

Air Emissions from Stationary Fuel Combustion

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- Methodology
- Energy statistics
- EMEP/EEA Guidebook
- Example calculation

Key categories

- Key categories are emissions sources which contribute to 80% of total national emissions
- Trend assessment
- Definition of category
 - Use of NFR sub-categories is sometimes too detailed
 - E.g. Road transport could be aggregated to one category (1.A.3.b)
- Higher „Tier“ methods should be used for key categories

Allocation of emissions

- Emissions are allocated to sources where the emissions occur
- Emissions from electricity or district heat production are allocated to power plants (NFR 1 A 1 a) and not to end consumers (industry, households).

Type of emission sources

- Area sources are sources where many installations are to be considered without knowledge of location but only on the base of fuel or housing statistics
 - Small combustion activities in residential/commercial/agricultural sector with a typical size of up to 350 kW_{th}
 - Smaller manufacturing industry facilities/power plant boilers <20 to 50 MW_{th}
 - Transport
- Point sources
 - IPPC (integrated pollution prevention and control) provides capacity thresholds
 - Typically boilers > 50 MW_{th}. At least boilers >= 300 MW_{th} should be considered as point source
 - Integrated iron and steel plants
 - Refineries
 - Other ... (cement, lime, glass)
- When combining area with point sources double counting must be avoided
 - Fuel input must be known for point sources

Methodologies for area sources

- EMEP/EEA air pollutant emission inventory guidebook (GB)
- Different Tier methods
- Tier 1
 - Multiply statistical data with default emission factors from GB
 - High uncertainty
 - Don't use for key categories
- Tier 2
 - Consider different technologies
 - Optional: Use of country specific emission factors
- Tier 3
 - Calculation models (e.g. transport model)

Tier 1 method

Use default emission factors from guidebook and multiply with activity rate. Emissions from a specific source, fuel, pollutant and year the following formula are calculated:

$$E_{\text{Source,Fuel,Pollutant,Year}} = AR_{\text{Source,Fuel,Year}} \times EF_{\text{Source,Fuel,Pollutant}}$$

E.....emissions [kg]

AR...activity rate =fuel consumption [TJ]

EF....emission factor [kg/TJ]

For fuel combustion activities the activity rate is always the fuel input.

Tier 2 method (1)

The tier 2 method needs fuel consumption by **technology** and emissions factors which are related to the **technology**.

$$E_{\text{Source,Fuel,Pollutant,Year}} = \sum_{\text{Technology}} (AR_{\text{Source,Fuel,Technology,Year}} \times EF_{\text{Source,Fuel,Technology,Pollutant}})$$

For each technology the fuel consumption must be known.

Tier 2 method (2)

Technologies are mostly related to specific categories, e.g.:

- Residential heating – solid biomass
 - Central heating
 - Fire places

- Electricity production – natural gas
 - Gas boilers
 - Gas turbines

Technologies may consider primary or secondary abatement technologies, e.g.:

- Low-NO_x burners (Primary)
- Flue gas cleaning (Secondary)

Use of energy statistics - Units

- In general energy statistics provides data in the unit of
 - Tons: solid and liquid fuels (coal, oil products, biomass)
 - 1000 Nm³ or TJ: Gaseous fuels (natural gas)
- International publications sometimes use ktoe (kilo tonne of oil equivalent).
 - 1ktoe = 41,868 TJ
- Unit conversion
 - All units should be converted to GJ or TJ NCV (Net calorific values).
 - To make energy carriers comparable.
 - For reporting of activity data.
 - Heating values: TJ/kt, TJ/Mio Nm³

Energy statistics (1)

- All members of the International Energy Agency (IEA) have to report energy statistics at a yearly basis.
- Energy statistics does not provide fuel combustion by technologies which is needed for Tier 2 methods.
- For fuel combustion the following aggregates have to be considered:
 - Final energy consumption
 - Transformation input (avoid double counting !)
 - Own use of energy industries
- The following aggregates are not considered:
 - Non energy use
 - Statistical differences
 - Losses

Energy statistics (2)

When taking data from energy statistics double counting has to be avoided, especially for:

- **Coke ovens**

 - Transformation input = coking coal

 - Transformation output = coke + coke oven gas

- **Blast furnaces**

 - Transformation input = coke

 - Transformation output = blast furnace gas

- **Refineries**

 - Transformation input = crude oil

 - Transformation output = oil products + refinery gas and other residuals

Energy statistics (3)

- Energy statistics may be in conflict with other bottom up data which are collected by environment agencies such as:
 - Large combustion plants (LCP directive)
 - Emissions trading
 - E-PRTR
- To avoid such conflicts it is good practice to exchange data with energy statistic institute.

