SNAP CODE:	**010101 & 010102** **010201 & 010202** **010301** **010401** **010501 & 010502** **020101 & 020102** **020201** **020301** **020302** **030101 & 030102**
SOURCE ACTIVITY TITLE:	COMBUSTION IN ENERGY & TRANSFORMATION INDUSTRIES ***Particulate emissions from large Combustion Plants (>50MWth)***
NOSE CODE:	**101.01** **101.02**
NFR CODE:	**1 A 1 a,b,c** **1 A 2 a-f** **1 A 4 b,c,i**
ISIC	**3510**

1 ACTIVITIES INCLUDED

This Supplement, to be read in conjunction with the existing Chapter B111, covers emissions of particulate matter (PM) released from combustion processes within the energy and transformation industries in boilers and furnaces larger than 50 MWth. This Supplement includes guidance on estimating total PM (TSP), PM_{10} and $PM_{2.5}$ emissions from these sources. Emissions of other pollutants from this sector are provided in chapter B111.

2 CONTRIBUTION TO TOTAL EMISSION

The contributions of PM_{10} and $PM_{2.5}$ emissions released from combustion in large combustion plant to total emissions in countries of the CORINAIR90 inventory is presented in Table 2.1.

Table 2.1 Contribution to total particulate matter emissions from 2004 EMEP database (WEBDAB)

NFR Sector	Data	PM_{10}	$PM_{2.5}$	TSP
1 A 1 a - Public Electricity and Heat Production[a]	No. of countries reporting	26	26	27
	Lowest Value	0.2%	0.2%	0.2%
	Typical Contribution	11.7%	10.1%	12.8%
	Highest Value	48.8%	47.8%	48.4%
1 A 2 - Manufacturing Industries and Construction[b]	No. of countries reporting	26	26	26
	Lowest Value	0.7%	0.6%	0.6%
	Typical Contribution	9.0%	9.5%	7.9%
	Highest Value	20.7%	22.1%	25.7%
1 A 4 a - Commercial / Institutional[c]	No. of countries reporting	23	23	23
	Lowest Value	0.1%	0.1%	0.1%
	Typical Contribution	3.9%	3.4%	4.5%
	Highest Value	19.3%	22.2%	29.5%
1 A 4 b - Residential[d]	No. of countries reporting	3	2	3
	Lowest Value	2.0%	6.5%	3.7%
	Typical Contribution	14.9%	26.2%	10.8%
	Highest Value	36.6%	45.8%	15.4%
1 A 4 b i - Residential plants[e]	No. of countries reporting	23	23	23
	Lowest Value	2.7%	5.8%	0.8%
	Typical Contribution	28.3%	33.1%	22.0%
	Highest Value	67.1%	74.6%	53.2%
1 A 5 a - Other, Stationary (including Military)[f]	No. of countries reporting	7	7	7
	Lowest Value	0.0%	0.0%	0.0%
	Typical Contribution	0.1%	0.1%	0.1%
	Highest Value	0.5%	0.4%	0.6%

[a] Includes contribution from Chapter 112

[b] Includes contributions from Chapter 112 and 316 (SNAP 030106)

[c] Includes contribution from Chapter 112 and 216 (SNAP 020205)

[d] Includes contribution from Chapter 810

[e] Includes contribution from Chapter 112

[f] Includes contribution from Chapter 112 and 216 (SNAP 020106)

3 GENERAL

3.1 Description

This chapter considers emissions of PM generated by boilers larger than 50 MWth. Other emissions from this source category are considered in B111.

3.2 Definitions

See B111.

3.3 Techniques

See B111 for information on boiler types and fuels. Combustion of coal and other solid fuels present the main source for primary PM emissions.

3.4 Emissions

Particulate emissions result from activities such as storage of fuels; on site transportation of solid fuel; combustion of fuels, transport, storage and disposal of combustion residues including furnace bottom ash, fly ash and, abatement residues.

Combustion of fuels will generate solid residues which may be deposited in the combustion chamber (furnace bottom ash), within the furnace, boiler surfaces or ducting (fly ash). Coal and other fuels with a significant ash content have the highest potential to emit PM. Suspended ash material in exhaust gases will be retained by particulate abatement or other emission abatement equipment (abatement residues). Material which remains in the flue gases beyond the abatement equipment and passes to the atmosphere is primary PM. Secondary PM is formed by chemical and physical processes after discharge to atmosphere and is NOT considered here.

3.5 Controls

Particulate emission reduction is usually achieved using abatement equipment. Electrostatic precipitators (ESPs) and fabric filters (FFs) are widely used on boilers. Cyclones (particularly multicyclones) can be found on smaller grate-fired boilers. Most pulverised coal fired power station boilers use ESPs although fabric filters are becoming more common. Flue gas desulphurisation (FGD) plant can also help reduce particulate emissions from pulverised coal-fired boilers. Wet limestone FGD systems retrofitted to existing plant are generally located downstream of existing ESPs and can provide a further stage of PM reduction. Dry lime injection FGD systems incorporate a FF for sorbent capture and PM removal.

Fabric filters are capable of achieving higher emission reductions than electrostatic precipitators but both are suitable[1] for the sector and can achieve PM emission concentrations of 5 - 30 mg/m^3.

4 SIMPLER METHODOLOGY

Emissions can be estimated at different levels of complexity; it is useful to think in terms of three tiers[2]:

[1] Either technology is considered part of Best Available Techniques (BAT) under EU Integrated Pollution Prevention and Control regulations.

[2] The term "Tier" is used in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and adopted here for easy reference and to promote methodological harmonization.

Tier 1: a method using readily available statistical data on the intensity of processes ("activity rates") and default emission factors. These emission factors assume a linear relation between the intensity of the process and the resulting emissions. The Tier 1 default emission factors also assume an average or typical process description.

