

0202/0203**Residential plants / plants in agriculture, forestry and fishing***Process description*

Covered here is the combustion of wood, coal and lignite mainly for room heating purpose in the above mentioned sectors. Combustion takes place in hand-fired stoves or fireplaces; in the case of larger central heating systems also automatically fired installations may be applied. Domestic fireplaces have, as a rule and in comparison with combustion installation which are subject to approval, a worse burn-out of the fuels and waste gases, especially for burning appliances for solid fuels.

On account of the large numbers of household equipment, domestic fire and combustion appliances contribute noticeably to the total emission of air polluting substances.

Abatement technologies:

Measures for the emission reductions from the waste gases are not common for domestic fire and combustion appliances. Generally there is no special abatement equipment connected to stoves or fireplaces; only large systems comparable to those used for industrial purposes may be equipped with cyclones or fabric filters. However, such systems are assumed to be rarely used in domestic heating appliances.

Plant data/European situation

From the national inventories numbers of wood burning facilities being operated are available only for D, NL, and S (1.4, 0.9 and 0.9 million, resp.). No data are reported for facilities using other solid fuels. Additional information for some countries can be taken from a Eurostat document on energy consumption of private households in 1988 < 1> :

Country	wood	solid fuels
B	1,3	8,9
Dk	4	1
E		11,5
F	5,2	4,4
UK		4,4

0202/0203—Table 1 Percentage of households with single-room heating facilities

According to the Eurostat study combustion of wood is very important in France , Italy, Greece and Portugal where wood constitutes the only energy source for room heating purposes. Among the other European countries not covered by the Eurostat data, room heating by wood combustion is of major importance in Austria and the Scandinavian countries (N, S, SF).

Coal and lignite are mainly utilised where they are mined. According to the available data nearly the entire European consumption of lignite is found in the former East-Germany (cf. 0202/0203—Table 7).

Activity data

Activity data (shown in the tables 6 and 7) were taken from the national inventories and from the above mentioned Eurostat publication <1>. As the data used for this study had been collected in 1988 it had to be assumed that no considerable change in wood consumption occurred within the last decade. This assumption is supported by the good agreement of the Eurostat data with information given in the Dutch and the UK inventory; though in the case of Germany the data do not fit. However, it must be noticed, that the value used in the German national inventory comprises other fuels like peat too and it is valid not only for households but for other „small consumers“ in the commercial sector as well.

Information about the relative consumption of different types of wood is given only in the Dutch Dioxin inventory; on the basis of a special study 16% of the total burned wood are assumed to be polluted, and about 1 % being contaminated

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with PCP. Since no better data are available, the Dutch values were taken here to assess the possible dioxin emissions.

Concerning coal and lignite less information could be found for these fuels and some data had to be completed by rough estimations.

Emission factors

a) wood:

Emission factors for wood combustion as reported by the national dioxin inventories are shown in 0202/0203—Table 4. They had been gained either by special measurement programs or by adoption of literature data. Several scientific studies were performed in the recent past to assess the formation of PCDD/F during wood combustion, however in part they were addressed to industrial installations <2-19>

A broad range of flue gas concentrations was found depending on the operation conditions and the contamination of wood used as fuel. Not unexpectedly, the highest emissions were observed if wood containing PCP as preserving agent was used.

From these studies and the emission factors shown above the following default emission factors are derived to be used for the emission estimation; in view of the broad range no further distinction is made between stoves and fireplaces:

clean wood	slightly contaminated (without PCP)	strongly contaminated (with PCP)
1	50	500

0202/0203—Table 2 Default emission factor for domestic wood combustion
[µg I-TEQ/t]

b) coal/lignite

From the data reported in the national inventories flue gas concentrations and emission factors shown in 0202/0203—Table 5 are obtained. Except for the high

factor taken from the Belgian inventory going back to the PARCOM-ATMOS document < 20> the emission factor range for coal combustion is between 0.5 and 10 µg I-TEQ/t. A **default emission factor of 2 µg I-TEQ/t** is used here to re-evaluate the annual emissions.

Concerning lignite combustion only few data exist indicating a range of about 0.5 - 3 µg I-TEQ/t. Since **lignite combustion** occurs almost entirely in Germany, the emission factor - **0,6 µg I-TEQ/t** - derived for this country is applied for the re-evaluation.

