Für Mensch & Umwelt

Umwelt Bundesamt

TFEIP Meeting May 2024

Combustion & Industry Expert Panel

Kristina Juhrich

50 Jahre Umweltbundesamt 1974–2024

Welcome to the Combustion & Industry Expert Panel!

Agenda

1 **Guidebook revision 2023: Lessons learned**

2 **Requests from the C&I Community**

NMVOC emissions from engines

Fireworks

PCB reporting

3 **Heavy metals**

4 **Emissions from asphalt production (Erik Honig, NL)**

5 **COFFEE BREAK**

6 **Results on the small combustion survey (Tommi Forsberg, FI)**

7 **Methodology for estimating atmospheric emissions from residential biomass heating considering technology turnover and real utilization (Alessandro Marongiu, IT)**

8 **EDGAR results on small combustion (Manjola Banja, JRC)**

9 **17:00 END OF THE MEETING**

Guidebook revision 2023 lessons learned (1)

- **Basis for the revision was the work plan and some additional feedback from the C&I community**
- **→ only a very little feedback**

- **We received a large number of comments after publishing the draft version**

- **Please send us potential issues and ideas (be)for(e) the next revision!**

- **Feedback is also necessary if some parts of the Guidebook can be deleted: for example the LCP BAT conclusions from 2006 and medium combustion plant data in the small combustion sector: is somebody using such concentration-level-data? However, reliable conversion factors could be useful.**

Guidebook revision 2023: refinery sector

- **Actually it was planned to change the chapter during the next Guidebook revision**
- **intensive discussion with CONCAWE during the Guidebook-revision-review-phase**
- **Many Emails and calculations…**
- **As a result we changed a lot**
- **Please let us know if there are any problems with the new method**

For those who are using country-specific PRTR data please pay attention:
The PRTR change to IEP will have several impacts on the reporting facility →installation (LCP + other installation sections)
possibly some installation sections will be below the emission thresholds…

Guidebook revision 2023 lessons learned (2)

- **There are many background paper und documentations available: everybody can ask us (Carlo for the old ones and me for the documents > 2023 Guidebook version); an inclusion into the annexes would be not practical**
- **In perspective we need some kind of archiving system**
- **It would be good to have a word version of the chapters available which enables us working outside of the revision cycle**
- **We have to start earlier with the revision process using the expert panels for collecting and discussing ideas**

We invite everybody to participate in the process!

NMVOC emissions from engines

Request from Brussels Environment why NMVOC EFs for engines are remarkable higher compared to boilers

Table	Technology	Fuel	Pollutant	Value	Unit	Tier
3-30	Stationary reciprocating engines	Natural gas	NMVOC	89	g/GJ	Tier 2
3-16	Small single house boiler	Natural gas	NMVOC	1.8	g/GJ	Tier 2
3-26	Midium size boiler	Natural gas	NMVOC	0.36	g/GJ	Tier 2

Nielsen at al., 2010

- **There are always zones in the engine where fuel is not fully oxidized**
- **VOC (CH_4 + MNVOC) emissions are particularly high in lean-burn gas engines where combustion takes place with a high surplus of air**
- **rich-burn gas engines are usually equipped with an oxy-cat**
- **An oxidation catalyst can significantly reduce NMVOC emission (no relevant CH_4 reduction)**
- **A relevant NMVOC emission decrease cannot be expected by the implementation of the Medium Combustion Plant Directive**

PCB reporting (1)