Tier 2: is similar to Tier 1 but uses more specific emission factors developed on the basis of knowledge of the types of processes and specific process conditions that apply in the country for which the inventory is being developed.

Tier 3: is any method that goes beyond the above methods. These might include the use of more detailed activity information, specific abatement strategies or other relevant technical information.

By moving from a lower to a higher Tier it is expected that the resulting emission estimate will be more precise and will have a lower uncertainty. Higher Tier methods will need more input data and therefore will require more effort to implement.

The Tier 1 simpler methodology, where limited information is available, uses a restricted set of default emission factors together with production capacity information specific to the country or region of interest; there is little or no specification of the type of industrial technologies or the type and efficiency of control equipment in place. The Tier 2 approach, in addition, requires an approximation of the mix of technologies in place, and more detailed activity data, but still allows the use of default sector or technology factors.

Consequently the simplest methodology (Tier 1) is to combine an activity rate (AR) with a comparable, representative, value of the emissions per unit activity, the emission factors (EF). The basic equation is:

$$\text{Emission} = AR \times EF$$

In the energy sector, for example, fuel consumption would be the measure of activity and mass of material emitted per unit of fuel consumed would be a compatible emission factor.

NOTE: The basic equation may be modified, in some circumstances, to include emission reduction efficiency (abatement factors).

The Tier 2 methodology is a modified version of this basic equation:

$$\text{Emission} = \sum((AR_1 \times EF_1) + (AR_2 \times EF_2) + \ldots .(AR_n \times EF_n))$$

Default emission factors for this purpose are provided in Sections 8.1 and 8.2.

5 DETAILED METHODOLOGY

The detailed methodology (equivalent to Tier 3) to estimate emissions of pollutants from combustion plant >50 MW_{th} is based on measurements or estimations using plant specific emission factors - guidance on determining plant specific emission factors is given in Measurement Protocol Annex.

In many countries, operators of combustion plant >50MWth will report emissions to comply with regulatory requirements and this data can be used to help compile the national inventory.

The recommended detailed methodology to estimate emissions of PM from combustion activities is based on measurements and/or estimations using technology-specific emission factors.

Information on the type of the process and activity data, for example combustion and abatement technologies, is required to assign appropriate emission factors.

Reference emission factors for comparison with users' own data are provided in Section 8.2.

6 ACTIVITY STATISTICS

Activity statistics for energy consumption or other relevant national activity data for estimating emissions using the simpler estimation methodology (Tiers 1 and 2) are available from national statistics.

The detailed methodology (Tier 3) requires more detailed information such as the amount and types of fuel consumed within individual combustion plant or industry sectors. These data are not always easily available although in many countries operators do report fuel use for emission trading or other legislative requirements.

Further guidance is provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 2 on energy, Chapter 1.

7 POINT SOURCE CRITERIA

Large combustion plants are regarded as point sources if plant specific data are available.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Default Emission Factors For Use With Simpler Methodology (Tier 1)

Fuel	Technology	Emission factor, g GJ^{-1}			Notes[3]
		TSP	PM_{10}	$PM_{2.5}$	
Hard coal, (assumes 20% ash) Brown coal, Other solid fuels	Pulverised coal, ESP	30	20	9	Based on AP 42 - assumes 20% ash content and PM emissions from solid mineral fuels generally similar to coal
	Pulverised coal, fluid bed, other FF	7.4	7.4	3.7	
	Cyclone furnace, ESP	6.1	4.2	2.3	
	Stoker with multicyclone	330	230	27	
	Pulverised coal ESP + wet limestone FGD	6	6	5	From CEPMEIP data (US EPA default factors for wet scrubbers are very high)
Natural gas		0.9	0.9	0.9	AP-42 filterable PM factor
Derived gases		5	5	5	CEPMEIP data, worst case for derived gases.
Heavy fuel oil (1% S)	No control	25	18	13	Assumes 1% sulphur as specified in the EU Sulphur content of liquid fuels Directive
	FGD	1.5	1.5	1.5	
Heavy fuel oil (3% S)	No control	64	45	33	Assumes 3% sulphur (maximum permitted in EU countries)
	FGD	3.8	3.8	3.7	
Other liquid fuels	LPG	2.0	2.0	2.0	
Biomass	FF	51	38	33	AP 42 Wood waste
	ESP	28	21	18	

The information provided in Section 8.2 provides further information for selection of more appropriate emission factors.

8.2 Reference Emission Factors For Use With Tier 2 Methodology

Tables 8.2a-z contain reference particulate emission factors for fuel combustion in various technologies with different types of abatement.

[3] Source: R. Stewart (2006); US EPA AP 42 (1996); CEPMEIP (2006)

Table 8.2a Emission factors for combustion processes burning hard coal.

Fuel	NAPFUE	NFR Codes	Activity description	Activity detail[4]	Emission factor $g.GJ^{-1}$			Notes[5]
Hard coal					**TSP**	**PM_{10}**	**$PM_{2.5}$**	
Bit. Coal	101	Various	Electricity plant, CHP plant	FGD, ESP or FF <20 $mg.Nm^{-3}$ (BAT)	6	6	5	CEPMEIP
				ESP (or FF) <50 $mg.Nm^{-3}$ (LCPD)	15	12	6	Scaled from CEPMEIP ESP factor
				ESP <100 $mg.Nm^{-3}$ (LCPD)	30	25	12	From CEPMEIP sub-bit coal 'high efficiency ESP', TSP scaled to the EU LCP Directive existing plant sub $100MW_{th}$ limit
				ESP Old/conventional <500 mg. Nm^{-3}	140	70	17	CEPMEIP
				Large unit with multicyclone	100	60	35	CEPMEIP
				Large unit, uncontrolled or cyclone	500	250	100	CEPMEIP (N.B. such a high emission concentration would apply to few if any plant)
Sub-bituminous coal	103	Various	Electricity plant, CHP plant, heat plant	FGD, ESP or FF <20 $mg.Nm^{-3}$ (BAT)	6	6	5	CEPMEIP
				ESP (or FF) <50 $mg.Nm^{-3}$ (LCPD)	15	12	6	Scaled from CEPMEIP ESP factor
				ESP <100 $mg.Nm^{-3}$ (LCPD)	30	25	12	From CEPMEIP sub-bit coal 'high efficiency ESP', TSP scaled to LCPD existing plant sub $100MW_{th}$ limit

