The European Dioxin Emission Inventory
Stage II

Volume 3

Assessment of dioxin emissions until 2005

This report was prepared by the North Rhine Westphalia State Environment Agency on behalf of the European Commission, Directorate General for Environment (DG ENV)

Contract No.: 96/771/3040/DEB/E1

Contract period: 01.01.1998 – 31.12. 2000

Release date: 31.12.2000

Authors: Ulrich Quass, Michael Fermann, Günter Bröker

Title	The European Dioxin Emission Inventory, Stage II
Customer	European Commission, Directorate General for Environment (DG ENV)
File reference	00_Deckblatt Band3.doc; 01_Intrductory_comments.doc; 02_A.doc; 03_B.doc; 04_CH.doc; 05_D.doc; 06_Dk.doc; 07_E.doc; 08_F.doc; 09_GR.doc; 10_I.doc; 11_IRL.doc; 12_L.doc; 13_N.doc; 14_NL.doc; 15_P.doc; 16_S.doc; 17_SF.doc; 18_UK.doc; 19_Alle_85_05.doc; Glossar.doc
Report number	Volume 3
Report status	Final version– December 2000

Project leader/contact

Prof. Dr. Günter Bröker
Landesumweltamt NRW
Wallneyer Str. 6
45133 Essen
Nordrhein-Westfalen
Germany
Telephone +49 (0)201 7995-1260
Facsimile +49 (0)201 7995-1446/1447/1575

	Name	**Signature**	**Date**
Authors	Ulrich Quass Michael Fermann Günter Bröker		

Content of Volume 3

1. Update of PCDD/F air emission inventory

1.1. Introduction

Volume 3 of the Stage II report aims at a critical review and actualisation of the available national information on dioxin emissions. For each country (the same 17 countries which had been considered in the Stage I report) first the previous emission inventories prepared by national institutions or within international projects are presented briefly. At least the inventories published in the Stage I report and in the TNO/UBA document [1] are used, but in most cases also national information is available.

Based on these inventories and further information obtained since 1997 a revised emission inventory for the year 1995 is made. Finally, it is attempted to predict the development of PCDD/F emissions for the years 2000 and 2005 by taking into account actual developments regarding abatement measures and sector activity.

The emission sources considered here are restricted to those which have been identified as most relevant in the Stage I report. Except for fossil fuel fired power plants (SNAP 01) which are additionally included (c.f. comments below). Thus, the overall emissions estimated for 1995, 2000 and 2005 may be assumed to cover about 90% of the annual emissions.

1.2. General comments

There is information concerning some of the considered emission source types which affects the emission estimates for all or at least several countries. In the following this information and its effects is discussed in detail.

1.2.1. Power plants (fossil fuels)

Using the criteria chosen in the Stage I report power plants for electricity generation had not been identified as a relevant source type o the European scale. This was mainly due to the low emission factors which have been measured for coal-fired power plants in a number of countries. For example, flue gas concentrations measured at German coal fired plants amounted to few pg I-TEQ/m³ which in case of coal combustion correspond to emission factors ranging from 0,03 up to 0,2 µg I-TEQ/ton. Similarly, for UK coal fired power plants emission factors between 0,06 and 0,32 µg I-TEQ/ton [2] and for Dutch plants a factor of 0,35 µg I-TEQ/ton [3] were used. Emissions from Belgian and Swedish installations were estimated in the national dioxin surveys using essentially the same factors taken from the international literature. No data were available at that time for France, Italy, Greece and Portugal. The annual PCDD/F emissions derived from these factors ranged from below 1 up to 10 g I-TEQ/a depending on the amount of coal being combusted yielding an European emission of some 10 g I-TEQ/a. This view was supported by the TNO/UBA study [1] which used an emission factor of 0,1 µg I-TEQ/ton and calculated the EU 15 countries to release 26 g I-TEQ annually.

Contrarily, the emission factor reported in the Swiss emission factor manual [4] is considerably higher (230 µg I-TEQ/TJ = 6,2 µg I-TEQ/ton); moreover, a further annual emission estimate of 26,6 g I-TEQ/a for 1995 was published for Italy [5] which would actually double the European emissions from coal fired power plants. However, for this estimate, too, reference is made to published emission factors (however, the factor used is not given explicitly). Moreover, in the Czech Republic dioxin inventory emission factors of 1,2 - 1,4 µg I-TEQ/m³ obtained from measurements were used to estimate the annual emissions from the power plants of this country. These higher emission factors indicate that the actual PCDD/F emissions from coal-fired power plants might also be a matter of state-of-technology.

Furthermore, in the TNO/UBA study on emissions in 1990 high releases are assigned to industrial hard coal combustion (SNAP 03 01). A ten-fold emission factor (1 µg I-TEQ/ton) was used but nearly a twenty fold annual emission (535 g I-TEQ/a) was estimated for EU 15. Of this estimate, nearly 90% was assigned to France, further 30 g I-TEQ/a to Belgium. This value, however, is not supported by the Belgian dioxin inventory report [6] which assessed the emissions in this sector to be 5 g I-TEQ in 1990 (emission factor: 25 µg I-TEQ/TJ = 0,7 µg I-TEQ/ton).

Nevertheless, taking all recent findings — even if contradictory — into account it must be concluded that coal combustion in industrial facilities and power plants perhaps might be of some greater relevance than indicated in the Stage I report. Further work will be necessary to achieve a final statement on this topic. For the Stage II report presented here it was therefore decided to include this source type into the source list for the updated inventory. Emission estimates are taken as reported in the national documents or, if no inventory exists, calculated from fuel consumption rates and the range of emission factors outlined above (0,1 – 0,4 µg I-TEQ/ton for power plants, 0,5 – 1,5 µg I-TEQ/ton for small and medium size industrial combustion facilities.

1.2.2. Iron and steel industry

Iron and steel production processes, in particular the iron ore sintering, have been identified as one of the most relevant emission sources besides the previously known waste treatment sector. The two processes considered here, sintering and electric arc steel production, are operated in the majority of the European countries. Due to changes in the economic structure of this industrial sector, the activity trends may considerably vary throughout the European countries. Based on statistics for the 1994 to 1998 published by the German steel association (VDEH, Düsseldorf) a trend extrapolation was made to forecast activity rates for the years 2000 and 2005. The obtained rates of change (in per cent of 1994 activity) is shown in table 1 (sinter process) and table 2 (electric arc steel production). The values shown were derived from production statistics and/or from information on material consumption of the particular process (e.g. iron ore input to sintering plant).

As the trend observed during the recent years may have various causes the extrapolation should be considered cautiously. For example, sharply decreasing activity rates in some countries lead to the assumption of zero production in the near future which might be a wrong view if at least one plant will be operated. On the other hand, the increase of activity rates will be limited by the capacity of plants yet in operation; activities predicted here therefore may sometimes imply that new plants will be built. Whether this actually will be done, is a matter of speculation.

	A	B	D	DK	E	F	GR	I	IRL	L	NL	P	S	SF	UK
1995	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
1996	89	92	102	113	92	103	90	87	110	111	60	109	91	100	94
1997	94	136	118	120	112	121	108	92	108	165	64	112	106	113	100
1998	112	142	119	121	122	124	118	95	116	206	58	124	105	121	82
1999	109	160	128	131	128	134	122	91	120	238	40	130	108	128	82
2000	**114**	**178**	**136**	**138**	**136**	**143**	**129**	**90**	**125**	**275**	**28**	**137**	**111**	**136**	**78**
2001	118	195	143	145	145	152	136	90	129	313	16	145	114	143	73
2002	122	212	150	152	153	161	144	89	134	350	3	152	117	151	68
2003	126	229	158	159	162	170	151	88	138	387	-9	159	120	159	64
2004	131	246	165	166	170	179	158	87	143	424	-21	167	123	167	59
2005	**135**	**263**	**173**	**173**	**179**	**188**	**165**	**86**	**148**	**461**	**-33**	**174**	**126**	**174**	**54**

table 1 Extrapolated index of production activity for electric arc steel production (dashed values according to VDEH statistics)

	A	B	D	E	F	I	L	NL	P	SF	UK
1994	100	100		100	100	100	100	100	100	100	100
1995	**111**	**104**		**103**	**96**	**96**	**50**	**106**	**93**	**113**	**102**
1996	99	98		82	89	89	50	100	99	111	104
1997	107	97		51	98	131	27	106	96	131	108
1998	107	96		42	92	125	2	106	95	137	110
1999	108	94		25	91	134	-19	107	95	146	112
2000	**109**	**92**		**8**	**89**	**143**	**-41**	**108**	**94**	**155**	**115**
2001	110	91		-9	88	151	-63	109	94	164	118
2002	111	89		-26	87	160	-85	110	93	173	120
2003	113	88		-43	85	168	-107	111	93	182	123
2004	114	86		-60	84	177	-128	112	92	191	125
2005	**115**	**84**		**-77**	**83**	**186**	**-150**	**113**	**92**	**201**	**128**

table 2 Extrapolated index of production activity for iron ore sintering (dashed values according to VDEH statistics)

1.2.3. Wood preservation

This source comprises the release of gaseous PCDD/F from wood products which have been treated with contaminated PCP. The only data available concerning the contribution of this source to PCDD/F air emissions stem from the Netherlands; emissions for all other countries had been estimated in the Stage I report by capita relation. Hence the emission estimates are very uncertain and might be largely overestimated.

Since application of PCP has been widely banned and contamination of actual PCP products are likely to be negligible [7]. Therefore, the emissions from old contaminated wood products will decrease continuously by depletion of the reservoir. This has taken into account by the yearly updated Dutch inventory (see chapter “Netherlands”). However, the estimate given for the year 1998 given in the latest official report is much lower than it might be expected from the series of previous values. An emission estimate that better fits into the time series is used in another — however non-official — publication [8]. This value is therefore used for linear extrapolation of the emissions for the years 2000 and 2005.

Year	PCDD/F emission in NL [9] g I-TEQ/year	%
1990	61	(not regarded)
1995	22,5	100
1996	22	98
1997	21,8	97
1998	17 (21,0 [8])	76 (93)
Extrapolation:		
2000	20,2	89,7
2005	17,9	79,2

table 3 modelled PCDD(F emissions from PCP treated wood products in the Netherlands

Besides air emissions generated by volatilisation of dioxin and furans from contaminated wood products other pathways exist which PCDD/Fs contained in PCP treated products may enter the food chain. A comprehensive review on this topic was published in 1999 [7]. Accordingly, sewage sludge spreading to pasture land might have a considerable impact through consumption of dairy products.

1.2.4. Domestic solid fuel combustion

<u>Illegal domestic waste combustion</u>

To assess the emissions from illegal domestic burning of household waste, which can take place on open field or in heating stoves, a constant fraction (0,25%) of the overall waste produced in the European countries was used. This is of course a simplification as the frequency of such practice will largely depend on the system of waste management applied in the countries and on their economic structure (rural/industrial). Also the availability of solid fuel heating installations and the costs for regular fuels may influence the extend of illegal waste burning. The estimates given in the Stage I report should therefore be taken as a rough indicator. There is no new data on this topic available in Europe; from the United States comprehensive investigations on so-called “barrel burning” of waste have been published in 1998 and 2000 [10]. The results confirm the very high emission factors which frequently have been found when domestic waste was experimentally burned under bad conditions. It must be concluded that this practice is an emission source which may not be ignored but, since the probable emission in Europe can be assessed only with large uncertainty, in the updated inventory the Stage I estimate for 1995 is maintained for the years 2000 and 2005.

<u>Domestic coal combustion</u>

In the Stage I report this particular emission source was assessed to be of only minor importance. From the measurement data available in 1995 a range of emission factors for hard coal burning from 0,5 to 10 µg I-TEQ/ton was derived; an emission factor of 2 µg I-TEQ/ton was taken to calculate the overall European emissions. Considerably larger uncertainty was found with regard to the relevant activity rates as energy statistics usually do not address household combustion directly but also includes the fuel consumption in small commercial heating facilities. Some additional information was available from an 1988 Eurostat publication on household heating; however, for an number of countries rough assumptions on the amount of coal or lignite being consumed had to be made. Finally, based on the chosen emission factor and activity rates an overall emission for domestic hard coal burning of ca. 32 g I-TEQ/year and for lignite burning of ca. 8 g I-TEQ was derived. Compared to the entire PCDD/F emission estimate of ~ 6.500 g I-TEQ/a domestic coal burning only appeared to contribute less than 1 % and thus was considered to be of minor importance.

However, the data situation became more complicate in 1998 when measurement results of the Austrian UBA were published [11]. Extraordinarily high emission concentrations of 13 to 87 ng I-TEQ/m³ (at 0% excess oxygen) were found when hard coal, purchased from the Austrian market and in fact being imported Polish hard coal was burned in a small single room heating stove under “on-site” conditions (i. E. measurements took place in a living house and not at a test rig). The measured concentrations were converted to emission factors of 109 - 664 µg I-TEQ/ton using a specific flue gas volume of ~ 8 m³/kg fuel (standard conditions, dry, 0% excess oxygen). With these emission factors, being a 50 to 330-fold higher than the factor used in Stage I, the assessment of domestic burning would change completely leading to the conclusion that this source would be the largest emission source type in Europe.

Since the data presented by the Austrian UBA was solely based on a single stove and only one hard coal type, the need of additional work to confirm or correct these results was urgently suggested. Therefore a quite comprehensive test-ring measurement program including two different single room heating stoves and 6 different sorts of coal including the Polish hard coal purchased in Austria was carried out by LUA in late 1999 (for details see Volume 2, chapter 6e). Simultaneously, the Austrian UBA repeated their own on-site measurements now using three stoves and comparing Polish hard coal combustion with wood and coke. Results of both programs were presented at the Dioxin 2000 symposium at Monterey, California [12], [13].

Despite certain differences in stove operation conditions and sampling conditions of the two independent experiments the flue gas concentrations found for the Polish hard coal were — as shown in table 4 — in quite good agreement:

Institute	Stove No	PCDD/F concentration [ng I-TEQ/m³, 0% excess O2)
LUA	1	2,6 – 4,4 (3 samples)
LUA	2	6,7 – 15,6 (3 samples)
A-UBA	1	22,9 – 38,7 (4 samples)
A-UBA	2	7,9 – 20,0 (3 samples)
A-UBA	3	7,5 (1 sample)

table 4 PCDD/F emission concentrations from small domestic single-room heating stoves fired with Polish hard coal purchased in Austria.

Compared to the first measurements made by the Austrian UBA the second experiment resulted in lower concentrations (by about factor 2). LUA ’s results were somewhat less than these results, but the range of concentrations obtained in the two sets of experiments overlap. Applying the specific combustion volume of ca. 8,7 m³/kg fuel, which was calculated from fuel composition taken from literature [14], emission factors ranging from ca. 17 to 310 µg I-TEQ/ton are obtained.[1]

However, concentrations measured for all other fuels investigated were considerably lower. Emission factors derived for Czech and German lignite, anthracite and hard coal briquettes ranged from 0,7 - 10,9 µg I-TEQ/ton fuel; for coke combustion LUA found values of 0,8 and

[1]Note: in the original publication by Moche and Thanner the emission factors were calculated using actual measured data of flow velocity in the stack and fuel consumption. Much higher emission factors were obtained by this procedure; however, this approach is considered to generate high uncertainty due to the problem of accurate determination of the volume flow rate at low and very fluctuating gas velocities of 1-2 m/s.

2,9 µg I-TEQ/ton while the Austrian UBA obtained concentrations of 0,9 – 4,4 ng I-TEQ/m³; pooled together these values can be converted to emission factors of 6,5 – 31,7 µg/ton fuel.

The following conclusions must be drawn from the findings of the test programs:

- Flue gas concentrations and emission factors of domestic coal combustion strongly vary with combustion conditions.
- Emissions from single room heating stoves were considerably higher (approximately 1 order of magnitude) than the values found in the investigation of a 32 kW central heating unit 10 years ago; single stoves operating differently (underburner / throughburner) also show somehow different emissions (but note: the number of samples was too small to assure the significance of this variation).
- Under poor combustion conditions (single room heating stoves) flue gas concentrations and emission factors of domestic coal combustion also considerably vary with fuel type.
- Lowest emissions were observed using brown coal (averaged emission factors 0,7 to 3,3 µg I-TEQ/ton, while coke and hard coal from German mines ranged from 4,4 – 11 µg I-TEQ/ton. These values compare well to emission factors found in previous publications which were quoted in the stage I report (Vol. I, p 53): for brown coal (lignite) combustion a range of 0,62 - 2,92 µg I-TEQ/ton was reported and for hard coal data from Switzerland and UK covered a range of 0,45 to 12,8 µg I-TEQ/ton (data listed for Austria and Germany were derived from measurements at central heating boilers).
- The emission factors for Polish hard coal used in Austria revealed to be exceptionally high with (averaged) emission factors between 27 - 88 (LUA) and 65 - 274 µg I-TEQ/ton (A-UBA). Including the results published in 1998 the range may be extended up to 664 µg I-TEQ/ton. These elevated emission factors might be due to a higher chlorine content of the coal (~ 1,5% compared to typical 0,3 % in German hard coal). Further factors like SO_2-concentration in the combustion gas also might play a role.
- The estimate of annual emissions from domestic coal combustion in Europe might have been significantly underestimated in the Stage I report.

In order to establish a reliable estimate comprehensive information would be needed on the amounts of different coal types consumed by the European households as well as on the fraction of each coal type being burned in small heating stoves. Further, emission measurement results would be needed for each coal type of considerable importance on the market. The coal types measured so far only cover a small part of the fuels used in Europe which also comprise coals imported from overseas (South Africa, Australia, United States, Central Europe).

Clearly, such detailed information is not yet available neither on the European scale nor for a single country. Therefore, in order to reassess the 1995 emissions from domestic coal combustion with regard to the new insights, a best case and worst case approach is chosen here using two different composite emission factors and two scenarios concerning the type of heating facilities (c.f. table 5):

	Worst case		**Best Case**	
	Assumed fraction of consumed fuel	Emission factors [µg I-TEQ/t]	Assumed fraction of consumed fuel	Emission factors [µg I-TEQ/t]
Central heating boilers	0,5	2	0,8	2
Single room ovens	0,5	40%*) 100 60% 7 44,2	0,2	10%: 100 90%: 7 16,3
OVERALL EMISSION FACTOR (µg I-TEQ/ton)	0,5* (2 + 44,2) = **23**		0,8*2 + 0,2*16,3 = **5**	

table 5 Assessment parameters used to estimate PCDD/F emission from domestic coal burning
***) percentages mentioned refer to the assumed consumption of "Polish-like" and "German like" coal, respectively**

Thus, for the revised 1995 inventory the emission estimates presented in the Stage I report (which were calculated with 2 µg I-TEQ/t) are multiplied by the ratios 5/2 and 23/2. According to the general decrease of solid fuel combustion in European households for each of the years 2000 and 2005 emission reductions of 10% are assumed.

1.2.5. Accidental fires

As numerous publications show, accidental fires of buildings, cars and especially of devices containing chlorinated compounds (PCB's, PVC) may be a source of dioxins which lead to contamination of the residues and the land in their vicinity. However, as it is impossible to measure PCDD/F emission directly from an open burning fire most information is available from case studies where concentrations in ambient air, soil and residue materials were determined. An estimation of the total atmospheric release of PCDD/F from such events naturally must be uncertain.

In the Stage I report the estimation of dioxin emissions from accidental fires was based solely on a publication by Lorenz et al [15]. In this paper, data on dioxin contamination in fire residues and on affected areas were evaluated in connection with corresponding statistical information about fire events in Germany. Several assumptions were made concerning the average residue mass, the average area being contaminated and the corresponding PCDD/F loads. From their assumptions regarding the affected areas (500 m² in case of domiciles, 2.500 m² in case of agricultural buildings and 5.000 m² in case of industrial fires) and mean surface concentrations (100, 100 and 500 ng I-TEQ/m², respectively) Lorenz et al. derived for Germany a PCDD/F potential of 81 g I-TEQ/year which is deposited in the vicinity of the fires. They further assumed that about the same amount may be emitted on particles which are not deposited near the source and which therefore can be termed as air emission.

As no better information was available this emission of 81 g I-TEQ/year in Germany estimate was used in the Stage I report as a basis for evaluation of potential emissions in the other countries considered. Since relevant statistical data were available only for few countries, the estimation was roughly made by multiplying the German estimate with the relation of the respective capita numbers. Summing up the estimates for all countries revealed the source type "accidental fires" to be of considerable importance for the annual dioxin emissions in Europe. Clearly, this procedure could only yield an indicating emission estimate associated with high uncertainty.

Consequently, this approach was subjected to criticism when the Stage I report had been released [16]. In particular, the presumptions on the size of affected areas as well as on their average PCDD/F content were challenged. Regarding the latter, it was stated that almost no wipe sample collected at different locations of accidental fires ever reached the chosen mean value of 500 ng I-TEQ/m². This statement was underlined by a list of results collected from the literature or from other information (c.f. Table 6)

Location/year	**Maximum surface load (ng –TEQ/m²)**	**Further values found (ng –TEQ/m²)**
Düsseldorf airport 1998	32	All <1
Aachen hospital	< 200	
Agency for telecommunication, Frankfurt	147	4 values between 0,5 and 7
Agency for telecommunication, Düsseldorf 1990	7000	
Room fire	54	48, 45
PVC carpet company, Sweden, 1987	292 (N-TEQ)	49 down to 1,4 with increasing distance
Art museum Düsseldorf, video installation	180	
PVC, Lengerich 1992	7	Nearly all other < 1
Underground, Bonn 1996	1,5	
Underground Munich, 1996	0,84	11 values below 0,84
PVC-storage building	247	4 values < 9, 1 value =11

Table 6 surface contamination measured on various occasions of accidental fires

Most of the results quoted above were obtained from samples taken at the fire location and thus do not necessarily reflect the surface contamination in the vicinity; and, if there is a contamination outside the buildings at all, a decrease of concentration with increasing distance to the core of the fire is very likely. Therefore, at first glance it appears obvious that the assumptions made by Lorenz et al. led to significant overestimation.

However, Lorenz et al did not reflect to the maximum concentrations, but to the combined values for an average concentration and a “standard” contaminated area. In fact, they assumed a particular amount of PCDD/F to be released by the different types of fires (domicile: 50 µg; agriculture 250 µg and industrial 2.500 µg (= 2,5 mg) I-TEQ per fire event).

Whether these specific releases may be taken as average values for all kinds of fires is hard to say in view of the limited measurement data available. From the incidents listed in Table 6 only the Swedish paper [17] allows for a plausibility check. Based on the results published therein, table 7 shows a calculation of the amount of dioxins and furans that have been deposited on the area affected by the fire plume which is assumed to have been emitted with an angle of 45° or 60°, respectively. Further, the surface concentrations found at one particular distance is assumed to be representative for the entire affected area between this distance and the distance of the previous sampling point.

As the calculation reveals, an overall deposition of 2 mg I-TEQ may have happened; moreover, this overall deposition is not determined by the maximum concentration found nearby the fire but by the much lower concentrations on the more distant surfaces. Finally, if the overall deposition on the affected area (~ 800.000 m² or ~ 1.200.000 m², respectively) was related to a “standard area” of 5.000 m² as proposed by Lorenz, average concentrations of 305 or 407 ng I-TEQ/m² are obtained. Quite similar values can be found for the Lengerich PVC fire (45°: 1,3 mg I-TEQ overall, 255 ng I-TEQ/5000 m²; the lowest concentration found at distance 6.600 m was taken for background correction). Thus, the average depositions of the real events related to 5000m² are only slightly less than the default value used in the paper of Lorenz. Taking further into account that the plumes probably affected even more distant surfaces which no measurement data are available for the German study appear to characterise the emissions on occasions of the both industrial PVC fires quite appropriately.

Number	radius	Area of circular ring with radius between r(n-1) and r(n)	Measured (corrected for background contamination)	Affected area	Deposition on affected area	Affected area	Deposition on affected area
				sector size 45°		sector size 60°	
n	m	m²	ng N-TEQ/m²	m²	mg N-TEQ	m²	mg N-TEQ
1	10	314	291,8	39	0,01	52	0,02
2	30	2.513	48,8	314	0,02	419	0,02
3	100	28.588	19,8	3.574	0,07	4.765	0,09
4	300	251.327	3,45	31.416	0,11	41.888	0,14
5	600	848.230	3,8	106.029	0,40	141.372	0,54
6	1000	2.010.619	1,3	251.327	0,33	335.103	0,44
7	1500	3.926.991	1,2	490.874	0,59	654.498	0,79
Totals		7.068.583		883.573	1,52	1.178.097	2,03
Mean deposition related to 5000 m² [ng N-TEQ/m²]:				**305**		**407**	
*) calculation: 3.1415 * 45/360 * [r(n)^2-r(n-1)^2])							

table 7 Swedish fire of a PVC-store: Calculation of total PCDD/F release and surface contamination normalised to 5.000 m² [17]

Nevertheless, it remains questionable whether the both PVC fire cases could be considered as representative for all industrial fires or whether they should better be recognised as extraordinary events. For illustration: during the fire at Düsseldorf airport about 25 tons of material was burned, whereas the Swedish fire took 200 tons of PVC and 500 tons of plastic carpets. Regarding the Lengerich PVC fire the impression that this fire was an extreme case is supported by the experience of the emergency measurement team of the North Rhine Westphalia Environment Agency (LUA).

Moreover, the assumption that an amount of PCDD/F similar to that disposed on the area nearby the fire will be emitted into the free atmosphere has no experimental support. The relation between deposition and air emission will largely be dependent on the meteorological conditions during the fire event and may therefore vary considerably. Actually, higher deposition rates in the vicinity of the fire are more likely at conditions (e.g. inversion) which prevent the fire plume to enter the atmospheric mixing layer. Thus, high contamination of the surroundings could mean low atmospheric emissions and vice versa. This relation complicates any assessment of the environmental impact of an accidental (open) fire.

As a conclusion, in the case of industrial fires the default values used for the estimation of dioxin deposition in the surroundings do not appear to be improbable but most likely mark the upper end of the range of surface contamination found on such occasions. This view is further supported by the fact that not all industrial fires involve high amounts of chlorinated compounds. Accordingly, in the revised inventory for 1995 the emissions from accidental fires are estimated to range from to 5% to 100 % of the estimate given in the Stage I report.

1.2.6. Landfill fires

It is well known that in some European countries still illegal and uncontrolled dump sites for municipal solid waste exist. Such dumping sites frequently are set to fire either by auto-ignition or intentionally in order to increase their capacity.

Data on PCDD/F emissions caused by this practice is scarce. Of the national dioxin reports revised in Stage I only the Swedish and the Swiss document relate to this source type. From simulation experiments the Swedish researchers obtained a range of PCDD/F concentrations in the combustion gas from 66 to 518 ng N-TEQ/m³ and a specific flue gas volume of 1700 m³/ton. From these values an emission factor of ca. 100 - 900 µg/ton can be derived. The

Swiss dioxin emission factor was calculated from msw incinerator filter dust contamination (15 µg I-TEQ/kg) and a dust release rate of 30 kg dust/ton waste to be 450 µg I-TEQ/ton.

Related to the topic, the US EPA carried out measurements on the practice of “backyard waste burning” which frequently can be found in rural areas of the United States [10]. Emission factors ranging from 1,7 up to 6.433 µg I-TEQ/ton depending on waste composition and burning conditions. However, these factors were obtained for containerised barrel burning and thus can only serve as an indication of values that would be obtained during open burning. The only open burning experiment performed within this series yielded 59 µg I-TEQ/ton.

Recently, Greenpeace Greece claimed large PCDD/F emissions from dumpsite fires [18]. Using different emission factors taken from the literature annual releases to air ranging from ca. 50 to 920 g I-TEQ/year were estimated. Greece presumably is the country having the most considerable problem with dumpsite fires of all Western European countries; it is estimated that some 3.500 to 5.000 uncontrolled dumpsites exist; particularly on the islands a large fraction (up to 80%) of the household waste is dumped and burned.

Putting all this information together landfill fires still could be a appreciable emission source for dioxins and furans at least in some European countries. However, the amount of waste being burned is hardly to estimate without more specific data from those countries. Moreover, it appears reasonable to assume that the emissions from dumpsite fires — due to their generation near ground level — are not entirely subjected to long-range transport processes but may have a considerable local impact. Hence this source type is not further considered in the following part of the report which mainly addresses those PCDD/F emissions contributing to Europe’s overall PCDD/F load.

References

1. J. M. Berdowski, J. Baas, J. J. Bloos, A. J. H. Visschedijk and P. Y. J. Zandveld, The European Atmospheric Emission Inventory for Heavy Metals and Persistent Organic Pollutants, UFOPLAN no. 104.02 672/03, 244 pp., TNO, Niederlande, Berlin (1997).
2. A Review of Dioxin Emissions in the UK, DOE/HMIP/RR/95/004, 113 pp., Her Majesty's Inspectorate on Pollution (1995).
3. H. J. Bremmer, L. M. Troost, G. Kuipers, J. de Koning and A. A. Sein, Emissions of Dioxins in the Netherlands, 770 50 1018, 178 pp., National Institute of Public Health and Environmental Protection (RIVM) - Bilthoven, Netherlands Organization for Applied Scientific Research (TNO) - Apeldoorn (1994).
4. Handbuch Emissionsfaktoren für stationäre Quellen -Ausgabe 1995, 341 pp., Bundesamt für Umwelt, Wald und Landschaft (BUWAL), econcept, Zürich (1995).
5. R. De Lauretis, Dioxins and Furans Italian National and Local Emission Inventories, Dioxin '99, Venice, 12.-17-09.1999. Organohalogen Compounds 41, pp. 487-489 (1999).
6. R. De Fré and M. Wevers, Stofdossier Dioxines, MIE-DI-9459, 127 pp., VITO (1995).
7. G. Eduljee, Secondary Exposure to dioxins through exposure to PCP and its derivatives, The Science of the Total Environment 232, 193-214 (1999).
8. C. E. J. Cuijpers, H. J. Bremmer and N. B. L. Luijckx, Dioxins and PCBs in the Netherlands, Dioxin '98, Stockholm, Organohalogen Compounds 38, pp. 59-64 (1998).
9. Emission data for the Netherlands, Inspectorate for Environmental Protection, `s-Gravenhage, NL .
10. B. K. Gullett, A. F. Sarofim, K. A. Smith and C. Procaccini, The role of chlorine in dioxin formation, Process Saf. Environ. Prot. 78, 47 - 52 (2000).
11. W. Moche and G. Thanner, PCDD/F-Emissions from Coal Combustion in Small Residential Plants, Dioxin '98, Stockholm, Organohalogen Compounds 36, pp. 329-332 (1998).
12. K.-J. Geueke, Gessner.A., E. Hiester, U. Quaß and G. Bröker, THE DG ENV EUROPEAN DIOXIN EMISSION INVENTORY - STAGE II: Elevated Emissions of Dioxins and Furans from Domestic Single Stove Coal Combustion, Dioxin 2000, Monterey, California, 13. - 18. August 2000. Organohalogen Compounds (2000).
13. W. Moche and G. Thanner, PCDD/F Emissions from Domestic Heating with Wood, Coal and Coke, Dioxin 2000, Monterey, California, 13.-17.08. Organohalogen Compounds 46, pp. 295-297 (2000).
14. W. Gumz, Kurzes Handbuch der Brennstoff- und Feuerungstechnik(, Springer, Berlin (1962).
15. W. Lorenz, H. Wichmann and M. Bahadir, Bilanzierung der Freisetzung von polychlorierten Dibenzo-p-dioxinen und Dibenzofuranen bei Brandunfällen - ein Diskussionsbeitrag, Gefahrstoffe - Reinhaltung der Luft 56, 49-53 (1996).
16. E. Spindler, Personal Communication., 1998.

17. S. Marklund, R. Andersson, M. Tysklind and C. Rappe, Emissions of PCDDs and PCDFs from a PVC-Fire in Holmsund, Sweden, Chemosphere 18, 1031-1038 (1989).

18. S. Psomas, Personal Communication., 2000.

2. Austria

The report to Stage I referred to the national Austrian emission inventory data supplied by the Austrian Umweltbundesamt (UBA). This inventory contained data prepared for the CORINAIR inventory. It was mainly based on the results of a study carried out by the Austrian institute FTU which had not been officially released at that time. Meanwhile this study is available and the emission data reported therein are shown in the fourth column (see A/Table 1). Compared to the data of UBA the FTU study provides some additional information which lead to a slightly increased total emission estimate.

The LUA re-estimation procedure yielded a much higher annual emission value for Austria, mainly due to a higher emission factor for domestic wood burning and iron ore sintering and because further sources were considered.

In view of the considerable amount of measurement data on domestic wood combustion in Austria reported in the FTU study, the emission estimate for this source type had to be revised. Thus the revised table for the year 1995 contains an estimate of 15 g TE/a found by FTU. Further, with respect to the measurement results from single stove coal combustion obtained by the Austrian UBA [1], [2], [3] a min-max range was introduced for this source type. The min-max ranges were also applied to the other highly uncertain source types " Preservation of wood" and „Fires".

Regarding iron ore sintering, the LUA estimate was corrected because abatement measures were already in operation at one of the two sintering plants (Airfine system).

The projected decrease of emission from some sources until 2005 is partly based on information given in the FTU study and partly just drawn from assumptions. Even with respect to the minimum estimates Austria already appears to have reached a situation of equal contributions to its overall dioxin emission by industrial and non-industrial emission sources (see A/Table 2).

AUSTRIA SNAP			ÖFZS 1987/88		TNO 1997 1990	A_UBA 1994	FTU 1997 1994/95		LUA 1997 1993-1995
01	Power plants	fossil fuels	0		0,61	0,1	0,15		nd
0202	Res. combustion: Boilers, stoves, fireplaces	wood	70,0	*1)	32,9	13,6	15,1		67,6
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite			11,6	0,6	0,843		1,2
0301	Combustion in Industry/boilers, gas turbines, stationary engines				4,8	1,5	2,3		0,4
30301	Sinter plants				19,0	8,0	8		27,2
030308	Secondary zinc production		19,0	*2)	nd	0,0	nd		0,1
030309	Secondary copper production				nd	0,3	0,27		2,4
030310	Secondary aluminium production				nd	1,8	1,8		1,0
30311	Cement		nd		nd	0,1	0,11		0,7
030326	Other: metal reclamation from cables		nd		ne	ne	ne		ne
040207	Electric furnace steel plant		see	*2)	0,7	nd	0,15		0,4
040309	Other: Non ferrous metal foundries		see	*2)		nd	0,215		0,1
040309	Other: sintering of special materials and drossing facilities		ne		ne	ne	ne		ne
060406	Preservation of wood		nd		nd	nd	nd		7,9
0701	Road transport		0,4			nd	0,3		0,4
090201	Inc. of Dom. or municipal wastes	legal combustion	3,0		12,0	0,1	0,099		0,1
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion	nd		nd	nd	nd		3,5
090202	Inc. of Industrial wastes	hazardous waste	6,0		nd	0,0	0,05		0,0
090207	Inc. of hospital wastes		4,0		nd	0,0	0,02	*3)	0,0
090901	Cremation: Inc. of Corpses		nd		nd	0,1	0,1		0,1
1201	Fires		10,0		nd	nd	0,1		7,9
Total of sources considered (g I-TEQ/year)			**112**		**82**	**26**	**30**		**121**
Total of referred Inventory (g I-TEQ/year)			112		85	27	33		121
% of entire inventory covered by considered sources			100%		96%	96%	90%		100%

nd: not determined
ne: not existent

*1) all small heating installations
*2) comprises entire metallurgical sector
*3) small pyrolytic facilities 1 t/d

A/table 1 overview on emission inventory data (annual emission in g I-TEQ/year)

AUSTRIA			Revised for 1995			Actual data 2000			Projection 2005			Uncertainty Assessment	Future Trend	Comments
SNAP			min	prob	max	min	prob	max	min	prob	max			
01	Power plants	fossil fuels		0,2			0,2			0,2		●●○○	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	wood		15,0			15,0			15,0		●●○○	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	3,0		13,8	2,7		12,4	2,4		11,2	●○○○	↓	High emission factors measured by Austrian UBA (1998); projected decrease as result of assumed corresponding public information campaigns
0301	Combustion in Industry/boilers, gas turbines, stationary engines			1,5			1,5			1,5		●●○○	⇔	
30301	Sinter plants			16,0			17,4			18,4		○○●●	↑	incl. diffuse and room-dedusting emissions; two thirds of 1994 production assumed to be produced by abated (Airfine) plant with emission factor of 1 µg I-TEQ/t for sinter process. Increasing trend due to increasing activity rates
030308	Secondary zinc production			0,1			0,1			0,1		●○○○	⇔	
030309	Secondary copper production			0,3			0,3			0,3		●●○○	⇔	
030310	Secondary aluminium production			1,8			1,2			0,6		●○○○	↓	Abatement measures at main producers started before 1995
30311	Cement			0,1			0,1			0,1		●○○○	⇔	
030326	Other: metal reclamation from cables			ne			ne			ne		●●●●		
040207	Electric furnace steel plant			0,4			0,5			0,5		●○○○	↑	increasing activity rates!
040309	Other: Non ferrous metal foundries			0,2			0,2			0,2		●○○○	⇔	
040309	Other: sintering of special materials and drossing facilities			ne			ne			ne		●●●●		
060406	Preservation of wood		0,1		8,0	0,1		7,2	0,1		6,3	○○○○	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	Road transport			0,4			0,4			0,2		●○○○	↓	decrease of mean fuel consumption; decreasing use of leaded fuels in neighborhood conuntries
090201	Inc. of Dom. or municipal wastes	legal combustion		0,1			0,1			0,1		●●●●	⇔	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion		3,5			2,0			0,5		○○○○	↓	increasing public knowledge on dioxin generation
090202	Inc. of Industrial wastes	hazardous waste		0,1			0,1			0,1		●●●●	⇔	
090207	Inc. of hospital wastes			0,0			0,0			0,0		●●○○	⇔	
090901	Cremation: Inc. of Corpses			0,1			0,1			0,1		●●○○	⇔	
1201	Fires		0,1		8,0	0,1		8,0	0,1		8,0	○○○○	⇔	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)			43 — 70			42 — 67			40 — 63					
industrial sources			24 — 24			24 — 24			23 — 23					
non-industrial sources			19 — 45			18 — 43			18 — 41					

Uncertainty assessment: ●●●●: low uncertainty; ○○○○: very high uncertainty; ne: presumalbly not existing process

A/table 2 assessment of dioxin emissions in Austria until 2005(annual emission in g I-TEQ/year)

References

1. W. Moche and G. Thanner, PCDD/F-Emissions from Coal Combustion in Small Residential Plants, *Dioxin '98,* Stockholm, *Organohalogen Compounds* **36**, pp. 329-332 (1998).

2. W. Moche and G. Thanner, PCDD/F Emissions from Domestic Heating with Wood, Coal and Coke, *Dioxin 2000,* Monterey, California, 13.-17.08. *Organohalogen Compounds* **46**, pp. 295-297 (2000).

3. K.-J. Geueke, Gessner.A., E. Hiester, U. Quaß and G. Bröker, THE *DG ENV* EUROPEAN DIOXIN EMISSION INVENTORY - STAGE II:

Elevated Emissions of Dioxins and Furans from Domestic Single Stove Coal Combustion, *Dioxin 2000,* Monterey, California, 13. - 18. August 2000. *Organohalogen Compounds* (2000).

3. Belgium

Compared to the emission estimates presented in the Belgian inventory study the LUA re-estimation in the Stage I report resulted in a lower annual emission rate (see B/Table 3). This was caused by considerably lower emissions assessed in the sector of domestic burning as well as in some industrial branches, particularly the non-ferrous metal industry. However, in view of the high emission factors for single stove coal burning found by the Austrian UBA the LUA estimate for this sector might have been too low. The uncertainties connected to the sector “domestic burning” are still thus high and are taken into account by setting min/max emission ranges.

Min/max emission ranges also were set for a number of other source types which no further information was obtained for since publication of the stage I report.

The aim to clarify the emission situation regarding iron ore sintering plants in Belgium could only be reached in part. No co-operation on doing measurements within the EU project was achieved with the Flemish steel industry or public environmental institutes, respectively. However, emission estimates submitted for the years 1998 and 1999 indicate that the emissions from sinter plants in Belgium had been underestimated considerably. The two sinter plants in Flanders were shown to have following emissions:

- 1998: 80,7 g TEQ
- 1999: 20,3 g
- 2000: 7 g foreseen on the basis of actual measurements,
- 2001: 5 g estimated by Sidmar,
  3,8 g using the emission guide value concentration of 0,4 ng/m³ they claim to be able to obtain.

Thus, for the year 1995 the default overall emission factor of 10 µg TE/ton sinter (yielding 98 g I-TEQ/year annual emision) chosen in the Stage I report appears to have been a quite good estimate. The operator of the Flemish sintering plants has joined the international consortium which has build a pilot sintering facility with state-of-the-art abatement installations (active carbon injection/catalyst).

Regarding the Walloon plants measurements were conducted within Stage II (see Vol. 2, chapter 3); Stack emissions were measured to be 0,7 (range 0,6- 0,8) and 6,8 (range 5,2 – 9,8) ng I-TEQ/m³. The low emission found for the Liége plant was measured after a considerable reconstruction of the plant took place in 1999 which comprised the installation of a separate circular cooler for the sintered material. Before, a part of the sintering strand was used for this purpose which resulted in a limited sintering capacity. After reconstruction the capacity was 15.000 tons sinter per day on a 517 m² strand. The flue gas volume amounted to ca. 1,5 million m³/hour; hence, the stack emission freight is about 1 mg I–TEQ/h or 8 g I-TEQ/year. This value is taken for the year 2000; for 1995 it is assumed that only 4 g I-TEQ/year were emitted due to the lower capacity of the plant.

The other plant is about half the size with 213 m² strand surface and 7000 tons sinter production per day. With a flue gas volume flow of 366,000 m³/h an emission freight of 2,5 mg I-TEQ/h or approx. 20 g I-TEQ/year can be calculated.

Summarising, the stack emissions from the Belgian iron ore sintering processes were 109, 35 and 32 g I-TEQ/year are assessed for the years 1995, 2000, and 2005, respectively. To account for additional emission sources like stack gases from sinter cooler and fugitive emissions, a 10% surplus is added.

The declining trend caused by improved emission levels is further enhanced by decreasing activity rates; from the trend of the years 1994-1998 the activity in the years 2000 and 2005 may be predicted to be 92% and 84% of the 1994 value, respectively. Taking this into account the emissions from iron ore sintering are assumed to be ca. 35 and 20 g I-TEQ/year in 2000 and 2005, resp.

However, this considerable emission reduction is partly countered by increasing emissions from electric arc steel production which has gained considerably importance during the recent years.

Considerable emission reduction can be assumed for the Belgian msw incinerators. Already the Belgian dioxin inventory report [1] predicted an overall reduction from 187 g TE/a in 1995 to ca. 63 TE/a in 1996. This prediction was based on abatement measures scheduled at that time. In 1998, in a further publication of the inventory’s author the emissions from msw incinerators in Flanders were assessed to be 5 to 20 g I-TEQ/a; this range was obtained by estimating the emissions from yearly measured flue gas concentrations and annual flue gas volumes (lower estimate) or from typical emission factors and annual waste throughput (upper estimate). The author believed the upper estimate to be more realistic because the yearly measurements are assumed to be carried out under optimum conditions which do not reflect real operation.

However, even more actual information regarding msw plants in Flanders was obtained on special request. Accordingly, in 1998, all municipal waste incinerators were equipped with a dioxin reduction system. Eleven of the thirteen installations were injecting activated carbon, IVRO has catalytic bag filters, ISVAG remained shut down during the whole year. IDM decided to close down after not being able to obtain the emission limit value.

The dioxin emission calculations shown in the table below (see B/Table 1) were based on the amounts of burned waste combined with an emission factor of 1,8 µg TEQ/ton (0,3 ng TEQ/Nm³ concentration in flue gas). From 1/1/1997 the 0,1 ng TEQ/Nm³ at 11% O_2 limit value was imposed in Flanders, to be verified by 2 measurements each year. As it is known that emissions sometimes were higher, especially during periods of start-up and technical problems with filters, average emission was estimated 3 times higher than the limit value.

Already in 1999 several msw incinerators were equipped with continuous dioxin sampling equipment. From January 1st this is obligatory, so the measurements will better reflect average yearly emissions. To obtain 0,1 ng TEQ/Nm³ on the continuous samples more efforts will have to be done by the msw incinerators, like installing more powerful support burners, warning systems on the activated carbon supply, combustion optimisation. Taking into account these facts it is anticipated that in the year 2000 the average emission concentration will be below 0,1 ng TEQ/Nm³.

Name of incinerator	Burned amount of waste 1998	Dioxin emission in g TEQ in 1998
IVAGO, Gent	90 506	0,160
IDM Lokeren	17 336	0,031
IMOG Harelbeke	63 498	0,114
INDAVER Beveren	192 708	0,347
ISVAG Wilrijk	-	-
IVBO Brugge	181 989	0,328
IVM Eeklo	64 274	0,116
IVMO Menen	55 992	0,101
IVOO Oostende	54 662	0,098
IVRO Roeselare	46 979	0,085
DALKIA Knokke	32 922	0,059
MIWA Sint-Niklaas	55 022	0,099
ReMi Houthalen	64 890	0,117
Total	**920 778**	**1,566**

B/table 1 annual dioxin emissions from waste incinerators in Flanders

Regarding the four **Walloon** incinerators actual measurement data could be found in the internet (see B/Table 2).

Plant location	Month of sampling	Line 1	Line 2	Line3	Line4	Annual emission [g I-TEQ/a]*)
Liege	06;08/1998	2,3	4,4	4,3	2,7	3,1
Charleroi	11/98 04;05/99	147 154	170 99	22,6	-	72
Thumaide	07/98	0,75	0,25	0,12	-	0,2
Virginal	07/99	0,11	-	-	-	0,03

B/table 2 PCDD/F concentrations measured at Walloon incinerators; *) annual emissions estimated from 1995 throughput rates, flue gas concentrations averaged for all lines and 6000 Nm³ flue gas per ton of waste

Finally, the Brussels incinerator was still told to be without any dioxin specific abatement system; hence the 1996 estimate of 26 g I-TEQ/year [1] is assumed to be valid for the year 2000.

Obviously, the recent dioxin emissions from incineration of municipal solid waste in Belgium was dominated by one plant. As no information was available if the situation at this plant has been improved meanwhile, the overall emission estimate for the year 2000 is set to 100 g I-TEQ. By contrast, the projected emission for 2005 anticipates wide compliance with the 0,1 ng I-TEQ/m³ limit.

Revision also was necessary with respect to the incineration of hospital wastes. In the Belgian study an emission factor of 2.250 µg I-TEQ/ton waste (150 ng/m³, averaged from 4 measurements, specific flue gas volume 15.000 m³/ton) was used, valid for on-site incinerators. Annual emission was estimated to have been 95 g I-TEQ/a, which is maintained as upper estimate for 1995. However, the study also mentioned that the amount of waste burnt in hospital on-site incinerators might be overestimated by about factor 2. Therefrom the lower estimate in B/Table 4 was calculated.

Belgium			VITO						TNO		LUA 1997	
SNAP			1985		1990		1995		1990		1993-1995	
01	Power plants	fossil fuels	1,5		2,1		2,3		2,5		nd	
0202	Res. combustion: Boilers, stoves, fireplaces	wood	128,7		85,5		85,5		nd		9,1	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	89,2		43,0		28,2		83,89		1,1	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		10,1		8,6		7,0		59,3		0,6	
30301	Sinter plants		62,6		67,5		53,2		nd		98,3	
030308	Secondary zinc production		0,1		0,5		0,8		nd		1,0	
030309	Secondary copper production		52,0		68,4		82,3		64,8		5,1	
030310	Secondary aluminium production		21,4		32,5		19,8		nd		0,1	
30311	Cement		16,1		19,7		20,8		3,1		1,1	
030326	Other: metal reclamation from cables		nd		nd		nd		nd		nd	
040207	Electric furnace steel plant		2,6		4,9		6,4		4,2		6,4	
040309	Other: Non ferrous metal foundries								0,215		0,8	
040309	Other: sintering of special materials and drossing facilities		nd		nd		nd		nd		nd	
060406	Preservation of wood		25,0		25,0		25,0		nd		10,1	
0701	Road transport		6,1		4,8		1,7		4,3		2,6	
090201	Inc. of Dom. or municipal wastes	legal combustion	297,0		385,0		187,0		341		187,0	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion	30,0		30,0		30,0		nd		4,3	
090202	Inc. of Industrial wastes	hazardous waste	7,7		11,2		20,9		nd		20,9	
090207	Inc. of hospital wastes		100,0		100,0		95,0		nd	*3)	95,0	
090901	Cremation: Inc. of Corpses		0,1		0,1		0,2		0,1		0,2	
1201	Fires		3,4		3,2		2,6		0,1		10,0	
Total of sources considered above (g I-TEQ/year) *)			**798**		**837**		**614**		**564**		**454**	
Total of Inventory referred to (g I-TEQ/year)			850	*	892	*	662	*	616		454	
%of repective inventory covered by considered sources			94%		94%		93%		91%		100%	

*) summed-up without values presented in dashed typing (55 g I-TEQ/a) and without additional each 5 g I-TEQ/a from open burning of demolition waste agricultural waste, resp.. Inclusion of this data leads to 915, 957 and 727 g I-TEQ/a for the considered reference years. The latter value (727 g I-TEQ/a) was reported in Stage I report VOL 2 (Belgium).

nd: not determined

ne: not existent

B/table 3 overview on emission inventory data (annual emission in g I-TEQ/year)

Belgium			Revised for 1995			Actual data 2000			Projection 2005			Uncertainty Assessment	Future Trend	Comments
SNAP			min	prob	max	min	prob	max	min	prob	max			
01	Power plants	fossil fuels		2,3			2,3			2,3		●●●○	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	wood	10,0		90,0	10,0		90,0	10,0		90,0	○○○○	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	2,9		13,1	2,6		11,8	2,3		10,6	○○○○	↓	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		0,6		7,0	0,6		7,0	0,6		7,0	●●○○	⇔	
30301	Sinter plants			120,0			35,4			29,6		●●●○	↓	incl. diffuse and room-dedusting emissions; primary abatement measures assumed to be effective
030308	Secondary zinc production			1,0			1,0			1,0		●○○○	⇔	
030309	Secondary copper production			5,0			5,0			5,0		○○○○	⇔	Belgian estimate disregarded because emission factors used are likely to be too high
030310	Secondary aluminium production		0,1		20,0	0,1		20,0	0,1		20,0	●○○○	⇔	
30311	Cement		1,0		20,0	1,0		20,0	1,0		20,0	○○○○	⇔	
030326	Other: metal reclamation from cables			ne			ne			ne		●●●●		
040207	Electric furnace steel plant			6,4			11,4			16,8		●●○○	↑	increasing activity rates
040309	Other: Non ferrous metal foundries			0,2			0,2			0,2		●●○○	⇔	
040309	Other: sintering of special materials and drossing facilities			ne			ne			ne		●●●●		
060406	Preservation of wood		0,1		10,0	0,1		8,9	0,1		7,9	○○○○	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	Road transport			2,6			2,0			2,0		●○○○	↓	decrease of mean fuel consumption; decreasing use of leaded fuels in neighborhood conuntries
090201	Inc. of Dom. or municipal wastes	legal combustion		187,0			65,0			3,0		●●○○	↓	assumption: continuing increase of abatement until comply with 0.1 ng limit.
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion	3,0		30,0	2,0		20,0	1,0		10,0	○○○○	↓	increasing public knowledge on dioxin generation
090202	Inc. of Industrial wastes	hazardous waste		20,9			18,0			0,5		●●●●	↓	
090207	Inc. of hospital wastes		35,0		95,0		6,0			0,1		●●○○	↓	decrease of on-site incineration; projected value assumes compliance to 0.1 ng/m³ limit
090901	Cremation: Inc. of Corpses			0,2			0,3			0,4		●●○○	↑	increasing cremation rate assumed
1201	Fires		0,1		10,0	0,1		8,0	0,1		8,0	○○○○	↓	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)			398 — 641			163 — 332			76 — 234					
industrial sources			383 — 515			148 — 212			62 — 116					
non-industrial sources			16 — 126			15 — 121			15 — 119					

Uncertainty assessment: ●●●●: low uncertainty; ○○○○: very high uncertainty

B/table 4 assessment of dioxin emissions in Belgium until 2005 (annual emission in g I-TEQ/year)

References

1. R. De Fré and M. Wevers, Stofdossier Dioxines, MIE-DI-9459, 127 pp., VITO (1995).

4. Switzerland

Switzerland has published a time series of dioxin emissions covering the period from 1950 to 2010 [1]. It is based on emission factors which were determined for the year 1990 on basis of available measurement data and related information. Emission factors for the other years were estimated mainly from assumptions and projections about the past and future trends.

For the revised inventory 1995 the Swiss estimates have been taken for most sectors; in some more uncertain cases (large difference between Swiss inventory data and LUA re-estimation) min/max estimates are given (see CH/Table 1).

The most dramatic decrease is projected for the incineration of municipal waste. Due to more stringent regulations regarding NO_x-emissions the release of dioxins and furans is reduced indirectly. All plants have to comply until 1998 with the regulation which came into force in 1991. The same regulation applies to hospital waste incinerators which have to install an upgraded flue gas cleaning or shut-down within periods which are set by the regional environmental authorities. Also incineration of hazardous and construction waste are projected to decrease considerably (see CH/Table2).

However, an increase of the illegal practice of burning waste in domestic solid-fuel heating devices (open chimneys, wood stoves) is anticipated by the Swiss inventory. From a recent publication [2] it can be derived that the problem mainly is due to illegal burning of waste wood materials which ist estimated to amount 200.000 tons per year. Applying an emission factor of 100 µg I-TEQ/ton burned waste wood the emissions are estimated to 20 g I-TEQ/year. Possibly, increasing fees for regular waste treatment (deposition/incineration) lead to this adverse development. Swiss environmental authorities expect this source to hold a share of more than 50% of the overall national dioxin emissions in a few years from now (see CH/Table2).

Switzerland			BUWAL						TNO		LUA 1997	
SNAP			1985		1990		1995		1990		1993-1995	
01	Power plants	fossil fuels	0,0		0,1		0,13		0,1		nd	
0202	Res. combustion: Boilers, stoves, fireplaces	wood	0,9		0,6		0,5		1,1		8,3	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite		*)					0,0		0,8	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		1,4		0,6		0,713		2,5		0,4	
30301	Sinter plants		ne		ne		ne		ne		ne	
030308	Secondary zinc production		ne		ne		ne		ne		ne	
030309	Secondary copper production										1,5	
030310	Secondary aluminium production		0,8		0,7				0,7		0,2	
30311	Cement		0,8		0,8		0,672		0,8		0,7	
030326	Other: metal reclamation from cables		14,2		0,1		nd		nd		0,0	
040207	Electric furnace steel plant		12,9		12,2		8,03		12,2		8,0	
040309	Other: Non ferrous metal foundries		13,6		6,4		1,827		6,4		0,0	
040309	Other: sintering of special materials and drossing facilities		ne		ne		ne		ne		ne	
060406	Preservation of wood								nd		7,1	
0701	Road transport		3,2		2,3		1,136		1,9		3,3	
090201	Inc. of Dom. or municipal wastes	legal combustion	251,0		120,0		96,2		193,0		123,1	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion	22,5		26,8		26,9		nd		4,57	
090202	Inc. of Industrial wastes	hazardous waste	60,9		31,7		20,021		nd		7	
090207	Inc. of hospital wastes		10,9		13,8		10,4		nd	*3)	10	
090901	Cremation: Inc. of Corpses		0,3		0,4		0,415		0,4		0,42	
1201	Fires		30,2		19,9		9,13		0,1		7,1	
Total of sources considered above (g I-TEQ/year) *)			**423,6**		**236,4**		**176,1**		**219,3**		**182,6**	
Total of Inventory referred to (g I-TEQ/year)			**439,0**		**242,0**		**182,0**		**242,0**		**183,0**	
%of repective inventory covered by considered sources			**96%**		**98%**		**97%**		**91%**		**100%**	
*) included in value for wood combustion												
nd: not determined												
ne: not existent												

CH/table 1 overview on emission inventory data (annual emission in g I-TEQ/year)

Switzerland			Revised for 1995			Actual data 2000			Projection 2005			Uncertainty Assessment	Future Trend	Comments
SNAP			min	prob	max	min	prob	max	min	prob	max			
01	**Power plants**	fossil fuels		0,13			0,13			0,13		●●●❍	⇔	
0202	**Res. combustion: Boilers, stoves, fireplaces**	wood		0,1			0,1			0,1		●●❍❍	⇔	
0202	**Res. combustion: Boilers, stoves, fireplaces**	coal/lignite	2,0		9,3	1,8		8,4	1,6		7,5	❍❍❍❍	↓	
0301	**Combustion in Industry/boilers, gas turbines, stationary engines**			0,71			1,1			1,1		●●●❍	↑	increasing activity rates?
30301	**Sinter plants**			ne			ne			ne		●●●●		incl. diffuse and room-dedusting emissions; primary abatement measures assumed to be effective
030308	**Secondary zinc production**			nd			nd			nd		❍❍❍❍		no facilities existing?
030309	**Secondary copper production**			ne			ne			ne		●❍❍❍		
030310	**Secondary aluminium production**			0			0			0,0		●❍❍❍	⇔	
30311	**Cement**			0,7			0,7			0,7		●❍❍❍	⇔	
030326	**Other: metal reclamation from cables**			0			0			0		●●●❍	⇔	
040207	**Electric furnace steel plant**			8,03			8,4			8,9		●●●❍	↑	increasing activity rates?
040309	**Other: Non ferrous metal foundries**			1,8			1,9			2		●●●❍	↑	
040309	**Other: sintering of special materials and drossing facilities**			nd						nd		❍❍❍❍		no facilities existing?
060406	**Preservation of wood**			7			6,279			5,5		❍❍❍❍	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	**Road transport**			1,14			0,3			0,2		●●●❍	↓	decrease of mean fuel consumption; decreasing use of leaded fuels in neighborhood conuntries
090201	**Inc. of Dom. or municipal wastes**	legal combustion		96,2			9,9			9,9		●●❍❍	↓	assumption: continuing increase of abatement until comply with 0.1 ng limit.
090201	**Inc. of Dom. or municipal wastes**	illegal (domestic) combustion	0,1		26,9	0,1		26,9	0,1		32,7	❍❍❍❍	↑	increasing activity rates projected for Switzerland?
090202	**Inc. of Industrial wastes**	hazardous waste		20			6,5			1,4		●❍❍❍	↓	includes incineration of construction wastes; projected decrease due to ongoing abatement measures
090207	**Inc. of hospital wastes**			10,4			6,9			3,5		●●❍❍	↓	projected decrease due to ongoing abatement measures
090901	**Cremation: Inc. of Corpses**			0,42			0,5			0,5		●●●❍	↑	increasing cremation rate assumed
1201	**Fires**			9,13			9,1			9,1		❍❍❍❍	↓	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)				**158 — 192**			**54 — 87**			**45 — 83**				
industrial sources				**138 — 165**			**36 — 63**			**28 — 61**				
non-industrial sources				**19 — 27**			**18 — 24**			**17 — 22**				

Uncertainty assessment: ●●●●: low uncertainty; ❍❍❍❍: very high uncertainty

CH/table2 assessment of dioxin emissions in Switzerland until 2005 (annual emission in g I-TEQ/year)

References

1. J. Dettweiler, G. Karlaganis, C. Studer, S. Joss, A. Stettler and D. Chambraz, Dioxine und Furane. Standortbestimmung, Beurteilungsgrundlagen, Massnahmen, Schriftenreihe Umwelt Nr. 290, p. 127. BUWAL (1997).
2. D. Noger and E. Pletscher, Der EMPA-Ascheschnelltest, *Schornsteinfegerhandwerk* **3**, 19-23;34-37 (2000).

5. Germany

No official dioxin emission inventory has been presented yet by the German government, but publications written by members of the German UBA appear to represent the official views. Accordingly, the emissions are estimated to have been around 1.200 g I-TEQ per year in 1990, decreasing sharply since then. For 1994/95 only about 300 g I-TEQ/a is assessed, and the most recent publication forecasts the emissions to decline further down to below 70 g I-TEQ in the year 2000 [1].

Almost simultaneously three emission inventories were developed for Germany in the years 1995 –1997. While the inventory presented by UBA/TNO was related to the year 1990, another compilation prepared by the IFEU institute on behalf of the German UBA has been set-up for 1994 and thus is comparable to the LUA Stage I inventory (see D/Table 1). A considerable difference of emission estimates (UBA 1994: 321 g I-TEQ/a, LUA 840 g I-TEQ/a) is revealed from these both studies. The reason is that in the LUA report some source types were included which had not been regarded by the UBA study (wood preservation, fires, illegal domestic waste incineration, special sintering plant). These sources together contribute about 310 g I-TEQ/a. Higher estimates were given by LUA for sintering plants (+ 87 g, to account for diffuse emission and room de-dusting), domestic combustion (+27 g), and municipal waste incineration (+ 127 g).

Regarding the latter, the LUA estimate was based on data from Bavarian plants (total ~ 21 g I-TEQ/year for 1994) and emission declarations of facilities located in North Rhine Westphalia (~82 g I-TEQ/year 1994). The mean emission factor of these plants was applied to annual waste throughput in Germany 1994 to obtain the reported annual emission. After publication of the Stage I report a measurement report from one particular facility in NRW revealed that emissions in 1994 actually were much lower than officially declared by the plant operator. The same might be the case regarding other plants; however no further 1994 measurement results were collected from the regional environmental offices. Thus the emission value given in the Stage I report might be somehow overestimated.

Since end of 1996 all msw incineration plants operated in Germany comply with the emission limit of 0,1 ng I-TEQ/m^3. At the present time 59 waste incineration plants are operated in Germany, with an annual capacity of ca. 13,6 million tons [2]. Some further are in the building or approval stage. These capacities appear not enough to satisfy the demands of the

Technical Regulation on Domestic Solid Waste (Technische Anleitung Siedlungsabfall) as from the year 2005. Additional thermal waste treatment plants must be built.

The special sintering plant mentioned before processes ferrous and non ferrous metal containing materials (filter dust, production residues) as input material. In 1994 the dioxin emissions from this plant had not been abated and thus the emissions had to be included in the inventory; since 1998 a fluidised bed charcoal reactor is in operation reducing the emissions by more than 99%.

The iron ore sintering plants in Germany have been measured repeatedly during the recent years; concentration in flue gases ranged in general from below 1 up to 3 ng I-TEQ/m³. Sinter production has been increasing slightly during the recent years (c.f. introductory comments); on the other hand, some sintering lines were closed. These closures might affect the emission situation positively if plants with higher PCDD/F concentrations in the flue gas are shut down while increasing the productivity of less polluting facilities. Moreover, fugitive emissions might be reduced if the number of plants declines. Besides one plant equipped with a high performance dedusting system (fabric filters) no special abatement facilities have yet been generally installed at the operating plants. However, at a real-scale experimental plant [3] a flue gas treatment was installed that comprises an active carbon injection and additionally a catalyst reactor. No measurement results of this facility have been released up to now officially.

For the inventories 2000 and 2005 therefore a decrease of emissions is predicted; however the quite optimistic assessment of ref. [1] where less than 20 g I-TEQ/year is forecasted for the year 2000 cannot be followed (see D/Table 2).

Germany			Fiedler		ref 3		ref 4		TNO		UBA		LUA 1997	
SNAP			1989		1990		1990		1990		1994		1993-1995	
01	Power plants	fossil fuels					5		365	2)	5,3		nd	
0202	Res. combustion: Boilers, stoves, fireplaces	wood			20,0		20,0		nd		0,6		27,2	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite							27,84		5,1		11,3	
0301	Combustion in Industry/boilers, gas turbines, stationary engines				25,0		20,0		50,0		6,2		4,5	
30301	Sinter plants				630,0	3)	575,0		576		168,0		254,5	
030308	Secondary zinc production						112,0		30		41,8		13,5	
030309	Secondary copper production								60		26,8		31,1	
030310	Secondary aluminium production						25,0		25		23,0		12,0	
30311	Cement				1,0		1,0		nd		0,2		4,9	
030326	Other: metal reclamation from cables								ne		ne		ne	
040207	Electric furnace steel plant						30,0		30		4,3		2,4	
040309	Other: Non ferrous metal foundries		380,0		119,0		3,0		8		nd	1)	0,6	
040309	Other: sintering of special materials and drossing facilities								nd		nd		115,0	
060406	Preservation of wood								nd		nd		81,3	
0701	Road transport		22,0		10,0		10,0		10		4,8		9,1	
090201	Inc. of Dom. or municipal wastes	legal combustion	440,0		403,0		400,0		nd	2)	30,0		157,3	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion							nd				30,9	
090202	Inc. of Industrial wastes	hazardous waste							nd		2,0		1,3	
090207	Inc. of hospital wastes								nd		0,1		0,0	
090901	Cremation: Inc. of Corpses				4,0		4,0		4		2,4		2,1	
1201	Fires								nd		nd		81,0	
Total of sources considered above (g I-TEQ/year) *)			**842**		**1212**		**1205**		**1186**		**321**		**840**	
Total of Inventory referred to (g I-TEQ/year)			846		1212		1210		1196		331		840	
% of repective inventory covered by considered sources			100%		100%		100%		99%		97%		100%	

References:

<1> The European Atmospheric Emission Inventory of heavy metals and Persistent Orgenic Pollutants for 1990, TNO/UBA, Berlin, 1997

<2>U. Quaß, M. Fermann, G. Bröker: Identification of relevant industrial sources of dioxins and furans in Europe. LUA-Materialien No. 43 (1997), Landesumweltamt Nordrhein-Westfalen, Essen, Germ

<3> Lange, UBA1995

<4> Johnke, B. UTA International 2/98, 92-103

Remarks:

1) one particular plant in Germany; emissions reduced since 1998

2) obvious error in TNO data base; value given for SNAP 01 should be assigned to msw incineration (09 02 01)

3) includes entire metallurgical sector

nd: not determined/no data

ne: not existent

D/table 1 overview on emission inventory data (annual emission in g I-TEQ/year)

SNAP	Germany		Revised for 1995 min	Revised for 1995 prob	Revised for 1995 max	Actual data 2000 min	Actual data 2000 prob	Actual data 2000 max	Projection 2005 min	Projection 2005 prob	Projection 2005 max	Uncertainty Assessment	Future Trend	Comments
01	Power plants	fossil fuels		5,0			5,0			3,0	*	●●●○	↓	
0202	Res. combustion: Boilers, stoves, fireplaces	wood		20,0			15,0			15,0		●●○○	↓	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	28,3		130,0	25,4		117,0	22,9		105,3	○○○○	↓	
0301	Combustion in Industry/boilers, gas turbines, stationary engines			10,0			10,0			10,0		●●●○	⇔	increasing activity rates?
30301	Sinter plants			200,0			100,0			70,0			↓	incl. diffuse and room-dedusting emissions; primary abatement measures and closure of old plants lead to decreasing emissions despite increasing activity rates.
030308	Secondary zinc production			40,0			10,0			10,0			↓	
030309	Secondary copper production			17,0			1,0			1,0		●●●○	↓	1995 estimate without direct use of scrap; emission for 2000 according to industry's information
030310	Secondary aluminium production			20,0			10,0			1,0		●○○○	↓	
30311	Cement			1,0			0,5			1,0		●○○○	⇔	
030326	Other: metal reclamation from cables											●●●○	⇔	
040207	Electric furnace steel plant			3,0			4,1			5,2		●●●○	↑	increasing activity rates
040309	Other: Non ferrous metal foundries		0,6		8,0		5,0			2,0		●○○○	↓	
040309	Other: sintering of special materials and drossing facilities			115,0			1,0			1,0			↓	
060406	Preservation of wood		0,1		81,0	0,1		72,7	0,1		64,2	○○○○	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory commments)
0701	Road transport			4,0	10,0		4,0			1,0		●●●○	↓	decrease of mean fuel consumption; decreasing use of leaded fuels in neighborhood conuntries
090201	Inc. of Dom. or municipal wastes	legal combustion	30,0		150,0		4,0			2,0		●●●○	↓	assumption: continuing increase of abatement until comply with 0.1 ng limit.
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion	0,1		30,0	0,1		30,0	0,1		30,0	○○○○	⇔	
090202	Inc. of Industrial wastes	hazardous waste		2,0			1,0			0,5			↓	ongoing abatement measures
090207	Inc. of hospital wastes			0,1			0,0			0,0		●○○○	↓	ongoing abatement measures
090901	Cremation: Inc. of Corpses			2,0			0,5			0,5		●●●○	↓	increasing cremation rate assumed
1201	Fires		0,1		81,0	0,1		81,0	0,1		81,0	○○○○	⇔	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)			498 — 929			197 — 472			146 — 404					
industrial sources			446 — 603			152 — 182			107 — 137					
non-industrial sources			52 — 326			45 — 290			39 — 266					

Uncertainty assessment: ●●●●: low uncertainty; ○○○○: very high uncertainty

D/table 2 assessment of dioxin emissions in Germany until 2005 (annual emission in g I-TEQ/year)

References

1. B. Johnke, Situation and Aspects of Waste Incineration in Germany, *UTA International*, 92-103 (1998).
2. Umweltbundesamt: http://www.umweltbundesamt.de/uba-info-daten/daten/tba.htm
3. W. Schüttenhelm, R. Wemhöner, H.-U. Hartenstein and K. Werner, Reduction of PCDD/F Emissions from Iron Ore Sintering Plants - The First Full-Scale SCR Installation, *Dioxin 99*, Venedig, 12.-17.9.1999. *Organohalogen Compounds* **40**, pp. 453-458 (1999).

6. Denmark

Most data shown in DK/Table 2 are drawn from the dioxin report published in 1997 [1]. From comments on likely future developments therein the estimates for the years 2000 and 2005 have been derived.

Based on the measurements performed within the European dioxin project (c.f. Vol. 2, chapter 4) the probable emissions from hospital waste incineration were set to virtually zero for the time being and for 2005. This is due to the fact that in Denmark hospital waste is largely co-incinerated with municipal solid waste. Hence, emissions from hospital waste incineration will be included in the emissions measured at the msw incinerators.

Within the European dioxin project it was attempted to clarify whether this co-incineration might cause elevated PCDD/F emissions from the msw incinerators. As outlined in Vol. 2, chapter 4 no significant difference could be found for a plant operated with and without hospital waste. Assuming that this result may be transferred to all similar plants, no additional dioxin emissions from hospital waste incineration can be stated.

Denmark			DK-Teknik				TNO		LUA 1997	
SNAP			1989		1995		1990		1993-1995	
01	Power plants	fossil fuels	nd		2		1,44		nd	
0202	Res. combustion: Boilers, stoves, fireplaces	wood	22,4	1)	1,1		12,2		2,9	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	nd		nd		1,91		0,3	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		0.05	2)	0,7		2,0		0,3	
30301	Sinter plants		ne							
030308	Secondary zinc production		ne							
030309	Secondary copper production		ne							
030310	Secondary aluminium production		ne						0,3	
30311	Cement				0,3				0,3	
030326	Other: metal reclamation from cables				0,1				0,1	
040207	Electric furnace steel plant		12,0		7,5	*			0,6	
040309	Other: Non ferrous metal foundries								0,0	
040309	Other: sintering of special materials and drossing facilities									
060406	Preservation of wood								5,3	
0701	Road transport		1,0		0,2				1,2	
090201	Inc. of Dom. or municipal wastes	legal combustion	34,0		20,0		50		25,0	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion							3,2	
090202	Inc. of Industrial wastes	hazardous waste	1,7		0,2				0,2	
090207	Inc. of hospital wastes		14,0		5,0				5,0	
090901	Cremation: Inc. of Corpses				0,2				0,2	
1201	Fires								5,3	
Total of sources considered above (g I-TEQ/year)			**85**		**37**		**68**		**50**	
Total of Inventory referred to (g I-TEQ/year)			85,5		39,5		71		50	
%of repective inventory covered by considered sources			99%		95%		96%		101%	

1) geometrical mean of range 10 to 50 g N-TEQ/year 2) only straw burning

nd: not determined

ne: not existent

DK/table 1 overview on emission inventory data (annual emission in g I-TEQ/year)

Denmark			Revised for 1995			Actual data 2000			Projection 2005			Uncertainty Assessment	Future Trend	Comments
SNAP			min	prob	max	min	prob	max	min	prob	max			
01	Power plants	fossil fuels		2			2			2		●●●○	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	wood	1,1		2,9	1,1		2,9	1,1		2,9	●●○○	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	0,8		3,5	0,7		3,1	0,6		2,8	○○○○	↓	nearly negligible use of coal for domestic heating purposes; emissions from other fuel combustion estimated to 0.02 g TEQ/a
0301	Combustion in Industry/boilers, gas turbines, stationary engines		0,1		6,6	0,1		6,6	0,1		6,6	●●●○	⇔	1995 estimate mainly due to straw combustion
30301	Sinter plants			ne			ne			ne		●●●●		no sintering plant in Denmark
030308	Secondary zinc production			ne			ne			ne		●●●●		
030309	Secondary copper production			ne			ne			ne		●●●●		
030310	Secondary aluminium production			ne			ne			ne		●●●●		
30311	Cement		0,1		1,5	0,1		1,5	0,1		1,5	●○○○	⇔	
030326	Other: metal reclamation from cables		0,1		10,0	0,1		10	0,1		10,0	○○○○	⇔	legal cable burning amounts to about 13.000 tons/year
040207	Electric furnace steel plant			7,5			6,8		1,0		8,6	●●●○	↓	improvements of process possible but increasing activity predicted
040309	Other: Non ferrous metal foundries			nd			nd			nd		○○○○		
040309	Other: sintering of special materials and drossing facilities			ne			ne			ne		○○○○		
060406	Preservation of wood			5,3			4,8			4,2		○○○○	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	Road transport		0,2		1,2		0,2			0		●●●○	↓	phase out of leaded fuel; decreasing use of leaded fuels in neighborhood countries
090201	Inc. of Dom. or municipal wastes	legal combustion	20,0		25,0	20		25,0		2		●●○○	↓	assumption: continuing increase of abatement until compliance with 0.1 ng limit.
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion		3,2			3,2			3,2		○○○○	⇔	perhaps increasing activity rates?
090202	Inc. of Industrial wastes	hazardous waste		0,2			0,2			0,2		●●●●	⇔	only one plant; constant operation condition assumed
090207	Inc. of hospital wastes			5								●○○○		2000/2005: most waste co-incinerated in MSW plants; emissions included there
090901	Cremation: Inc. of Corpses		0,2		0,2	0,16		0,16	0,2		0,16	●●●○	⇔	constant cremation rate (70% in 1997) assumed
1201	Fires			5,3			5,3			5,3		○○○○	⇔	from LUA report; value likely to be overestimated
Total of sources considered (g I-TEQ/year)			51 — 79			45 — 72			20 — 49					
industrial sources			38 — 61			33 — 55			9 — 34					
non-industrial sources			13 — 18			12 — 16			11 — 15					

Uncertainty assessment: ●●●●: low uncertainty; ○○○○: very high uncertainty; ne= presumably not existing process

DK/table 2 assessment of dioxin emissions in Denmark until 2005 (annual emission in g I-TEQ/year)

References

1. A. A. Jensen, Dioxins, Report No 50, 1997, 89 pp., DK-Teknik (1997).

7. Spain

As outlined in the Stage I report an inventory on dioxin emissions in Spain was first developed within the framework of CORINAIR in 1995 for the reference year 1990. It was based entirely on emission factors drawn from other countries or from an PARCOM-ATMOS report [1] on emission factors, respectively. This inventory was set up in co-operation with the Dutch TNO institute; hence, the data presented in the European Inventory on heavy metals and POPs are almost the same. It is apparent that a number of emission sources which are likely to exist in Spain have not been considered in both documents. For this reason, but also because higher default emission factors were used, the LUA estimates were nearly three times higher. In particular, the very low estimate for municipal waste incinerators was proven erroneous by a 1997 publication which told the emissions from such facilities located in the province Catalonia alone to be around 20 g I-TEQ [2] (see E/Table 1).

Meanwhile, the Ministry of environment in Spain has become aware of these contradictory assessments and started to take an inventory of the dioxin emission sources more systematically. A first output from these activities was a survey on the actual emissions from msw incineration presented on occasion of the dioxin ’99 symposium at Venice [3].

According to this survey, six of the eight plants operated in Spain do comply with the emission limit of 0,1 ng I-TEQ/m³. The other 2 facilities have emissions around 1 ng I-TEQ/m³ and thus contribute about 80% of the overall emissions from this source type which sum up to 1,0 - 1,2 g I-TEQ/ year. Besides air emission estimates also data on fly ash and slag contamination and emission is presented. Based on less measurements than in the case of air emission overall emissions of 47 to 111 g I-TEQ/year (fly ash) and 19 g I-TEQ/year (slags) are reported. Fly ashes are either landfilled or used for cement production, slags are used for construction materials to some extent.

From some yet unpublished results a contamination of the untreated municipal solid waste of around 60-80 ng I-TEQ/kg is revealed (no indication is given whether wet or dry waste is meant). This concentration is comparable to values found in Germany 10 years ago (73 ng I-TEQ/kg wet waste) but a ten-fold of the contamination reported for UK waste.

Regarding other emission source types not much additional information is available. According to a Dioxin 2000 publication [4] the first and only incinerator for hazardous waste went into operation recently at Constanti, Catalonia. No emission data are reported so far; the environmental impact of this plant will be followed by soil measurements in the vicinity. Hence, the estimates made in he Stage I report are maintained taking into account the consideration on the non-industrial sources given in the introductory comments (c.f. chapter III-1.2) .

A source inventory comprising emission data to air land and water was presented recently for the province Tarragona (Catalonia) Within this region chemical industry (PVC and perchloroethylene production, petrochemical complex) and the new hazardous waste incinerator mentioned above is located. Further cement kilns and oil combustion facilities exist.

Finally, from a remark in the Danish dioxin report [5] stating that filter dusts from Danish electric arc steel plants are exported to Spain for zinc recovery it appears likely that a secondary zinc production plant is operated in Spain. In case this assumption is true and depending on the process applied this plant could be a considerable source for PCDD/F air emissions (c. f. the “Recytech” case in France and the “BUS” plant located in Germany). However, the existence of this plant type in Spain has not yet been confirmed by the Spanish Ministry of Environment (CIEMAT).

Based on the limited available data the revised 1995 is set up mainly by using the estimates of the official Spanish inventory as minimum and the Stage I estimates as maximum data. Actualisation has been possible only regarding the sources considered in the introductory comments and with respect to msw and hazardous waste incineration (see E/Table 2).

Spain			Env. Ministry	1)	TNO	1)	LUA 1997	
SNAP		ref.-year:	1990		1990		1993-1995	
01	Power plants	fossil fuels	3,95		3,95		nd	
0202	Res. combustion: Boilers, stoves, fireplaces	wood	25,4		28		70,3	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	18,5		15,85		3,7	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		5,7		5,7		2,2	
30301	Sinter plants		50,2		50,2		62,0	
030308	Secondary zinc production						0,8	
030309	Secondary copper production						3,2	
030310	Secondary aluminium production		11,6		11,6		2,2	
30311	Cement						3,6	
030326	Other: metal reclamation from cables							
040207	Electric furnace steel plant		18,0		17,9		13,2	
040309	Other: Non ferrous metal foundries						0,2	
040309	Other: sintering of special materials and drossing facilities							
060406	Preservation of wood						39,6	
0701	Road transport						11,3	
090201	Inc. of Dom. or municipal wastes	legal combustion	0,6	2)	0,6		0,6	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion					16,4	
090202	Inc. of Industrial wastes	hazardous waste					nd	
090207	Inc. of hospital wastes						57,5	
090901	Cremation: Inc. of Corpses						1,4	
1201	Fires						39,4	
Total of sources considered above (g I-TEQ/year) *)			**134**		**134**		**327**	
Total of Inventory referred to (g I-TEQ/year)			134		134		327	
%of repective inventory covered by considered sources			100%		100%		100%	

1) Apparently data provided by the ministry of Environment and TNO data are identical

2) According to Abad, Caixach and Rivera (Chemosphere 45 (1997), 453-463) emissions from MSW incinerators located in Catalonia alone were estimated to 20 g I-TEQ/year; the tab

nd: not determined

ne: not existent

E/table 1 overview on emission inventory data (annual emission in g I-TEQ/year)

Spain			Revised for 1995			Actual data 2000			Projection 2005			Uncertainty Assessment	Future Trend	Comments
SNAP			min	prob	max	min	prob	max	min	prob	max			
01	Power plants	fossil fuels		4,0			4,0			4,0		●●●○	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	wood	25,4		70,3	25,4		70,3	25,4		70,3	●●○○	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	9,3		42,6	8,3		38,3	7,5		34,5	○○○○	↓	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		2,2		5,7	2,2		5,7	2,2		5,7	●●●○	⇔	
30301	Sinter plants		25,0		62,0	2,0		5,0		0,0			↓	sharply decreasing activity rates in 1994-1998
030308	Secondary zinc production			0,8			0,8			0,8			✍	perhaps underestimated (recycling plant for zinc-containing filter dusts?)
030309	Secondary copper production			2,1			2,1			2,1		●○○○	⇔	without direct use of scrap
030310	Secondary aluminium production		2,2		11,6	2,2		11,6	2,2		11,6	●○○○	⇔	
30311	Cement			3,6			3,6			3,6		●○○○	⇔	
030326	Other: metal reclamation from cables			0,0			0,0			0,0		●●●○	⇔	
040207	Electric furnace steel plant		13,2		18,0		24,5			32,2		●●●○	↑	increasing activity rates in 1995-1998
040309	Other: Non ferrous metal foundries			0,2			0,2			0,2		●●●○	⇔	
040309	Other: sintering of special materials and drossing facilities			ne			ne			ne				
060406	Preservation of wood		4,0		39,6	3,5		35,5	3,1		31,3	○○○○	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	Road transport			11,3			11,3			11,3		●●●○	⇔	
090201	Inc. of Dom. or municipal wastes	legal combustion	1,0		1,2		1,0			0,5		●●●●	↓	max(1995): from measured data presented at dioxin '99; projected value for 2005: 0.1 ng/m³ assumed for all plants
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion	16,4		16,4		16,4			16,4		○○○○	↓	
090202	Inc. of Industrial wastes	hazardous waste		ne		0,0		0,0	0,0		0,0	●●●○		new installation operated since 2000
090207	Inc. of hospital wastes		5,0		57,5	5,0		57,5	5,0		57,5	●○○○	⇔	
090901	Cremation: Inc. of Corpses		1,4		1,4					2,0		●●●○	↑	increase of activity rate assumed
1201	Fires		4,0		39,4	4,0		39,4	4,0		39,4	○○○○	⇔	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)			131 — 388			117 — 327			122 — 323					
industrial sources			77 — 184			64 — 132			71 — 137					
non-industrial sources			54 — 203			53 — 195			51 — 187					

Uncertainty assessment: ●●●●: low uncertainty; ○○○○: very high uncertainty; ne= presumably not existing process

E/table 2 assessment of dioxin emissions in Spain until 2005 (annual emission in g I-TEQ/year)

References

1. P. F. J. Van der Most and C. Veldt, Emission Factors Manual Parcom-Atmos: Emission factors for air pollutants 1992, 92-235, TNO, NL (1992).
2. E. Abad, J. Caixach and J. Rivera, PCDD/PCDF from Emission Sources and Ambient Air in Northeast Spain, *Chemosphere* **35**, 453-463 (1997).
3. B. Fabrellas, P. Sanz, E. Abad and J. Rivera, TheSpanish Dioxin Inventory: Proposal and Preliminary Results from Municipal Waste Incinerator Emissions., *Dioxin'99*, Venice, Italy, Sept.12-17. *Organohalogen Compounds* **41**, pp. 491-494 (1999).
4. J. L. Domingo, M. Schumacher, M. C. Rodriguez-Larena, J. Diaz-Ferrero, M. C. Agramunt and J. M. Llobet, Baseline Contamination Assessment For a New Hazardous waste Incinerator In Catalonia, Spain. I. Levels of PCDD/Fs in Soil Samples, *Dioxin 2000*, Monterey, California, 13.-17.08. *Organohalogen Compounds* **46**, pp. 126-129 (2000).
5. A. A. Jensen, Dioxins, Report No 50, 1997, 89 pp., DK-Teknik (1997).

8. France

In the stage I report a preliminary dioxin emission inventory for France was presented which had been set up by the French agency ADEME [1]. This preliminary inventory was based on few measurements results at Municipal solid waste incinerators and on estimates for other industries relying on emission factors gathered from other countries. The ADEME inventory identified the urgent need for more information; hence, there was considerable interest in participating in the Stage II of the European project.

However, at that stage (by end of 1997) the French ministry of environment decided to follow the recommendations of ADEME and set up a fund for a comprehensive emission testing program. Consequently, no contract with ADEME could be made within the DG XI project. It was agreed, nevertheless, that data gathered within the French measurement program shall be reported in the framework of the European Dioxin Project as well.

The results of the emission measurements in France have been made available to the public on the internet site of the ministry of environment [2]. The site contains data on large msw incinerators (> 6 tons waste per hour overall capacity) and facilities in the metal industry. In the following, this data is used to set-up an updated inventory for France.

A. Industrial sources

1. msw incineration:

In the Stage I report an emission freight of ca. 160 g I-TEQ/year was calculated from the geometrically averaged emission factors which had been presented in the preliminary dioxin inventory. By contrast, ADEME estimated the annual emissions to be around 400 g I-TEQ/year from the arithmetic mean of the emission factors (see F/Table2).

Looking at the measurement values meanwhile published ADEME’s view appears to be the more realistic assessment. Using the published concentrations and multiplying them with a typical specific flue gas volume of 5000 m³/ton waste and with an yearly operation time of 8000 hours the following annual emissions are obtained for the years 1997, 1998 and 1999 (see F/Table 1):

1997	1998	1999
435	350	227

F/table 1: annual PCDD/F emissions from municipal waste incineration in France calculated from published measurement results in g I-TEQ/year (for details see text)

For this calculation, the following further assumption were made in view of the different data available:

- *Case 1: Measurement results available for all years*

  If decreasing trend, values were used as presented

  If fluctuating values were found, the average concentration was used for all years.

- *Case 2: Results missing for 1997:*

  If decrease from 1998 to 1999 occurred then 1998 value was chosen for 1997, too; else the average value of 1998 and 1999 was taken for 1997

- *Case 3: Results missing for 1998 and/or 1999:*

  Depending on observed trend, the most recent result was prescribed or average of presented values were used.

Besides the larger plants in France there exist a huge number of small furnaces with capacities well below 6 tons/hour which are operated intermittently a few days per month. No measurement results have been published by the French authorities until the deadline for the preparation of this Stage II report; however, the overall annual emission from municipal waste incineration in France is estimated to have been 500 g I-TEQ in 1997. By comparison of this value to the emission calculated for large msw plants given above it may be concluded that the emissions from small facilities might have been around 70 g I-TEQ in 1997.

Based on these results, in the revised inventory (see F/Table 3) the emission of 500 g I-TEQ calculated for 1997 is used for the year 1995. Clearly, abatement measures as well as closures of plants have reduced the emissions from msw incinerators in France considerably. The actual situation in 2000 is likely to be improved further (indicated closures of some plants by end of 1999 will save about 10 g I-TEQ/year). Hence, for the year 2000, annual emissions are assessed to be around 200 g I-TEQ/year.

In view of the large number of plants it appears unlikely that all existing plants will be retrofitted until 2005 to comply with the emission limit of 0,1 ng I-TEQ/m³. Thus, for 2005 it is assumed that the trend observed during the recent years will continue and that a further emission reduction by 50% might be realistic.

2. Metal industry

From experiences made during dioxin emission assessments in other countries it was known that metallurgical plants might have considerable impact on the annual dioxin release. In particular, iron ore sintering plants and secondary non-ferrous metal production facilities are of concern. Thus, a number of measurements were done at such emission sources within the French dioxin program. The results were published only in terms of annual emission freights. These values could be converted to emission concentrations if the specific production values of the investigated plants were known.

Regarding iron ore sintering, annual dioxin emissions of 128 g I-TEQ/year had been estimated in the Stage I report for the six French plants based on the 1994 production and an emission factor of 7 µg I-TEQ/ton sinter (considering only the main process; inclusion of hot sieving/ crushing and fugitive emissions led to an overall estimate of 183 g I-TEQ/year). Actually, not much less emissions (93 g I-TEQ/year) are reported from the French dioxin survey. No data on fugitive emissions and emissions from the sinter treatment processes are given. Hence the LUA stage I estimate is reduced by ca. 30 g I-TEQ/a for the revised 1995 inventory. The more pessimistic assessment of the French preliminary dioxin inventory which estimated 400 g I-TEQ/a at a range of estimation from 220 to 2200 g I-TEQ/year fortunately was not confirmed. Nevertheless, as in other countries with integrated steel works also the French iron ore sintering processes constitute a considerable emission source.

Besides sintering plants also a number of electric arc steel works revealed to be rather strong dioxin emitting sources. Overall, an annual emission of 36 g I-TEQ/year was calculated from the measurement results, generated mainly by 6 plants which contribute by 33 g I-TEQ/year. In this case, the estimate presented in the Stage I report, which was based on results from other countries, was too low. Due to abatement measures realised since 1997 the emissions from these plants were reduced to about 21 g I-TQ/year [2]; however, as in other countries a trend to increasing production is observed also in France which is likely to compensate the improvements of flue gas cleaning.

Another 11,5 g I-TEQ was assigned to secondary aluminium production, whereas copper and lead production facilities were estimated to cause emissions of each little more than 2 g I-TEQ/year. Slightly higher emissions of 3,4 g were measured to come from iron foundries; whereas coke ovens and some other installations in the metallurgical industries appeared to be of minor importance.

It was a surprise to the French public that one particular facility of the non-ferrous metal sector revealed to be by far the most relevant single source. The Recytech plant, a sister company of the German BUS which PCDD/F emissions also has been of major concern in Germany, was estimated to emit about 141 g I-TEQ/year. According to the company, a three step abatement program has been carried out since these high emission data became public. The company expected the PCDD/F concentrations in the flue gas would to decrease from 130 ng I-TQ/m³ to less than 1 ng I-TEQ/m³. By mid of June 1999, having finished the second of three abatement steps, measurements showed concentrations between 1 and 5 ng I-TEQ/m³, thus confirming an emission reduction by more than 90% . Details on the process and about the abatement measures installed can be found in Volume 2, chapter 6.

Besides the facilities mentioned above it is estimated that 40 g I-TEQ/year might be emitted from cable burning installations. This estimate is based on an amount of 40.000 tons processed cables and an emission factor of 1 mg I-TEQ/ton. From industrial combustion of natural wood and of wooden materials that partly are contaminated about 15 g I-TEQ/year might be released.

3. Hospital waste incineration

Regarding industrial emission sources a considerable lack of knowledge still exists with respect to clinical waste incineration in France. From information found in the internet [3] the general situation of hospital waste incineration in France could be extracted (c.f. Volume 2, chapter 6).

Regarding the overall dioxin emissions from this sector it can be stated, that emissions caused from the hospital waste being co-incinerated with municipal waste already are counted within the estimate for that sector. It may be therefore concluded that the Stage I emission value for hospital waste incineration presumably had been an overestimate. Unfortunately, no statistical data on the distribution of hospital waste to the different types of plants could be obtained, and, furthermore, no measurement results from on-site incinerators have been published yet. Hence, for the revised 1995 estimation a range of 10 up to 50 g I-TEQ/year is chosen. Regarding the actual situation in 2000 it is assumed that the lower of these estimates is more probable due to continuing closures of small on-site incinerators and abatement measures at the co-incineration plants. Based on the presumption that this trend continues in the near future for the year 2005 an emission of 1 g I-TEQ/year might be possible (see F/Table 3).

B. Non-industrial sources

1. Domestic solid fuel combustion

According to the statistical data already at hand for the Stage I report the main solid fuel used for domestic heating and cooking purposes in France is wood. Due to the high consumption rates reported and based on the model chosen for the fractions of clean, contaminated and highly contaminated wood a very high emission estimate of 323 g I-TEQ/ year was obtained. Also the TNO study reported considerable emissions (159 g I-TEQ/year) from this source (see F/Table2).

The French environmental ministry estimates the emissions from domestic wood combustion (23,4 million tons/year) to range from 30 to 100 g I-TEQ/year for 0% and 5% combustion of contaminated wood, respectively. As this estimate does not appear to be based on better data than the estimate set up in the Stage I report, the Stage I value will be maintained for the revised inventory.

Also in the case of domestic coal combustion the estimate given in the Stage I report is considered to be valid in view of the recent results obtained by LUA within this project (see Vol. 2, chapter 6e).

2. Wood preservation, illegal domestic waste combustion, accidental fires

Concerning these sources see the general comments in chapter Introductory comments.

Summarising, the dioxin emission situation in France in 1995 can be characterised by emissions from industrial sources of about 900 to 1000 g I-TEQ/year and additional 300-500 g I-TEQ/year from non-industrial activities. Considerable abatement measures in the waste sector and at the most important single source already lowered the industrial emissions by ca. 50%; for the near future a further decrease to 1/3 of the 1995 values can be anticipated. However, due to lack of better information, no considerable decrease of emissions estimated for non-industrial sources can be stated. Hence, in the year 2005 non-industrial sources might cause the main part of atmospheric emissions of dioxins and furans in France (see F/Table 3).

France			CITEPA		ADEME		TNO <1>		LUA 1997 <2>	
SNAP		ref.-year:	1990		1995		1990		1993-1995	
01	Power plants	fossil fuels					2			
0202	Res. combustion: Boilers, stoves, fireplaces	wood					159,0		323,17	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite					15,0		3,99	
0301	Combustion in Industry/boilers, gas turbines, stationary engines				10,0		892,0		3,16	
30301	Sinter plants				400,0				183,85	
030308	Secondary zinc production				7,0				0,99	
030309	Secondary copper production				10,0				6,45	
030310	Secondary aluminium production				10,0				5,15	
30311	Cement				0,5				3,08	
030326	Other: metal reclamation from cables									
040207	Electric furnace steel plant						31,7		6,15	
040309	Other: Non ferrous metal foundries								0,29	
040309	Other: sintering of special materials and drossing facilities									
060406	Preservation of wood								57,75	
0701	Road transport		15,8		5,0		20,0		18,41	
090201	Inc. of Dom. or municipal wastes	legal combustion	834		400,0		514,0		161,4	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion							24,69	
090202	Inc. of Industrial wastes	hazardous waste	17		2,0				2	
090207	Inc. of hospital wastes		28						262,5	
090901	Cremation: Inc. of Corpses								2,17	
1201	Fires								57,1	
Total of sources considered above (g I-TEQ/year) *)			**895**		**845**		**1634**		**1122**	
Total of Inventory referred to (g I-TEQ/year)			906		865		1636		1122,7	
% of repective inventory covered by considered sources			99%	a)	98%		100%		100%	

a) main further source considerd: iron foundries 10 g I-TEQ/a

References: <1> The European Atmospheric Emission Inventory of heavy metals and Persistent Orgenic Pollutants for 1990, TNO/UBA, Berlin, 1997

<2>U. Quaß, M. Fermann, G. Bröker: Identification of relevant industrial sources of dioxins and furans in Europe. LUA-Materialien No. 43 (1997), Landesumweltamt Nordrhein-Westfalen, Essen, Germany

nd: not determined

ne: not existent

F/table2 overview on emission inventory data (annual emission in g I-TEQ/year)

France			Revised for 1995			Actual data 2000			Projection 2005			Uncertainty Assessment	Future Trend	Comments
SNAP			min	prob	max	min	prob	max	min	prob	max			
01	Power plants	fossil fuels		2,0			2,0			2,0		○○○○		value from TNO study
0202	Res. combustion: Boilers, stoves, fireplaces	wood		323,0			323,0			323,0		●○○○	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	10,0		45,9	9,0		41,3	8,1		37,2	○○○○	↑	max values: high emission factors found by Austrian EPA taken into account.
0301	Combustion in Industry/boilers, gas turbines, stationary engines			3,2			3,2			3,2		●●●○	⇔	
30301	Sinter plants			150,0			133,5			124,5		●●●○	↓	decreasing activity rates
030308	Secondary zinc production			200,0			10,0			5,0		●●●●	↓	
030309	Secondary copper production			2,0			2,0			2,0		●●○○	⇔	according to updated inventory
030310	Secondary aluminium production			11,5			11,5			11,5		●●○○	⇔	
30311	Cement			3,1			3,1			3,1		●●○○	⇔	
030326	Other: metal reclamation from cables			40,0			40,0			40,0		●●●○	⇔	
040207	Electric furnace steel plant			36,0			21,0			27,6		●●●○	↓	increasing activity in 1995-1998
040309	Other: Non ferrous metal foundries			0,3				0,3		0,3		●●●○	⇔	
040309	Other: sintering of special materials and drossing facilities													
060406	Preservation of wood		6,0		57,8	5,4		51,8	4,8		45,7	○○○○	↑	
0701	Road transport			18,4				15,0		10,0		●●●○	↓	
090201	Inc. of Dom. or municipal wastes	legal combustion		500,0			200,0			100,0		●●●○	↓	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion		24,7			20,0			15,0		○○○○	↓	
090202	Inc. of Industrial wastes	hazardous waste		2,0			2,0			2,0			⇔	
090207	Inc. of hospital wastes		10,0		50,0		10,0			1,0		●○○○	↓	
090901	Cremation: Inc. of Corpses			2,2			2,5			3,0		●●●○	↑	
1201	Fires		6,0		57,1	6,0		57,1	6,0		57,1	○○○○	↑	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)			1350 — 1529			804 — 949			692 — 813					
industrial sources			987 — 1027			461 — 461			340 — 340					
non-industrial sources			363 — 502			343 — 488			352 — 473					

Uncertainty assessment: ●●●●: low uncertainty; ○○○○: very high uncertainty

F/table 3 assessment of dioxin emissions in France until 2005 (annual emission in g I-TEQ/year)

References

1. A. Milhaut and H. Pernin, Preliminary Dioxin Emission Inventory in France, 6 pp., ADEME (1996).
2. Ministère du l'Aménagement du territoire et de l'Environnement: http://www.environnement.gouv.fr/actua/cominfos/dosdir/DIRPPR/dioxine/tabdioxines.htm#s.
3. Cadre de Santé: http://www.multimania.com/ca1998/LAGESTIONWEBDESDECHETSHOSPITALIERS.htm.

9. Greece

During Stage I of the project no data could be obtained regarding Greek dioxin emissions at all. Hence for this country the estimation presented in the Stage I report was entirely based on the default emission factors chosen from other country's experiences and on statistical data reported in related statistical documents.

Meanwhile, a second assessment has been published in the TNO/UBA inventory prepared for the year 1990. As considerably less source types were addressed in this inventory also the overall emission freight came out with a lower value (see GR/Table 1).

In view of the scarce data it was attempted to install a sub-project with the aim to get a few emission measurement results from potentially relevant industries. As no experienced partner institute could be found in Greece this measurement program was conducted by a German research institute (for details see Volume 2, chapter 12). Three facilities covering four emission sources were investigated:

- A hospital waste incinerator (1 stack)
- An electric arc steel plant (2 stacks for primary and secondary de-dusting, resp.)
- A drying kiln for residual materials from olive oil production

The latter facility was included – despite not being on the list of relevant sources – because for this type of process which is used only in Southern European countries no experiences had been made so far.

From the results of these measurements the following conclusion could be drawn:

Of the plants measured the steel plant revealed to cause the largest annual PCDD/F emission freight (1,1 g I-TEQ/year); however, the measured emission concentrations were comparable to values found in similar European plants. The annual emission from this plant alone was comparable to the previous estimates made by TNO or by LUA for this sector. However, the emission was estimated assuming 10 smelting processes per day for 300 days per year. With one batch amounting to 75 tons of steel the annual production of this plant can be assessed to be ca. 225 kt/a. This is about 20% of the production of electrosteel in Greek which was 1108 kt in 1998. Providing that all Greek plants (according to steel statistics there were 8 plants operated in 1998) have similar emission factors the actual emissions (for year 2000) can thus be estimated to ca. 5 g I-TEQ/year. According to the trend of annual production the emissions are assessed to 3,9 and 6,4 g I-TEQ/year for 1995 and 2005, respectively (see GR/Table 2).

At the hospital waste incineration plant the highest concentrations (360 ng I-TEQ/m³) of all installations measured within Stage 2 were found. Due to the fact that this plant is operated discontinuously with low throughput the annual emission freight is “only” about 0,3 g I-TEQ/year. It should however be emphasised that this emission nevertheless might lead to a higher local impact than the nearly ten times higher emission of the steel plant. Concerning the practice of hospital waste incineration in Greece it was told that nearly every small and middle-sized town has such a plant. The emission factor of the measured plant can be derived by multiplication of the measured flue gas concentration with a specific flue gas volume of 7.000 m³ per ton waste. A value of 2.270 µg I-TEQ/ton is obtained. Assuming that all clinical waste is incinerated in Greece in similar facilities the overall emissions are estimated from the activity rate used already in the Stage I report (15 kt/year) and the calculated emission factor to 34 g I-TEQ/year (see GR/Table 2).

Almost no PCDD/F emission was found for the olive residue drying kiln and thus there is no need to extend the list of potentially relevant sources.

Besides the measurement results some additional information was obtained recently from a Greenpeace study that addresses the Greek situation regarding pollution with dioxins and furans.

The study focused on uncontrolled landfill fires. Annual PCDD/F releases to air ranging from about 50 to 920 g I-TEQ per year was estimated for this source type. The broad range is caused by the variety of emission factors used (originating from the USA, Switzerland, Sweden and Finland.

The emission estimate is further based on following data:

- 10-13 % of the 4,5 million tons of household waste is burned annually by landfill fires; on the islands the percentage may be in the order of 50 - 80%
- Some 5.000 dumpsites exist in Greece, of which only 1500 are legal (but practically uncontrolled) and only 22 comply to some European standards
- It has recently been proven by investigations of soil samples obtained at the Kouroupitos dumpsite on Crete that the uncontrolled landfill fires may be associated

considerable dioxin formation; soil concentrations > 1.000 ng I-TEQ/kg were found at the site, elevated concentrations were also found outside the dumpsite.[1]

According to this estimation the emissions from uncontrolled landfill fires could be the dominating PCDD/F air emission source in Greece. Even if the air emissions were better assessed to be at the lower limit of the given range there is no doubt, that considerable amounts of dioxins and furans may be produced by uncontrolled landfill fires which contaminate at least the area of the dumping sites and thus may be considered as emissions to land.

Greece			TNO <1>		LUA 1997 <2>	
SNAP		ref.-year:	1990		1993-1995	
01	Power plants	fossil fuels	6,79			
0202	Res. combustion: Boilers, stoves, fireplaces	wood	8,2		51,57	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	1,2		0,2	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		3,0		0,56	
30301	Sinter plants					
030308	Secondary zinc production					
030309	Secondary copper production				0	
030310	Secondary aluminium production				0,2	
30311	Cement				1,89	
030326	Other: metal reclamation from cables					
040207	Electric furnace steel plant		2,0		0,89	
040309	Other: Non ferrous metal foundries				0,06	
040309	Other: sintering of special materials and drossing facilities					
060406	Preservation of wood				10,28	
0701	Road transport				4,46	
090201	Inc. of Dom. or municipal wastes	legal combustion			0	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion			3,89	
090202	Inc. of Industrial wastes	hazardous waste				
090207	Inc. of hospital wastes				37,5	
090901	Cremation: Inc. of Corpses				0,4	
1201	Fires				10,24	
Total of sources considered above (g I-TEQ/year) *)			**21**		**122**	
Total of Inventory referred to (g I-TEQ/year)			25		122,0	
%of repective inventory covered by considered sources			83%		100%	
References:	<1> The European Atmospheric Emission Inventory of heavy metals and Persistent Orgenic Pollutants for 1990, TNO/UBA, Berlin, 1997					
	<2>U. Quaß, M. Fermann, G. Bröker: Identification of relevant industrial sources of dioxins and furans in Europe. LUA-Materialien No. 43 (1997), Landesumweltamt Nordrhein-Westfalen, Essen, Germany					
nd: not determined						
ne: not existent						

GR/table 1 overview on emission inventory data (annual emission in g I-TEQ/year)

Greece			Revised for 1995			Actual data 2000			Projection 2005			Uncertainty Assessment	Future Trend	Comments
SNAP			min	prob.	max	min	prob.	max	min	prob.	max			
01	Power plants	fossil fuels		6,8			6,8			6,8		●●●❍	⇔	value taken from TNO as no further data available
0202	Res. combustion: Boilers, stoves, fireplaces	wood	8,2		51,6	8,2		51,6	8,2		51,6	●❍❍❍	↑	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	0,5		2,3	0,5		2,1	0,4		1,9	❍❍❍❍	↓	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		0,6		3,0	0,6		0,6	0,6		0,6	●●●❍	↓	
30301	Sinter plants		0,0		0,0	0,0		0,0	0,0		0,0	●●●❍	⇔	
030308	Secondary zinc production		0,0		0,0	0,0		0,0	0,0		0,0	●●●●	⇔	
030309	Secondary copper production		0,0		0,0	0,0		0,0	0,0		0,0	●●❍❍	⇔	
030310	Secondary aluminium production		0,2		0,2	0,2		0,2	0,2		0,2	●●❍❍	⇔	
30311	Cement		1,9		1,9	1,9		1,9	1,9		1,9	●●❍❍	⇔	
030326	Other: metal reclamation from cables		0,0		0,0	0,0		0,0	0,0		0,0	●●●❍	⇔	
040207	Electric furnace steel plant			3,9			5,0			6,4		●●●❍	↑	increasing activity rates
040309	Other: Non ferrous metal foundries		0,1		0,1	0,1		0,1	0,1		0,1	●●●❍	⇔	
040309	Other: sintering of special materials and drossing facilities		0,0		0,0	0,0		0,0	0,0		0,0		⇔	
060406	Preservation of wood		10,3		10,3	10,3		10,3	10,3		10,3	❍❍❍❍	⇔	
0701	Road transport		4,5		4,5	4,5		4,5	4,5		4,5	●●●❍	⇔	
090201	Inc. of Dom. or municipal wastes	legal combustion	0,0		0,0	0,0		0,0	0,0		0,0	●●●❍	⇔	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion	3,9		3,9	3,9		3,9	3,9		3,9	❍❍❍❍	⇔	
090202	Inc. of Industrial wastes	hazardous waste	0,0		0,0	0,0		0,0	0,0		0,0		⇔	
090207	Inc. of hospital wastes		37,5		37,5	37,5		37,5	37,5		37,5	●❍❍❍	⇔	
090901	Cremation: Inc. of Corpses		0,4		0,4	0,4		0,4	0,4		0,4	●●●❍	⇔	
1201	Fires		10,2		10,2	10,2		10,2	10,2		10,2	❍❍❍❍	⇔	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)			89 — 136			90 — 135			91 — 136					
industrial sources			55 — 58			56 — 56			58 — 58					
non-industrial sources			34 — 79			34 — 79			34 — 78					

Uncertainty assessment: ●●●●: low uncertainty; ❍❍❍❍: very high uncertainty

GR/table 2 assessment of dioxin emissions in Greece until 2005 (annual emission in g I-TEQ/year)

References

1. D. Marten, K. Balta-Brouma, R. Brotsack, B. Michalke, P. Schramel, C. Klimm, B. Henkelmann, K. Oxnyos, K. W. Schramm, E. Diamadopoulos and A. Kettrup, Chemical Impact of uncontrolled solid waste combustion to the vicinity of the Kouroupitos Ravine, Crete, Greece, *Chemosphere* **36**, 2855-2866 (1998).

10. Italy

A first national inventory of dioxin emission sources was presented at the dioxin 99 symposium at Venice [1]. It was merely based on emission factors drawn from studies made in other countries and from activity rates taken from national statistics. Details of these basic data were not published (see I/Table 1).

However, on the same occasion a detailed inventory of emissions from municipal solid waste incineration was presented [2]. This inventory was partly based on measurement results obtained at 7 plants located in the region named Lombardy during 1991 to 1997 [3]. From these measurements, average emission factors of 6,6 µg I-TEQ/ton and 19,9 µg I-TEQ/ton were derived for grate furnace installations equipped with ESP/wet scrubber and for rotary kilns, respectively. Using minimum and maximum concentrations found, the emission factors ranged from 1,4 to 21 and 3,9 to 70,9 µg I-TEQ/ton waste, respectively. A number of installations already comply with the 0,1 ng /m³ emission limit which converts into an emission factor of about 0,6 µg I-TEQ/ton. For four plants an emission factor of 1,6 µg I-TEQ/ton was applied the origin of which could not be deduced from the publication.

By multiplying the annual waste throughput of the individual facilities with the corresponding emission factors an overall annual PCDD/F emission range from 2,2 to 38 g I-TEQ/year is obtained. This is considerably less than the estimate given in the Italian inventory mentioned above (134 g I-TEQ/year) and in other reports (TNO [4]: 131 g I-TEQ/year; TNO [5]: 420 g I-TEQ/year; LUA [6]: 256 g I-TEQ/year).

Hence, for the revised inventory 1995 the new lower emission estimates are used in the case of msw incineration. Regarding all other sources, the values reported in [1] are taken as minimum estimates, whereas the LUA data [6] are assumed to be maximum emissions.

Since no additional information has been obtained in the meantime, it is reasonable to assume, that the situation has not changed and the 1995 data can generally be assumed to be valid also for the year 2000. Similarly, future emissions are assessed to be at least as projected by De Lauretis for the year 2010, while maximum emission might be the same as estimated for the present time (see I/Table 2).

According to the data presented by ANPA decreasing trends are likely for fossil fuel combustion sources. Further it may be expected that PCDD/F emissions from road transport will decline due to cease of leaded fuel use. In the case of msw incineration the min/max range of future emissions is determined by different scenarios with respect to the amount of waste being burned; emission factors are assumed to be the same and to reflect compliance to the upcoming European emission limit of 0,1 ng I-TEQ/m³. As this will also affect the incineration of hospital wastes the maximum estimate for 2005 has been lowered by a factor of 5.

A slight increase is assumed here for emissions from crematoria on basis of general European trend of annual cremation numbers

Italy			**ANPA 1999 <3>**					**1)**	**TNO <1>**		**LUA 1997 <2>**	
SNAP		**ref.-year:**	**1990**		**1995**		**2010**		**1990**		**1993-1995**	
01	**Power plants**	fossil fuels	23		27		14,5		21,9		nd	
0202	**Res. combustion: Boilers, stoves, fireplaces**	wood							15,7		198,8	
0202	**Res. combustion: Boilers, stoves, fireplaces**	coal/lignite	23,6		26,4		18,5		12,4		0,5	
0301	**Combustion in Industry/boilers, gas turbines, stationary engines**	x	13,6		10,8		10,3		12,5		3,1	
30301	**Sinter plants**	x	67,9		60,5		40,5		65,4		128,0	
030308	**Secondary zinc production**	x									0,4	
030309	**Secondary copper production**	x	1,7		2		2		1,7		16,5	
030310	**Secondary aluminium production**	x	0,7		0,8		0,8				7,9	
30311	**Cement**	x	6,1		5,1		5,3				0,0	
030326	**Other: metal reclamation from cables**	x										
040207	**Electric furnace steel plant**	x	29,5		28,6		28,6		28,5		26,1	
040309	**Other: Non ferrous metal foundries**	x									0,6	
040309	**Other: sintering of special materials and drossing facilities**	x										
060406	**Preservation of wood**	xx									56,8	
0701	**Road transport**	x	6,4		5,1		0				29,9	
090201	**Inc. of Dom. or municipal wastes**	legal combustion	134,3		170,6	2)	12,8		420,0		252,0	
090201	**Inc. of Dom. or municipal wastes**	illegal (domestic) combustion									21,6	
090202	**Inc. of Industrial wastes**	hazardous waste	97,4		97,4		4,6				nd	
090207	**Inc. of hospital wastes**	x	27,5		27,5		1,3				250,0	
090901	**Cremation: Inc. of Corpses**	x	nd		nd		nd				2,2	
1201	**Fires**	x	nd		nd		nd				56,5	
Total of sources considered above (g I-TEQ/year) *)		x	**432**		**461**		**139**		**578**		**1051**	
Total of Inventory referred to (g I-TEQ/year)			450,8		558,8		143,4		583		1051	
%of repective inventory covered by considered sources			96%	a)	83%	a)	97%	a)	99%		100%	

1) ANPA = Agenzia Nazionale Protezione dell' Ambiente, Rome

2) According to Pastorelli et al (Organohalogen Compounds 41 (1999), 495-498) emissions from MSW incinerators in Italy were estimated to 11.5 g I-TEQ/year only for the year 1997. This is based on measurements at 7 plants and emission factors derived therefrom

a) sources not included: sec. lead prod. (2/2.5/2.5 g TE/a) and sewage sludge inc. (16.8/95/1.8 g TE/a) for 1990, 1995 and 2010 resp.

References:

<1> The European Atmospheric Emission Inventory of heavy metals and Persistent Orgenic Pollutants for 1990, TNO/UBA, Berlin, 1997

<2>U. Quaß, M. Fermann, G. Bröker: Identification of relevant industrial sources of dioxins and furans in Europe. LUA-Materialien No. 43 (1997), Landesumweltamt Nordrhein-Westfalen, Essen, Germany

<3> R. De Lauretis: Dioxins and furans Italian national and local emission inventories. Organohalogen Compounds 41 (1999) 487-489 (Dioxin '99)

nd: not determined

ne: not existent

I/table 1 overview on emission inventory data (annual emission in g I-TEQ/year)

Italy			*Revised for 1995*			*Actual data 2000*			*Projection 2005*			*Uncertainty Assessment*	*Future Trend*	*Comments*
SNAP			*min*	*prob*	*max*	*min*	*prob*	*max*	*min*	*prob*	*max*			
01	**Power plants**	fossil fuels		26,6			23,0			20,0		●●●○	↓	decrease according to ANPA
0202	**Res. combustion: Boilers, stoves, fireplaces**	wood	26,4		198,8	26,4		198,8	18,5		198,8	●○○○	↓	***trend according to ANPA data***
0202	**Res. combustion: Boilers, stoves, fireplaces**	coal/lignite	1,3		5,8	1,1		5,2	1,0		4,7	○○○○	↓	
0301	**Combustion in Industry/boilers, gas turbines, stationary engines**		3,1		10,8	3,1		10,8	3,1		10,3	●●●○	↓	trend according to ANPA data
30301	**Sinter plants**		60,5		128,0	77,1		163,1	67,1		142,0	○○○○	↑	trend according to ANPA data (decreasing emission levels) but incresing activity taken into account
030308	**Secondary zinc production**		0,4		0,4	0,4		0,4	0,4		0,4	○○○○	⇔	
030309	**Secondary copper production**		2,0		3,8	2,0		3,8	2,0		3,8	●○○○	⇔	max value estimated without direct scrap use
030310	**Secondary aluminium production**		0,8		7,9	0,8		7,9	0,8		7,9	●○○○	⇔	
30311	**Cement**		0,0		5,1	0,0		5,1	0,0		5,3	●○○○	↑	
030326	**Other: metal reclamation from cables**		nd		nd	nd		nd	0,0		0,0	●●●○	⇔	
040207	**Electric furnace steel plant**		26,1		28,6	23,5		25,7	22,5		24,6	●●●○	↓	trend: decreasing activity rates
040309	**Other: Non ferrous metal foundries**			0,6						0,6		●●●○	⇔	
040309	**Other: sintering of special materials and drossing facilities**					0,0		0,0	0,0		0,0		⇔	
060406	**Preservation of wood**			56,8			50,9			45,0		○○○○	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	**Road transport**		5,1		29,9	5,1		25,0	5,0		20,0	●●●○	↓	decreasing use of leaded fuel assumed
090201	**Inc. of Dom. or municipal wastes**	legal combustion	2,2		36,8	2,2		36,8	5,6		8,5	●●●○	↓	1995 data: from measured data of 7 Lombardian incinerators (presented at dioxin '99); projected values for 2005: 0.1 ng TE/m³ assumed for all plants, different amounts of waste
090201	**Inc. of Dom. or municipal wastes**	illegal (domestic) combustion	21,6		21,6	21,6		21,6	21,6		21,6	○○○○	⇔	
090202	**Inc. of Industrial wastes**	hazardous waste	97,4		97,4	97,4		97,4	4,6		4,6		↓	compliance with emission limit of 0.1 ng I-TEQ/m3
090207	**Inc. of hospital wastes**		27,5		250,0	27,5		250,0	1,3		50,0	●○○○	↓	reduction due to legislatory and waste management actions presumed
090901	**Cremation: Inc. of Corpses**			2,2			2,5			3,0		●●●○	↑	increase of activity rates presumed
1201	**Fires**		5,0		56,5	5,0		56,5	5,0		56,5	○○○○	⇔	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)			**366 — 967**			**370 — 985**			**227 — 628**					
industrtial sources			**271 — 620**			**281 — 648**			**153 — 303**					
non-industrial sources			**95 — 348**			**89 — 336**			**74 — 325**					

Uncertainty assessment: ●●●●: low uncertainty; ○○○○: very high uncertainty; nd=not determined

I/table 2 assessment of dioxin emissions in Italy until 2005 (annual emission in g I-TEQ/year)

References

1. R. De Lauretis, Dioxins and Furans Italian National and Local Emission Inventories, *Dioxin '99,* Venice, 12.-17-09.1999. *Organohalogen Compounds* **41**, pp. 487-489 (1999).
2. G. Pastorelli, R. De Lauretis, P. De Stefanis, L. Morselli and G. Viviano, PCDD/PCDF From Municipal Solid Waste Incinerators in Italy; An Inventory of Air Emissions, *Dioxin '99,* Venice, 12.-17-09.1999. *Organohalogen Compounds* **41**, pp. 495-498 (1999).
3. C. Martines, R. Fanelli, G. Pastorelli and P. L., Development of dioxin and furan air emission factors from municipal solid waste incinerators in Regione Lombardia (Italy), *Dioxin '99,* Venice, 12.-17.09.1999. *Organohalogen Compounds* **41**, pp. 247-250 (1999).
4. I. L. P. M. Rijpkema, The Impact of a Change in EC Legislation on the Combustion of Municipal Solid Waste, 93-312, 95 pp., TNO, Apeldoorn, NL (1993).
5. J. M. Berdowski, J. Baas, J. J. Bloos, A. J. H. Visschedijk and P. Y. J. Zandveld, The European Atmospheric Emission Inventory for Heavy Metals and Persistent Organic Pollutants, UFOPLAN no. 104.02 672/03, 244 pp., TNO, Niederlande, Berlin (1997).
6. U. Quaß, M. Fermann and G. Bröker, Identification of Relevant Industrial Sources of Dioxins and Furans in Europe, LUA Materialien Nr. 43, 936 pp., Landesumweltamt NRW (1997).

11. Ireland

As already mentioned in the stage I report no national information is available on the PCDD/F emissions in this country. Hence, the emission inventories made so far by LUA and TNO both rely on default emission factors and statistical activity rates.

Comparison of these attempts to set up an inventory for Ireland reveals that despite good agreement of the overall emission estimate considerable divergence exists between the Dutch and German study. From a comparison of the basic data used (see IRL/Table 1) it can be seen that LUA assumed the main fraction of energy consumption for domestic heating to be due to coal and lignite burning. By contrast, TNO used different activity data indicating that coal combustion amounts to about one third of the total energy consumption and assigning the major part to “other fuels” which include gas, peat and wood.

Source	TNO (ref. year 1990)			LUA (ref. year 1994)	
	Emission factor [µg I-TEQ/t]	Activity [TJ/a]	Activity [kt/a]*)	Emission factor [µg I-TEQ/t]	Activity [kt/a]
Coal	10	19.000	1266	2	2295
Lignite	10	3.540	237	0,6	645
Peat	10				
Gas					
Wood	5			1/50/500	
Other solid fuels	10	35600	2433		

IRL/table 1 basic data used in the TNO and LUA study for estimation of PCDD/F emissions from domestic combustion of solid fuels in Ireland
***) conversion factor used :15 GJ/ton**

In view of this contradictory data it was attempted to get more reliable information. Fortunately, the Irish Peat Board (Bord na Móna) provides a survey on the use of different fuels in the residential heating sector (see IRL/Table 2):

Year	Turf	Briquettes	Wood	Coal	Oil	Natural Gas	Electricity
1987/88	23,2	7,7	9,8	41,1	11,6	4,4	2,2
1988/89	23,1	7,3	11,5	39,1	11,7	4,9	2,4
1989/90	23	7,6	11,8	37,1	11,	6,1	2,6
1990/91	22,9	8,5	10,6	35	12,7	7,4	2,9
1991/92	22,7	7,6	10,9	32,7	13,9	8,7	3,3

1992/93	22,6	7,8	9,9	30,4	15,5	10,1	3,7
1993/94	22,4	,3	8,2	28,1	17,5	11,5	4
1994/95	22,4	7,8	6,7	25,6	20,6	12,9	4
1995/96	21,4	6,3	6,8	23	24	14,4	4,1
1996/97	21,3	6,1	5	20,5	27,2	15,8	4,1
1997/98	19,9	6	4,4	18,3	30,3	17	4,1

IRL/table 2 energy Sources in Residential Heating Sector in Ireland by percentage (taken from www.bnm.ie)

According to IRL/table 2 the combustion of peat (as turf or briquettes) amounted to ca. 30% of the energy consumption for domestic heating by mid of the 80s and experienced a steady decrease since then down to ca. 25%. Similarly, the use of other solid fuels wood and coal decreased considerably; Currently, oil, natural gas and electricity together make up more than 50% of the energy consumption in this sector.

A comparison of the Peat Board data with the basic data used in the TNO and Stage I reports (see IRL/table 1) clearly shows that none of the studies used realistic information on the fuel distribution. According to Bord na Móna in 1990, peat and wood combustion together amounted to 42% of the annual energy consumption, whereas a percentage of 35% is reported for coal combustion. The (peat + wood) to coal ratio therefore was 1,2. From TNO data a ratio of 1,6 for „other solid fuels“ compared to the sum of coal and lignite consumption rates is revealed. The Stage I report on he other hand did entirely ignore peat and wood combustion.

With the differentiated data of the Irish Peat Board it is possible to produce a more reliable estimate of the dioxin emissions from domestic heating in Ireland. However, considerable uncertainties remain because there is no measurement data available which allow to derive an emission factor for peat combustion in residential heating facilities. For the estimate presented here it was assumed that peat briquettes (which are dried to a water content of 10%) are likely to behave similar to brown coal (lignite). Thus the emission factor chosen for peat briquettes is 1,8 µg I-TEQ/ton (which is the mean value of emission factors recently measured for German and Czech lignite in small single room heating ovens [1]. Turf having a higher water content (~35%) and being known to produce considerably more smoke is assumed to cause 5 fold emissions (emission factor:10 µg I-TEQ/ton). For coal combustion the generation of 7µg

I-TEQ/ton is assumed (emission factors for German coal 6,8 µg I-TEQ/ton [1], for UK bituminous coal ca. 7,5 µg I–TEQ/ton [2]). Regarding wood combustion the Stage I approach is maintained which assumes 83, 16 and 1 per cent use of clean, polluted and heavily polluted wood with emission factors of 1, 50 and 500 µg I-TEQ/ton, respectively. Emissions from oil and natural gas combustion are considered to be negligible (c.f. Stage I report).

In 1995 the final energy consumption rate of the residential sector was 2127 kt oil equivalents (kt_{oe}) as taken from http://www.irlgov.ie/tec/energy/finalenergy.htm. Using this figure the respective energy consumption rates amounts of the different fuel types can be calculated from the percentages listed in IRL/table 2. With the appropriate conversion factors the mass consumption rates are calculated from which the annual PCDD/F emissions are obtained by multiplication with the emission factors mentioned before. The result is presented in IRL/table 3.

Accordingly, peat and wood combustion reveal to be the major PCDD/F emission source under the chosen conditions for the estimation. It should be noted, that the final energy balance for Ireland presented on the mentioned web page does not contain any value for wood consumption and a value for coal combustion being about 50% less than the data taken from the Irish Peat Board. Thus, some uncertainty remain also with regard to the activity rates. Nevertheless, the estimate evaluated here is used in the revised 1995 inventory for Ireland; emissions from peat combustion is assigned to the subgroup “wood” to avoid implementation of a new subgroup for only one country (see IRL/Table 3).

The emission estimates for the year 2000 and 2005 are based on the development of the energy balance from 1995 to 1997. Accordingly, coal combustion increased by 45% whereas the use of turf and briquettes declined by 26 and 11%, respectively. Thus an increase of coal combustion by 50% per 5 years and a decrease of peat and wood combustion by 15% per 5 years is assumed to allow for estimating the 2000 and 2005 emissions.

Fuel	% of fuel consumption in 1995	kt_{oe} in 1995	Conversion factor kt_{fuel}/kt_{oe}	Kt fuel per year	Emission factor µg I-TEQ/t	PCDD/F emission g I-TEQ/a
Turf	21,4	455	3,19	1454	1,8 -10	2,6 - 14,5
Briquettes	6,3	134	2,26	302	1,8	0,5

Wood	6,8	145	2,86	413		5,7
clean	5,64				1	0,3
polluted	1,09				50	3,3
heavily polluted	0,07				500	2,1
Subtotal “wood”						**8,3 – 20,7**
Coal	23	489	1,41	689	7	4,8
Other		904				
TOTAL		**2127**				**13,1 - 25,6**

IRL/table 3 revised 1995 PCDD/F emissions from domestic heating in Ireland

The second difference between the TNO and LUA Stage I study concerns the incineration of clinical waste (see IRL/Table4). While TNO does not present any estimate, in the LUA stage I report this source revealed to be the most important PCDD/F emission source in Ireland. This assessment was based on the assumption that all hospital waste might be incinerated in small on-site installations which a high emission factor was assigned to. However, information obtained since then indicates that already in the time period covered by the Stage I report a considerable fraction of hospital waste was exported and treated in UK incinerators. If and how many on-site incinerators were at operation in Ireland at that time remains unclear; however, from the web site of the Irish EPA Integrated Pollution Control (IPC) licensing documents for two on-site incinerators are available. According to these documents PCDD/F emission limits of 50 and 5 ng I-TEQ/m³, respectively, apply until mid of 2001 then going to be changed to 0,1 ng I-TEQ/m³. (note: as these documents published via the internet are considered uncontrolled there might have been changes in licensing in the meantime). Presuming these limits are describing actual flue gas concentrations and using the maximum flow rates mentioned in the licenses hourly emission rates of 250 µg I-TEQ/h and 9 µg I-TEQ/h can be calculated. As on-site incinerators usually are not operated continuously an operation period of 2000 h per year may be assumed leading to an estimate of ca. 0,520 g I-TEQ being released annually. Of course emissions could be much less depending on the actual PCDD/F concentrations measured in the flue gases which has to be done biannually and annually, respectively.

There are two further hospitals having IPC licenses and there might be additional ones without an IPC license. Hence it is clear that some PCDD/F emission must be taken into account from on-site hospital waste incinerators. On the other hand, the calculation shown above indicates that the previous estimates were much too high. Therefore the upper range of the emission estimate for this sector is set to ca. 10% of the previous Stage I value (see IRL/Table 5).

The different assessments obtained in the LUA and TNO studies clearly highlight the difficulties in preparing an emission inventory when only minimal and second or third hand information is available. Fortunately, in the case of Ireland, the Irish EPA is currently going to support a project aiming at the development of national Irish dioxin emission inventory for emissions to air, land and water. Therefore a large improvement on the data basis and on the general information related to the subject can be expected in the near future.

Ireland			TNO <1>		LUA 1997 <2>	
SNAP		ref.-year:	1990		1993-1995	
01	Power plants	fossil fuels	0,691			
0202	Res. combustion: Boilers, stoves, fireplaces	wood	27,0	1	0	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	12,2		5	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		1,6		0,19	
30301	Sinter plants					
030308	Secondary zinc production				0,0153	
030309	Secondary copper production				0	
030310	Secondary aluminium production				0	
30311	Cement				0,23	
030326	Other: metal reclamation from cables					
040207	Electric furnace steel plant		0,7		0,27	
040309	Other: Non ferrous metal foundries				0	
040309	Other: sintering of special materials and drossing facilities					
060406	Preservation of wood				3,5	
0701	Road transport				1,2	
090201	Inc. of Dom. or municipal wastes	legal combustion			0	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion			1,4	
090202	Inc. of Industrial wastes	hazardous waste				
090207	Inc. of hospital wastes				22,5	2
090901	Cremation: Inc. of Corpses				0,1	
1201	Fires				3,5	
Total of sources considered above (g I-TEQ/year) *)			**42**		**38**	
Total of Inventory referred to (g I-TEQ/year)			44		37,9	
%of repective inventory covered by considered sources			96%		100%	
sources not included: 01 and 02 fuel oil combustion (1,1 g I-TEQ/a); 0801 Other mobile sources (0,43 g I-TEQ/a)						
References:	<1> The European Atmospheric Emission Inventory of heavy metals and Persistent Orgenic Pollutants for 1990, TNO/UBA, Berlin, 1997					
	<2>U. Quaß, M. Fermann, G. Bröker: Identification of relevant industrial sources of dioxins and furans in Europe. LUA-Materialien No. 43 (1997), Landesumweltamt Nordrhein-Westfalen, Essen, Germany					
nd: not determined						
ne: not existent						
Remarks:	1 emission assigned to sub-group "other fuels" (gas, peat, wood, other solid fuels) in TNO report					
	2 worst case consideration					

IRL/table4 overview on emission inventory data (annual emission in g I-TEQ/year)

Ireland			Revised for 1995			Actual data 2000			Projection 2005			Uncertainty Assessment	Future Trend	Comments
SNAP			min	prob	max	min	prob	max	min	prob	max			
01	Power plants	fossil fuels		0,7			0,7			0,7		●●●❍	⬄	value from TNO study
0202	Res. combustion: Boilers, stoves, fireplaces	wood	8,3		20,7	7,1		17,6	6,0		15,0	●❍❍❍	↓	*including peat combustion; declining by 15% per 5 years)*
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite		4,8			7,2			10,8		❍❍❍❍	↑	inclreased activity rates (50% per 5 years)
0301	Combustion in Industry/boilers, gas turbines, stationary engines		0,2		1,6	0,2		1,6	0,2		1,6	●●●❍	⬄	
30301	Sinter plants			ne			ne			ne				
030308	Secondary zinc production			nd			nd			nd		❍❍❍❍		
030309	Secondary copper production			nd			nd			nd		❍❍❍❍		
030310	Secondary aluminium production			nd			nd			nd		❍❍❍❍		
30311	Cement		0,2		0,2	0,2		0,2	0,2		0,2	●●❍❍	⬄	
030326	Other: metal reclamation from cables			nd			nd			nd		❍❍❍❍		
040207	Electric furnace steel plant		0,3		0,7	0,3		0,8	0,4		1,0	●●●❍	↑	1 plant, capacity 500 kt/a; increasing activity rates; forecast 2005: 458 kt/a
040309	Other: Non ferrous metal foundries			nd			nd			nd		❍❍❍❍		
040309	Other: sintering of special materials and drossing facilities			ne			ne			ne				
060406	Preservation of wood			3,5			3,1			2,8		❍❍❍❍	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	Road transport		1,2		1,2	1,2		1,2	1,2		1,2	●●●❍	⬄	
090201	Inc. of Dom. or municipal wastes	legal combustion		ne			ne			ne				
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion	1,4		1,4	1,4		1,4	1,4		1,4	❍❍❍❍	⬄	
090202	Inc. of Industrial wastes	hazardous waste		ne			ne			ne				
090207	Inc. of hospital wastes		0,0		2,0	0,0		2,0		0,0		●●❍❍	↓	on-site incineration shall cease until 2003 or comply with 0.1 ng I-TEQ/m³ limit value
090901	Cremation: Inc. of Corpses		0,1		0,1	0,1		0,1	0,1		0,1	●●●❍	⬄	
1201	Fires		3,5		3,5	3,5		3,5	3,5		3,5	❍❍❍❍	⬄	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)			24 — 40			25 — 39			27 — 38					
industrial sources			3 — 7			3 — 7			3 — 5					
non-industrial sources			21 — 34			22 — 33			24 — 33					

nd: no data; ne: not existent
Uncertainty assessment: ●●●●: low uncertainty; ❍❍❍❍: very high uncertainty

IRL/table 5 assessment of dioxin emissions in Ireland until 2005 (annual emission in g I-TEQ/year)

References

1. K.-J. Geueke, Gessner.A., E. Hiester, U. Quaß and G. Bröker, THE *DG ENV* EUROPEAN DIOXIN EMISSION INVENTORY - STAGE II: Elevated Emissions of Dioxins and Furans from Domestic Single Stove Coal Combustion, *Dioxin 2000,* Monterey, California, 13. - 18. August 2000. *Organohalogen Compounds*. (2000).

2. A Review of Dioxin Emissions in the UK, DOE/HMIP/RR/95/004, 113 pp., Her Majesty's Inspectorate on Pollution (1995).

12. Luxembourg

The documents listed in L/Table 1 are based on information gained from the national environmental authorities. The TNO data have been in part estimated by default emission factors. This is the explanation for the much higher emission reported for municipal solid waste incineration presented by TNO which in turn has not been regarded for the revised 1995 inventory.

The difference regarding sec. aluminium production between the inventory provided by EPA and the Stage I report LUA is due to statistical inaccuracy. In most European statistics the BENELUX countries are considered together; thus, when preparing the Stage I report the activities in the non-ferrous metal industries of Luxembourg were included in the Belgian activity rates.

The higher estimate for sinter plants presented in the LUA report results from inclusion of fugitive and sideline source emissions.

With respect to a revised inventory and the description of the actual and future situation additional data could be obtained only from statistics on the iron and steel industry. Accordingly, consumption of iron ore in sinter plants has been decreasing steadily in the last years. Hence, also the production of sinter is likely to have lowered. Already in 1996 closure of the sinter plants was announced. By contrast, steel production in electric arc furnaces has been increasing from 1994 to 1998. Extrapolation of these developments indicates minimum overall emissions in 2000 and a new increase until 2005 (see L/Table 2).

With regard to all other emission source no further information has been published; hence, the estimates of the revised 1995 inventory are maintained for the other years.

Luxemburg			EPA Lux.		TNO <1>		LUA 1997 <2>	
SNAP		ref.-year:			1990		1993-1995	
01	Power plants	fossil fuels			0,007			
0202	Res. combustion: Boilers, stoves, fireplaces	wood					0	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite			0,0		0,06	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		0		0,2		0,02	
30301	Sinter plants		24		23,0		46	
030308	Secondary zinc production							
030309	Secondary copper production						0	
030310	Secondary aluminium production		3				0	
30311	Cement		0				0	
030326	Other: metal reclamation from cables							
040207	Electric furnace steel plant		2				2,35	
040309	Other: Non ferrous metal foundries						0	
040309	Other: sintering of special materials and drossing facilities							
060406	Preservation of wood						0,4	
0701	Road transport				0,2		0,4	
090201	Inc. of Dom. or municipal wastes	legal combustion	0		4,2		0,1	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion					0,2	
090202	Inc. of Industrial wastes	hazardous waste						
090207	Inc. of hospital wastes						0	
090901	Cremation: Inc. of Corpses						0	
1201	Fires						0,4	
Total of sources considered above (g I-TEQ/year) *)			**29,2**		**27,6**		**49,9**	
Total of Inventory referred to (g I-TEQ/year)			29,2		28		49,9	
%of repective inventory covered by considered sources			100%	a)	100%		100%	
References:	<1> The European Atmospheric Emission Inventory of heavy metals and Persistent Orgenic Pollutants for 1990, TNO/UBA, Berlin, 1997							
	<2>U. Quaß, M. Fermann, G. Bröker: Identification of relevant industrial sources of dioxins and furans in Europe. LUA-Materialien No. 43 (1997), Landesumweltamt Nordrhein-Westfalen, Essen, Germany							
nd: not determined								
ne: not existent								

L/table 1 overview on emission inventory data (annual emission in g I-TEQ/year)

Luxemburg			Revised for 1995			Actual data 2000			Projection 2005			Uncertainty Assessment	Future Trend	Comments
SNAP			min	prob	max	min	prob	max	min	prob	max			
01	Power plants	fossil fuels		0,0			0,0			0,0		●●●○	⇔	value from TNO study:0.007 g I-TEQ/a
0202	Res. combustion: Boilers, stoves, fireplaces	wood		0,0			0,0			0,0		●○○○	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	0,2		0,7	0,1		0,6	0,1		0,6	○○○○	↓	max values: high emission factors found by Austrian EPA taken into account.
0301	Combustion in Industry/boilers, gas turbines, stationary engines		0,0		0,2	0,0		0,2	0,0		0,2	●●●○	⇔	
30301	Sinter plants		23,0		46,0		0,0			0,0		●●○○	↓	sharply declining activity until 1998; closure of plant already announced in 1995.
030308	Secondary zinc production			0,0			0,0			0,0		●●●●	⇔	
030309	Secondary copper production			0,0			0,0			0,0		●●○○	⇔	
030310	Secondary aluminium production		0,0		2,7	0,0		2,7	0,0		2,7	●●○○	⇔	
30311	Cement		0,0		0,1	0,0		0,1	0,0		0,1	●●○○	⇔	
030326	Other: metal reclamation from cables			0,0			0,0			0,0		●●●○	⇔	
040207	Electric furnace steel plant			2,4			6,5			10,8		●●○○	↑	sharply increasing activity rates in 1995-1998
040309	Other: Non ferrous metal foundries			0,0			0,0			0,0		●●●○	⇔	
040309	Other: sintering of special materials and drossing facilities			0,0			0,0			0,0			⇔	
060406	Preservation of wood			0,4			0,4			0,3		○○○○	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	Road transport		0,2		0,4	0,2		0,4	0,2		0,4	●●●○	⇔	
090201	Inc. of Dom. or municipal wastes	legal combustion		0,1			0,1			0,1		●●●○	⇔	
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion		0,2			0,2			0,2		○○○○	⇔	
090202	Inc. of Industrial wastes	hazardous waste		0,0			0,0			0,0			⇔	
090207	Inc. of hospital wastes			0,0			0,0			0,0		●○○○	⇔	
090901	Cremation: Inc. of Corpses			0,0			0,0			0,0		●●●○	⇔	
1201	Fires			0,4			0,4			0,4		○○○○	⇔	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)			27 — 54			8 — 12			12 — 16					
industrial sources			26 — 52			7 — 10			11 — 14					
non-industrial sources			1 — 2			1 — 2			1 — 2					

Uncertainty assessment: ●●●●: low uncertainty; ○○○○: very high uncertainty

L/table 2 assessment of dioxin emissions in Luxembourg until 2005 (annual emission in g I-TEQ/year)

13. Norway

Norway is — besides Switzerland — the second non-member country which had been included in the Stage 1 Inventory as well as in the start up phase of Stage 2.

Information on dioxin emissions were made available for the Stage I report by the Norwegian air pollution control authority but included only few sources and almost no information on measurements. Interestingly, in the Norwegian inventory two plants of the non-ferrous metal sector were considered which had not been mentioned anywhere else: magnesium and ferrosilicone production (see N/Table 2).

In the Stage I inventory and the TNO/UBA study some striking differences appear when compared to the Norwegian data. These differences are partly caused by the difficulty to obtain the needed information on industrial activity, which are not included in statistics covering the EC member states.

The most surprising difference might be the absence of an emission estimate for sinter plants in the LUA Stage I study. This was a data compilation error. By contrast, the Norwegian Agency assigned the major part (37 g N-TEQ/year [1]) of the annual emission freight to the sintering process. However, as revealed by more actual information obtained from SFT [1], the plant (called "iron pellet plant") has been shut down in 1997.

Regarding the production of steel in electric arc furnaces production rates are available for the years 1995-1998 and reveal a considerable increase of activity. Extrapolation of this trend leads to increases by 45 % and 93 % in 2000 and 2005 resp., compared to the 1995 level.

More comprehensive data could be obtained from the SFT internet web site about the sector of waste incineration. According to that information an emission limit of 2 ng N-TEQ/m³ has been set for municipal solid waste and hospital waste incineration plants. There were 8 msw incinerators, partly having a licence for co-combustion of health care wastes and 2 special hospital waste incinerators operated in Norway in 1995 (c.f. . Besides these facilities, 6 small-capacity incinerators for biological/pathological waste are mentioned which apparently are located at the hospital sites.

[1] For the purpose of this report the differences between the Nordic **T**oxicity **E**quivalence **F**actors and the international TEFs may be neglected.

Unfortunately no operation times or annual throughputs are given. Assuming 8000 hours per year operation the annual throughputs shown in N/table 1 are obtained. In the case of msw the throughput fairly compares with the value used in the Stage 1 report of 440 kt/year.

	No	capacity [t/h]	rem.
Municipal and production waste	1	9,00	
	2	20,00	*)
	3	13,00	*)
	4	12,00	*)
	5	5,00	*)
	6	3,00	
	7	1,10	
	8	1,30	
	Total t/h	64,40	
	Total t/year	**515.200**	
Hospital	1	0,60	
	9	0,35	
	10	0,20	
	Total t/h	**1,15**	
	Total t/year	**9.200**	
*) includes waste from health care facilities			

N/table 1 data on waste incinerators in Norway

With the Norwegian emission limit and a specific flue gas volume of 5.500 m³/ton waste annual emissions of

5,7 and 0,1 g I-TEQ/m³ are obtained for msw and hospital waste incineration, resp. However, with respect to hospital waste incineration there remains some uncertainty on the emissions of the small on-site incinerators.

Presumably from measurement results (all msw incinerators are obliged to annually carry out an emission measurement) SFT counted an emission of 2,6 g N-TEQ/year in 1995. The value of 5,7 g I-TEQ/m³ calculated before is therefore considered as the upper limit of the range given in N/table 3. It agrees well with the estimated for 1998 of 5 g I-TEQ/year submitted recently [1]. For the year 2000 and the future a slight increase of incineration activity (30% per 5 years) is assumed, while it appears reasonable to predict a decrease until 2005 due to more strict emission limits which might be adopted from EC regulations.

Interesting data is available concerning a plant producing anhydrous magnesium chloride. This plant was, according to SFT [1], the most important point source for dioxins and furans in Norway in the late 80s. Abatement measures implemented during the early 90s reduced the emissions to water from 500 g I-TEQ/year to 1 g I-TEQ/year; emissions to air that were 25 g I-TEQ/year are now assessed to be 2 g I-TEQ/year.

The plant tried further to reduce the air emissions by primary measures [2]. A set of lab scale and full scale experiments revealed that substitution of the normal coke by petrol coke reduces the stack gas PCDD/F emissions by 90%. However, since the use of petrol coke adversely effected the product quality the plant still is using its former coke type; emissions from this plant are told to be 2 g N-TEQ/a to air and 1 g N-TEQ/a to water. As this plant is a significant point source of dioxins and furans in Norway which is the only country having such a plant this estimate is assigned to source 040309 “Non ferrous metal foundries” in N/table 3. Since possibilities of abatement appear to be limited the emission of 1995 is maintained for 2000 and 2005.

The same approach is applied for all other sources not mentioned before due to lack of more actual information.

For 1998, an total of approximately 22 g I-TEQ/year of PCDD/F released to ambient air is estimated by SFT. However, non-industrial sources like traffic and domestic solid fuel combustion have not been regarded. This estimates fits well to the air emission range of 9 to 52 g I-TEQ/year presented in N/table 3 for industrial sources in 1995.

Norway			**SFT**		**TNO <1>**		**LUA 1997 <2>**	
SNAP		**ref.-year:**	**1995**		**1990**		**1993-1995**	
01	**Power plants**	fossil fuels			0,094			
0202	**Res. combustion: Boilers, stoves, fireplaces**	wood			14,2		23,9	
0202	**Res. combustion: Boilers, stoves, fireplaces**	coal/lignite			0,1		0,3	
0301	**Combustion in Industry/boilers, gas turbines, stationary engines**				3,8		0,2	
30301	**Sinter plants**				0,3			2,0
030308	**Secondary zinc production**		37,0				0,0	
030309	**Secondary copper production**						0,0	
030310	**Secondary aluminium production**						0,0	
30311	**Cement**		0,2					
030326	**Other: metal reclamation from cables**							
040207	**Electric furnace steel plant**				0,8		0,5	
040309	**Other: Non ferrous metal foundries**						0,0	
040309	**Other: sintering of special materials and drossing facilities**							
060406	**Preservation of wood**						4,3	
0701	**Road transport**						1,3	
090201	**Inc. of Dom. or municipal wastes**	legal combustion	2,6		17,2		2,6	
090201	**Inc. of Dom. or municipal wastes**	illegal (domestic) combustion					2,5	
090202	**Inc. of Industrial wastes**	hazardous waste					0,1	
090207	**Inc. of hospital wastes**		0,1				0,1	
090901	**Cremation: Inc. of Corpses**		0,2	1			0,1	
1201	**Fires**						4,3	
Total of sources considered above (g I-TEQ/year) *)			**40**		**36**		**40**	
Total of Inventory referred to (g I-TEQ/year)			45		39		41	
% of repective inventory covered by considered sources			89%	b)	94%		98%	

b) further sources considered: magnesium (3,5 g i-TEQ/a) , ferrosilicone (13 g I-TEQ/a) and vinyl chloride production (0,002 g I-TEQ/a)

References: <1> The European Atmospheric Emission Inventory of heavy metals and Persistent Orgenic Pollutants for 1990, TNO/UBA, Berlin, 1997

<2>U. Quaß, M. Fermann, G. Bröker: Identification of relevant industrial sources of dioxins and furans in Europe. LUA-Materialien No. 43 (1997), Landesumweltamt Nordrhein-Westfalen, Essen, Germany

nd: not determined

ne: not existent

Remarks:

1 maximum estimate; minimum at 0.03 g I-TEQ/a

2 The Norwegian sintering plant(s) erroneously had not been regarded in the Stage 1 report

N/table 2 overview on emission inventory data (annual emission in g I-TEQ/year)

Norway			Revised for 1995			Actual data 2000			Projection 2005			Uncertainty Assessment	Future Trend	Comments
SNAP			min	prob	max	min	prob	max	min	prob	max			
01	Power plants	fossil fuels		0,1			0,1			0,1		●●●❍	⇔	value from TNO study
0202	Res. combustion: Boilers, stoves, fireplaces	wood	14,2		23,9	14,2		23,9	14,2		23,9	●❍❍❍	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	0,8		3,5	0,7		3,1	0,6		2,8	❍❍❍❍	↓	
0301	Combustion in Industry/boilers, gas turbines, stationary engines		0,2		3,8	0,2		3,8	0,2		3,8	●●●❍	⇔	
30301	Sinter plants		0,3	0,6	37,0		0,0			0,0		●●●❍	↓	plant closed in 1997
030308	Secondary zinc production			0,0			0,0			0,0		●●●●	⇔	no process inoperation
030309	Secondary copper production			0,0			0,0			0,0		●●❍❍	⇔	
030310	Secondary aluminium production		0,0		0,1	0,0		0,1	0,0		0,1	●●❍❍	⇔	
30311	Cement			0,2			0,2			0,2		●●❍❍	⇔	
030326	Other: metal reclamation from cables			0,0			0,0			0,0		●●●❍	⇔	
040207	Electric furnace steel plant		0,5		0,8		0,9			1,2		●●●❍	↑	increasing activity rates
040309	Other: Non ferrous metal foundries			2,0			2,0			2,0		●●●❍	⇔	reflects magnesium chloride production
040309	Other: sintering of special materials and drossing facilities			0,0			0,0							
060406	Preservation of wood			4,3			4,3			4,3		❍❍❍❍	⇔	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	Road transport			1,3			1,3			1,3		●●●❍	⇔	
090201	Inc. of Dom. or municipal wastes	legal combustion	2,6		5,7	3,4		7,4	0,2		0,5	●●●❍	↓	data 1995/2000: Norwegian limit value of 2 ng N-TEQ/m³ used for calculation; 2005: limit value of 0.1 ng I-TEQ/m³ assumed
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion		2,5			2,5			2,5		❍❍❍❍	⇔	
090202	Inc. of Industrial wastes	hazardous waste		0,1			0,1			0,1			⇔	
090207	Inc. of hospital wastes			0,1			0,1			0,1		●❍❍❍	⇔	
090901	Cremation: Inc. of Corpses		0,1		0,2	0,1		0,2	0,1		0,2	●●●❍	⇔	
1201	Fires			4,3			4,3		0,0	4,3	0,0	❍❍❍❍	↓	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)				34 — 90			34 — 54			31 — 47				
industrial sources				9 — 53			10 — 17			7 — 11				
non-industrial sources				25 — 37			25 — 37			25 — 37				

Uncertainty assessment: ●●●●: low uncertainty; ❍❍❍❍: very high uncertainty

N/table 3 assessment of dioxin emissions in Norway until 2005 (annual emission in g I-TEQ/year)

References

1. C. Benestad, Personal Communication.;, 2000.
2. U. I. Musdalslien, P. H. Nokleby and O. Wallevik, Formation of dioxins from carbonaceous materials in production of anhydrous magnesium chloride, *Dioxin '98,* Stockholm, *Organohalogen Compounds* **36**, pp. 81-84 (1998).

14. The Netherlands

The Netherlands were among the first countries which prepared an extensive dioxin emission inventory in the early 90s. A first total estimate on dioxin emissions to air was published for the year 1990 and amounted to 606 g I-TEQ/year [1]. A more detailed inventory published in another report [2] which was structured according to the CORINAIR source codes summed up to 618 g I-TEQ/a. In 1994 a comprehensive report on dioxin emissions was released [3] comprising data for the situation in 1991 and revealed an emission of 484 g I-TEQ/year. Since then, the CORINAIR compatible inventory has been updated annually (see NL/Table 1). Besides, non-official inventories can be found in the scientific literature. The most recent publication [4] covers a number of source types ahead of the official inventory and thus totals to a slightly higher overall emission for the year 1998.

A pronounced decrease of air emission is revealed from NL/Table 1, mostly because of the abatement measures undertaken at msw incinerators. From 1995 on also emissions from sources in the metal industry were lowered; most recently, one of the iron ore sinter plants was equipped with an Airfine high performance flue gas washing which allows the emission concentration to be lowered to around 0,1 - 0,2 ng I-TEQ/m³.

Compared to the official Dutch inventory for the year 1995 the LUA report estimated around twice the overall emissions. This is due to higher estimates for sintering processes with LUA also taken into account the emissions from fugitive emissions and sideline sources. Further, a high but very uncertain estimate was given for accidental fires (see also introductory Comments chapter III-1.2). The same is valid for the source category of illegal waste burning and partly for domestic burning (SNAP 0202) which includes a high estimate of waste wood combustion.

Special attention should be given to the source category “wood preservation” as The Netherlands is the only country including this source of fugitive emissions into their official inventory. A remarkable jump in this emission estimate is predicted for 1998 compared to the 1997 inventory. The reason for this decrease is not explained in the basic document.

With respect to the considerations outlined in the introductory remarks the revised inventory shown in NL/Table 2 was drafted. If available, the official Dutch emission estimates as the lower limits of the range. Thus, the lower limit of the overall range is almost identical with the official annual emission while the upper limit unifies the maximum values. For the estimate of the year 2000 the official values for 1998 were taken and completed by LUA estimates in case official estimates are missing. For the sources “090207: illegal waste incineration” and “12: Fires” an average of the range given in the revised 1995 estimation is taken.

Finally, regarding the year 2005, it is assumed that — in view of the low level of dioxin emissions already achieved — only minor additional decreases will occur. From the estimated values it reveals that the emissions from non-industrial sources — if they were as high as estimated here — might make up more than 50% of the overall emissions.

The Netherlands					TNO/RIVM <3>		EDNL 95/96		EDNL 96		EDNL 97/98		EDNL 97/98		ref <4>]		TNO <1>		LUA 1997 <2>
SNAP		ref.-year:	1990		1991		1995		1996		1997		1998		1998		1990		1993-1995
01	Power plants	fossil fuels	16				0,003		0,003		0,0076		0,00602						
0202	Res. combustion: Boilers, stoves, fireplaces	wood	9		12	4	9,4		9,5		5,2								14,0
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite			4	4							4		14				0,11
0301	Combustion in Industry/boilers, gas turbines, stationary engines		58,1				2,71		0,0196		3,67		2,89						0,84
30301	Sinter plants		0,06	1	26			6		6		6		6	2,5	9			41,4
030308	Secondary zinc production																		0
030309	Secondary copper production																		2,6
030310	Secondary aluminium production																		3,4
30311	Cement				2,7	5									1,8	5			0,5
030326	Other: metal reclamation from cables				1,5										0,3				1,52
040207	Electric furnace steel plant		23	2			26,5	7	30	7	16,9	7	13,4	7					1,3
040309	Other: Non ferrous metal foundries														3,3				0
040309	Other: sintering of special materials and drossing facilities																		
060406	Preservation of wood		61	3	25	3	22,5	3	22	3	21,5	3	17		21				15,4
0701	Road transport		2,9		7		1,96		1,865		1,516		2,011		0,8				2,2
090201	Inc. of Dom. or municipal wastes	legal combustion	431		382		6,23		3		3,56		2,81		1,6				6,2
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion																	9,5
090202	Inc. of Industrial wastes	hazardous waste			16										0,5				1
090207	Inc. of hospital wastes				2,1										1,5				1
090901	Cremation: Inc. of Corpses		0,23		0,2		0,26		0,26		0,26		0,204		0,2				0,2
1201	Fires		nd		nd										4				15,3
Total of sources considered above (g I-TEQ/year) *)			**601**		**478**		**69,6**		**66,7**		**52,6**		**42**		**55,5**		**0**	8	**116,5**
Total of Inventory referred to (g I-TEQ/year)			618		484		74,2		71,2		55,3		43,6		57		505		116,5
% of repective inventory covered by considered sources			97%	a)	99%		94%	b)	94%	b)	95%	b)	97%	b)	0,97	b)	0%		100%

a) sources not included: 0406 Proc. In wood, papaer pulp, food, drink and other industries (12 g I-TEQ/a); 08 Other mobile sources (ca. 4 g I-TEQ)

b) sources not included:08 Other mobile sources (4,4 g; 1997:1,1 g/a; 1998:0,88g);0405 Inorg.Chem:1997: 0,59 g,1998: 0,47g; 0910 Other waste treatment 1997: 0,9 g; 1998: 0,7 g

References:
<1> The European Atmospheric Emission Inventory of heavy metals and Persistent Orgenic Pollutants for 1990, TNO/UBA, Berlin, 1997
<2>U. Quaß, M. Fermann, G. Bröker: Identification of relevant industrial sources of dioxins and furans in Europe. LUA-Materialien No. 43 (1997), Landesumweltamt Nordrhein-Westfalen, Essen, Germany
<3> Emission of Dioxins in The netherlands. Report by TNO/RIVM 1994
<4> Cuijpers, C.E.J, Bremmer, H.J., Luijckx, N.B.L.:Dioxins and PCBs in the Netherlands

Remarks:
1: comprises all sources of category 0303; 2: comprises all sources in iron and steel industry; 3: originally assigned to 0604:other use of solvents and related activities; 4: also comprises industrial plants
5: various high-temperature processes; 6: sinter plants included in 0402 Processes in iron and steel industries; here assigned to 040207; 7: includes emissions for sintering process;
8: TNO document only contains total estimate without source related breakdown; 9: ref <4> also includes etimates for 1991 and 1996 of 26 and 18 g I-TEQ/a, resp.
nd: not determined; ne: not existent

NL/table 1 overview on emission inventory data (annual emission in g I-TEQ/year)

The Netherlands			*Revised for 1995*			*Actual data 2000*			*Projection 2005*			*Uncertainty Assessment*	*Future Trend*	*Comments*
SNAP			*min*	*prob.*	*max*	*min*	*prob.*	*max*	*min*	*prob.*	*max*			
01	**Power plants**	fossil fuels		0,0			0,0			0,0		●●●○	⇔	0.003 g -TEQ/a acc. to EDNL data
0202	**Res. combustion: Boilers, stoves, fireplaces**	wood	9,4		14,0		4,1			4,0		●○○○	↓	
0202	**Res. combustion: Boilers, stoves, fireplaces**	coal/lignite	0,3		1,3	0,2		1,1	0,2		1,0	○○○○	↓	max values: high emission factors found by Austrian EPA taken into account.
0301	**Combustion in Industry/boilers, gas turbines, stationary engines**		0,8		2,7		2,9			#####		●●●○	↑	
30301	**Sinter plants**		26,5		41,4	19,4		30,4	2,8		4,4	●●●○	↓	improving abatement acc. To ref.<4> at slightly increasing activity rates (prediction 2005: 113% of 1995)
030308	**Secondary zinc production**			0,0			0,0			0,0		●●●●	⇔	no process inoperation
030309	**Secondary copper production**			ne			ne			ne		●●○○		only direct scrap use known
030310	**Secondary aluminium production**		3,4		3,4		0,0	3,4		3,4		●●○○	⇔	
30311	**Cement**		0,5		0,5		0,0	0,5		0,5		●●○○	⇔	
030326	**Other: metal reclamation from cables**		1,5		1,5		0,0			0,0		●●●○	↓	
040207	**Electric furnace steel plant**		0,0		1,3	0,0		0,4		0,0		●●●○	↓	sharply decreasing activity rates
040309	**Other: Non ferrous metal foundries**		0,0		0,0		0,0			0,0		●●●○	⇔	no process inoperation?
040309	**Other: sintering of special materials and drossing facilities**		0,0		0,0		0,0			0,0			⇔	
060406	**Preservation of wood**			22,5			20,2			17,8		○○○○	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	**Road transport**		2,0		2,2		2,0			2,0		●●●○	↓	
090201	**Inc. of Dom. or municipal wastes**	legal combustion	6,2		6,2		2,8			2,5		●●●○	↓	
090201	**Inc. of Dom. or municipal wastes**	illegal (domestic) combustion	1,0		9,5		5,0			2,5		○○○○	↓	
090202	**Inc. of Industrial wastes**	hazardous waste	1,0		1,0		1,0			1,0			⇔	
090207	**Inc. of hospital wastes**		1,0		1,0		1,0			1,0		●○○○	⇔	
090901	**Cremation: Inc. of Corpses**		0,2		0,3		0,2			0,2		●●●○	↓	
1201	**Fires**		1,5		15,3		7,0			7,0		○○○○	↓	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)			**78 — 124**			**66 — 82**			**48 — 50**					
industrial sources			**42 — 69**			**32 — 48**			**17 — 19**					
non-industrial sources			**36 — 55**			**34 — 34**			**31 — 32**					

Uncertainty assessment: ●●●●: low uncertainty; ○○○○: very high uncertainty

NL/table 2 assessment of dioxin emissions in The Netherlands until 2005 (annual emission in g I-TEQ/year)

References

1. Emission data for the Netherlands, Inspectorate for Environmental Protection, `s-Gravenhage, NL.
2. J. J. M. Berdowski, G. P. J. Draaijers, H. J.H.J., O. C.S.M., S. W.L.M. and S. J., Emissions to Air for The Inventories of Corinair, EMEP and Osparcom, Publication Series Emission Inventory No. 43, Inspectorate for Environmental Protection, 's-Gravenhage, NL (1998).
3. H. J. Bremmer, L. M. Troost, G. Kuipers, J. de Koning and A. A. Sein, Emissions of Dioxins in the Netherlands, 770 50 1018, 178 pp., National Institute of Public Health and Environmental Protection (RIVM) - Bilthoven, Netherlands Organization for Applied Scientific Research (TNO) - Apeldoorn (1994).
4. C. E. J. Cuijpers, H. J. Bremmer and N. B. L. Luijckx, Dioxins and PCBs in the Netherlands, *Dioxin '98*, Stockholm, *Organohalogen Compounds* **38**, pp. 59-64 (1998).

15. Portugal

First national information on the dioxin emission situation in Portugal could be obtained from a publication on occasion of the “dioxin ’98” conference [1]. Data were restricted to the Oporto region and thus did not cover the entire country. It was entirely based on emission factors; hence a large variance of emission estimates was given. The presented data indicated that the TNO values for 1990 most likely are incomplete; on the other hand the LUA estimate presented in the Stage I report is considerably higher, mainly due to the estimate calculated for hospital waste incineration and non-industrial sources (see P/Table 1).

Within Stage II a number of emission measurements at various plants were performed (see Vol. 2, chapter 13). As outlined there, the results show that the PCDD/F emissions from hospital waste incineration most probably have been overestimated. Thus for the revised 1995 inventory the previous emission estimate was divided by a factor of 50 and 10 to give the new lower and upper estimate, respectively.

With regard to other industrial sources changes also were made for secondary aluminium production, sec. copper production and non-ferrous metal foundries. Concerning the first of these metallurgical emission sources one aluminium production plant included in the measurement program revealed to be an important emission source releasing about 2 g I-TEQ/year if operated 8000 hours/year.

No production rate had been found for sec. copper production in Portugal when preparing the stage I report. As one plant of this industrial branch was measured within Stage II, at least the emissions of that plant must be introduced into the revised Inventory. The estimate for non-ferrous metal foundries was corrected on basis of the recently published emission inventory for he Oporto region.

Further, as outlined in the introductory comments (this volume), the emissions probably produced by accidental fires had to be reduced.

Effectively, the mean PCDD/F emissions in Portugal for 1995 are estimated to be about 30g less than in the previous Stage I report. The overall emissions are dominated by the estimates of non industrial sources which make up around 90 % of the annual emissions. This reflects on the one hand that Portugal is less industrialised than other European countries, on the other hand that a better knowledge on the industrial structure should be gathered.

Since the measurement results obtained in Stage II have been produced in winter 1999 and spring 2000 the emission estimates of the revised 1995 inventory are considered to be still valid for the year 2000 (see P/Table 2). The following probable future developments will certainly decrease the emissions from industrial sources:

- shut-down or upgrading of hospital waste incinerators with high emissions
- dedusting of the flue gas released from secondary aluminium smelter which has been investigated
- change of activity in the iron and steel sector

However, in view of the results of the measurement program it appears reasonable to assume that further industrial emission sources may be found which may make further revisions of the inventory necessary.

Portugal			ref. <3>		TNO <1>		LUA 1997 <2>	
SNAP		**ref.-year:**	**1997**	1)	**1990**		**1993-1995**	
01	**Power plants**	fossil fuels			2,4			
0202	**Res. combustion: Boilers, stoves, fireplaces**	wood			6,1		59,2	
0202	**Res. combustion: Boilers, stoves, fireplaces**	coal/lignite			0,0		0,0	
0301	**Combustion in Industry/boilers, gas turbines, stationary engines**		0,2		4,9		0,5	
30301	**Sinter plants**				1,8		4,0	
030308	**Secondary zinc production**						0,0	
030309	**Secondary copper production**						0,0	
030310	**Secondary aluminium production**						0,0	2)
30311	**Cement**						1,1	
030326	**Other: metal reclamation from cables**							
040207	**Electric furnace steel plant**				0,8		0,7	
040309	**Other: Non ferrous metal foundries**		4,6		0,1		0,1	
040309	**Other: sintering of special materials and drossing facilities**							
060406	**Preservation of wood**						9,9	
0701	**Road transport**		0,3				3,0	
090201	**Inc. of Dom. or municipal wastes**	legal combustion	0,2				0,0	
090201	**Inc. of Dom. or municipal wastes**	illegal (domestic) combustion					3,3	
090202	**Inc. of Industrial wastes**	hazardous waste					0,2	
090207	**Inc. of hospital wastes**		3,2-26,4				35,0	
090901	**Cremation: Inc. of Corpses**						0,4	
1201	**Fires**						9,8	
Total of sources considered above (g I-TEQ/year) *)			**8,5-31**		**16**		**127**	
Total of Inventory referred to (g I-TEQ/year)					17		127	
% of repective inventory covered by considered sources				b)	93%		100%	

1) this inventory was prepared for the OPORTO region only!

2) In the Stage I report erroneously not determined.

References:
<1> The European Atmospheric Emission Inventory of heavy metals and Persistent Orgenic Pollutants for 1990, TNO/UBA, Berlin, 1997
<2>U. Quaß, M. Fermann, G. Bröker: Identification of relevant industrial sources of dioxins and furans in Europe. LUA-Materialien No. 43 (1997), Landesumweltamt Nordrhein-Westfalen, Essen, Germany
<3> Coutinho, M.; Borrego, C.; Ferreira, C. Organohalogen Compounds, Stockholm 1998; 153-156

nd: not determined

ne: not existent

Remarks:

P/table 1 overview on emission inventory data (annual emission in g I-TEQ/year)

Portugal			*Revised for 1995*			*Actual data 2000*			*Projection 2005*			*Uncertainty Assessment*	*Future Trend*	*Comments*
SNAP			*min*	*prob*	*max*	*min*	*prob*	*max*	*min*	*prob*	*max*			
01	**Power plants**	fossil fuels		2,4			2,4			2,4		○○○○	⇔	value from TNO study; emissions included in 0301?
0202	**Res. combustion: Boilers, stoves, fireplaces**	wood		59,2			59,2			59,2		●○○○	⇔	
0202	**Res. combustion: Boilers, stoves, fireplaces**	coal/lignite	0,1		0,5	0,1		0,4	0,1		0,4	○○○○	↓	
0301	**Combustion in Industry/boilers, gas turbines, stationary engines**		0,2		0,5				0,2		0,5	●○○○	⇔	
30301	**Sinter plants**			4,0			3,8					●●○○	✂ ✂ ✂	slightly decreasing activity rates; plant scheduled for closure in 2001
030308	**Secondary zinc production**											●●●●		no process inoperation
030309	**Secondary copper production**		0,0		1,0	0,0		1,0	0,0		1,0	●○○○	⇔	at least one facility in operation in spite of lacking activity rates
030310	**Secondary aluminium production**		0,0		2,0	0,0		2,0	0,0		0,1	●●○○	↓	installation of dust filters assumed (see chapter on Portugeese sub-project)
30311	**Cement**			1,1			1,1			1,1		●●○○	⇔	
030326	**Other: metal reclamation from cables**											●○○○		no process inoperation?
040207	**Electric furnace steel plant**			0,7			1,0			1,3		●●●○	↑	increasing activity rates
040309	**Other: Non ferrous metal foundries**		0,1		4,6	0,1		4,6	0,1		4,6	●○○○	⇔	
040309	**Other: sintering of special materials and drossing facilities**													
060406	**Preservation of wood**			9,9			8,9			7,8		○○○○	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	**Road transport**			3,0			3,0			1,0		●●●○	↓	decrease of leaded fuel
090201	**Inc. of Dom. or municipal wastes**	legal combustion		0,0			0,0			0,5		●●●○	↑	building of new incineration plants announced
090201	**Inc. of Dom. or municipal wastes**	illegal (domestic) combustion		3,3			3,3			3,3		○○○○	⇔	
090202	**Inc. of Industrial wastes**	hazardous waste	4,0		30,0	4,0		30,0	4,0		30,0	○○○○	⇔	
090207	**Inc. of hospital wastes**		0,7		3,5	0,7		2,5		0,1		●○○○	↓	projection 2005: reduction of emission concentration to about 1 ng I-TEQ/m³ assumed
090901	**Cremation: Inc. of Corpses**			0,4			0,4			0,4		●●●○	⇔	
1201	**Fires**		0,5		9,8	0,5		9,8	0,5		9,8	○○○○	⇔	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)				**90 — 136**			**88 — 133**			**82 — 123**				
industrial sources				**17 — 54**			**17 — 52**			**13 — 45**				
non-industrial sources				**73 — 82**			**72 — 81**			**69 — 78**				

Uncertainty assessment: ●●●●: low uncertainty; ○○○○: very high uncertainty

P/table 2 assessment of dioxin emissions in Portugal until 2005 (annual emission in g I-TEQ/year)

References

1. M. Coutinho, C. Borrego and C. Ferreira, Atmospheric Emissions of PCDD/PCDF and Heavy Metals in the Oporto Urban Area, *Dioxin '98*, Stockholm, *Organohalogen Compounds* **36**, pp. 153-156 (1998).

16. Sweden

Swedish activities aiming at gathering data on dioxin and furan emissions already started in 1985 and are put together since the early 90s within the so-called “Swedish Dioxin Survey”.

For the LUA Stage I report a draft version of a report on this survey had been submitted; up to date this report has not been released in its final version and thus the draft still is the most recent source of information.

A first source inventory regarding PCDD/F emissions in Sweden was compiled for the year 1987 showing an estimated emission range of about 100 to 200 g N-TEQ/year. From the 1990 data presented in the survey draft it can be seen, that the annual emissions already appeared to be halved despite identification of additional sources. This development was mainly due to actions undertaken in the waste sector (closure and/or upgrading of incinerators) but in part also might result from measurement data which in turn led to reduced estimates (see S/Table 1).

The 1993 data of the Swedish survey were taken as basis for the LUA Stage I report; hence, the estimates widely are comparable except for domestic wood burning which was estimated much higher in the Stage I inventory due to the special approach applied therein (c.f. introductory comments, this volume).

While disregarding a number of sources already identified in the Swedish reports the TNO inventory mostly presents higher estimates than the corresponding Swedish values. This compilation thus appears to be largely based on the 1987 inventory made by the Swedish EPA.

For the revised 1995 inventory mainly the LUA Stage I estimates were taken with consideration of the reassessments presented in the introductory comments. In some cases data from the Swedish dioxin survey report have been used for the setting of the upper limit of estimation.

Except for the projections on electric arc steel production and wood preservation (c.f. introductory comments) all estimates were maintained for the year 2000. In the case of iron ore sintering the announced closure of the Swedish plant in 1995 was assumed to be realised. The resulting estimate for the industrial sources of 13 - 24 g I-TEQ/a is thus quite comparable to the estimate submitted by the Swedish EPA (23 - 30 g N-TEQ/year including 5 - 10 g N-TEQ/year for traffic emissions).

Taking into account that a very low level of industrial emissions has already been achieved in Sweden, only slight additional reductions may be anticipated for 2005 (see S/Table 2). Moreover, from recent trends a growing activity in the iron and steel industry (electric arc steel production) can be predicted. Non-industrial emissions on the other hand are likely to remain on the previous levels except for traffic which emissions are expected to decrease with decreasing use of leaded fuel and increasing fraction of modern vehicle technologies.

Sweden			EPA			Swedish dioxin survey							TNO <1>		LUA 1997 <2>
SNAP		ref.-year:	1987				1990			1993			1990		1993-1995
			lower	upper		min	prob	max	min	prob	max				
01	Power plants	fossil fuels	1	1			1			0,61			1		
0202	Res. combustion: Boilers, stoves, fireplaces	wood				3		14	2		9,8				48,4
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite													0,6
0301	Combustion in Industry/boilers, gas turbines, stationary engines					1,2		6,4	1,4		7,7	4)			0,48
30301	Sinter plants		16	50	1)	1,3		3,7	1,3		3,7		22,7		9,6
030308	Secondary zinc production		5	20	2)		4,3			4,9		5)			0,025
030309	Secondary copper production											6)			1,03
030310	Secondary aluminium production											6)			0,5
30311	Cement		5	10	3)		0,3			0,3			7,0		0,3
030326	Other: metal reclamation from cables														
040207	Electric furnace steel plant								0,4		15		5,3		2,45
040309	Other: Non ferrous metal foundries											7)			0
040309	Other: sintering of special materials and drossing facilities														
060406	Preservation of wood														8,7
0701	Road transport		5	15		0,17		3,2	0,22		1,4	8)	9,0		0,5
090201	Inc. of Dom. or municipal wastes	legal combustion	50	100			4,5			3			10,0		3
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion													4
090202	Inc. of Industrial wastes	hazardous waste	2	6			0,01			0,007					0,007
090207	Inc. of hospital wastes		10	10			0,01			0,01					0
090901	Cremation: Inc. of Corpses					0,34		0,68	0,37		0,73				0,5
1201	Fires					2,8		30	2,8		30	9)			8,7
Total of sources considered above (g I-TEQ/year) *)			94	212		**19**		**68**	**17**		**77**		**55**		**89**
Total of Inventory referred to (g I-TEQ/year)			98	218					21,6		88		84		88,8
% of repective inventory covered by considered sources			96%	97%					81%		88%	b)	66%	c)	100%

b) further important sources are
1. 030320 lime production with 10.3 - 24.3 and 2.5 - 4.35 g N-TEQ for 1990 and 1993 resp.
2. Maritime traffic with 0.1 to 7 g N-TEQ/a

c) TNO data include 10 g I-TEQ/a for Pb idustry, 4.5 g I-TEQ/a for paper and pulp prod. and 14 g I-TEQ/a for waste treatment not further described (may also be calculation error)

References:

<1> The European Atmospheric Emission Inventory of heavy metals and Persistent Orgenic Pollutants for 1990, TNO/UBA, Berlin, 1997

<2>U. Quaß, M. Fermann, G. Bröker: Identification of relevant industrial sources of dioxins and furans in Europe. LUA-Materialien No. 43 (1997), Landesumweltamt Nordrhein-Westfalen, Essen, Germany

Remarks:

1) entire iron and steel sector; 2) entire non-ferous metal sector, 3) cement and lime production; 4) only special fuels like wood, woodchips,peat and industrial wastes

5) refers to entire sector of secondary non-ferrous metal production; 6) included in 030308; 7) some facilities exist but no dara were reported

8) Besides, emissions from maritime and air traffic were estimated to be 0.1 to 7 and 0.03 to 0.9 g N-TEQ/a , respectively; 9) uncontrolled landfill fires

nd: not determined; ne: not existent

S/table 1 overview on emission inventory data (annual emission in g I-TEQ/year, except for N-TEQ used by EPA and in the Swedish dioxin survey))

Sweden			*Revised for 1995*			*Actual data 2000*			*Projection 2005*			*Uncertainty Assessment*	*Future Trend*	*Comments*
SNAP			min	prob.	max	min	prob.	max	min	prob.	max			
01	**Power plants**	fossil fuels	0,6		1,0	0,6		1,0	0,6		1,0	●●●❍	⇔	values from Swed. Dioxin survey/TNO study
0202	**Res. combustion: Boilers, stoves, fireplaces**	wood	2,1		48,4	2,1		48,4	2,1		48,8	●❍❍❍	↑	
0202	**Res. combustion: Boilers, stoves, fireplaces**	coal/lignite	1,5		6,9	1,4		6,2	1,2		5,6	❍❍❍❍	↓	max values: high emission factors found by Austrian EPA taken into account.
0301	**Combustion in Industry/boilers, gas turbines, stationary engines**		0,5		7,7	0,5		7,7		5,0		●●●❍	↑	
30301	**Sinter plants**		1,3		10,0	0,1		1,0	0,1		0,8	●●●❍	↓	
030308	**Secondary zinc production**		0,0		3,0	0,0		3,0		3,0		●●●●	↑	
030309	**Secondary copper production**			1,0			1,0			1,0		●●❍❍	⇔	
030310	**Secondary aluminium production**			0,5			0,5			0,5		●●❍❍	⇔	
30311	**Cement**			0,3			0,3			0,3		●●❍❍	⇔	
030326	**Other: metal reclamation from cables**			nd			nd			nd		❍❍❍❍		
040207	**Electric furnace steel plant**			2,5			2,8			3,2		●●●❍	↑	2000:111%; 2005: 126%
040309	**Other: Non ferrous metal foundries**			nd			nd			nd		●❍❍❍		
040309	**Other: sintering of special materials and drossing facilities**													
060406	**Preservation of wood**			8,7			7,8			6,9		❍❍❍❍	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	**Road transport**		0,2		1,4	0,2		1,4		0,1		●●●❍	↓	
090201	**Inc. of Dom. or municipal wastes**	legal combustion		3,0			3,0			2,0		●●●❍	↓	
090201	**Inc. of Dom. or municipal wastes**	illegal (domestic) combustion		4,0			4,0			4,0		❍❍❍❍	⇔	
090202	**Inc. of Industrial wastes**	hazardous waste		0,0			0,0			0,0			⇔	
090207	**Inc. of hospital wastes**			0,0			0,0			0,0		●❍❍❍	⇔	
090901	**Cremation: Inc. of Corpses**		0,4		0,7	0,4		0,7		0,5		●●●❍	↓	
1201	**Fires**		0,9		9,0	0,9		9,0	0,9		9,0	❍❍❍❍	⇔	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)			**28 — 108**			**26 — 98**			**31 — 92**					
industrial sources			**14 — 34**			**13 — 25**			**20 — 21**					
non-industrial sources			**13 — 74**			**12 — 73**			**11 — 70**					

Uncertainty assessment: ●●●●: low uncertainty; ❍❍❍❍: very high uncertainty

S/table 2 assessment of dioxin emissions in Sweden until 2005 (annual emission in g I-TEQ/year)

17. Finland

There are only scarce national data on dioxin emission sources; no updated information could be found compared to the estimates reviewed in the Stage I report. As the emission inventory prepared by UBA/TNO also appears to be quite incomplete and refers to the year 1990 the revised 1995 inventory was based on the compilation of the stage I report (see SF/Table 1).

Alterations of the estimates for 1995 are presumed for the emissions from sinter plants and electric steel production in view of activity trends (c.f. introductory comments, this volume). Further changes may occur regarding emissions from traffic and from msw incinerators due to technological developments (see SF/Table 2).

Increasing and decreasing partial emissions appear to compensate resulting in a virtually constant overall emission situation.

Finland			Ref <3> min	max		TNO <1>		LUA 1997 <2>	
SNAP		**ref.-year:**	**1990**			**1990**		**1993-1995**	
01	**Power plants**	fossil fuels	2,1	2,1	1	0,95			
0202	**Res. combustion: Boilers, stoves, fireplaces**	wood				18,1		28,1	
0202	**Res. combustion: Boilers, stoves, fireplaces**	coal/lignite				0,1		0,3	
0301	**Combustion in Industry/boilers, gas turbines, stationary engines**					15,4		0,28	
30301	**Sinter plants**					12,6		19,2	
030308	**Secondary zinc production**							0	
030309	**Secondary copper production**							1,25	
030310	**Secondary aluminium production**							0,6	
30311	**Cement**							0,17	
030326	**Other: metal reclamation from cables**								
040207	**Electric furnace steel plant**		4,0	6,0	2	1,0		0,7	
040309	**Other: Non ferrous metal foundries**		5,0	15,0	3			0	
040309	**Other: sintering of special materials and drossing facilities**								
060406	**Preservation of wood**							5,1	
0701	**Road transport**		1,3	10,2				0,5	
090201	**Inc. of Dom. or municipal wastes**	legal combustion	2,5	3,5	4	2,0		3	
090201	**Inc. of Dom. or municipal wastes**	illegal (domestic) combustion						3,1	
090202	**Inc. of Industrial wastes**	hazardous waste	0,2	0,2				0,88	
090207	**Inc. of hospital wastes**		2,0	5,0	5			0	
090901	**Cremation: Inc. of Corpses**							0,2	
1201	**Fires**							5,1	
Total of sources considered above (g I-TEQ/year) *)			**17**	**42**		**50**		**68**	
Total of Inventory referred to (g I-TEQ/year)			19	44		53		68,5	
% of repective inventory covered by considered sources			90%	95%		94%		100%	

References:	<1> The European Atmospheric Emission Inventory of heavy metals and Persistent Orgenic Pollutants for 1990, TNO/UBA, Berlin, 1997
	<2>U. Quaß, M. Fermann, G. Bröker: Identification of relevant industrial sources of dioxins and furans in Europe. LUA-Materialien No. 43 (1997), Landesumweltamt Nordrhein-Wes
	<3> Mroueh, U. M.: Emissions of hazardous air pollutants; VTT Chemical Laboratory, Espoo, Finland 1992; 1235-0605 VTT Research Notes
Remarks:	1 comprises SNAP 01-03 (energy productionfacilities > 1 MW power and estimates for oil and wood combustion); 2 entire iron and steel sector; 3 entire non-ferrous metal sector
	4 ref. Year 1988; one plant only; 5 ref. Year 1988; control and renewing of facilities since then
	nd: not determined; ne: not existent

SF/table 1 overview on emission inventory data (annual emission in g I-TEQ/year, except for N-TEQ used in ref. 3)

Finland			Revised for 1995			Actual data 2000			Projection 2005			Uncertainty Assessment	Future Trend	Comments
SNAP			min	prob	max	min	prob	max	min	prob	max			
01	Power plants	fossil fuels	1,0		2,1	1,0		2,1	1,0		2,1	●●●○	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	wood	18,1		28,1	18,1		28,1	18,1		28,1	●○○○	⇔	
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	0,8		3,5	0,7		3,1	0,6		2,8	○○○○	↓	
0301	Combustion in Industry/boilers, gas turbines, stationary engines			1,0			1,0			#####		●●●○	⇔	
30301	Sinter plants			19,2			29,8			38,6		●●●○	↑	increasing activity rates
030308	Secondary zinc production			0,0								●●●●		
030309	Secondary copper production			1,3			1,3			1,3		●●○○	⇔	
030310	Secondary aluminium production			0,6			0,6			0,6		●●○○	⇔	
30311	Cement			0,2			0,2			0,2		●●○○	⇔	
030326	Other: metal reclamation from cables			0,0								●●●○		
040207	Electric furnace steel plant			0,7			1,0			1,2		●●●○	↑	increasing activity rates
040309	Other: Non ferrous metal foundries											●●●○		
040309	Other: sintering of special materials and drossing facilities			0,0										
060406	Preservation of wood			5,1			4,6			4,0		○○○○	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	Road transport			0,5			0,3			0,2		●●●○	↓	decreasing use of leaded fuel
090201	Inc. of Dom. or municipal wastes	legal combustion		3,0			1,0			0,1		●●●○	↓	improvement of flue gas cleaning according to EU directive assumed
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion		3,1			3,1			3,1		○○○○	⇔	
090202	Inc. of Industrial wastes	hazardous waste		0,9			0,9			0,9			⇔	
090207	Inc. of hospital wastes			0,0			0,0			0,0		●○○○	⇔	
090901	Cremation: Inc. of Corpses			0,2			0,2			0,2		●●●○	⇔	
1201	Fires		0,5		5,0	0,5		5,0	0,5		5,0	○○○○	⇔	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)				56 — 74			64 — 82			72 — 89				
industrial sources				31 — 32			40 — 41			48 — 49				
non-industrial sources				25 — 42			24 — 41			23 — 40				

Uncertainty assessment: ●●●●: low uncertainty; ○○○○: very high uncertainty

SF/table 2 assessment of dioxin emissions in Finland until 2005 (annual emission in g I-TEQ/year)

18. United Kingdom

Among the first studies on PCDD/F emissions were publications concerning the situation in the UK. Estimates for three types of emission sources (msw and hazardous waste incineration and traffic) were given by Eduljee [1] on basis of Eadon-TEQ. More comprehensive, Harrad and Jones set up an emission inventory reporting emissions as total PCDD/F values now including clinical waste incineration, coal combustion and volatilisation from chlorinated aromatic compounds. In a ECETOC report of 1989 [2] emissions from a comparative list of sources were estimated as TEQs; however, these estimates were derived from total PCDD/F values using conversion factors which were not presented in detail. Thus, all these studies cannot easily be taken for a comparison with the more actual one published by DoE ([3], see UK/Table 1) and its follow-up.

The 1995 report published by DoE was taken as basis for the estimates presented in the LUA Stage I report [4]; as the UK report did not follow the CORINAIR source structure, for the national inventory chapter (Stage I report, Volume 2) a part of the aggregated data of the UK report had to be separated again. Further, in cases where the UK report used a range of emission factors the geometric mean value of the range boarder values was used for the LUA report. The resulting inventory estimates are given in the second column of UK/Table 1 (headed DoE/LUA).

The UK inventory as presented for the year 1995 has been updated for the year 1997 on basis of emission measurement results obtained in the meantime [5]. The new inventory is shown in the last column of UK/Table 1. Bold figures indicate changed estimates compared to the 1995 inventory. All other emission values were maintained. Regarding the source types “0202 domestic wood combustion” and “12 Fires” an increase of emissions is indicated; however, this is an artificial increase due to including estimates for domestic combustion of treated wood and accidental fires. Not shown in the table is an estimate for sewage sludge combustion which ranges from 0,001 to 0,37 g I-TEQ/year (estimate 1995: 0,7 - 6 g I-TEQ/year).

Further comment appears necessary regarding the emissions from the non-ferrous metal industry. Whilst in the 1995 inventory the emissions — without having any measurement results — were roughly estimated to be in the range from 5 to 35 g I-TEQ/year, the updated inventory refers to measurements at one site including a multi-melting furnace (10,6 and 32,6 ng I-TEQ/m³) and a foundry (8,9 and 7,5 ng I-TEQ/m³). These two sources alone were calculated to emit nearly 30 g I-TEQ/year; which value was taken for the inventory. The authors correctly comment that “If measured data from this one site was representative of the others, the metal recycling sector could contribute a significant amount to the national annual TEQ emission estimate”. Unfortunately no information is given on the number of other plants or the relative activity rate of the measured site compared to the total activity in that industrial branch. Nevertheless, it appears likely that other plants will also have considerable emissions and thus the annual emissions from the non-ferrous metal sector might be higher than given in the updated inventory. Therefore, in the revised inventory for 1995 (see UK/Table 2) the emission from the measured site has been taken as the lower limit and twice that value as the upper limit of the range of estimation.

Regarding the other sectors which new measurement results are reported for it may be assumed that similar emissions were — at least partly — already valid for 1995 and the respective estimates given in the 1995 inventory should be corrected. This has been taken into account for the revised inventory shown in UK/Table 2. However, the adaptation of the emission estimate of 81 g I-TEQ for accidental fires which had been evaluated for Germany (c.f. introductory comments, chapter III-1.2) appears to be inadequate in view of the considerably lower capita number in the UK.

Putting together all changes and adjustments, the revised inventory for 1995 results in an overall emission estimate ranging from about 250 to 750 g I-TEQ/year. Regarding the actual (year 2000) and future developments already mentioned in the UK reports an publications are taken into account which presumably will lead to further emission reduction. Like in other countries the non-industrial emissions currently might contribute more than 50% of the total emissions (in case for industrial sources the minimum estimates are more realistic than the pessimistic values). In the future this relationship between non-industrial and industrial sources is likely to be enhanced.

United Kingdom			**ref <4>**		**DoE <3>**		**TNO <1>**		**LUA 1997 <2>**		**ref <4>**	
SNAP		**ref.-year:**	**1994**		**1995**	6	**1990**		**1993-1995**		**1997**	7
01	**Power plants**	fossil fuels	5-67	1	10,7		24,1				5-67	
0202	**Res. combustion: Boilers, stoves, fireplaces**	wood	2-18		6,6		8,9		12,4		3-23	
0202	**Res. combustion: Boilers, stoves, fireplaces**	coal/lignite			25,5		29,6		10,5		20-34	
0301	**Combustion in Industry/boilers, gas turbines, stationary engines**		6,7-17,2	2	13,5		31,8		3,2		6,7-17,2	
30301	**Sinter plants**		29-54		39,5		38,2		136		25-30 (4)	
030308	**Secondary zinc production**								2,4			
030309	**Secondary copper production**								5,75			
030310	**Secondary aluminium production**								5,5			
30311	**Cement**		0,2-11		1,4		8,1		1,71		0,29-10,4 (5)	
030326	**Other: metal reclamation from cables**											
040207	**Electric furnace steel plant**		3-41	3	10,9		24,1		10,9		3-41	
040309	**Other: Non ferrous metal foundries**		5-35	4	13,2		22,3		0,2		29,8(1)	
040309	**Other: sintering of special materials and drossing facilities**											
060406	**Preservation of wood**		0,8		0,3		0,4		58		08	
0701	**Road transport**		1-45		4,3		25,5		21,5		1-45	
090201	**Inc. of Dom. or municipal wastes**	legal combustion	460-580		515,0		643,0		515,7		122-199 (14)	
090201	**Inc. of Dom. or municipal wastes**	illegal (domestic) combustion							37			
090202	**Inc. of Industrial wastes**	hazardous waste	1,5-8,7		3,6				3,6		0,02-8,7 (10)	
090207	**Inc. of hospital wastes**		18-88		39,4				39,4		0,99-18,3 (5)	
090901	**Cremation: Inc. of Corpses**		1-35		6,1		18,6		6,1		1-35	
1201	**Fires**		0,4-12	5	2,2				57,8		10,4-93	
Total of sources considered above (g I-TEQ/year) *)			**554-1047**		**692**		**875**		**928**		**214-654**	
Total of Inventory referred to (g I-TEQ/year)			560-1100		715		881		928		219-663	
%of repective inventory covered by considered sources			95%		97%	b)	99%		100%		99%	

nd: not determined; ne: not existent

References:	<1> The European Atmospheric Emission Inventory of heavy metals and Persistent Orgenic Pollutants for 1990, TNO/UBA, Berlin, 1997
	<2>U. Quaß, M. Fermann, G. Bröker: Identification of relevant industrial sources of dioxins and furans in Europe. LUA-Materialien No. 43 (1997), Landesumweltamt Nordrhein-Westfalen, Essen, Germany
	<3> HMIP/DoE: A Review of Dioxin Emissions in the UK; 1995 (arranged to fit into structure by LUA)
	<4> Eduljee, G.H.; Dyke, P. (1996) An updated inventory of potential PCDD and PCDF emission sources in the UK.
Remarks:	1) reflects coal combustion as a whole; 2) includes straw, tyres and landfill gas combustion; 3) varius processes in iron and steel industry; 4) various processes in non-ferrous metal production; 5) only forest fires considered 6) typical values given here as presented in the national part (volume 2) of the LUA stage I report; 7) numbers in brackets indicate numbers of emission measurements

UK/table 1 overview on emission inventory data (annual emission in g I-TEQ/year)

United Kingdom			*Revised for 1995*			*Actual data 2000*			*Projection 2005*			*Uncertainty Assessment*	*Future Trend*	*Comments*
SNAP			*min*	*prob*	*max*	*min*	*prob*	*max*	*min*	*prob*	*max*			
01	**Power plants**	fossil fuels	5,0		67,0	5,0		20,0	5,0		20,0	●●○○	↓	range given for 1995 appears too large in view of other countries experiences
0202	**fireplaces**	wood	3,0		23,0	3,0		23,0	3,0		23,0	○○○○	⇔	
0202	**fireplaces**	coal/lignite	26,3		120,8	23,6		108,7	21,3		97,8	○○○○	↓	
0301	**turbines, stationary engines**		6,7		17,2	6,7		17,2	6,7		17,2	●○○○	⇔	
30301	**Sinter plants**		25,0		30,0	28,8		34,5	32,0		38,4	●●●●	↑	actualemissions are comparatively low; hence no further abatement measures expected. Trend due to increasing activity rates
030308	**Secondary zinc production**													
030309	**Secondary copper production**													
030310	**Secondary aluminium production**													
30311	**Cement**		0,3		10,0	0,3		10,4	0,3		10,0	●●●○	⇔	
030326	**cables**													
040207	**Electric furnace steel plant**		3,0		41,0	2,3		32,0	1,6		22,1	●○○○	↓	decreasing activity rates
040309	**Other: Non ferrous metal foundries**		30,0		60,0	30,0		60,0	30,0		60,0	●○○○	⇔	might be underestimated
040309	**Other: sintering of special materials and drossing facilities**													
060406	**Preservation of wood**		0,8		58,0	0,8		52,0	0,8		45,9	○○○○	↓	maximum value likely to be overestimated; decrease dur to depletion of reservoir (see introductory comments)
0701	**Road transport**		1,0		45,0	1,0		10,0	1,0		5,0	●●○○	↓	steady decrease of leaded fuel assumed
090201	**Inc. of Dom. or municipal wastes**	legal combustion	122,0		199,0	100,0		150,0	50,0		100,0	●●●○	↓	further abatement measures likely;projected value might be over-estimated
090201	**Inc. of Dom. or municipal wastes**	illegal (domestic) combustion		37,0			37,0			37,0		○○○○	⇔	
090202	**Inc. of Industrial wastes**	hazardous waste	0,0		8,7	0,0		8,7	1,0		4,0	●●○○	↓	
090207	**Inc. of hospital wastes**		1,0		18,0	1,0		18,0	1,0		10,0	●●○○	↓	closure or upgraing of plants ongoing
090901	**Cremation: Inc. of Corpses**		1,0		35,0	1,0		10,0	1,0		10,0	●●○○	↓	closure of old crematoria ongoing
1201	**Fires**		2,9		57,8	2,9		57,8	2,9		57,8	○○○○	⇔	maximum value likely to be overestimated
Total of sources considered (g I-TEQ/year)			**265 — 827**			**243 — 649**			**195 — 558**					
industrial sources			**231 — 523**			**212 — 398**			**166 — 329**					
non-industrial sources			**34 — 305**			**31 — 252**			**29 — 230**					

Uncertainty assessment: ●●●●: low uncertainty; ○○○○: very high uncertainty

UK/table 2 assessment of dioxin emissions in the UK until 2005 (annual emission in g I-TEQ/year)

References

1. G. Eduljee, Dioxins in the Environment, Chem Britain 24, 1223-1226 (1988).
2. Exposure of man to dioxins: A pespective on industrial waste incineration, Technical Report no. 49, 91 pp., European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC) (1992).
3. A Review of Dioxin Emissions in the UK, DOE/HMIP/RR/95/004, 113 pp., Her Majesty's Inspectorate on Pollution (1995).
4. U. Quaß, M. Fermann and G. Bröker, Identification of Relevant Industrial Sources of Dioxins and Furans in Europe, LUA Materialien Nr. 43, 936 pp., Landesumweltamt NRW (1997).
5. R. E. Alcock, R. Gemmill and K. C. Jones, Improvements to the UK PCDD/F and PCB Atmospheric Emission Inventory Following an Emissions Measurement Programme, Chemosphere 38, 759-770 (1999).

19. Development of European PCDD/F emissions to ambient air 1985-2005

19.1. Background and Approach

In its 5th Action Program the European Community laid down the aim to reduce PCDD/F emissions by 90% when comparing the emissions in 1985 to the emissions of the year 2005.

The following part of the Stage II report has been prepared to produce an assessment on the current state of this process emission reduction.

The assessment presented here is restricted to emissions to air because this pathway has been of major importance for the background exposure to chlorinated dioxins and furans throughout the whole period, data on the emissions to other pathways is often scarce and even if available associated with much higher uncertainties than in the case of emissions to air.

To evaluate the overall changes of dioxin emissions to ambient air a multi-step procedure is followed which includes

a) for each country considered in the Stage I report (see previous chapters)

- a revision of the 1995 inventory of emissions to air from the sources identified as relevant in Stage I by introducing additionally available information (e.g. new measurement data, plant related information, updated national inventories)
- the assessment of actual emissions on basis of the revised 1995 inventory
- a forecast of probable emissions in the year 2005 based on e.g. activity trends, already announced technological changes in the different industrial and non industrial sectors and upcoming national or EU wide legislation

b) for all considered countries as a whole

- summation of the sector-related minimum and maximum emission estimates for the years 1995, 2000 and 2005
- approaching upper emission estimates for the reference year 1985
- evaluation of the relative changes of PCDD/F emissions comparing the emission estimates for 1985 and 2005.

Part b) of this process is presented in the following.

19.2. Results

19.2.1. 1995 revised inventory

Total emissions of PCDD/F (in g I-TEQ/year) to ambient air for the 17 countries considered and for the years 1995, 2000, and 2005 are shown in table 1. Compared to the inventory presented in the Stage I report the revised 1995 inventory reveals considerable differences. A methodological alteration is that in the Stage I report for each source type a definite emission estimate was presented; contrarily, in order to provide an indicator on still existing uncertainties the revised 1995 inventory is presented with minimum and maximum estimates.

While for most of the emission source categories the maximum estimates increased compared to the corresponding Stage I inventory value, some considerable overestimation made in the Stage I inventory has become apparent with regard to iron ore sintering, municipal solid waste incineration and hospital waste incineration. On the other hand, a remarkable increase of the emission estimate had to be introduced for secondary zinc production. Further, domestic coal combustion had to be reconsidered and the overall emission estimate for this source again was enlarged. Both, reductions and increases of estimated emissions in the revised 1995 inventory are mainly due to increased knowledge gained from emission measurements which had been carried out within the Stage II project or by independent ongoing national inventory programs, respectively.

However, increases and decreases due to the sector related changes more or less compensate for each other and thus the overall 1995 PCDD/F emission estimate ranging from 3.703 to 6.491 g I-TEQ/a for the considered European countries fits fairly well to the Stage I fixed value of 5.728 g I-TEQ/year.

19.2.2. Inventories for 2000 and 2005

Based on the revised 1995 inventory and with regard to current trends and available information on future developments which probably affect the emission situation the inventories for the years 2000 and 2005 were established. According to these estimates a general reduction of PCDD/F emissions to air is expected to take place which might led to more than 50% lower emissions by 2005 compared to 1995. Most of the emission reduction is primarily anticipated with respect to the industrial sources while the emissions from non-industrial sources will remain nearly constant. Therefore it appears likely for the near future that the emissions from industrial process will be equalised — if not exceeded — by non-industrial emissions from spatial distributed and hardly to control emission sources. However, it should again be emphasised that the emission estimates for the non-industrial sectors to a large part are more uncertain than the estimates for the most industrial sectors.

19.2.3. Inventory for the year 1985 based on upper emission estimates

With respect to the goal laid down in he 5th EU action program the estimated emissions of the years 2005 and 1985 are to be compared. Clearly, since a number of abatement measures went into realisation meanwhile the PCDD/F emissions to ambient air in Europe were much higher in 1985 than the actual emissions are. However, to give a reliable quantitative estimate for the 1985 emissions is much more difficult than for the time after 1990. This is due to following aspects:

- Availability of related national studies

There is only a limited number of publications which present aggregated estimates for the pre-1990 period. Only the Belgian and the Swiss national dioxin inventory comprise emission estimates for the year 1985; all other inventory documents refer to 1990 or later. Compared to the 1995 emission data for both countries higher emissions are reported for 1985. However, while in Switzerland a steady decrease is assumed from 1985 to 1995, in the Belgian inventory emissions peaked in 1990. From the compilation presented in volume 3 chapters 3 and 4 the ratio of 1985 emissions to 1995 emissions is 1,3 and 2,4 for Belgium and Switzerland, respectively. Clearly, the development of PCDD/F emissions is subject to considerable variation from country to country and cannot easily be assessed by an European-wide approach.

- The state of analytical methods for PCDD/F determination

Around 1985, information data on PCDD/PCDF in environmental samples generally was reported without congener specific data. The analysis of dioxin and furan isomers had first been published in 1984 [1] and this method still suffered from limited availability of suited chromatographic phases. Thus, there is a lack of analytical information hindering from a direct comparison of emission levels with the TEQ related data reported since ca. 1990.

The other principle way to go, to compare homologue data of the more recent results with the early 1985 data is also difficult since in most emission inventory reports and related publication only aggregated emission values given in TEQ units are shown. Hence a consultation and evaluation of a large number of measurement reports from several European countries would be necessary. In view of the uncertainties which are introduced by other parameters (like activity data, number of emission sources, representativeness of measured installations) such effort appeared not justifiable.

- The limited knowledge on emission sources already established by 1985

In 1985, the Seveso incident just was 9 years ago and PCDD/F in fly ash from municipal waste incineration had been found only 8 years before. Therefore, during this less than one decade period the main emphasis of research has been put on the investigation of PCDD/F sources in the chemical industries and on the mechanisms of dioxin formation in municipal solid waste incinerators.

The formation and releases of dioxins and furans from chemical processes mainly addressed contamination of products (pentachlorophenol, organic dyes, pesticides) and to releases by residual materials from production processes (sludge, effluent water). An example was the pulp and paper production which was in discussion because dioxins had been shown to be formed in the bleaching processes using elementary chlorine. A quantification of PCDD/F releases to the environment through these processes is hardly to made, since for the most products which are likely to be contaminated the marketed amounts cannot be determined accurately. Moreover, production processes in sometimes were changed rapidly to reduce the danger of further contamination.

With respect to PCDD/F emission to ambient air the waste incineration was the best known sector at that time. However, most emission data published referred to municipal solid waste incineration; considerably less information can be found for hazardous waste incineration and for hospital waste burning [2]. These and some further processes like waste oil combustion [3], sewage sludge incineration and cable reclamation [4] were investigated. Based on the results obtained in this early stage of research in some countries (like Germany, the Netherlands, Austria, Sweden) immediate actions were undertaken to reduce PCDD/F emissions. From a historical point of view it appears worth to mention that already in September 1985 the North Rhine-Westphalia ministry of environment set emission limit values of 0,1 ng 2,3,7,8-TCDD and 1 ng 2,3,7,8 TCDF per m³ for waste oil combustion facilities. Emission measurements at different waste oil combustion facilities using waste oil which was slightly contaminated by PCBs (1,5 to 62 ppm, authorised limit was 1.000 ppm) showed that the PCDD/F emission limits were exceeded frequently [3].

The same experience was made with hospital waste incinerators and cable reclamation installations; consequently, within a short period most of the facilities were shut down. Thus, only few measurement results and almost no statistics about the number of installations or their activity rates in 1985 are available today.

For Germany, PCDD/F concentrations in flue gases from municipal solid waste incinerators was estimated retrospectively to cover a range from 10 - 50 ng I-TEQ/m³ [5]. Up to 100 ng I-TEQ/m³ have been recalculated for flue gases of cable burning facilities [5].

As a conclusion, any emission estimate derived for the year 1985 must be recognised as being associated with considerable higher uncertainty than the estimates published for the post 1990 period. However, in the following an attempt will be made to obtain an upper estimate of the European PCDD/F emissions to air in order to answer the question whether a 90% reduction until the year 2005 would be possible at all.

19.2.3.1. SNAP 0101 — Coal-fired power plants

As outlined in the introductory comments (c.f. volume 3, chapter 1) this source category has been additionally introduced into the list of potentially relevant PCDD/F sources because some indications exist that in some countries the emission factors might be considerably higher than those applied in the Stage I report. For the year 1985 this can be particularly true since upgrading the power plants with de-sulphurisation and $DeNO_x$-installations was not completed throughout Europe at that time. These technologies are known to reduce PCDD/F emissions to some degree through enhanced dust reduction and catalytic PCDD/F destruction, respectively.

Hence to obtain an upper estimate for the emissions of PCDD/F the 1985 coal consumption rates of power plants (190.354 kt excluding Values for Norway and Switzerland) were multiplied by an emission factor of 3,5 µg I-TEQ/ton. This factor is a ten-fold of the upper emission factor which has been used in several 1995 emission inventories (NL, UK, S). The overall upper estimate for the PCDD/F emission thus amounts to 666 g I-TEQ/a.

19.2.3.2. SNAP 0202 — Domestic solid fuel combustion

19.2.3.2.1. Wood combustion:

In the Stage I report domestic combustion (mainly for heating purposes) has been identified as a considerable emission source. This appeared mainly to be due to wood combustion which occurs on a large scale in several European countries (Scandinavia, France, Austria, Southern Germany). However, while burning clean, dry wood does not lead to high emissions, co-combustion of polluted wood materials (like PVC coated wastes from furniture or in the worst case wooden materials being treated with PCP) has been found to increase the emission factors by orders of magnitude.

The extent of these practices can only be estimated roughly and has been done in the Stage I report on basis of an approach which was first used in the Dutch inventory report. This approach assigned different emission factors and different percentages of consumption to the 3 types of wood fuels. As wood consumption rates were not available for all countries missing values had roughly been calculated by specific consumption rates per capita.

Overall, this approach is associated with considerable uncertainty and the 1995 emission, which is dominated by the small fraction of PCP-treated wood assumed to be combusted, might have been overestimated. Regarding the 1985 emission estimate, on the other hand, it appears reasonable to assume that PCP contaminated wood was used to a higher extent since in most countries the stop of production and use of this agent had become legally binding only short time before. Taking this into account the upper value of 1995 emission estimate which in the revised inventory presented in this report ranges from 544 to 989 g I-TEQ/year may be considered as the best available estimate also for 1985.

19.2.3.2.2. Coal combustion

As outlined in detail in the introductory chapter of this volume there has been gathered new information recently which makes it necessary to reconsider the relevance of domestic coal combustion. Accordingly the 1995 emission estimate which was assessed to be about 40 g I-TEQ/year in the Stage I report had to be increased significantly. The revised 1995 inventory thus gives a range of 92 to 408 g I-TEQ/year.

As in the case of domestic wood combustion there still is uncertainty since the extent of coal combustion cannot be described completely due to the lack of statistics which are sufficiently de-aggregated and detailed. The very first approach which reaches these demands was published recently in a report of the German Umweltbundesamt [6]; together with a corresponding research report [7] a detailed emission inventory for domestic burning (reference year 1994) is provided which besides the main atmospheric pollutants also covers PCDD/F emissions. Unfortunately the emission factors used in these reports do not include the recent findings for hard coal burning in small single room heating stoves; hence the emission estimate given in these reports are likely to be an underestimation.

Compared to 1985 (EU 15: ~ 17.800 kt) the consumption of coal for domestic burning has nearly halved by 1995 (EU 15: ~ 9.200 kt) [8]. The statistical documents do not provide information whether this development was equally distributed with regard to central heating and single room heating. As the emission factors differ considerably for these types of coal combustion (see introductory comments, chapter 1.2.4 of this volume) this information would be needed to calculate the 1985 emission value more exactly.

With the data available and further assuming a constant fuel mix (different sorts of European and overseas coal types are used in different amounts) the upper estimate of 1985 emissions is hence calculated to be approximately twice the value of the 1995 maximum estimate, i.e. 900 g I-TEQ.

19.2.3.3. SNAP 0301 — Industrial solid fuel combustion

Regarding coal consumption the same emission factor (3,5 µg I-TEQ/ton) as applied in the case of power plants is assumed to have been valid for industrial coal combustion plants. With an EU 15 activity rate of 33.780 kt combusted hard coal in 1985 the annual PCDD/F emission is estimated to ca. 118 g I-TEQ/year.

Concerning industrial wood combustion in the Stage I report the emissions were calculated on an average per-capita emission derived from the emission estimates that were available for some of the considered countries. The specific per capita emission was assessed to range from 0,02 to 0,32 µg I-TEQ/capita with a mean value of 0,055 µg I-TEQ/capita. As no statistical data could be found which may allow for a more reliable estimation the upper bound PCDD/F emission for the year 1985 is estimated here by application of the largest reported per capita value. Hence the upper bound emissions for 1985 are roughly estimated to have been 6 times higher than the value of 20,9 g I-.TEQ/a derived for 1995 in the Stage I report, thus yielding 120 g I-TEQ/a.

19.2.3.4. SNAP 030301 — Iron ore sinter plants

As described in the introductory comments the usual flue gas concentration range currently found to date at iron ore sintering plants is 0,5 to 3 ng I-TEQ/m³. This corresponds to emission factors of ca. 1 to 7,5 µg I-TEQ/ton sinter. Nevertheless, even in recent measurement programs some plants with higher emissions (up to 20 ng I-TEQ/m³ = 40 to 50 µg I-TEQ/ton) have been found (c.f. Volume 2, Chapter 3).

The most remarkable result ever found at an European sinter plant was a flue gas concentration of more than 40 ng I-TEQ/m^3 [9] from which an annual emission of more than 240 g I-TEQ/year could be calculated.

However, although the reasons for these exceptionally high emissions still have not been clarified it would certainly be unrealistic to use these high values for establishing an upper 1985 emission estimate. On the other hand, it should be taken into account that in that period considerable amounts of PCBs were still in use which also may have entered the sintering process through the input of residual materials from steel production. Further, as it has been done in the Stage I report, fugitive emissions and emissions from the sinter cooler, crushing and sieving processes should be regarded.

Therefore, for an upper estimate of emissions from this source it is assumed that the average emission factor was 50% higher than the factor used for the 1995 estimate. Using this factor of 15 µg I-TEQ/ton and the 1985 sinter production of ca. 110 million tons the annual PCDD/F emission is estimated to 1650 g I-TEQ/year.

19.2.3.5. SNAP 030308 — Secondary zinc production

The emissions of dioxins and furans from secondary zinc production facilities have been shown to be mainly due to plants which recover zinc from filter dusts of steel scrap processing plants. Two plants located in Germany and France, respectively, have been measured and were identified as highly relevant sources. The annual emissions of these installations could might been up to ca. 45 and 200 g I-TEQ/year.

However, strongly fluctuating PCDD/F concentrations in the flue gases indicated that these figures might have been an overestimation. Despite this, there are considerable hints that further plants of similar type are operated in other European countries (e.g. in Spain, probably also in Italy). It is not possible to make any unequivocal statement about the emissions of these plants since neither their number nor their activity rates are known. Moreover, it might be possible that the other plants use different processes which have a much lower dioxin formation potential.

Nevertheless, for an upper estimate it is assumed here that in Europe in 1985 there were at least 3 plants in operation each emitting 150 g I-TEQ/a thus giving a total upper emission estimate of 450 g I-TEQ/a. for this sector. According to available measurement results all other processes for secondary zinc production generate much less dioxins and furans and can be neglected for the time period of interest.

19.2.3.6. SNAP 030309 — Secondary copper production

According to statistical data the production of copper from scrap recovery was 572 kt in 1985 [10]. This was little more than one third of the production reported for 1992 which had been used in the Stage I report (1490 kt/a). Hence a strong increase of the activity rate of this industrial sector can be stated. However, these figures include the direct use of high quality scrap for direct production of semis and other products. Without this direct scrap recovery the activity rates reduce to ca. 570 and 720 kt/a for 1985 and 1995, respectively.

According to information of the German copper industry [11] direct use of copper scrap does not appear to have a considerable dioxin emission potential. Hence the emission estimate presented in the Stage I report might have been a 2-fold overestimation.

However, the emission factor of 50 µg I-TEQ/t used in Stage I was based on a very poor data pool. Accordingly a high uncertainty was assigned to this sector. Recent emission measurements performed in the France inventory program suggest that the emission factors are lower. Nevertheless, on a European wide scale this cannot be stated with certainty. Since an upper estimate is required for 1985, the Stage I emission factor is maintained here and applied to the rates of secondary production of refined copper. Thus an emission estimate of 28,5 g I-TEQ/year is obtained.

19.2.3.7. SNAP 030310 — Secondary aluminium production

From statistical information [10] a production of 1356 kt is revealed for 1985 which is ca. 400 kt less than in 1992.

The emission factors used in Stage I ranged from 5-100 µg TEQ/t; a typical value of 22 µg I-TEQ/t was used for the estimation. Since it is not likely that abatement measures already took place in 1985 and because at this time chlorinated hydrocarbons (hexachloroethane) might have been used more widely, for the year 1985 the emission factor is assumed to be about twice the value mentioned before: 50 µg I-TEQ/t.

Therefrom a total emission of 65 g I-TEQ/a is assessed as the upper PCDD/F emission from secondary aluminium production.

19.2.3.8. SNAP 030311 — Cement

Using the production rate of 137.655 kt Cement which is reported for the year 1986 [12] and the emission factor derived in the Stage I (0,15 µg I-TEQ/t) the annual emission is calculated to 21 g I-TEQ/a.

19.2.3.9. SNAP 030326 — Other: metal reclamation from cables

Cable burning was (and probably still is in some countries) a common practice to recover the metal content of electromotors and electric wires. It had been done either by just putting fire to a heap of material placed on open field or within special furnaces which were equipped with flue gas cleaning devices (washers, dust filters) [4]. Severe soil contamination was the result of open field cable reclamation. It is reasonable to assume that this practice has also caused considerable emissions to air.

Emission measurements at furnaces used for cable reclamation belong to the first measurements made at installations of the metal industries [4]. Elevated PCDD/F emissions were found; the results are available only in form of homologue sums and thus no definite I-TEQ value can be given. A worst case consideration assuming that the result obtained for a homologue sum is entirely caused by the corresponding single 2,3,7,8-congener which a TEF value is set for results in a upper flue gas concentration of 290 ng I-TEQ/m³ (at 11% O_2). This value fits well to measurements carried out later in the Netherlands which revealed PCDD/F concentrations of up to 254 ng I-TEQ/m³ [13]. This result corresponds to an emission factor of ca. 500 µg I-TEQ/ton; the Swiss Federal Environmental Agency used an emission factor of 2340 µg I-TEQ/ton for their national emission estimate of 14,2 g I-TEQ in 1985 [14].

Activity data for cable reclamation in the European countries are not available. However, from the Swiss data the activity rate for Switzerland can be recalculated to have been about 6000 tons in 1985. Which information this estimate is based on is not known but it must be regarded as considerably uncertain. For the Netherlands a quite similar activity of ca. 4000 tons/year processed cables and motors was reported [13]; these figures can be transformed to per-capita values of 0,84 and 0,26 kg scrap/capita.

The larger of these values is taken here as upper estimate which can be transferred to the other European countries regarding the capita ratios. With ca. 380 million people living in the 17 countries considered, the upper estimate for cable reclamation activity can be assessed to have been ca. 320 kt in 1985. Consequently, the upper annual PCDD/F emission using the Swiss emission factor would have been ca. 750 g I-TEQ/year.

19.2.3.10. SNAP 040207 — Electric furnace steel plant

Activity data for the production of steel using electric arc furnaces could be obtained only for some of the countries of interest excluding Sweden, Finland and Austria. For the other 14 countries the production was 37276 kt in 1987. This is considerably less than the production in 1995 (summed up for the same 14 countries) which was 51337 kt (+ 37%). For A, S and SF additionally 3010 kt are reported for the year 1995. Hence the 1985 production rate in these countries can be estimated to 2186 kt assuming the same trend as observed for the other 14 countries. Overall, the 1985 activity rate used for the following emission estimation is calculated to be 39.462 kt.

Regarding the emission factors it might be reasonably assumed that in 1985 the flue gas cleaning was worse and that more installations used scrap preheating devices which have been shown to increase dioxin emissions. Therefore an emission factor of 3 µg I-TEQ/t is used here which is 3 times higher than the typical factor used in Stage I but still falling into the range if factors presented in the Stage I report (0,3 to 5,7 µg I-TEQ/t).

The annual emission in 1985 thus might have been 120 g I-TEQ/a.

19.2.3.11. SNAP 040309 — Other: Non ferrous metal foundries

According to statistical data of the non-ferrous metal industry the production of die castings in 1985 was about 3.300 kt. However, this value might be somehow underestimated because for some countries die castings and semis are reported together; as semis usually make up the larger part, these values were not included in the production rate mentioned before.

In the Stage I report a production rate of 2.590 kt was extracted from the metal statistics for the year 1993; estimates for countries not listed or for those reporting only semis/casting aggregated values were approached by a per capita consideration finally revealing ca. 3.043 kt overall production. Due to this approach also this production rate might be somehow underestimated. Nevertheless, it appears reasonable to assume that the activity rates of die casting in the non ferrous metal industry did not change significantly from 1985 to 1995.

A large variability of emission factors was revealed from the few measurement data available when the Stage I report was prepared. In Stage I a “typical” emission factor of 1 µg I-TEQ/t was used for the estimation yielding an overall emission of 3 g I-TEQ/year; however, the revision of the 1995 inventory presented here takes the considerable uncertainty into account by using a min/max range instead of one typical emission estimate. Moreover, emission estimates reported in the national inventories and other documents are considered. Accordingly (see table 1) the emissions in 1995 are now assessed to range from 36 to 78 g I-TEQ/year. Comparing this estimate with the Stage I assessment it can be concluded that the emission factor might have been underestimated considerably. Therefore, for the upper estimate requested for the year 1985 an emission factor of 15 µg I-TEQ/year is applied.

With this emission factor the above mentioned production rate the 1985 PCDD/F emission is calculated to be about 50 g I-TEQ/year.

19.2.3.12. SNAP 040309 — Other: sintering of special materials and drossing facilities

This sector refers to a special processes in the non ferrous metal industry which makes use of residual materials produced in the main non-ferrous metal recovery processes. In particular one sintering plant located in Germany which agglomerates various iron and non-ferrous metal containing materials purchased from the European market for further metal recovery had been identified to be considerable dioxin emitter. This plant is said to be the only one operated in Europe; its PCDD/F emissions were assessed in the Stage I report to be about 115 g I-TEQ/year. Since no measurement data from earlier periods are known this emission level is assumed to be a realistic estimate also for 1985.

Furthermore, there was another German facility processing a broad spectrum of materials (syringe needles, electro motors, silver coated materials, working place dusts etc.) which was found to have high PCDD/F concentrations in the flue gas (up to 83 ng I-TEQ/m³). No emission freight was published; assuming 5000 m³/h flue gas flow rate and continuous operation the annual PCDD/F release might be up to 3,6 g I-TEQ/year. In order to set up an upper estimate for emissions released by similar installations in Europe it is assumed here that there were 20 similar installations in operation in Europe which caused emissions of ca. 80 g I-TEQ/year.

Hence the overall 1985 upper estimate for this sector is assessed to be in the order of 200 g I-TEQ/year.

19.2.3.13. SNAP 060406 — Preservation of wood

Around 1980, agents for wood preservation, in particular if containing Pentachlorophenol or its salts, were found to be highly contaminated with dioxins and furans. Such wood preservatives have been used widely for treatment of wooden constructions to be used outside and frequently also for indoor application. PCDD/F contained in these preservatives may slowly volatise from the contaminated material and can be found in airborne dust by indoor air pollution measurements. The hourly emission rate per square meter of wood treated with lindane and PCP was determined to 0,8 - 14,2 ng I-TEQ/m^{2}h [15].

The only emission inventory taking into account this source type was the Dutch dioxin report [13]. For the Netherlands an annual emission of about 25 g I-TEQ/a was estimated. In the Stage I report for the 17 European countries a range of 145-388 g I-TEQ/ a was derived based on this Dutch figure and using capita relationships. Since this value is highly uncertain due to lack of further relevant data and might have been considerably overestimated by the per-capita approach, it is assumed here that an emission of ca. 390 g I-TEQ/a may also serve as the upper emission estimate for 1985.

19.2.3.14. SNAP 0701 — Road transport

Dioxin emissions from internal combustion and diesel engines have been frequently in the focus of research during the last two decades (c.f. Vol. 2, chapter 6d). Meanwhile there appears to be sufficient evidence that diesel engines are not of considerable relevance. Contrarily, it has been shown that cars operated with leaded fuel may emit PCDD/F which are at least formed from chlorinated additives serving as scavengers. According to statistics on fuel production ca. 116,000 kt gasoline (incl. aviation fuel) was produced in Europe; it is assumed here that the major part of this production was sold and consumed on the European market. Further, the entire amount shall be treated as if being leaded (certainly an overestimate); using the emission factor of 2200 ng I-TEQ/ton an upper emission estimate

254 g I-TEQ/year is revealed which is slightly increased by some 8 g I-TEQ/year stemming from diesel fuel combustion **(**Activity rate158,000 kt (production); emission factor 43 ng I-TEQ/t);

19.2.3.15. SNAP 090201 — Incineration of Domestic or municipal wastes

According to the TNO report on waste incineration in Europe [16] most of the msw incinerators listed for in 1993 already were in operation in 1985. Only a few facilities had been shut down, newly build or upgraded within this period. Thus it can be assumed that the overall waste throughput was the same as in 1993, namely ca. 43,000 kt

Regarding the PCDD/F emissions TNO assumed a raw gas concentration of 15 ng I-TEQ/m³; in case of dedusting only this concentration was said to be maintained in the clean gas while for scrubber technologies an abatement efficiency of 50% was taken into account.

Since from emission measurements made in the recent years it became obvious that there are a number of plants with considerable higher emissions for the upper emission estimate to be made for 1985 it might be assumed that the 15 ng I-TEQ/m³ was valid for all plants regardless of their abatement technology. This is corresponding to an emission factor of ca. 90 µg I-TEQ/ton waste.

The total emission from waste incineration in 1985 thus can be estimated to about 4,000 g I-TEQ/a.

19.2.3.16. SNAP 090201 — Incineration of Domestic or municipal wastes (illegal)

In the Stage I report an emission of 174 g I-TEQ/year was roughly estimated for the year 1995 based on German and Swiss emission factors and the assumption that 0,25 % of the annual waste production is combusted illegally. Since even today no better data are available for the activity rates and emission factors used still appear to be possible ([17] it is assumed here that the 1995 estimate may represent the right order of magnitude. Thus for 1985 an overall upper-bound emission estimate of 200 g I-TEQ/year is assumed.

19.2.3.17. SNAP 090202 — Incineration of Industrial wastes

As already outlined in the Stage report no complete data base concerning the amount of wastes treated in Europe could be found for the years of interest. From the data available an annual throughput of ca. 4,300 kt/year industrial and hazardous wastes was derived. With respect to the 1985 situation there are indications (c.f. Stage I report, Vol. 2, chapter Belgium and Switzerland) that the activity rates were lower than in the mid 90s. As no exact statistics appear to exist it is assumed that the overall amount of industrial waste incinerated in Europe have been about 3000 kt/year.

Emission factors ranging from well below 1 µg I-TEQ/ton up to more than 300 µg I-TEQ/ton could be found in the literature (c.f. Stage I report). For 1995 the emissions were calculated using a factor of 20 µg I-TEQ/ton. Those countries also presenting data for the pre-1995 period (B, CH, NL) generally state that the emission factors decreased from 1985 to 1995. For example, the Dutch dioxin survey considerable success to reduce the emissions from one of the largest incinerators is reported reducing the countries annual PCDD/F emissions from 16 to 2 g I-TEQ/year. Taking this trend into account and in order to obtain an upper emission estimate the emission factor for 1985 is set here to 100 µg I-TEQ/ton.

Hence, with the activity rate mentioned before an annual emission of 300 g I-TEQ/year is obtained.

19.2.3.18. SNAP 090207 — Incineration of hospital wastes

This sector has been subject of significant changes in the decade between 1985 and 1995. In the late 80s flue gases of small incinerators operated at the hospital’s location were identified to have very high PCDD/F concentrations (up to several hundred ng I-TEQ/m³). Consequently in a number of countries (D, NL, A, S) these facilities were closed within a short period and hospital waste incineration shifted to industrial incinerators or to larger facilities which could be upgraded with dioxin absorbing flue gas cleaning devices. However, as the measurements carried out in the Stage II project reveal still an unknown, but considerable number of small on-site incinerators are in operation in several countries.

No data could be found on the number or on the total capacities of the incinerators that existed in 1985. In a paper on emission measurements at waste incinerators in Germany mentions 26 hospital waste incinerators which were investigated in the German State Baden-Württemberg [2].

A French information source [http://www.multimania.com/ca1998/LAGESTIONWEBDESDECHETSHOSPITALIERS.htm] claims that in 1991 54% of 2676 health care institutions had their own in-situ combustion facility; 58 % of these facility were aged more than ten years, 2/% more than 27 years. This number indicates that in 1985 there might have been about some 100 installations in Germany and some 1,000-2,000 facilities in Europe.

In spite of the high flue gas concentrations frequently found the annual PCDD/F release of these small installations are quite small due to their intermittent operation and low overall waste throughput. On the average, annual PCDD/F emissions of 1 g I-TEQ per year and per facility appears to be a reasonable assumption. Hence, the 1985 overall emissions from these facilities might have been between 1,000 and 2,000 g I-TEQ/year. For the upper estimate to be set up here, the value of 2000 g I-TEQ/year is taken.

19.2.3.19. SNAP 090901 — Cremation: Incineration of Corpses

Generally spoken, during the last 15 years cremation has experienced increasing attraction in a number of European countries. However, the fraction of cremation differs largely from country to country. For 1985 it is assumed here that 20% of all burials have been a cremation. The number of deaths in 1985 can be obtained from statistics and was 3,4 million based on data collected for 1985 – 1988 (without A, N, S, SF) [12]. Thus the number of cremation is estimated to about 700.000.

Emission reduction at crematories only took place recently and therefore the emission factors found in the early 90s may assumed to be applicable also for 1985. The emission factors chosen in the Stage I report ranged from 3 to 40 µg I-TEQ/body; to obtain an upper estimate the highest value is used here.

The overall PCDD/F emission from cremation therefore is estimated to 28 g I-TEQ/year.

19.2.3.20. SNAP 1201 — Fires

As outlined in the introductory chapter to this volume the estimation of PCDD/F emissions from accidental fires is difficult and can be done only on a very small data base. It appears reasonable to assume that the emission factors may not have changed from 1985 until today as there are only limited possibilities to influence the PCDD/F formation during fires (whether a reduction of PVC used in buildings and for cable insulation could be an appropriate measure in this direction still is a matter of discussion).

Exact data on the number and extent of fires are difficult to obtain. Again, there appears no fist-sight reason why the number of fires should have decreased or increased considerably. For instance, as the number of cars has increased an increase of car fires could be possible; on the other hand also safety of operation was enhanced thus lowering the likelihood for accidents.

Hence, it is assumed here that the PCDD/F emissions from accidental fires remained almost constant throughout the period of interest; thus the upper estimate given in the 1995 revised inventory of 382 g I-TEQ/year is chosen as upper estimate for 1985, too.

19.3. Evaluation

In table 1 the 1985 upper emission estimates are compiled and shown in comparison to the emissions which are forecasted for the year 2005. Minimum and maximum emission reduction or emission increases are calculated using the min/max emission estimates for 2005. The trend observed is also displayed graphically by down/up arrows.

According this evaluation there appear to be some emission sources which might achieve a 90% reduction until the year 2005. In particular this applies to municipal solid waste combustion, but also hospital waste incineration, secondary zinc production, power plants and cable burning are indicated to have drastically reduced emissions.

However, it should again be stressed that this evaluation is based on an upper emission estimate for 1985. Thus the probability that the actual emissions in 1985 were not as high as the estimate presented here is higher than the likelihood for emissions exceeding this upper estimate. Therefore all the reduction percentages given in table 2 are likely to be overestimated.

Taking this into account the result that the overall PCDD/F emission reduction probably will not reach the 90% aim as set in the 5th action program is underlined. This view is supported further by time trends of PCDD/F ambient air concentrations, depositions [18] [19], human milk [20] and blood contamination [21] which in general show reductions between 30 and 70% over the past decade. However, the decline of dioxin concentrations in these matrices appears to slow down; this might be due to singular events of feed-stuff contamination which have occurred in the recent years (e.g. the case of citrus pellets from Brazil) but could also reflect that emission reduction has reached a point where additional successes are more difficult to obtain.

Nevertheless, with the industrial sources nearly reaching 90% reduction in comparison to the upper bound 1985 emission estimate a satisfying success of reduction strategies regarding emissions to ambient air can be stated. Exceptions of this general development appear to be the sector of electric arc furnace steel plants (where the effect of abatement measures is exceeded by a significant increase of activity rates) and some further sources with indifferent time trend or low reduction assessment (cement production, non-ferrous metal foundries, domestic wood combustion, illegal waste burning).

Compared to the industrial sources far less reductions have been achieved and probable will be achievable concerning emissions from non-industrial processes. There are only limited possibilities to influence emissions from accidental fires and environmental misbehaviour as in the case of illegal waste combustion. Significant emission reduction in the near future is only to expect for domestic coal combustion if the trend observed during the recent decades will continue.

Development of European PCDD/F emissions to ambient air 1985-2005

Annual emissions (g I-TEQ/year) SNAP			*Revised for 1995*			*Actual data 2000*			*Projection 2005*			*Change 1995 2000*	*Change 1995 2005*
			min	*prob.*	*max*	*min*	*prob.*	*max*	*min*	*prob.*	*max*		
01	**Power plants**	**fossil fuels**	59		122	55		72	50		67	-30%	-35%
0202	**Res. combustion: Boilers, stoves, fireplaces**	**wood**	544		989	532		971	523		969	-2%	-3%
0202	**Res. combustion: Boilers, stoves, fireplaces**	**coal/lignite**	92		408	86		370	82		337	-9%	-16%
0301	**Combustion in Industry/boilers, gas turbines, stationary engines**		32		83	34		81	39		78	0%	**2%**
030301	**Sinter plants**		671		864	447		554	383		467	-35%	-45%
030308	**Secondary zinc production**		242		245	22		25	20		20	-90%	-92%
030309	**Secondary copper production**		31		33	15		17	15		17	-50%	-50%
030310	***Secondary aluminium production***		41		82	27		72	21		60	-20%	-34%
30311	**Cement**		14		50	13		49	14		50	-2%	0%
030326	**Other: metal reclamation from cables**		42		52	40		50	40		50	-3%	-3%
040207	**Electric furnace steel plant**		115		162	120		153	141		172	-1%	**13%**
040309	**Other: Non ferrous metal foundries**		36		78	40		74	38		72	0%	-4%
040309	**Other: sintering of special materials and drossing facilities**		145		145	31		31	31		31	-79%	-79%
060406	**Preservation of wood**		145		388	131		349	118		310	-10%	-20%
0701	**Road transport**		57		138	37		82	41		60	-39%	-48%
090201	**Inc. of Dom. or municipal wastes**	legal combustion	973		1213	412		506	178		232	-58%	-81%
090201	**Inc. of Dom. or municipal wastes**	illegal (domestic) combustion	129		221	126		200	116		187	-7%	-13%
090202	**Inc. of Industrial wastes**	hazardous waste	149		183	131		166	16		45	-10%	-81%
090207	**Inc. of hospital wastes**		133		530	96		392	51		161	-27%	-68%
090901	**Cremation: Inc. of Corpses**		11		46	9		19	13		22	-51%	-40%
1201	***Fires***		54		382	60		371	60		371	-1%	-1%
Total of sources considered			**3715 — 6415**			**2465 — 4605**			**1989 — 3779**			-30%	-43%
industrial sources			**2823 — 4110**			**1619 — 2461**			**1165 — 1731**			-41%	-58%
non-industrial sources			**892 — 2305**			**846 — 2144**			**824 — 2048**			-6%	-10%

table 1 PCDD/F emission estimates (in I-TEQ/year) for the years 1995, 2000 and 2005 as revealed from the country-related evaluations

Development of European PCDD/F emissions to ambient air 1985-2005

Annual emissions (g I-TEQ/year) SNAP			1985 upper estimate	2005 min	max	Increases % max	min	Trend	90% reduction likely?
01	Power plants	fossil fuels	666	50	67	-92	-90	↓↓↓↓	YES
0202	Res. combustion: Boilers, stoves, fireplaces	wood	989	523	969	-47	-2	↓	NO
0202	Res. combustion: Boilers, stoves, fireplaces	coal/lignite	900	82	337	-91	-63	↓↓↓	NO
0301	Combustion in Industry/boilers, gas turbines, stationary engines		238	39	78	-84	-67	↓↓↓	NO
030301	Sinter plants		1650	383	467	-77	-72	↓↓↓	NO
030308	Secondary zinc production		450	20	20	-96	-96	↓↓↓↓	YES
030309	Secondary copper production		29	15	17	-49	-40	↓↓	NO
030310	*Secondary aluminium production*		65	21	60	-68	-7	↓↓	NO
30311	Cement		21	14	50	-32	**+137**	⇔	NO
030326	Other: metal reclamation from cables		750	40	50	-95	-93	↓↓↓↓	YES
040207	Electric furnace steel plant		120	141	172	**+17**	**+43**	↑	NO
040309	Other: Non ferrous metal foundries		50	38	72	-25	**+44**	⇔	NO
040309	Other: sintering of special materials and drossing facilities *)		200	31	31	-85	-85	↓↓↓	NO
060406	Preservation of wood		390	118	310	-70	-20	↓↓	NO
0701	Road transport		262	41	60	-84	-77	↓↓↓	NO
090201	Inc. of Dom. or municipal wastes	legal combustion	4000	178	232	-96	-94	↓↓↓↓	YES
090201	Inc. of Dom. or municipal wastes	illegal (domestic) combustion	200	116	187	-42	-6	↓	NO
090202	Inc. of Industrial wastes	hazardous waste	300	16	45	-95	-85	↓↓↓	NO
090207	Inc. of hospital wastes		2000	51	161	-97	-92	↓↓↓↓	YES
090901	Cremation: Inc. of Corpses		28	13	22	-55	-23	↓↓	NO
1201	*Fires*		382	60	371	-84	-3	↓↓	NO
Total of sources considered			13690	1989	3779	-85	-72	↓↓↓	NO
industrial sources			10539	1037	1522	-90	-86	↓↓↓	NO
non-industrial sources			3151	952	2257	-70	-28	↓↓	NO

*) emission 2005 for sintering plant 1 g I-TEQ/a, for unknown number of drossing facilities 30 g I-TEQ/a assumed

table 2 1985 upper emission estimate compared to 2005 emission forecast (both in I-TEQ/a) and evaluation of PCDD/F emission reduction trends for the most relevant sources of PCDD/F
reduction: ↓↓↓↓ >90%; ↓↓↓ 60-90%; ↓↓ 30-60%; ↓ 0-30%;
"⇔":min/max reduction with opposite trend; „↑": min/max both indicating increases of emission

References

1. H. R. Buser and C. Rappe, Isomer-specific Separation of 2,3,7,8-substituted Polychlorinated Dibenzo-p-dioxins by High Resolution Gas Chromatography/Mass Spectrometry, *Anal. Chem.* **56**, 442 (1984).

2. H. Hagenmaier, H. Brunner and M. Kraft, Emissionsmessungen von polychlorierten Dibenzodioxinen und Dibenzofuranen an Abfallverbrenungsanlagen, *Aktuelle Probleme der Luftreinhaltung Teil I -Peudokrupp; Teil II Dioxine/Furane*, Arolsen, 9./10.12.1985. *VDI Schriftenreihe* **2**, pp. 199-224. VDI-Verlag Düsseldorf (1986).

3. G. Bröker and H. Gliwa, Dioxin- und Furanemissionen bei der Verbrennung von Altöl, *Staub, Reinhaltung der Luft* **46**, 435-438 (1986).

4. G. Bröker and B. Schilling, Emission polychlorierter Dibenzodioxine und Dibenzofurane aus Kabelabbrennanlagen, *Jahresbericht der Landesanstalt für Immissionsschutz NRW* , 17-20 (1986).

5. H. Fiedler, K. Fricke and H. Vogtmann, Bedeutung polychlorierter Dibenzo-p-dioxine und polychlorierter Dibenzofurane in der Abfallwirtschaft(.Organohalogen Compounds *17*, Ecoinforma Press, Bayreuth (1994).

6. F. Pfeiffer, M. Struschka and G. Baumbach, Ermittlung der mittleren Emissionsfaktoren zur darstellung der Emissionsentwicklung aus feuerungsanlagen im Bereich Haushalte und Kleinverbraucher, UBA-FB 295 46 364, p. ca. 400. Universität Stuttgart, Institut für Verfahrenstechnik und Dampfkesselwesen, Stuttgart (2000).

7. P. Blank, B. Wickert, A. Obermeier and R. Friedrich, Erstellung eines Emissionskatasters für Feuerungsanlagen in Haushalt und Kleinverbrauch, FB 104 02 830, Universität Stuttgart, Stuttgart (1999).

8. Statistik der Energiewirtschaft 1994/95. ; VIK Verband der Industriellen Energie- und Kraftwirtschaft e. V., Ed.; Verlag Energieberatung GmbH: Essen, 1995, pp 195.

9. G. Bröker, P. Bruckmann, K. J. Geueke, E. Hiester, V. Hoffmann, L. Radermacher and H. Gliwa, Abschlußbericht der Projektgruppe "Dioxinmeßprogramm Nordrhein-Westfalen", LUA Materialien 30 (available in English language), Landesumweltamt Nordrhein-Westfalen (1995).

10. Metal Statistics. ; Metallgesellschaft, Ed.: Frankfurt/M, 1993, pp 508.

11. C. Meyer-Wulf, Dioxinemissionen bei der Kupfergewinnung und Maßnahmen zu ihrer Minderung, *VDI Kolloqium Dioxine - Vorkommen, Minderungsmaßnahmen, Meßtechnik,* Fulda, 29/30.10.1996. *VDI-Berichte* **1298**, pp. 319-336. VDI-Verlag, Düsseldorf (1996).

12. Statistisches Jahrbuch für das Ausland(, Bundesamt für Statistik, (1990).

13. H. J. Bremmer, L. M. Troost, G. Kuipers, J. de Koning and A. A. Sein, Emissions of Dioxins in the Netherlands, 770 50 1018, 178 pp., National Institute of Public Health and Environmental Protection (RIVM) - Bilthoven, Netherlands Organization for Applied Scientific Research (TNO) - Apeldoorn (1994).

14. Handbuch Emissionsfaktoren für stationäre Quellen -Ausgabe 1995, 341 pp., Bundesamt für Umwelt, Wald und Landschaft (BUWAL), econcept, Zürich (1995).

15. W. Rotard, Sekundäre Dioxinquellen, *Dioxin-Informationsveranstaltung,* Bayreuth, 11.-13.11.1991. *Organohalogen Compounds* **6**, pp. 242-273. ECo-Informa press (1991).

16. I. L. P. M. Rijpkema, The Impact of a Change in EC Legislation on the Combustion of Municipal Solid Waste, 93-312, 95 pp., TNO, Apeldoorn, NL (1993).

17. B. K. Gullett, P. M. Lemieux, C. K. Winterrowd and D. L. Winters, PCDD/F Emisssions from Uncontrolled, Domestic Waste Burning, *Dioxin 2000*, Monterey, CA, 13.-17.08. *Organohalogen Compounds* **46**, pp. 193-196. University of california, Davis, CA (2000).

18. G. Knetsch, A. Basler and M. Büchen, The German Dioxin Database Application in Trend Monitoring of Polychlorinated Dibenzo-p-dioxins and furans in the environment, *Dioxin 2000,* Monterey, CA, *Organohalogen Compounds* **46**, pp. 31-34 (2000).

19. D. Cleverly, The historical evidence of the human contribution to dioxin-like compounds present in the environment, *Dioxin 2000,* Monterey, CA, *Organohalogen Compounds* **46**, pp. 27-30 (2000).

20. P. Fürst, PCDD/s/PCDFs in human milk - still a matter of concern?, *Dioxin 2000,* Monterey, CA, *Organohalogen Compounds* **46**, pp. 111-114 (2000).

21. O. Päpke, Lessons learned on performing more than 15,000 dioxin analyses, *Dioxin 2000,* Monterey, CA, *Organohalogen Compounds* **46**, pp. 115-118 (2000).

Glossary and list of abbreviations for Volumes 1-3

µg	**m**icro**g**ram (10^{-6} g)
2,3,7,8-TCDD	2,3,7,8-**T**etra**c**hlorodibenzo-**p**ara-**d**ioxin (“Seveso dioxin”)
a	Annum
Ahh	**A**ryl **h**ydrocarbon **h**yroxylase, enzyme used in bioassays as an indicator for Ah-receptor activity
Airfine	Emission abatement system for iron ore sintering plants sold by the company Voest-Alpine, Austria
Alicyclic compounds	Chemical compounds with a cyclic structure build only from carbon atoms
Aroclor®	Trade name of technical mixtures of polychlorinated biphenyls
CO	Carbon monoxide
CO_2	Carbon dioxide
CYP1A1	Specific cytochrome P 450 enzyme, induced by dioxin-like compounds through affection of the Ah receptor
CYP1A2	Specific cytochrome P 450 enzyme, induced by dioxin-like compounds through affection of the Ah receptor
d	**D**ay
d.s.	**d**ry **s**ubstance
DNA	**D**esoxyribo**n**ucleic **a**cid
Dibenzofurans	Class of chemical compounds; often used as a short form for polychlorinated dibenzofurans
Dibenzo-p-dioxins	Class of chemical compounds; often used as a short form for polychlorinated dibenzo-p-dioxins
EC	**E**uropean **C**ommunity
EDC	**E**thylene**dic**hloride (1,2-Dichloroethane)
EPA	**E**nvironmental **P**rotection **A**gency
EROD	7-**e**thoxy**r**esorufin-**O**-**d**iethylase, enzyme used in bioassays as an indicator for Ah-receptor activity
ESP	**E**lectro**s**tatic **P**recipitator
Eurostat	Statistical office of the European Community
fg	**f**emto**g**ram (10^{-15} g)
HCW	**H**ealth **Care** **W**aste
Heterocyclic compounds	Chemical compounds with a cyclic structure build from carbon atoms and at least one other element
HWI	**H**azardous **w**aste **i**ncineration
I-TEF	**I**nternational **T**oxic **E**quivalence **F**actor according to the NATO/CCMS list
I-TEQ	**I**nternational **T**oxic **E**quivalent; unit based on the I-TEFs and used to express the toxicity of a mixture of PCDDs and PCDFs compared to the so-called Seveso dioxin
Keramsit	Product from natural zeolithes; used e.g. for water filtration
kg	**K**ilo**g**ram
L.D.	**L**ethal **d**ose
mg	**M**illi**g**ram (10^{-3} g)
Mpa	**M**ega **Pa**scal, pressure unit, (10^{6} