Für Mensch & Umwelt

Umwelt Bundesamt

15th Expert Meeting on Data for the IPCC Emission Factor Database (EFDB)

Emission Factors for Fossil Fuels in Germany

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Section I 2.6 - Emissions Situation

With the friendly assistance of
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Basic idea of the publication

INITIAL SITUATION:

- **Thousands of measurement data available from ETS**
- **Measurement data available from different unpublished studies**
- **Results of measurement campaigns from several institutes**

A large number of high quality data but no quotable source!

IDEA:

- **Getting an overview of all data sources**
- **Providing a publication to make it available for other inventory compiler**

Emission Factor Documentation

PUBLICATION: "CO_2 EMISSION FACTORS FOR FOSSIL FUELS", UBA 2016 CONTAINS INFORMATION ON:

- **Hard coal**
- **Raw lignite**
- **Lignite products**
- **Derived gases from iron and steel**
- **Petroleum products**

Original source: measurement data ETS

- **Natural gas** → Original source: measurements DBI GUT Leipzig

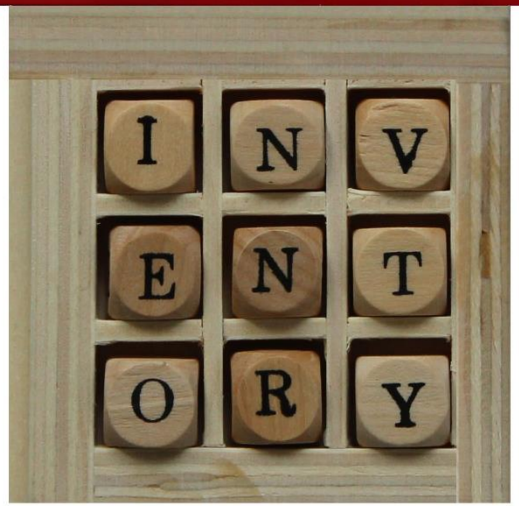
- **Brown coal briquettes** → Original source: measurements university Dresden

PUBLICATION: DFIU, KIT, EIFER "FORTSCHREIBUNG DER EMISSIONSFAKTOREN FÜR FEUERUNGS- UND GASTURBINENANLAGEN NACH13./17. BIMSCHV UND TA LUFT" PAGE 109, CALCULATED EMISSION FACTORS USING MEASUREMENT DATA FROM THE VGB POWERTECH E.V. PROJECT: „ MESSTECHNISCHE ERMITTLUNG DER CH_4- UND N_2O-EMISSIONEN VON KRAFTWERKEN"

- **N_2O and CH_4 from power plants**

Quality aspects

Data and the report where reviewed
By different experts from UBA and industrial associations:
German energy association
Coal associations
Oil association
Gas institute
Steel institute



According to the ETS regulation values have to be checked by an independent, accredited o certified evaluation body.

Measured by accredited laboratories using standard measurement methods:
Gases: DIN EN 15984, DIN 51872, DIN EN ISO 10723,
petroleum products: DIN ISO 10694, DIN EN ISO 22854, DIN 51425
coal: DIN 51721 (Radmacher-Hoverath-method), ISO 29541, DIN 51732

Measurement frequency according to ETS instructions:
Coal and liquid petroleum products: every 20 000 tons, minimum 6 times a year,
Natural gas: once a week other gases: daily measurement