[4] KEY: FGD: Flue gas desulphurisation, ESP: Electrostatic Precipitator, FF: Fabric Filter, BAT: Best Available Techniques, LCPD: Large Combustion Plant Data
[5] Sources: R. Stewart (2006); US EPA AP 42 (1996); CEPMEIP (2006)

Fuel	NAPFUE	NFR Codes	Activity description	Activity detail[4]	Emission factor g.GJ^{-1}			Notes[5]
				ESP Old/conventional <500 mg. Nm^{-3}	140	70	17	CEPMEIP
				Conventional large unit with multicyclone	100	60	35	CEPMEIP
				Conventional unit, uncontrolled or cyclone	500	250	100	CEPMEIP (N.B. such a high emission concentration would apply to few if any plant)
Coke	107							Coke is unlikely to be burned as primary fuel, when co-fired use the factor for the principal fuel.

Table 8.2b Emission factors for combustion processes burning brown coal.

Fuel	NAPFUE	NFR Code	Activity description	Activity detail	Emission factor			Reference/Comments
					TSP	PM_{10}	$PM_{2.5}$	
Brown coal	105	Various	Electricity plant, CHP plant, heat plant	FGD, ESP or FF <20 mg.Nm^{-3} (BAT)	9	8	6	CEPMEIP
				High efficiency ESP (or FF)	40	30	14	CEPMEIP (N.B. such a high emission concentration would apply to few if any plant)
				Conventional large unit with multicyclone	100	60	35	CEPMEIP (N.B. such a high emission concentration would apply to few if any plant)
				Older ESP	160	80	20	CEPMEIP (N.B. such a high emission concentration would apply to few if any plant)
				Older installation	500	250	100	CEPMEIP (N.B. such a high

Fuel	NAPFUE	NFR Code	Activity description	Activity detail	Emission factor			Reference/Comments
				uncontrolled or cyclone				emission concentration would apply to few if any plant)
Peat	113	Various	Electricity plant, CHP plant, heat plant	BAT/new LCPD, Modern end-of-pipe abatement FGD, ESP or FF. <30 mg.Nm3	9	8	6	CEPMEIP
				Efficient abatement LCP larger facility, <50 mg.Nm3	20	15	10	TSP Scaled from LCP emission limit of 50 $mg.Nm^{-3}$
				Efficient abatement LCP <100 MW_{th}, <100mg.Nm3	40	30	20	TSP Scaled from LCP emission limit of 50 $mg.Nm^{-3}$
				Conventional technology	120	40	20	CEPMEIP
				Conventional smaller, multicyclone	300	40	20	CEPMEIP

Table 8.2c Emission factors for combustion processes burning other solid fuels

Fuel	NAPFUE	NFR Code	Activity description	Activity detail	Emission factor			Reference
					TSP	PM_{10}	$PM_{2.5}$	
Municipal solid waste	114	Various	Electricity plant, CHP plant, heating plant	Effective emission control (BAT)	15	13	10	CEPMEIP, (N.B. care should be taken using this factor as waste burning is often controlled under national/international regulation to a more stringent specification)
(Solid)				Conventional emission control	100	70	55	CEPMEIP (uncontrolled. optimised combustion), (N.B. care should be taken using this factor as waste burning is often controlled under national/international regulation to a more stringent specification)
Ind. waste	115	Various	Electricity, CHP, heating plant	Effective emission control (BAT)	15	13	10	CEPMEIP, (N.B. care should be taken using this factor as waste burning is often controlled under national/international regulation to a more stringent specification)
				Conventional emission control	100	70	55	CEPMEIP (uncontrolled, optimised combustion), (N.B. care should be taken using this factor as waste burning is often controlled under national/international regulation to a more stringent specification)

Table 8.2d Emission factors for combustion processes burning natural gas.

Fuel (IPCC Cat)	NAPFUE	NFR Code	Activity description	Activity detail	Emission factor			Reference
					TSP	PM_{10}	$PM_{2.5}$	
Natural gas	301	Various	Electricity, CHP and heating plant	Burner with optimised combustion	0.1	0.1	0.1	CEPMEIP
				Conventional installation	0.2	0.2	0.2	CEPMEIP
				Conventional installation	0.9	0.9	0.9	USEPA AP-42 filterable PM (all PM stated to be PM_1)

Table 8.2e Emission factors for combustion of derived gases.