Request from Poland how to deal with the different units of the Guidebook

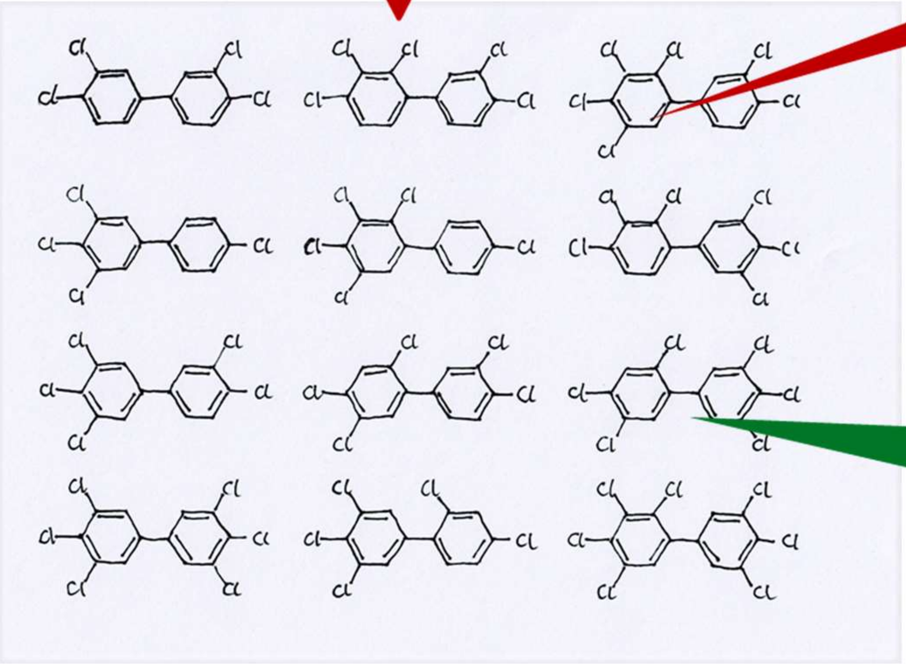
chapter	activity/fuel	value	unit	Tier	source
1.A.1.a	hard coal	3,3	ng WHO-TEQ/GJ	Tier 1	Grochowalski & Konieczynski, 2008
1.A.1.a	brown coal	3,3	ng WHO-TEQ/GJ	Tier 1	Grochowalski & Konieczynski, 2008
1.A.1.a	solid biomass	3,5	µg/GJ	Tier 1	US EPA (2003), chapter 1.6
1.A.1.a	wood/wood waste	3,5	µg/GJ	Tier 2	US EPA (2003), chapter 1.6
1.A.1.a	gas oil/ engines	0,13	ng I-TEQ/GJ	Tier 2	Nielsen et al., 2010
1.A.1.b	gas oil/ engines	0,13	ng I-TEQ/GJ	Tier 2	Nielsen et al., 2010
1.A.2	solid fuels	170	µg/GJ	Tier 1	Kakareka et al. (2004)
1.A.2	biomass	0,06	µg/GJ	Tier 1	Hedman et al. (2006)
1.A.2.f.i	cement clinker	103	µg/te clinker	Tier 2	VDZ (2011)
1.A.4.b.i	hard coal and brown coal	170	µg/GJ	Tier 1	Kakareka et al. (2004)
1.A.4.b.i	solid biomass	0,06	µg/GJ	Tier 1	Hedman et al. (2006)
1.A.4.a/c, 1.A.5.a	hard coal and brown coal	170	µg/GJ	Tier 1	Kakareka et al. (2004)
1.A.4.a/c, 1.A.5.a	solid biomass	0,06	µg/GJ	Tier 1	Hedman et al. (2006)
small combustion	same PCB Values for Tier 2				
2.C.1	Iron and steel production	2,5	mg/Mg steel	Tier 1	European Commission (2012)
2.C.1	sinter production	0,09	mg/Mg sinter	Tier 2	European Commission (2012)

PCB reporting (example waste incineration)

PCB – LAGA
sum of 28, 52, 101, 138, 153, 180 multiplied by factor 5
34 – 506 ng/m³

Ballschmiter

PCB
sum of 28, 52, 101, 138, 153, 180, 209 (internal standard)
12 – 16 ng/m³



WHO-TEQ/TEF
(Dioxin-like PCBs)

PCB – WHO 2005
sum of 77, 81, 126, 169, 105, 114, 118, 123, 156, 157, 167, 189 TEF
0,001 – 0,006 ng/m³

PCB reporting (3)

DIFFERENT DETERMINATION METHODS
AS A RESULT EMISSION FACTORS AND EMISSIONS IN A DIFFERENT ORDER OF MAGNITUDE

- **Waste incineration: 0.XY g**
- **Industrial processes: XY.XY kg**
- **Consumption of POPs: XY.XY tons**
- **Actually two PCB columns in the NFR tables would be necessary**
- **But the German legislation changed → required PCB measurement method changed to WHO-TEF maybe new EFs will be available for cement and iron and steel in a few years**
- **However, the measurement method of PCBs used in buildings and transformers cannot be changed – a reporting goes beyond the scope of the inventory**

Fireworks (2.D.3.i, 2.G Other solvent and product use):

Request from Switzerland: why emission factors from fireworks have not been updated in the Guidebook revision 2023?