German background

2014
Worlds largest lignite producer

Important hard coal user in Europe

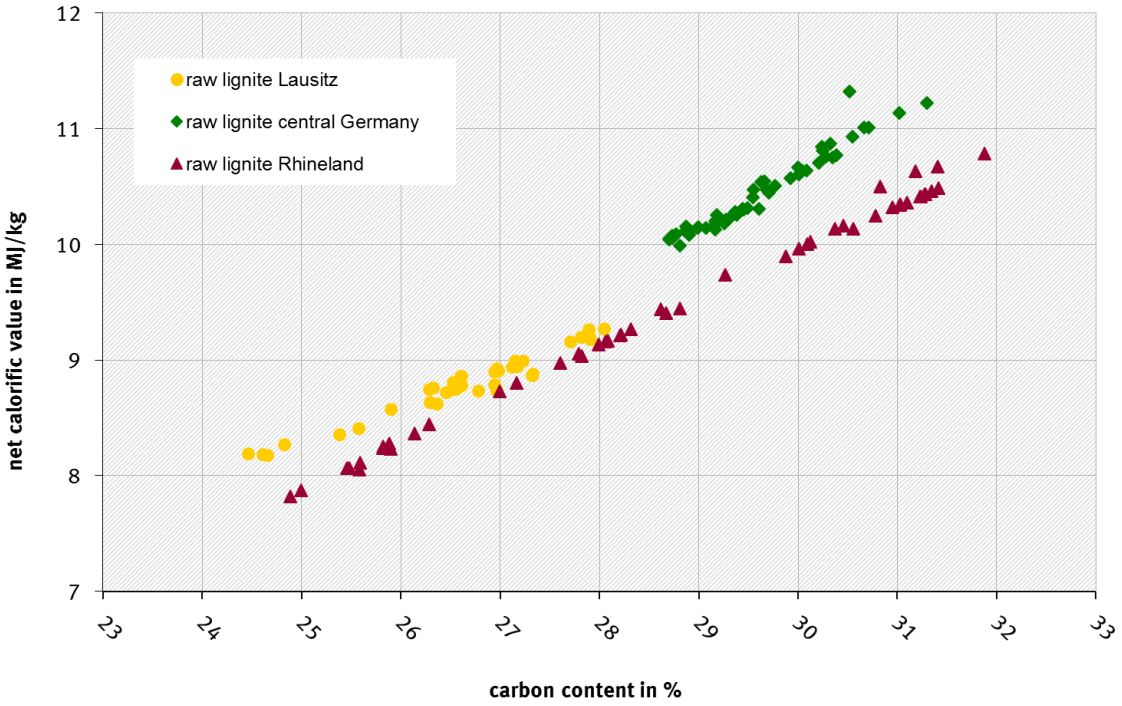
7th largest steel producer in the world

Highest refinery production in Europe

Important gas transfer

Many data for different fuel categories available!

Lignite - Evaluation of ETS data 2005 - 2014



Source: Own figure, compiled with data from DEHSt 2015

2014 values of raw lignite:

Lusatian mining district:
Sulfur content: 0.3 – 1.5%
NCV: 8.5 MJ/kg
CO_2 EF: 111.2 t/TJ

Central Germany:
Sulfur content: 1.3 – 2.3%
NCV: 10.7 MJ/kg
CO_2 EF: 102.8 t/TJ

Rhineland:
Sulfur content: 0.15 – 0.5%
NCV: 8.7 MJ/kg
CO_2 EF: 113.1 t/TJ

Default IPCC 2006 Guidelines:
Lignite: 101.0 t CO_2/TJ

Lignite products

Lignite coke:
EF: 109.6 t CO_2/TJ NCV: 29.9 MJ/kg

No default value (only hard coal coke)

Lignite dust and fluidized bed coal:
98.1 t CO_2/TJ NCV: 21.06 MJ/kg

Default value: 97.5 t CO_2/TJ

Brown coal briquettes:
Lusatian mining district:
98.5 t CO_2/TJ NCV: 20.12 MJ/kg

Rhineland district:
99.0 t CO_2/TJ

Default value: 97.5 t CO_2/TJ

Difficulties with fuel definitions according to the IPCC Guidelines

Black Lignite:
EF: 95.6 t CO_2/TJ NCV: 17.9 MJ/kg

According to the 2006 IPCC Guidelines this is Sub-Bituminous Coal, the GCV is between 17 435 kJ/kg and 23 865 kJ/kg

But in several years the GCV is < 17 435 kJ/kg
According to the 2006 IPCC Guidelines this is considered as lignite

→ **More user friendly values in the Guidelines**

Hard coal:
Coking coal: "…refers to bituminous coal with a quality that allows the production of a coke…"
other bituminous coal: "…includes all bituminous coal that is not included under coking coal…" **GCV** > 23 865 kg/TJ **on an ash-free but moist basis**

Hard coal

CO_2 EF: 93.28 t/TJ (coal regions)

Hard coal mix used in Germany 2013:
CO_2 EF: 93.36 t/TJ (weighted average)

Default EF: 94.6 t CO_2/TJ

Hard coal from:

Germany: 93.28 t/TJ

South Africa: 94.96 t/TJ

Australia: 95.06 t/TJ

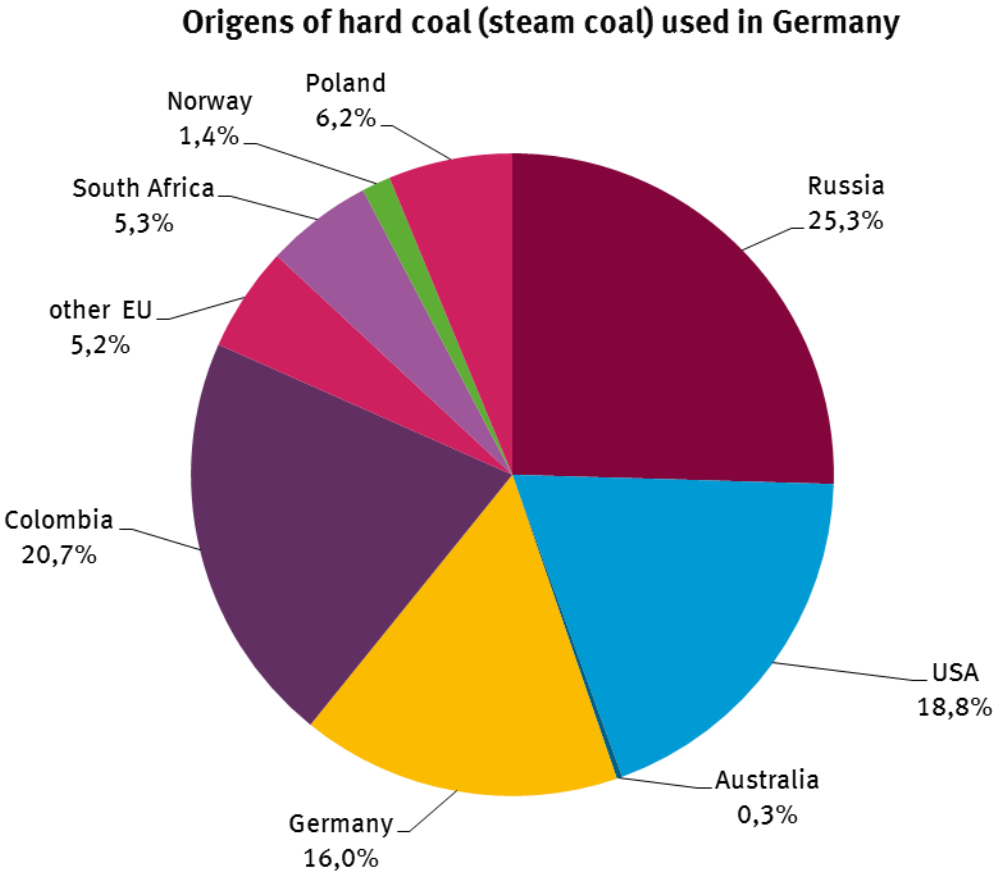
Colombia: 93.84 t/TJ

Norway: 93.43 t/TJ

Poland: 93.96 t/TJ

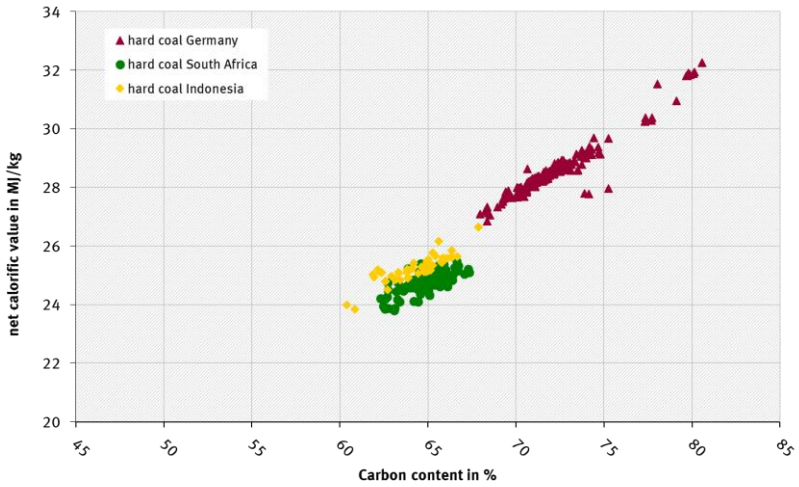
Russia: 93.02 t/TJ

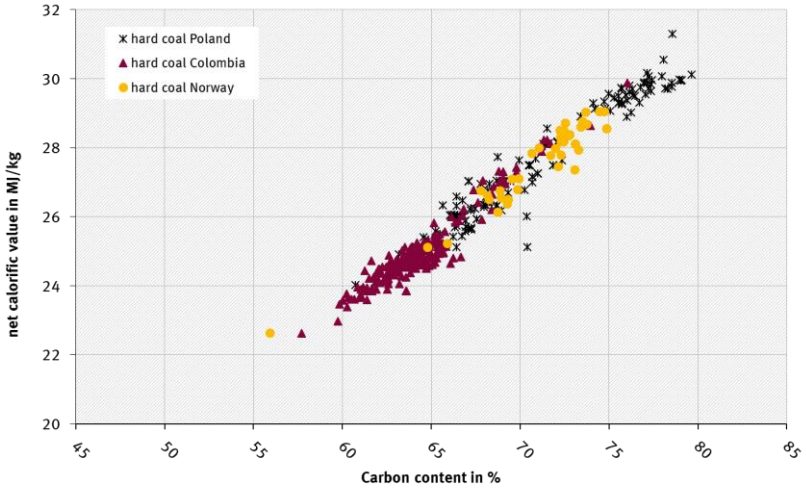
USA: 91.41 t/TJ

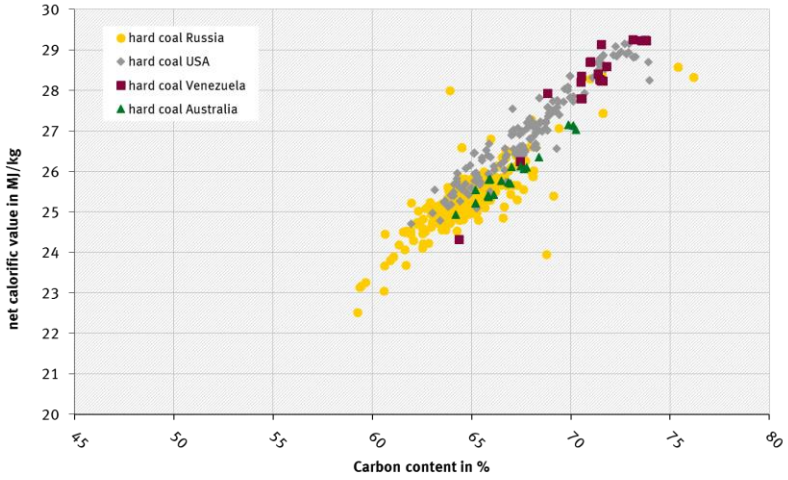


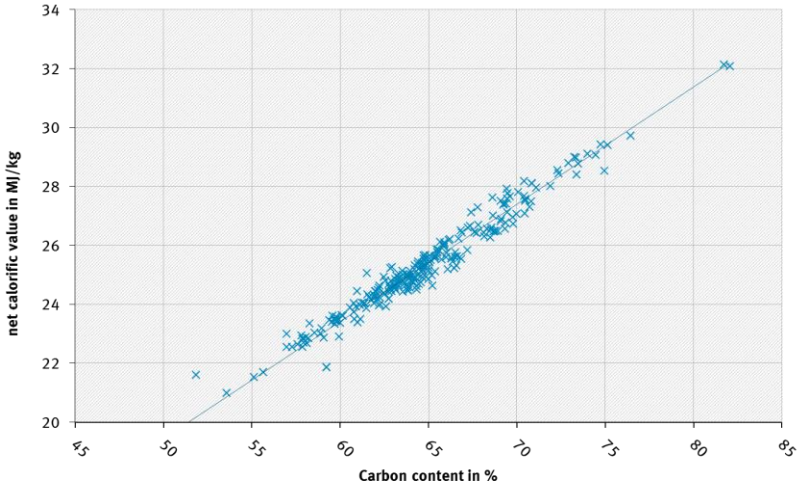
Source: VDKI 2015, AGEB 2016

Different hard coal profiles









Source: Own figures, compiled with data from DEHSt 2015

Derived gases Iron & Steel – data evaluation from ETS

Coke oven gas:
EF: 41.2 t CO_2/TJ
NCV: 16.6 MJ/m³

Default value: 44.4 t CO_2/TJ

Blast furnace gas:
EF: 261.9 t CO_2/TJ
NCV: 3.6 MJ/m³

Default value: 260.0 t CO_2/TJ

Basic oxygen furnace gas:
EF: 194.3 t CO_2/TJ
NCV: 8.3 MJ/m³

Default value: 182.0 t CO_2/TJ

Natural gas (1)

Measurement project in 2014
in order to analyze the main gas qualities from the different entry and exit points
Measured by an accredited laboratory with decade-long experience in gas measurements (DBI Gas- und Umwelttechnik GmbH)