Fuel (IPCC Cat)	NAPFUE	NFR Code	Activity description	Activity detail	Emission factor			Reference
					TSP	PM_{10}	$PM_{2.5}$	
Gas works gas	311	Various	Electricity, CHP and heating plant	Clean fuel, efficient combustion	0.1	0.1	0.1	CEPMEIP
				Clean fuel, Conventional installation	0.2	0.2	0.2	CEPMEIP (conventional installation)
				Conventional installation	5	5	5	CEPMEIP. (N.B. High PM due to fuel quality)
Other gaseous	314	Various	Electricity, CHP and heating plant	Clean fuel, efficient combustion	0.1	0.1	0.1	CEPMEIP

Fuel (IPCC Cat)	**NAPFUE**	**NFR Code**	**Activity description**	**Activity detail**	**Emission factor**			**Reference**
fuel								
				Conventional installation	5	5	5	CEPMEIP
Coke oven gas	304	Various	Electricity, CHP heating plant, coke ovens	Clean fuel, efficient combustion	0.1	0.1	0.1	CEPMEIP
				Clean fuel, conventional installation	0.2	0.2	0.2	CEPMEIP (conventional installation)
				Conventional installation	5	5	5	CEPMEIP.
Blast furnace gas	305	Various	Electricity, CHP and heating plant, coke ovens	Clean fuel, efficient combustion	0.1	0.1	0.1	CEPMEIP
				Clean fuel, Conventional installation	0.2	0.2	0.2	CEPMEIP (conventional installation)
				Conventional installation	5	5	5	CEPMEIP.

Table 8.2f Emission factors for combustion of heavy fuel oil.

Fuel (IPCC Cat)	NAPFUE	NFR Code	Activity description	Activity detail	Emission factor			Reference
					TSP	**PM_{10}**	**$PM_{2.5}$**	
Residual fuel oil	203	Various	Electricity, CHP and heating plant	Low S fuel with optimised burner or abatement	3	3	2.5	CEPMEIP (equivalent to about 10 mg.Nm3 or BAT)
				Low S fuel, efficient combustion	14	12	10	CEPMEIP. About 50 mg.Nm3 (EU LCPD limit for existing plant)
				Low-Medium S fuel, conventional installation	20	15	9	CEPMEIP (equivalent. to about 70 mg.Nm3.
				Low-Medium S fuel, conventional installation	60	50	40	CEPMEIP, the higher of two entries used about 200 mg.Nm3
				High S fuel	210	190	130	CEPMEIP, the lower of two entries for high S used. (N.B. such a high emission concentration 750 mg.Nm3 would apply to few if any plant)
Petroleum coke	110	1 A 1 b	Oil refineries	Conventional, multicyclone	100	60	35	CEPMEIP, N.B the factor is very high compared to the EU LCP Directive ELVs and BAT for large furnaces. Bit Coal factors more appropriate.

Table 8.2g Emission factors for combustion of other liquid fuels.

Fuel (IPCC Cat)	NAPFUE	NFR Code	Activity description	Activity detail	Emission factor			Reference
					TSP	PM_{10}	$PM_{2.5}$	
Gas/Diesel oil	205	Various	Electricity, CHP, heating plant	Optimised burner	2	2	2	CEPMEIP
				Conventional burner	5	5	5	CEPMEIP
Naphtha	210	1 A 1 b	Oil refineries	All units	5	5	5	CEPMEIP
Liquefied Petroleum gas	303	Various	Electricity, CHP, heating plant	Optimised burner	0.1	0.1	0.1	CEPMEIP
				Conventional burner	5	5	5	CEPMEIP
Refinery gas	308	Various	Electricity, CHP, heating plant	Optimised burner	0.1	0.1	0.1	CEPMEIP
				Conventional burner	5	5	5	CEPMEIP
Other oil	224	Various	Electricity, CHP, heating plant	Low S fuel, optimised burner	3	3	2.5	CEPMEIP
				Low S fuel, efficient combustion	14	12	10	CEPMEIP for residual oil. About 50 mg.Nm3 (LCPD limit for existing plant)
				Low-Medium S fuel, conventional installation	20	15	9	CEPMEIP (equiv. to about 70 mg.Nm3.
				Low-Medium S fuel, conventional installation	60	50	40	CEPMEIP (highest of similar entries with TSP of 35, 40, 50 and 60 used. About 200 $mg.Nm^{-3}$)

Fuel (IPCC Cat)	NAPFUE	NFR Code	Activity description	Activity detail	Emission factor			Reference
					TSP	PM_{10}	$PM_{2.5}$	
				High S fuel	210	190	130	CEPMEIP, lower of two entries for high S used. (N.B. this is a very high emission concentration ~750 mg.Nm3)

Table 8.2h Emission factors for combustion of biomass

Fuel (IPCC Cat)	NAPFUE	NFR Code	Activity description	Activity detail	Emission factor			Reference
					TSP	PM_{10}	$PM_{2.5}$	
Wood	111	Various	Electricity, CHP, heating plant	Modern, BAT unit <20 mg.Nm3 TSP	7	7	6	TSP scaled from BAT benchmark, fractions applied based on Bit coal
				Older unit, <100 mg.Nm3 TSP	35	25	12	TSP scaled from emission concentration, fractions based on bit coal
				Uncontrolled conventional	100	70	55	CEPMEIP (equiv. To an uncontrolled multicyclone)
Charcoal	112	1 A 2 c	Chemicals	Conventional large unit with multicyclone	100	60	35	CEPMEIP (N.B. the use of charcoal in LCP is likely to be rare.
Black liquour	215	1 A 2 f	Textile & leather (Pulp and Paper ?)	Conventional installation	160	150	150	CEPMEIP (N.B. such a high emission concentration would apply to few if any plant)

Fuel (IPCC Cat)	**NAPFUE**	**NFR Code**	**Activity description**	**Activity detail**	**Emission factor**			**Reference**
					TSP	**PM_{10}**	**$PM_{2.5}$**	
Biogas	309	Various	Electricity, CHP, heating plant	Modern optimised large installation	3	3	2.5	CEPMEIP (cleaned fuel)
				Conventional burner	5	5	5	CEPMEIP
				Modern, optimised	20	15	10	CEPMEIP (gasification plant), *seems high for gaseous fuel*
				Conventional installation	*160*	*150*	*150*	CEPMEIP (N.B. such a high emission concentration would apply to few if any plant)

8.3 Measured Emission Factors for consideration in Tier 3 Methodology

Annex 1 lists measurement derived PM emission factor data typical of that required for a tier 3 approach for large combustion plant – see also Section 15.