Table 3-13 Tier 2 emission factor for source category 2.D.3.i, 2.G Other solvent and product use, Other, Use of Fireworks

Tier 2 emission factors						
	Code	Name				
NFR Source Category	2.D.3.i, 2.G	Other solvent and product use				
Fuel	NA					
SNAP (if applicable)	060601	Other, Use of Fireworks				
Technologies/Practices						
Region or regional conditions	European Union					
Abatement technologies						
Not applicable						
Not estimated	NH3, Se, Zn, HCH , PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB					
Pollutant	Value	Unit	95% confidence interval		Reference	
			Lower	Upper		
SO_2	3020	g/t product	1500	4500	N=2 (NNWB, 2008; Swiss IIR, 2012)	
CO	7150	g/t product	6800	7500	N=2 (NNWB, 2008; Swiss IIR, 2012)	
NO_x	260	g/t product	130	520	N=1 (Swiss IIR, 2012)	
TSP	109,830	g/t product	50,000	170,000	N=2 (Klimont et al., 2002; Swiss IIR, 2012)	
PM10	99,920	g/t product	40,000	160,000	N=2 (Klimont et al., 2002; Swiss IIR, 2012)	
PM2.5	51,940	g/t product	10,000	90,000	N=2 (Klimont et al., 2002; Swiss IIR, 2012)	
As	1.33	g/t product	0.1	13	N=1 (Passant et al., 2003)	
Cd	1.48	g/t product	0.1	14	N=2 (Passant et al., 2003; Swiss IIR, 2012)	
Cr	15.6	g/t product	0.1	150	N=1 (Passant et al., 2003)	
Cu	444	g/t product	100	2000	N=1 (Passant et al., 2003)	
Hg	0.057	g/t product	0.005	0.5	N=2 (Fyrv. Miljö, 1999, Swiss IIR, 2012)	
Ni	30	g/t product	0.6	150	N=1 (Fyrv. Miljö, 1999)	
Pb	784	g/t product	200	3000	N=2 (Passant et al., 2003; Swiss IIR, 2012)	
Zn	260	g/t product	26	2000	N=1 (Fyrv. Miljö, 1999)	

Guidebook version 2019 (2023)

Fireworks (2.D.3.i, 2.G Other solvent and product use):

According to the presentation from David Kuntze in 2021:

Article	EF_{PM10}	$EF_{PM2,5}$
	g PM_{10} / kg NEC	g $PM_{2,5}$ / kg NEC
Battery	325	281
Rocket	298	231
Fountain	200	168
Banger	213	134
Average value	**253**	**200**

