berlin, 2019. : 2 : BAFA (2019): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl-daten für die Bundesrepublik Deutschland; URL: [https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2017\\_dezember.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2017_dezember.html), Eschborn, 2019 : 3 : Knörr et al. (2019b): Knörr, W., Heidt, C., Gores, S., & Bergk, F. (2019b): ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2018, Heidelberg, 2019. : 4 : EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook 2019, Copenhagen, 2019. : 5 : 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> : 6 : Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; URL: <https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf>, FKZ 360 16 023, Heidelberg & Zürich, 2009. bibliography

---

<sup>1)</sup> (bibcite 1)

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

<sup>3)</sup> (bibcite 3)

<sup>4)</sup> (bibcite 3)

<sup>5)</sup> (bibcite 3)

<sup>6)</sup> (bibcite 3)

<sup>7)</sup> (bibcite 3)

<sup>8)</sup> (bibcite 4)

<sup>9)</sup> (bibcite 6)

<sup>10)</sup> (bibcite 4)

<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.