Emission estimation

On the basis of the default emission factor data and the activity rates shown before the standardised annual PCDD/F emissions are derived. The values obtained are compared to those reported in the national inventories in 0202/0203—Table 8, 0202/0203—Table 9 and 0202/0203—Table 10. For all 17 countries considered the following results are obtained (0202/0203—Table 3):

	wood	coal	lignite	TOTAL
national inventories	153.1	73.7	7.0	233.8
Re-evaluation	945.0	32.3	7.7	985.0

**0202/0203—Table 3 Summary of re-evaluated typical PCDD/F air emissions
[g I-TEQ/a] from domestic combustion of solid fuels**

Due to the chosen approach making use of default emission factors for different types of wood the estimated emissions generally are higher than in the national reports. Only in the case of Belgium a considerable decrease was observed; this is because in the Belgian survey the high emission factor of the PARCOM-ATMOS Manual was applied (130 µg I-TEQ/t).

Conclusions/recommendations

It is quite obvious that domestic wood combustion is of significant relevance for the total emission of PCDD/F in Europe; while coal and lignite combustion in residential plants contribute only to a minor degree. Actually, lignite combustion seems to be a specific problem in Germany. However, the use of lignite shows a falling trend and it is likely to decrease to a level as in the western part of Germany within a few years with the rise of living standards in the former East-Germany.

However, all calculations in this chapter are associated with considerable uncertainties since the activity rates are largely based on assumptions. A new study of the Eurostat on energy consumption in private households <1> covering at least all EC member states would be very helpful. Furthermore, concerning wood combustion a brief inventory of the amounts and different types of annually burnt wood could be very necessary for a better precision of the estimates.

Moreover, in view of their broad range considerable uncertainties exist with regard to the applied emission factors. In the past most studies on PCDD/F emissions from stoves and fireplaces for wood combustion were performed at test facilities with well controlled conditions. Only a few information exists about emissions under realistic circumstances; hence, on-site measurements involving facilities of different type and age and real fuel mixtures which might consist of wood, wood waste, domestic waste and the like should be performed.

	Measured flue gas conc. [ng I-TEQ/m ³]			Emission factors [µg/t]			Remark
	typ	min	max	typ	min	max	
A	0.58 1.16			2.355 4.71			valid for central heating facilities valid for stoves and fireplaces
B				130.00			EF taken from PARCOM-ATMOS assuming high fractions of treated wood.
CH				0.35	0.90	0.95	Mean of the results obtained in 4 studies was chosen (0.9 [190],23 [129],7.6 [261],65 [187]). EF originally given in given in ng I-TEQ/GJ was converted to tabled value by 14.65 GJ/t.
D	0.19	0.01	0.22	0.71	0.53	0.94	according to LIS study
Dk	0.18			1.90			N-TEQ
E				50			EF according to data kindly submitted by TNO, NL
NL	0.38	0.12	1.20		2.20	500.00	NL study gives values for clean wood and polluted wood with and without PCP, further separated for stoves and fireplaces.
S					1.00	2.00	EF's taken from literature only for untreated wood
UK					1 10	29 50	Efs given for clean wood and treated wood, resp. (derived from literature data); EF max refers to open fires; for stoves EF max, clean is 3 µg/t, EF max, treated is 50 µg/t.

0202/0203—Table 4 PCDD/F air emission factors for domestic wood combustion from the national dioxin inventories; factors used for estimation (see text)

		Measured flue gas conc. [ng I-TEQ/m ³]			Emission factors [µg/t fuel]			Remark
		typ	min	max	typ	min	max	
COAL	A	0.13 0,26	0.073	0.19	0.51 1.02	0.94	1.88	valid for central heating facilities valid for stoves and fireplaces
	B				50			EF taken from PARCOM-ATMOS
	CH				6.8	0.45	12.8	originally reported in ng/GJ; conversion factor: 29761 GJ/kt data taken from literature
	D		0.0007	1.58	0.29	0.12	0.68	
	NL				1.6			
	UK					0.7	9.3	EF range and activity rates given for all types of coals
LIGNITE	A	0.19 0.38			0,94 1,88			valid for central heating facilities valid for stoves and fireplaces
	D				0.62	0.13	2.92	

0202/0203—Table 5 **Flue gas concentrations and emission factors for domestic coal and lignite combustion from national dioxin inventories**