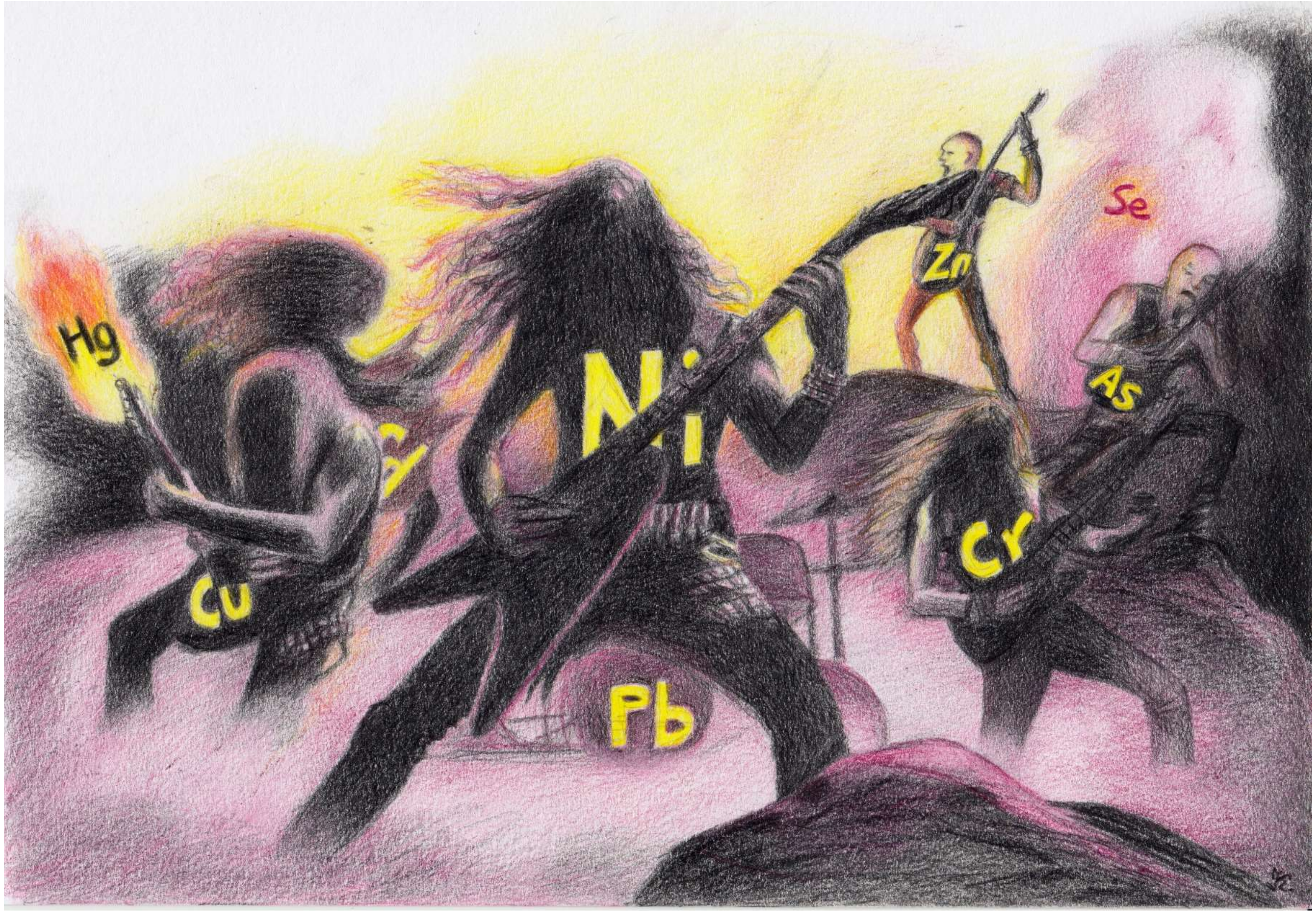
Comparison of EFs and Emissions

	EF_during year		EF_weighted_2019_new years eve		EMEP Guidebook 2019
	kg/t NEC	kg/t total mass	kg/t NEC	kg/t total mass	kg/t total mass
PM10	253	63,2	286,2	48,1	99,9
PM2.5	200	49,9	238,3	40,0	51,9

For the EF during the year Germany chose the lower „average value“. But the higher fraction as during the year fireworks of all kinds (e.g. Professional, theatrical and consumer) are used.

We have to assure the consistency with TSP, heavy metals and other pollutants.

Heavy metals



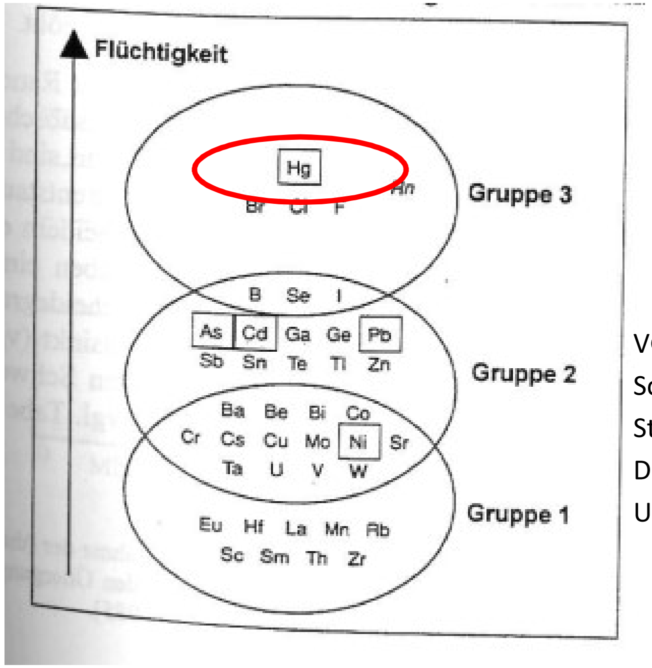
Heavy metals: overview of 1.A.1.a (coal and lignite)

TABLE 4-11. ENRICHMENT RATIOS FOR CLASSES OF ELEMENTS

Class	Description	Metals	Fly ash enrichment ratio
I	Nonvolatile	Cr, Sc, Ti, Fe	ER ≈ 1
IIa	Volatile with varying condensation on ash particles	As, Cd, Pb, Sb	ER > 4
IIb		Be, Co, Ni	2 < ER < 4
IIC		Mn	1.3 < ER ≤ 2
III	Very volatile, almost no condensation	Hg, Se	