9 SPECIES PROFILES

The US EPA (2003) undertook a review of species profiles within $PM_{2.5}$ and reports particle size distribution data for a variety of fuels and combustion and abatement technologies. Some of these data are dated and have high uncertainty ratings. Profiles of other materials are not available.

Table 8.2j US EPA (2003) $PM_{2.5}$ species profiles

Profile ref	Profile name	Component				
		POA	PEC	GSO4	PNO3	Other
22002	Residual Oil Combustion	0.1075	0.0869	0.5504	0.0005	0.2547
22003	Distillate Oil Combustion	0.0384	0.0770	0.3217	0.0024	0.5605
22004	Natural Gas Combustion	0.6000	0.0000	0.2000	0.0055	0.1945
22007	Liquid Waste Combustion	0.0540	0.1050	0.0680	0.0000	0.7730
22009	Solid Waste Combustion	0.0068	0.0350	0.0680	0.0000	0.8902
NCOAL	Coal Combustion	0.20	0.01	0.16	0.005	0.625
NWWAS	Wood Waste Boiler	0.39	0.14	0.08	0	0.39

Notes:
POA - Primary organic aerosol derived from organic carbon
PEC - Elemental Carbon
GSO4 - Sulphate
PNO3 - Nitrate
Other – Remainder of $PM_{2.5}$ material emitted.

Note that the data for the coal combustion and other profiles are derived from dilution tunnel measurements and may not be directly comparable with primary $PM_{2.5}$.

10 UNCERTAINTY ESTIMATES

The overall 'Uncertainty' in national emission inventories may be significant – as illustrated in Table 9.1.

Table 9.1 Uncertainty estimate for selected pollutants in the UK air emission inventory (NAEI, 2005).

Pollutant	Estimated Uncertainty (%)
PM_{10}	-20 to +50
$PM_{2.5}$	-20 to +30
$PM_{1.0}$	-10 to +20
$PM_{0.1}$	+/- 10
Sulphur Dioxide	+/- 3
Oxides of Nitrogen	+/- 8
NMVOCs	+/- 10
Ammonia	+/- 20

There is uncertainty in both the aggregated emission factors and activity data used to estimate emissions i.e. the imprecision and error to be expected from the application of an 'average' emission factor or activity statistic to estimate emissions from a specific sector - an artificial grouping of 'similar' sources.

The uncertainty is partly the result of how emission factors are developed and applied. In the case of primary particulate matter, the expanded statistical uncertainty is made up of: between plant variance, within plant variance, and uncertainties associated with the measurement methodology used and the aggregation of data. The measurement data in Annex 1 illustrates the variability in emission factors that occurs from between plant variance.

Process measurements, from which emission factors are developed at individual facility level, are subject to both systematic and random errors in the determination of mass concentration, mass emission, size distribution, and analytical errors etc.

In addition bias may exist in emission factors arising from:

1. Assumptions made about the abatement used on 'typical' industrial installations. For example emission factors 'age', the factors widely used in the Guidebook and hence by many countries as default emission factors in their national inventories become out of date. Recent measurement work suggests that they may overestimate emissions from the industrial processes subject to more modern industrial emissions regulation. They may, however, still be fully representative for older plant, small plant, or for poorer fuels;
2. Assumptions about the relationship between TSP and PM10/$PM_{2.5}$. The technical literature is comprehensive for TSP and the data quality can be good if measurements have been made using the international standard methods that are available (typically the 95% confidence limit ~10%). But a variety of methods are used for particle size fractionation and as yet there are no harmonised international standards to ensure comparability. Published measurement data for PM10 is sparse, that for $PM_{2.5}$ emissions more so. An added complication is that the methodology for the

determination of TSP differs from that of PM10 and $PM_{2.5}$ and so the two need not correlate directly.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The stack emission factors described in the Guidebook, and all the PM_{10} emission factors, are based whenever possible on measurements. Particle measurements have often been made on the mass of total particulate matter and then converted to PM_{10} based either on the size distribution of the sample collected or, more usually, on size distributions given in the literature. There may be secondary sources of particulate matter, that are diffuse or fugitive in nature e.g. emissions from coke ovens, stockpiles, ash handling etc. These emissions are difficult to measure and in some cases it is likely that no entirely satisfactory measurements have ever been made, in many cases estimates of emissions from such sources are missing.

There is very little published data suitable for emission inventory compilation. I.e. representative data of known quality relating a) quantities of (particulate) material released to b) the activity associated with the release of that pollutant. Suitable data and associated information would record the determination of mass emissions rates using standardized measurement methods or calculation-based methods. Ideally such methods would cover the planning and execution of the data collection programme including: the selection of sampling methodology, choice of equipment, suitable working procedures, the calculation of representative emissions rates, the selection of matching activity data, the determination of sampling/measurement uncertainty, and the reporting of information in a form that is suitable for calculating emissions factors.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Combustion plants should be considered as point sources if plant specific data are available. Otherwise national emissions should be disaggregated on the basis of plant capacity, employment or population statistics.

13 TEMPORAL DISAGGREGATION CRITERIA

Combustion processes can be considered as a continuous process however individual combustion plant may have daily and/or seasonal temporal profiles.

14 ADDITIONAL COMMENTS

See chapter B111.

15 SUPPLEMENTARY DOCUMENTS

Digest of UK Energy Statistics

Recommendations for the Update and Improvement of Existing $PM_{2.5}$ Split Factors – Note from Pacific Environmental Services to US EPA 29 September 2003

IIASA RAINS data

16 VERIFICATION PROCESSES

The applicability of the emission factors quoted, in Section 8 above, for use with highly regulated plant may be verified using the measurement data listed in Annex 1.

