

1.A.3.c - Transport: Railways

Short description

In category 1.A.3.c - Railways, emissions from fuel combustion in German railways and from the related abrasion and wear of contact line, braking systems and tyres on rails are reported.

Method	AD	EF	Key Category
T1, T2	NS, M	CS, D, M	L: TSP, PM _{2.5} , L&T: PM ₁₀ , PM _{2.5} , L: TSP

T = key source by Trend L = key source by Level

Methods	
D	Default
T1	Tier 1 / Simple Methodology *
T2	Tier 2*
T3	Tier 3 / Detailed Methodology *
C	CORINAIR
CS	Country Specific
M	Model

* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in the group specific chapters.

AD - Data Source for Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific data
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential

EF - Emission Factors	
D	Default (EMEP Guidebook)
C	Confidential
CS	Country Specific
PS	Plant Specific data
M	Model / Modelled

Germany's railway sector is undergoing a long-term modernisation process, aimed at making electricity the main energy source for rail transports. Use of electricity, instead of diesel fuel, to power locomotives has been continually increased, and electricity now provides 80% of all railway traction power. Railways' power stations for generation of traction current are allocated to the stationary component of the energy sector (1.A.1.a) and are not included in the further description that follows here. In energy input for trains of German railways, diesel fuel is the only energy source that plays a significant role apart from electric power.

Method

Activity Data

Basically, total inland deliveries of *diesel oil* are available from the National Energy Balances (NEBs) (AGEB, 2019) ¹⁾. This data is based upon sales data of the Association of the German Petroleum Industry (MWV) ²⁾. As a recent revision of MWV data on diesel oil sales for the years 2005 to 2009 has not yet been adopted to the respective NEBs, this original MWV data has been used for this five years.

Data on the consumption of biodiesel in railways is provided in the NEBs as well, from 2004 onward. But as the NEBs do not

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	
Σ 1.A.3.c	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) ⁵⁾ 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 ⁶⁾. On the other hand, constant default values from (EMEP/EEA, 2019) ⁷⁾ are used for all reported PAHs and heavy metals and from Rentz et al. (2008) ⁸⁾ 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 PM₁₀, emission estimates directly provided by the German railroad company Deutsche Bahn AG. As these original emissions are only available as of 2013, implied EF(PM₁₀) were calculated from the emission estimates extrapolated backwards from 2013 to 1990 and the transport performance data available from TREMOD. Regarding PM_{2.5}, and TSP, due to lack of better information, a fractional distribution of 0.5 : 1 : 1 (PM_{2.5}, : PM₁₀, : 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, in kg/TJ

	= 1990	= 1995	= 2000	= 2005	= 2010	= 2011	= 2012	= 2013	= 2014	= 2015	= 2016	= 2017	= 2018						
< Diesel fuels																			
NH ₃	> 0.54	> 0.54	> 0.54	> 0.54	> 0.54	> 0.54	> 0.54	> 0.54	> 0.54	> 0.54	> 0.54	> 0.54	> 0.54						
NM VOC	> 109	> 100	> 90.2	> 64.8	> 52.0	> 54.3	> 44.8	> 42.2	> 41.2	> 38.5	> 38.2	> 37.2	> 35.9						
NO _x	> 1,170	> 1,207	> 1,225	> 1,111	> 970	> 990	> 919	> 899	> 886	> 826	> 801	> 775	> 748						
SO _x	> 191	> 60.5	> 14.1	> 0.32	> 0.32	> 0.32	> 0.32	> 0.32	> 0.33	> 0.32	> 0.33	> 0.33	> 0.33						
PM ₂			> 44.4	> 43.6	> 36.6	> 23.4	> 17.7	> 18.5	> 16.0	> 14.7	> 14.3	> 13.3	> 13.1	> 12.4	> 11.8				
BC			> 28.8	> 28.3	> 23.8	> 15.2	> 11.5	> 12.0	> 10.4	> 9.55	> 9.29	> 8.65	> 8.48	> 8.05	> 7.64				
CO	> 287	> 292	> 255	> 162	> 121	> 121	> 105	> 101	> 98.9	> 94.7	> 93.3	> 92.6	> 89.6						
1																			
2																			
3																			

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

	NH ₃	NM VOC	NO _x	SO _x	PM _{2.5}	PM ₁₀	TSP	BC	CO
Hard coal	4.00	15.0	120	650	222	250	278	14.2	500
Hard coal coke	4.00	0.50	120	500	15.0	15.0	15.0	0.96	1,000

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

[gallery size="medium" : 1A3c_EM_SO2.png gallery](#)

Regarding **heavy metals**, emissions from combustion of diesel oil and from abrasion and wear are estimated from tier1 default emission factors. Therefore, the emission trends reflect the development of diesel use and - for copper, chromium and nickel emissions resulting from the abrasion & wear of contact line and braking systems - the annual transport performance (see description of activity data above).

[gallery size="medium" : 1A3c_EM_Cu.png : 1A3c_EM_Cd.png gallery](#)

Recalculations

Given the revised NEB 2018, both the **activity data** fo 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%

Due to the routine revision of the TREMOD model ¹⁰⁾, 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_x													
~ 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%
< Non-methane volatile organic compounds - NMVOC													
~ 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%

< Particulate matter - PM (PM _{2.5} , = PM ₁₀ , = TSP)													
~ 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%
< Black carbon - BC													
~ 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%
< Carbon monoxide - CO													
~ 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 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 (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)¹¹⁾.

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 ¹²⁾ 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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¹⁾ (bibcite 1)

²⁾ (bibcite 2)

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⁴⁾ (bibcite 4)

⁵⁾ (bibcite 5)

⁶⁾ (bibcite 4)

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⁹⁾ (bibcite 5)

¹⁰⁾ (bibcite 5)

¹¹⁾ (bibcite 7)

¹²⁾ (bibcite 5)