ER = Enrichment ratio

Table 4-11: US EPA 1998
used for hard coal and lignite
All Enrichment factors are rated with E-quality



VGB 1998: „Analyse der Schwermetallströme in Steinkohlefeuerungen“
Deutsch-Französisches Institut für Umweltforschung (DFIU)

Heavy metals: US EPA calculation method

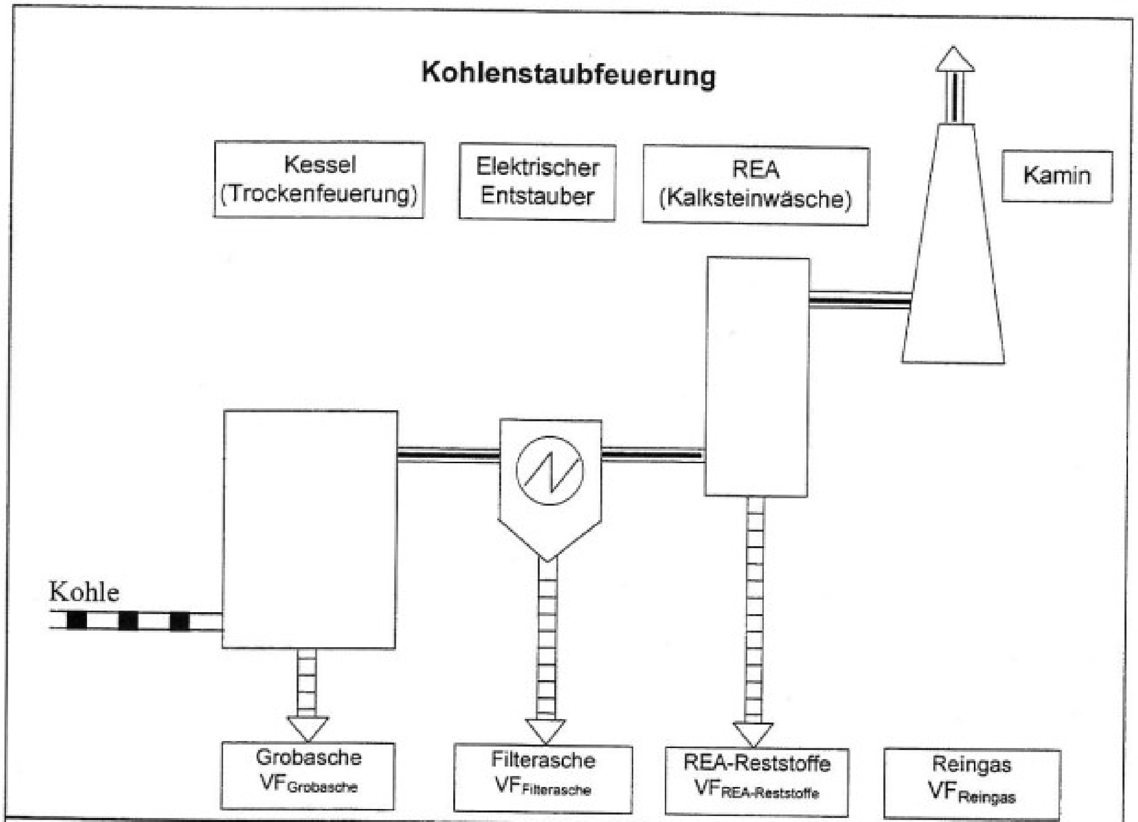
$$EF = (C/H)*F*(1-E)*ER*10^3$$

where:

- EF = emission factor for a specific trace element, ng/J
- C = concentration of element in coal, ug/g
- H = higher heating value of coal, kJ/kg
- F = fraction of coal ash as fly ash
- E = fractional particulate collection efficiency of control device, which is 0 for uncontrolled emissions
- ER = enrichment factor for the trace element (ratio of concentration of element in emitted fly ash to concentration of element in coal ash) sometimes based on Al