analyzis data on natural gas (low gas)

	unit	Netherlands winter	Netherlands summer	Germany winter	Germany summer
nitrogen	Mol.-%	13,20	11,89	11,67	11,24
carbon dioxide	Mol.-%	0,91	0,73	0,77	0,53
methane	Mol.-%	82,92	85,30	85,10	86,58
ethane	Mol.-%	2,45	1,70	2,01	1,47
propane	Mol.-%	0,30	0,18	0,22	0,06
GCV	MJ/m³	35,26	35,50	35,80	35,65
NCV	MJ/m³	31,81	32,02	32,30	32,15
emission factor	t CO2 /TJ	55,90	55,63	55,76	55,41

source: DBI Leipzig 2014

Natural gas (2)

analyzis data on natural gas (high gas)

	unit	Norway winter	Norway summer	Russia winter	Russia summer
nitrogen	Mol.-%	1,15	1,18	0,83	0,67
carbon dioxide	Mol.-%	1,11	1,68	0,07	0,13
methane	Mol.-%	92,96	90,94	97,26	96,60
ethane	Mol.-%	4,10	5,09	1,39	1,97
propane	Mol.-%	0,44	0,88	0,31	0,44
GCV	MJ/m³	40,64	40,96	40,18	40,53
NCV	MJ/m³	36,68	36,98	36,23	36,56
emission factor	t CO2 /TJ	56,12	56,62	55,16	55,32

source: DBI Leipzig 2014

Gas samples from 32 measuring points in Germany