Energy statistics (4)

- For final consumption the IEA energy statistics shows enough details for all NFR fuel combustion sub categories to be reported, e.g, subcategories of 1.A.1, 1.A.2, 1.A.4
- For transport 1.A.3 usually a model and other (vehicle, transport) statistics are used to estimate emissions for the different vehicle types.

EUROSTAT/IEA Joint Questionnaires (1)

- Join Questionnaires (JQ) include time series from 1990 on.
- One JQ for each of
 - Natural gas (in TJ on **gross basis**) -> must be converted into net CV.
 - Oil (1000 t)
 - Coal (1000 t)
 - Electricity (GWh) and heat (TJ)
 - Renewables and waste (in TJ)
- The structure is slightly different between the JQs.
- Gas, oil and coal: JQs include net calorific heating values.
- Consumption of industrial autoproducers is not reported by sector

EUROSTAT/IEA Joint Questionnaires (2)

Example for
residual fuel oil
(1000 tons)

Flow	2005	2006	2007	2008	2009
Transformation Sector	585	539	492	441	331
Main Activity Producer Electricity Plants	79	91	73	66	40
Autoproducer Electricity Plants	3	3	0	1	0
Main Activity Producer CHP Plants	179	159	99	95	106
Autoproducer CHP Plants	9	7	5	4	8
Main Activity Producer Heat Plants	81	52	42	49	57
Autoproducer Heat Plants	0	0	0	0	0
Gas Works (Transformation)	0	0	0	0	0
For Blended Natural Gas	0	0	0	0	0
Coke Ovens (Transformation)	0	0	0	0	0
Blast Furnaces (Transformation)	234	227	273	226	120
Petrochemical Industry	0	0	0	0	0
Patent Fuel Plants (Transformation)	0	0	0	0	0
Non-specified (Transformation)	0	0	0	0	0
Energy Sector	0	0	0	0	0
Coal Mines	0	0	0	0	0
Oil and Gas Extraction	0	0	0	0	0
Coke Ovens (Energy)	0	0	0	0	0
Blast Furnaces (Energy)	0	0	0	0	0
Gas Works (Energy)	0	0	0	0	0
Own Use in Electricity, CHP and Heat Plants	0	0	0	0	0
Non-specified (Energy)	0	0	0	0	0
Distribution Losses	0	0	0	0	0
Total Final Consumption	481	550	379	338	336
Transport Sector	0	0	0	0	0
Industry Sector	263	260	220	215	256
Iron and Steel	15	16	6	28	66
Chemical (including Petrochemical)	13	11	13	14	17
Non-Ferrous Metals	6	6	5	5	4
Non-Metallic Minerals	45	46	49	49	48

Census data (residential)

- National census may be used to elaborate the different technologies applied in household heatings together with fuel consumption.
- Collecting of census data is expensive and quality of reporting is questionable. Face to face interviews are better than telephone interviews but much more expensive.
- Other data used for validation
 - Housing statistics
 - Heating degree days
- Biomass consumption has a rather high uncertainty

Use of point source data

- Using continuous measurements from large point sources (LPS), e.g. data from LCP-Directive (boilers ≥ 50 MW) double counting as well as omission must be considered.
- When using emissions from LPS for the emissions inventory the fuel consumption should be known.