Heavy metals: DFIU method

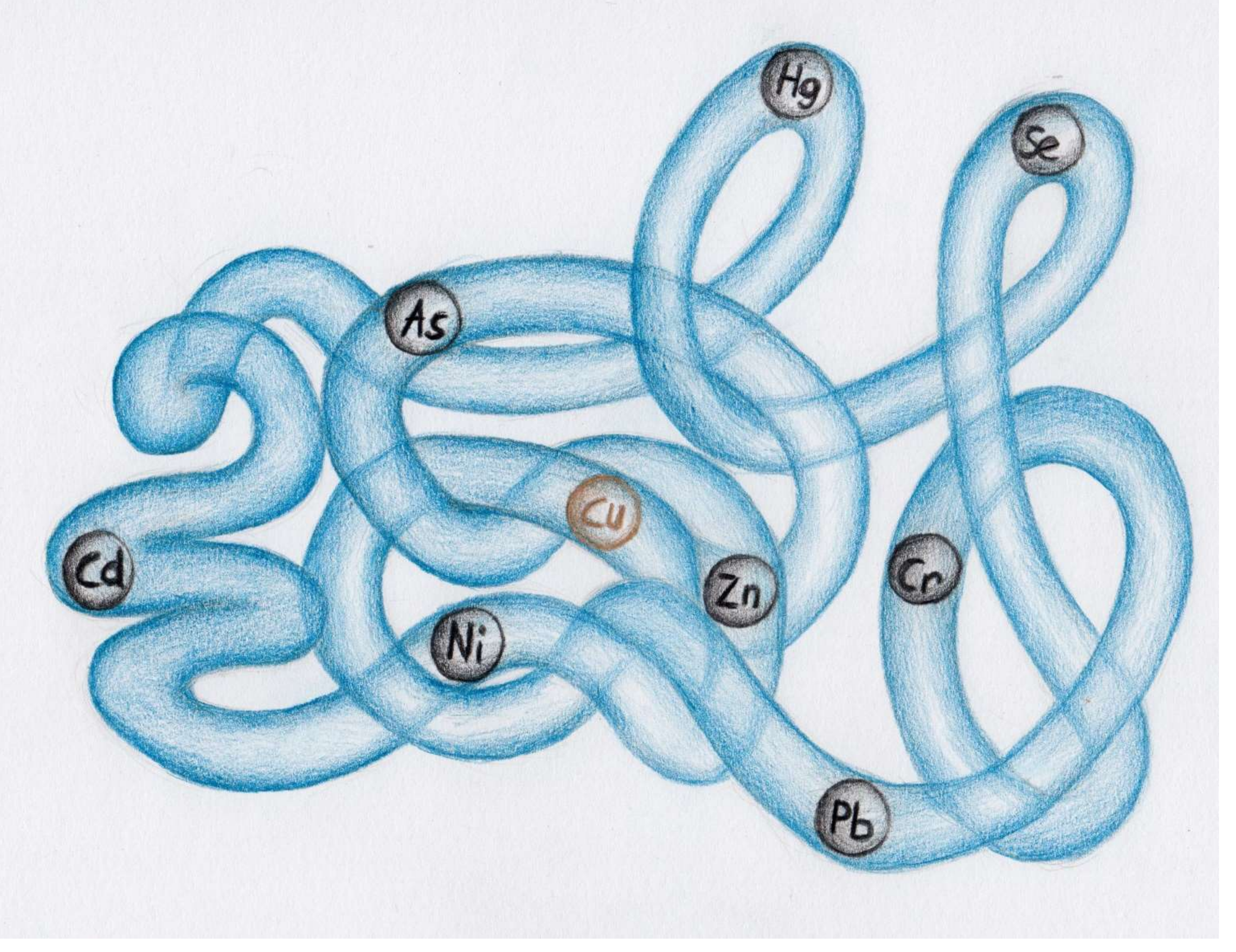
VGB 1998: „Analyse der Schwermetallströme in Steinkohlefeuerungen“
Deutsch-Französisches Institut für Umweltforschung (DFIU)