17 REFERENCES

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ANNEX 1A – SUMMARY OF RECENT MEASURED PM_{10} DATA ON COMBUSTION SOURCES

Combustion Type	Process	Size indication	Fuel	Abatement Measures	PM_{10} Emission Factor or concentration	Units	Source[6]	CEPMEIP Factor	CEPMEIP Units
Coal	Combustion Plant	180 MW	dry brown coal	ESP horizontal, scrubber	1.44	g/GJ	LAU	30.00	g/GJ
		146 MW	brown coal briquette, Limestone	ESP horizontal, drying desulphurisation	1.35	g/GJ	LAU		g/GJ
		119 MW	raw brown coal	ESP horizontal, desulph., NOx removal	6.13	g/GJ	LAU	30.00	g/GJ
		1000MW	hard coal	ESP, desulphurisation, NOx removal	0.33	g/GJ	LAU	25.00	g/GJ
		1000MW	hard coal	ESP, desulphurisation, NOx removal	0.30	g/GJ	LAU	25.00	g/GJ
		-	sub-bituminous coal	ESP	11.00	mg/MJ	NRCAN	25.00	g/GJ
		-	lignite	ESP	1.80	mg/MJ	NRCAN	30.00	g/GJ
		-	75% lignite/25% bituminous	ESP	1.10	mg/MJ	NRCAN		
		120 MW	Powdercoal	ESP	51.30	mg/Nm3	VITO	70.00	g/GJ
		-	lignite	Fabric filter, desulphurisation	0.1	mg/m3	TESO	8.00	g/GJ

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Combustion Type	Process	Size indication	Fuel	Abatement Measures	PM_{10} Emission Factor or concentration	Units	Source[6]	CEPMEIP Factor	CEPMEIP Units
				system					
		-	lignite	ESP, desulphurisation system	1.3	mg/m3	TESO	30.00	g/GJ
		-	hard coal	Fabric filter	7.5	mg/m3	TESO	6.00	g/GJ
		-	lignite	ESP, desulphurisation system	0.4	mg/m3	TESO	30.00	g/GJ
	Dry Bottom Ash Furnace	-	hard coal	ESP	24.4	mg/m3	TESO	25.00	
		-	lignite	ESP, desulphurisation system	1.5	mg/m3	TESO	30.00	g/GJ
		-	lignite, heavy fuel oil	ESP, desulphurisation system, fabric filter	0.2	mg/m3	TESO		
		-	lignite	ESP, desulphurisation system	14.9	mg/m3	TESO	80.00	g/GJ
		-	hard coal	ESP	0.2	mg/m3	TESO	25.00	g/GJ
		-	hard coal	Fabric filter	0.8	mg/m3	TESO	6.00	g/GJ
		-	hard coal	Fabric filter	0.2	mg/m3	TESO	6.00	g/GJ
		-	coal	ESP	1.5	mg/m3	TESO	25.00	g/GJ
	Grate and Dry Bottom Ash Furnace	-	lignite	ESP, desulphurisation system	1.2	mg/m3	TESO	80.00	g/GJ
	Grate Boiler	-	hard coal	Fabric Filter	0.7	mg/m3	TESO	6.00	g/GJ
	Grate Firing	-	lignite	ESP	6.8	mg/m3	TESO	30.00	g/GJ
	Boiler for Pulverised Solid Fuel	-	hard coal, light fuel oil	ESP	22.8	mg/m3	TESO		
		-	hard coal, lignite	ESP, desulphurisation	6.3	mg/m3	TESO	25.00	g/GJ

Combustion Type	Process	Size indication	Fuel	Abatement Measures	PM_{10} Emission Factor or concentration	Units	Source[6]	CEPMEIP Factor	CEPMEIP Units
				system					
		-	lignite	ESP, desulphurisation system	1.9	mg/m3	TESO	30.00	g/GJ
		-	lignite	ESP, desulphurisation system	4.2	mg/m3	TESO	30.00	g/GJ
		-	hard coal	Fabric filter	0.1	mg/m3	TESO	6.00	g/GJ
	Fluidised bed boiler	-	lignite	ESP, desulphurisation system, fabric filter	2.5	mg/m3	TESO	8.00	g/GJ
		-	lignite	Fabric filter, desulphurisation system	0.9	mg/m3	TESO	8.00	g/GJ
		-	hard coal, blast furnace gas	ESP	0.2	mg/m3	TESO		
		-	hard coal, blast furnace gas	ESP	0.4	mg/m3	TESO		
		-	hard coal, coke oven gas, blast furnace gas	ESP	4.3	mg/m3	TESO		
	Combustion Plant	10 MW	heavy oil	additive	12.33	g/GJ	LAU	15.00	g/GJ
		10 MW	heavy oil	additive	12.95	g/GJ	LAU	15.00	g/GJ
		10 MW	heavy oil, urea	additive, SNCR	15.29	g/GJ	LAU	15.00	g/GJ
		10 MW	heavy oil, urea	additive, SNCR	18.04	g/GJ	LAU	15.00	g/GJ
		20 t/h steam	heavy oil	SNCR	1.86	g/GJ	LAU	3.00	g/GJ
		270 MW	heavy oil	NOx removal	5.75	g/GJ	LAU	3.00	g/GJ
		270 MW	heavy oil	additive, NOx removal	4.49	g/GJ	LAU	3.00	g/GJ
		270 MW	heavy oil	NOx removal	4.79	g/GJ	LAU	3.00	g/GJ
		270 MW	heavy oil	additive, NOx removal	4.65	g/GJ	LAU	3.00	g/GJ