European Dioxin Inventory - Results

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Country	Eurostat 1988 (domestic use only)		nat. Inv.	specific consumption	remark
	<1> wood				
	kt raw oil unit/a	kt/a	kt/a	t/capita	
A			4889	0.617	
B			660	0.065	
CH			600	0,084	according to data from Swiss study on wood combustion
D	136	397	1968	0.005	
Dk			210	0.040	re-calculated from annual emission and EF
E			5080	0.128	re-calculated from annual emission and EF
F	8008	23367		0.405	
GR	1278	3729		0.363	
I	4926	14374		0.253	
IRL			0	0.000	assumed to be negligible
L			0	0.000	assumed to be negligible
N			1727	0.400	calculated using per-capita consumption rate valid for Sweden
NL	360	1050	1015	0.068	
P	1466	4278		0.434	
S			3500	0.401	
SF			2033	0.400	calculated using per-capita consumption rate valid for Sweden
UK	267	779	900	0.013	

0202/0203—Table 6 Activity rates related to domestic wood combustion

Country	Eurostat 1988 (domestic use only) <1>		nat. Inv.		remark
	„solid fuels“ kt raw oil unit/a	kt/a	hard coal kt/a	lignite kt/a	
A			567	50	
B	678	974	565	10	spec. Coal consumption: 96,6 t/capita
CH			405		recalculated from emission factor and annual emission valid for entire domestic comb.; wood combustion was taken into account
D	2609	3749	2145	11377	
Dk	118	170		0	spec. coal consumption: 32 t/capita
E	2870	4124	1842	4.9	acc. to data submitted to TNO
F	1342	1928		152	lignite: assumed to be equal to final energy consumption
GR	37	53		163	lignite: assumed to be equal to final energy consumption
I	176	253		4	lignite: assumed to be equal to final energy consumption
IRL	1597	2295		645	
L			22	10	Coal: calculated from per capita consumption of B Lignite: assumed to be equal to final energy consumption
N			139		calculated from per capita consumption of Dk
NL	26	37	42	21	
P	15	22		0	
S		0	281	0	calculated from per capita consumption of Dk
SF		0	163	0	calculated from per capita consumption of Dk
UK	6194	8899	5246	0	

0202/0203—Table 7 Activity rates related to domestic coal and lignite combustion

WOOD	national Inventories	Re-evaluation		Remark
		inventory available	no inventory available	
A	15.2	67.6		
B	85.8	9.1		
CH	0.5*)	8.3		*) estimate for all types of fuels
D	2.8	27.2		
Dk	1.1	2.9		
E	25.4	70.3		
F			323.2	
GR			51.6	
I			198.8	
IRL			0.0	
L			0.0	
N			23.9	
NL	11.2	14.0		
P			59.2	
S	4.5	48.4		
SF			28.1	
UK	6.6	12.4		
Subtotal	<i>153.1</i>	<i>260.3</i>	<i>684.7</i>	
TOTAL	153.1	945.0		

0202/0203—Table 8 Comparison of PCDD/F air emission estimates [g I-TEQ/a] for domestic wood combustion from national inventories with those derived in this study

COAL	national Inventories	Re-evaluation using activity rates from		Remark
		Eurostat Data	nat. Inv.	
A	0.7		1.1	
B	28.2		1.1	
CH			0.8	
D	1		4.3	
Dk		0.3		
E	18.5		3.7	
F		3.9		
GR		0.1		
I		0.5		
IRL		4.6		
L			0.05	
N		0.3		calculated using per capita emissions of Dk
NL	0.07		0.1	
P		0.04		
S		0.6		calculated using per capita emissions of Dk
SF		0.3		calculated using per capita emissions of Dk
UK	25.5		10.5	
Subtotal	<i>73.97</i>	<i>10.64</i>	<i>21.65</i>	
TOTAL	74	32.3		

0202/0203—Table 9 Comparison of PCDD/F air emission estimates [g I-TEQ/a] for domestic coal combustion from national inventories with those derived in this study

LIGNITE	national Inventories	Re-evaluation	Remark
A		0.03	
B		0.01	
CH			no data
D	7	7,0	
Dk			no data
E		0.00	
F		0.09	
GR		0.10	
I		0.00	
IRL		0.40	
L		0.01	
N			no data
NL		0.01	
P		0.00	
S			no data
SF			no data
UK		0.00	
<i>Subtotal</i>	7	7	0.65
TOTAL	7	7.65	

0202/0203—Table 10

Comparison of PCDD/F air emission estimates [g I-TEQ/a] for domestic lignite combustion reported by national inventories with those derived in this study

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