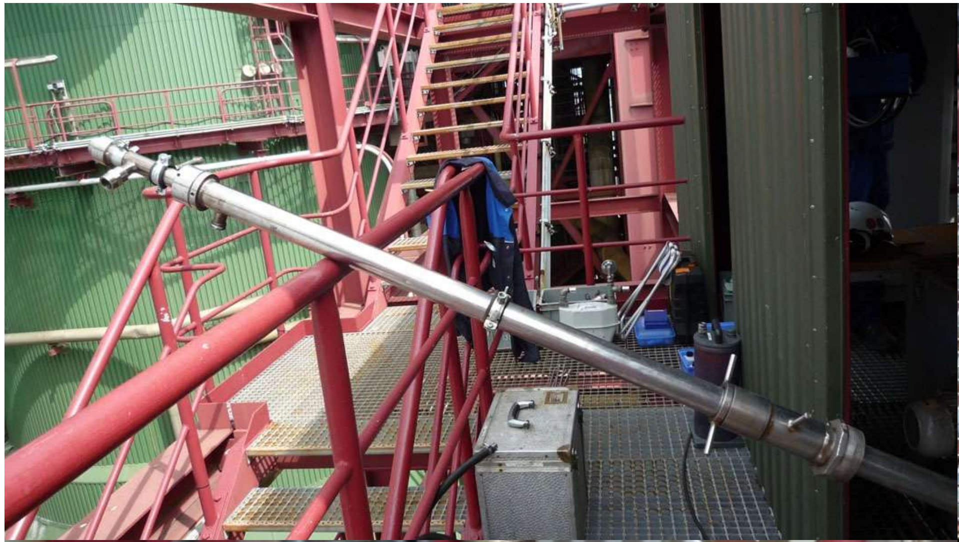
	Grobasche	Filterasche	REA-Reststoffe	Reingas
As	2,7 %	96,5 %	0,77 %	0,03 %
Cd	2,7 %	96,4 %	0,85 %	0,05 %
Ni	5,0 %	94,6 %	0,39 %	0,01 %
Pb	2,8 %	96,6 %	0,59 %	0,01 %

Abbildung 5-30: Verteilung der partikelgebundenen Schwermetallströme in einer Kohlenstaubfeuerung einschließlich Rauchgasreinigung (in Gew.-% vom Eintrag durch die Kohle; Berechnung mit der mittleren Schwermetallanreicherung)

We need a simple approach!



Evaluation of measurements from German coal fired power plants



Particle bounded Heavy metals: new emission factor method

HM emission factors as fraction of TSP: (%)

- **TSP is often measured (HMs not)**
- **Would solve problems with the emission trend**
- **There is a clear correlation between TSP and particle bounded HMs**

Particle bounded HMs: preliminary results of the new idea

Comparison between measurement data of German coal fired power plants (2019-2021) and Guidebook Emission factors from the US EPA (1998), expressed as share of TSP:

HM	dry-bottom-boiler	wet-bottom-boiler	Guidebook Tier1
Ni	0,12%	0,28%	0,04%
Pb	0,01%	0,18%	0,06%
Cr	0,03%		0,04%
Cu	0,07%		0,07%
As	0,06%	0,18%	0,06%
Cd	0,01%		0,01%
Zn	0,28%		0,17%
Hard coal			

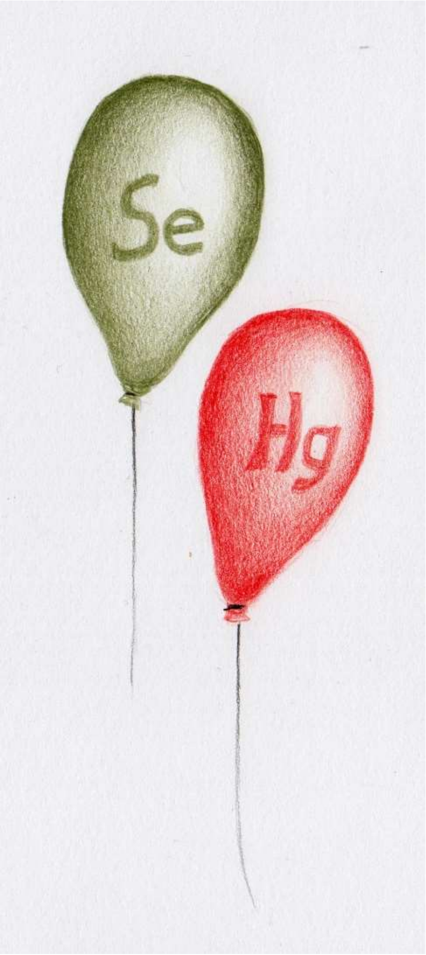
HM	region 1	region 2	region 3	fluidized-bed	Guidebook Tier1
Ni	0,08%	0,11%	0,04%	0,43%	0,08%
Pb	0,15%	0,32%	0,11%		0,13%
Cr	0,05%	0,11%	0,04%	0,53%	0,08%
Cu	0,11%	0,17%	0,06%	0,60%	0,01%
As	0,03%	0,03%	0,01%		0,12%
Cd	0,01%	0,03%	0,01%		0,02%
Zn	0,82%	0,57%	0,09%	4,13%	0,08%
Lignite					

- **Hard coal: values are almost consistent with the Guidebook (US EPA 1998)**
- **Lignite: there are discrepancies due to differences in coal quality (Pb, Cu, Zn & As)**
- **Lignite: the differences between the regions can be explained by variable coal qualities but also by different TSP emission factors (most of the plants from region 1 & region 2 have lower TSP emission factors)**