Method of sampling: DIN 51853 and DIN EN ISO 10715
Analyzes: DIN EN ISO 6975, DIN 51872-4 and DIN EN ISO 6974-6

EF (calculated by gas streams): 55.93 t CO_2/TJ EF (ETS): 55.88 t CO2/TJ
Default value: 56.1 t CO_2/TJ

Petroleum products – data evaluation from ETS

Light fuel oil (ETS):
EF: 74.02 t CO_2/TJ
NCV: 42.47 MJ/kg

Default value: 74.1 t CO_2/TJ

Heavy fuel oil:
EF: 79.8 t CO_2/TJ
NCV: 40.5 MJ/kg

Default value: 77.4 t CO_2/TJ

Liquefied petroleum gas:
EF: 65.5 t CO_2/TJ (modeled)
NCV: 45.98 MJ/kg
(mix of 60 % propane & 40 % butane known from the LPG statistic)

Default value: 63.1 t CO_2/TJ

Petroleum coke:
EF: 95.7 t CO_2/TJ
NCV: 31.7 MJ/kg

Default value: 97.5 t CO_2/TJ

Special case: “other petroleum products”

Other petroleum products (residues)
EF: 82.7 t CO_2/TJ
NCV: 38.5 MJ/kg
Data evaluation from ETS

According to the 2006 Guidelines: this is residual fuel oil – same fuel category like heavy fuel oil

In the German inventory this fuel is defined as residue from refineries, because there is no standardization