Combustion Type	Process	Size indication	Fuel	Abatement Measures	PM_{10} Emission Factor or concentration	Units	Source[6]	CEPMEIP Factor	CEPMEIP Units
		-	residual oil	-	29.00	mg/MJ	NRCAN	20.00	g/GJ
		-	heavy fuel oil, natural gas	-	6.80	mg/m3	TESO		
		-	heavy fuel oil, gas fuels	-	15.30	mg/m3	TESO		
	Combustion Plant	1.4 MW	saw chips, saw dust	cyclone	100.37	g/GJ	LAU	70.00	g/GJ
		1.4 MW	saw chips, saw dust	cyclone	75.87	g/GJ	LAU	70.00	g/GJ
		0.8 MW	saw chips, saw dust	cyclone	102.81	g/GJ	LAU	70.00	g/GJ
		3 MW	hogged wood	cyclone	96.32	g/GJ	LAU	70.00	g/GJ
		2.3 MW	rest of chipboards	multicyclone	119.09	g/GJ	LAU	70.00	g/GJ
		1.1 MW	piece of wood, saw chips	cyclone	131.93	g/GJ	LAU	70.00	g/GJ
		2 MW	hogged wood, wood waste	ESP	21.41	g/GJ	LAU	70.00	g/GJ
		7.9-9.5 MW	wood, wood chips	ESP	7.53	g/GJ	LAU	70.00	g/GJ
		7.9-9.5 MW	natural gas, wood, wood chips	ESP	7.41	g/GJ	LAU	70.00	g/GJ
		15 MW	hogged wood, rest wood, wood chips	ESP	3.22	g/GJ	LAU	70.00	g/GJ
		1.5 MW	hogged wood	chimney gas condensation, multi-cyclone	17.30	g/GJ	LAU	70.00	g/GJ
		1.5 MW	hogged wood	chimney gas condensation, multi-cyclone	21.05	g/GJ	LAU	70.00	g/GJ
		31 t/h steam	matured wood	cyclone, fabric	4.72	g/GJ	LAU	70.00	g/GJ

Combustion Type	**Process**	**Size indication**	**Fuel**	**Abatement Measures**	**PM_{10} Emission Factor or concentration**	**Units**	**Source**[6]	**CEPMEIP Factor**	**CEPMEIP Units**
				filter, NO_x removal					
	Grate Boiler		bark, natural gas	ESP	4.90	mg/m3	TESO		
Waste	hazardous waste incineration plant	-	hazardous waste	fabric filter, desulphurisation system	10.30	mg/m3	TESO		
	waste incineration plant	-	municipal solid waste	ESP, desulphurisation system	0.90	mg/m3	TESO	100.00	g/tonne
	home heating boiler	-	mixture of fuels and household waste	-	39.90	mg/m3	TESO		
	old growth , shredder	30 t/h	lumber, demolition wood, timber waste	fabric filter	2.71	g/tonne	LAU		

ANNEX 1B – SUMMARY OF RECENT MEASURED $PM_{2.5}$ DATA ON COMBUSTION SOURCES

Combustion Type	**Process**	**Size indication**	**Fuel**	**Abatement Measures**	**$PM_{2.5}$ Emission Factor or concentration**	**Units**	**Source**	**CEPMEIP Factor**	**CEPMEIP Units**
Coal	Combustion Plant	180 MW	dry brown coal	ESP horizontal, scrubber	1.20	g/GJ	LAU	14.00	g/GJ
		146 MW	brown coal briquette, Limestone	ESP horizontal, drying desulphurisation	1.09	g/GJ	LAU		g/GJ
		119 MW	raw brown coal	ESP horizontal, desulph., NOx removal	4.15	g/GJ	LAU	14.00	g/GJ
		1000MW	hard coal	ESP, desulphurisation,	0.26	g/GJ	LAU	12.00	g/GJ

Combustion Type	Process	Size indication	Fuel	Abatement Measures	$PM_{2.5}$ Emission Factor or concentration	Units	Source	CEPMEIP Factor	CEPMEIP Units
				NOx removal					
		1000MW	hard coal	ESP, desulphurisation, NOx removal	0.23	g/GJ	LAU	12.00	g/GJ
		-	sub-bituminous coal	ESP	8.30	mg/MJ	NRCAN	3.00	g/GJ
		-	lignite	ESP	1.20	mg/MJ	NRCAN	3.00	g/GJ
		-	75% lignite/25% bituminous	ESP	28.10	mg/MJ	NRCAN		
		120 MW	Powdercoal	ESP	30.24	mg/Nm3	VITO	17.00	g/GJ
		-	lignite	Fabric filter, desulphurisation system	0.1	mg/m3	TESO	6.00	g/GJ
		-	lignite	ESP, desulphurisation system	1.3	mg/m3	TESO	14.00	g/GJ
		-	hard coal	Fabric filter	7.4	mg/m3	TESO	5.00	
		-	lignite	ESP, desulphurisation system	0.4	mg/m3	TESO	14.00	g/GJ
	Dry Bottom Ash Furnace	-	hard coal	ESP	9.6	mg/m3	TESO	12.00	
		-	lignite	ESP, desulphurisation system	1.3	mg/m3	TESO	14.00	g/GJ
		-	lignite, heavy fuel oil	ESP, desulphurisation system, fabric filter	0.2	mg/m3	TESO		
		-	lignite	ESP, desulphurisation system	12.3	mg/m3	TESO	20.00	g/GJ
		-	hard coal	ESP	0.2	mg/m3	TESO	12.00	
		-	hard coal	Fabric filter	0.6	mg/m3	TESO	5.00	