Volatile Heavy metals: modification of the existing method

No changes in the unit (still g/GJ)

- **Considering a wider range of fuel qualities**
- **For a default approach the Se and Hg content of the fuel can be used**
- **The removal efficiency of the wet flue gas desulfurization plant has to be included into the calculation method**



Volatile heavy metals

	Hard coal		Lignite		
Se	**Germany**	**US EPA**	**Germany**	**US EPA**	**unit**
95% min	0,78	16,00	0,09	32,80	g/TJ
95% max	8,41	37,30	8,32	76,50	g/TJ
mean	3,82	23,00	4,21	45,00	g/TJ

Seems to be plausible considering a high removal efficiency of the WFGD
US EPA is an appropriate Tier 1

	Hard coal		Lignite				
Hg	**Germany**	**US EPA**	**G1**	**G2**	**G3**	**US EPA**	**unit**
95% min	0,27	1,02	4,44	1,59	1,38	2,09	g/TJ
95% max	2,19	2,38	8,24	3,58	3,31	4,88	g/TJ
mean	1,06	1,40	6,02	2,62	2,08	2,90	g/TJ

US lignite quality is different and therefore not representative for the whole UNECE region

Wet flue gas desulphurization has a significant influence on Se and Hg emissions!

Removal efficiency (according to the literature):

Se: 13 – 96%, Hg: 7 – 73%

it has to be considered *somehow* in the Guidebook

Additional measures for removing mercury have to be considered country-specific. In such cases mercury is usually measured.

Heavy metals: conclusions and further steps

- **Particle-bounded HMs can be expressed as share of TSP**
- **the calculation method has to be checked for very high TSP emissions (Calculated emission factors should be always lower than the heavy metal concentration in fuels)**
- **For volatile heavy metals as a Tier 1 approach the average Se and Hg concentration in hard coal and lignite can be used (100% is emitted)**
- **For plants using wet flue gas desulphurization the removal efficiency has to be considered (as a Tier 2 approach)**
- **The plants who are using additional measures for removing mercury have to measure Hg in that cases country specific emission data is available**
- **If the new method for calculating heavy metals works, it has to be checked if it can be also used for other sectors too (in modified form)**

Umwelt Bundesamt

Thank you very much for your attention

Please contact us if there are any further questions:

kristina.juhrich@uba.de

carlo.trozzi@techne-consulting.com

Jahre
Umweltbundesamt
1974–2024

Asphalt production:

Standard VDI 2283 table 4:

Emission data from German asphalt-mixing plants with measured oxygen values (evaluation of measurement results from 2012 to 2018)

fuel	light fuel oil		natural gas		pulverized lignite	
ashalt production	without recycling material	> 40% recycling material	without recycling material	> 40% recycling material	without recycling material	> 40% recycling material
pollutant	Median in mg/m³					
TOC	29	45	22	39	18	41
CO	170	166	210	157	457	500
Benzene	0,4	0,8	0,1	1,3	0,2	0,8
Dust	3	2	3	5	4	3
SO_2	< 5	8	< 5	< 5	105	63
NO_X	43	44	25	34	199	190
O_2	15,7	14,7	14,4	15,1	15,8	14,9

9 mg/m³ benzene for wood combustion (referred to 15% O_2)

- **Heterogeneous fuel qualities**
- **Varied recycling input-rates (no recycling material used - > 80% recycling material used)**
- **Use of different techniques: cold feed process, parallel drum process…**
- **Campaign production (cannot be transported over long distances)**

- **Emission level is not relevant in Germany compared to other sources**

Wood combustion summarized questions:

- **How can we give some Guidance on the inclusion on collected wood? Share of collected wood, some examples?**
- **Surveys: What is a sufficiently large sample? How can we avoid artefacts when we start a new survey?**
- **Combustion technologies: Which information is essential? Combustion technology? Which appliance types are essential? How can we find a good compromise in the Guidebook? Do we have to update the GAINS data?**
- **How can we define various emission stages being able to describe the technological evolution?**
- **Appropriate solution for POPs and HMs, BC, NMVOC and CO, considering the correlations (PAH, NMVOC, BC + CO)**
- **How to include user impacts? Definition of “real world” and “bad combustion”? What could be a reference level of “optimized combustion”? What is the character of the current Tier 1 EFs? Do they already include bad combustion?**