N_2O and CH_4 Emissions

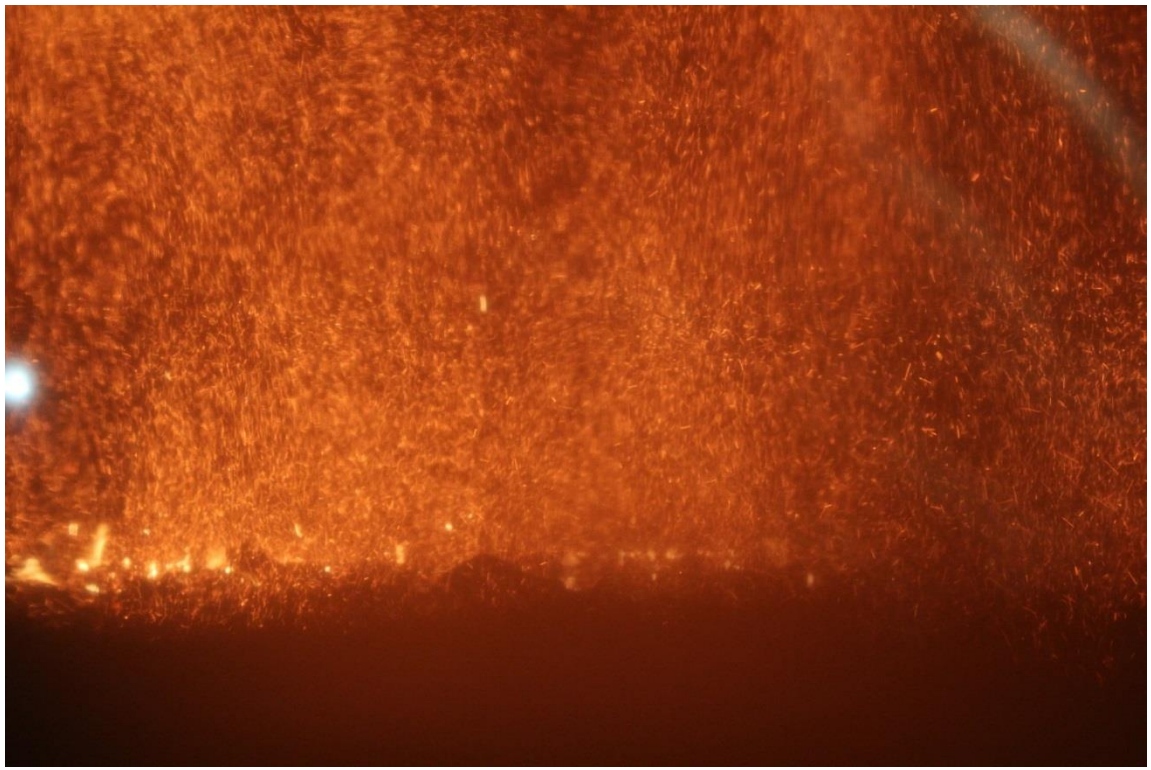
Not extremely relevant: in Germany N_2O + CH_4 equivalents of source category 1.A are just 1.3 % of all greenhouse gases from combustion processes

Nevertheless regular problems to explain why several German values are higher than the default values.

Depend on the combustion technology

- Fluidized combustion: high N_2O emissions
- Gas engines: high CH_4 emissions

- N_2O should be consistent with NOX
- CH_4 should be consistent with NMVOC



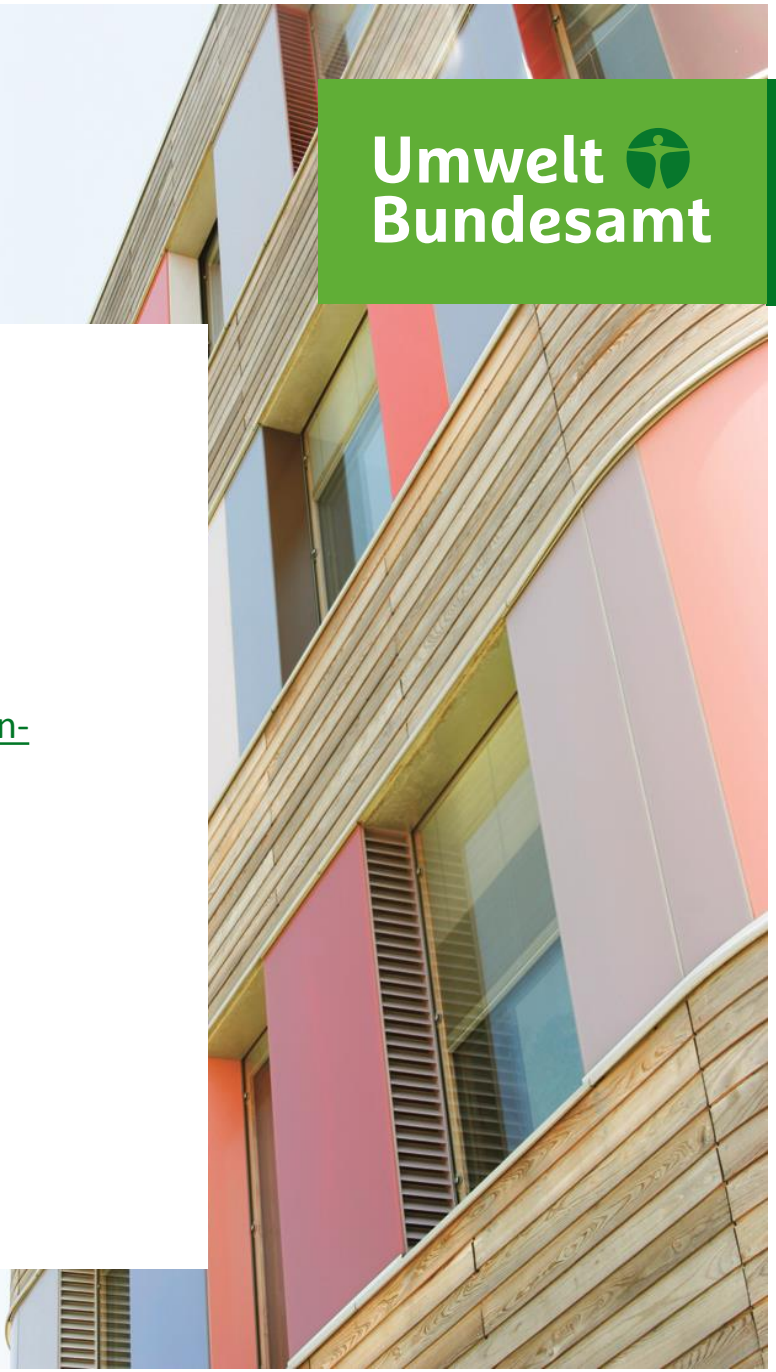
N_2O and CH_4 Emission factors (results of a measurement project)

Nitrous oxide and methane emission factors

	dust firing (hard coal)	wet bottom firing (hard coal)	dust firing (lignite)	combined-cycle gas turbine (natural gas)
	Emission factor in kg/TJ			
N2O at full load	< 1,1	0,73 - 3,3	2,5 - 4,2	< 1,7
N2O at partial load	< 1,1	0,73 - 2,55	2,5 - 3,8	< 1,7
N2O during load changes (half-hour average)	< 1,1	3,3	4,2	1,7
N2O during load changes (instantaneous value)	1,1	4,7	7,5	1,7
CH4 at full load	0,36	0,73 - 4,7	< 0,42 - 0,84	1,7 - 8,4
CH4 at partial load	0,36 - 1,1	0,36 - 4,7	< 0,42 - 0,84	8,4 - 25,2
CH4 during load changes (half-hour average)	1,1 - 4,37	4,7	1,7	25,2
CH4 during load changes (instantaneous value)	1,1	3,3	10,9	36,1

Source: [Fichtner 2011] DFIU, KIT, EIFER "Fortschreibung der Emissionsfaktoren für Feuerungs- und Gasturbinenanlagen nach13./17. BImSchV und TA Luft" page 109, table 8.1-4 calculated emission factors using measurement data from the VGB PowerTech e.V. project: „ Messtechnische Ermittlung der CH_4- und N_2O-Emissionen von Kraftwerken" (continuous measurement considering various load conditions)

Also available: N_2O EF of a lignite fired fluidized combustion plant (annual average, continuously measured) of: 11.08 kg/TJ [Fichtner 2011] page 108, table 8.1-1



Thank you very much for your attention

The report is available at UBA website:

https://www.umweltbundesamt.de/publikationen/co2-emission-factors-for-fossil-fuels

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