Combustion Type	Process	Size indication	Fuel	Abatement Measures	$PM_{2.5}$ Emission Factor or concentration	Units	Source	CEPMEIP Factor	CEPMEIP Units
		-	hard coal	Fabric filter	0.2	mg/m3	TESO	5.00	
		-	coal	ESP	1.4	mg/m3	TESO	12.00	g/GJ
	Grate and Dry Bottom Ash Furnace	-	lignite	ESP, desulphurisation system	0.5	mg/m3	TESO	20.00	g/GJ
	Grate Boiler	-	hard coal	Fabric Filter	0.6	mg/m3	TESO	5.00	g/GJ
	Grate Firing	-	lignite	ESP	6	mg/m3	TESO	14.00	g/GJ
	Boiler for Pulverised Solid Fuel	-	hard coal, light fuel oil	ESP	20.8	mg/m3	TESO		
		-	hard coal, lignite	ESP, desulphurisation system	5.9	mg/m3	TESO		
		-	lignite	ESP, desulphurisation system	1.9	mg/m3	TESO	14.00	g/GJ
		-	lignite	ESP, desulphurisation system	4.1	mg/m3	TESO	14.00	g/GJ
		-	hard coal	Fabric filter	0.1	mg/m3	TESO	5.00	g/GJ
	Fluidised bed boiler	-	lignite	ESP, desulphurisation system, fabric filter	1.2	mg/m3	TESO	6.00	g/GJ
		-	lignite	Fabric filter, desulphurisation system	0.8	mg/m3	TESO	6.00	g/GJ
		-	hard coal, blast furnace gas	ESP	0.4	mg/m3	TESO		
		-	hard coal, blast furnace gas	ESP	0.1	mg/m3	TESO		
		-	hard coal, coke oven gas, blast furnace gas	ESP	4.1	mg/m3	TESO		

Combustion Type	Process	Size indication	Fuel	Abatement Measures	$PM_{2.5}$ Emission Factor or concentration	Units	Source	CEPMEIP Factor	CEPMEIP Units
Oil	Combustion Plant	10 MW	heavy oil	additive	10.30	g/GJ	LAU	10.00	g/GJ
		10 MW	heavy oil	additive	9.18	g/GJ	LAU	10.00	g/GJ
		10 MW	heavy oil, urea	additive, SNCR	12.21	g/GJ	LAU	10.00	g/GJ
		10 MW	heavy oil, urea	additive, SNCR	13.12	g/GJ	LAU	10.00	g/GJ
		20 t/h steam	heavy oil	SNCR	1.38	g/GJ	LAU	11.00	g/GJ
		270 MW	heavy oil	NOx removal	4.69	g/GJ	LAU	2.50	g/GJ
		270 MW	heavy oil	additive, NOx removal	4.15	g/GJ	LAU	2.50	g/GJ
		270 MW	heavy oil	NOx removal	4.41	g/GJ	LAU	2.50	g/GJ
		270 MW	heavy oil	additive, NOx removal	4.23	g/GJ	LAU	2.50	g/GJ
		-	residual oil	-	28.10	mg/MJ	NRCAN	10.00	g/GJ
		-	heavy fuel oil, natural gas	-	6.70	mg/m3	TESO		
		-	heavy fuel oil, gas fuels	-	15.20	mg/m3	TESO		
Waste	Combustion Plant	1.4 MW	saw chips, saw dust	cyclone	71.66	g/GJ	LAU	55.00	g/GJ
		1.4 MW	saw chips, saw dust	cyclone	52.25	g/GJ	LAU	55.00	g/GJ
		0.8 MW	saw chips, saw dust	cyclone	65.47	g/GJ	LAU	55.00	g/GJ
		3 MW	hogged wood	cyclone	90.13	g/GJ	LAU	55.00	g/GJ
		2.3 MW	rest of chipboards	multi-cyclone	91.92	g/GJ	LAU	55.00	g/GJ
		1.1 MW	piece of wood, saw chips	cyclone	80.80	g/GJ	LAU	55.00	g/GJ
		2 MW	hogged wood, wood waste	ESP	16.10	g/GJ	LAU	55.00	g/GJ
		7.9-9.5 MW	wood, wood chips	ESP	5.49	g/GJ	LAU	55.00	g/GJ

Combustion Type	Process	Size indication	Fuel	Abatement Measures	$PM_{2.5}$ Emission Factor or concentration	Units	Source	CEPMEIP Factor	CEPMEIP Units
		7.9-9.5 MW	natural gas, wood, wood chips	ESP	5.21	g/GJ	LAU	55.00	g/GJ
		15 MW	hogged wood, rest wood, wood chips	ESP	1.95	g/GJ	LAU	55.00	g/GJ
		1.5 MW	hogged wood	chimney gas condensation, multi-cyclone	17.25	g/GJ	LAU	55.00	g/GJ
		1.5 MW	hogged wood	chimney gas condensation, multi-cyclone	20.46	g/GJ	LAU	55.00	g/GJ
		31 t/h steam	matured wood	cyclone, fabric filter, NO_x removal	1.85	g/GJ	LAU	55.00	g/GJ
		-	wooden briquettes	-	12.10	mg/m3	TESO	135.00	g/GJ
	Grate Boiler		bark, natural gas	ESP	4.80	mg/m3	TESO		
Waste	hazardous waste incineration plant	-	hazardous waste	fabric filter, desulphurisation system	8.80	mg/m3	TESO		
	waste incineration plant	-	municipal solid waste	ESP, desulphurisation system	0.80	mg/m3	TESO	100.00	g/tonne
			municipal solid waste	ESP	1.80	ng/Nm3	VITO	101.00	g/tonne
	home heating boiler	-	mixture of fuels and household waste	-	34.60	mg/m3	TESO		
	old growth , shredder	30 t/h	lumber, demolition wood, timber waste	fabric filter	0.49	g/tonne	LAU		