Process emissions

- Doublecounting with process emissions should be avoided, especially for:
 - Cement clinker kilns
 - Lime kilns
 - Glass furnaces

SO₂ emissions

- SO₂ emissions are in general estimated by using the Sulphur-content of a fuel.
- The sulphur which remains in the ash must be subtracted
- Fuel gas desulphurisation must be considered (usually large plants)

$$EF\ SO_2 = [S] \times 20,000 / CVNet$$

EF SO₂ = SO₂ emission factor (g/GJ)

[S] = sulphur content of the fuel (% w/w)

CVNet = Net calorific value (GJ/tonne)

EMEP/EEA EI Guidebook (1)

Example for tier 1 emission factors (source: GB).

Table 3-3 Tier 1 emission factors for source category 1.A.1.a using hard coal

Tier 1 default emission factors					
	Code	Name			
NFR Source Category	1.A.1.a	Public electricity and heat production			
Fuel	Hard Coal				
Not estimated	NH ₃ , Benzo(b)fluoranthene, Benzo(k)fluoranthene				
Not applicable	Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCP, SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NO _x	310	g/GJ	70	700	US EPA 1998, chapter 1.1; average of bituminous coal combustion techniques
CO	150	g/GJ	5.8	1000	US EPA 1998, chapter 1.1; average of bituminous coal combustion techniques
NM VOC	1.2	g/GJ	0.6	2.4	US EPA 1998, chapter 1.1
SO _x	820	g/GJ	300	5000	See note
TSP	30	g/GJ	3.0	300	US EPA 1998, chapter 1.1
PM ₁₀	20	g/GJ	2.0	200	US EPA 1998, chapter 1.1
PM _{2.5}	9	g/GJ	0.9	90	US EPA 1998, chapter 1.1

EMEP/EEA EI Guidebook (2)

Example for tier 2 emission factors (source: GB).

Table 3-11 Tier 2 emission factors for source category 1.A.1.a, dry bottom boilers using coking coal, steam coal and sub-bituminous coal

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.A.1.a	Public electricity and heat production			
Fuel	Coking Coal, Steam Coal & Sub-Bituminous Coal				
SNAP (if applicable)					
Technologies/Practices	Dry Bottom Boilers				
Region or regional condition	NA				
Abatement technologies	NA				
Not estimated	NH ₃ , Benzo(b)fluoranthene, Benzo(k)fluoranthene				
Not applicable	Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCP, SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NO _x	324	g/GJ	200	350	US EPA 1998, chapter 1.1
CO	10	g/GJ	6	15	US EPA 1998, chapter 1.1
NMVOG	1.2	g/GJ	0.6	2.4	US EPA 1998, chapter 1.1
SO _x	820	g/GJ	330	5000	See note
TSP	30	g/GJ	3	300	US EPA 1998, chapter 1.1
PM ₁₀	20	g/GJ	2	200	US EPA 1998, chapter 1.1
PM _{2.5}	9	g/GJ	0.9	90	US EPA 1998, chapter 1.1

Tier 1 - Example

Calculate NO_x emissions (Gg) from hard coal combustion in residential heatings (NFR 1.A.4.b.i) for the year y.

From energy statistics we need

- AR ...Activity rate => Fuel consumption (1000 t) for a specific year
- NCV ...Heating value (MJ/kg) for a specific year

From the guidebook we need

- EF_{NOX}...Tier 1 emission factor (g/GJ)

$$E_{\text{NOX}} = \text{AR} * \text{NCV} * \text{EF}_{\text{NOX}}$$

$$E_{\text{NOX}} = 10\,000 \text{ kt} * 28.5 \text{ MJ/kg} * 110 \text{ g/GJ}$$

$$E_{\text{NOX}} = 10 * 10^6 \text{ t} * 28.5 \text{ GJ/t} * 110 \text{ g/GJ} = 3.135 * 10^{10} \text{ g} = \boxed{31.35 \text{ Gg NO}_x}$$

Austrian Experience

- Tier 1 methods are (in general) not applied because „We know it better“.
- Tier 2 methods are accepted but because they are applied for key sources (e.g. residential heatings) there is a discussion about uncertainty.
- Higher tier methods indicate higher work load in documentation and justification.
- Models (Transport) are accepted but still suspicious because hard to follow (low transparency).
- Industry: The integration or comparison of LCP, ETS and E-PRTR data with the inventory „works“.

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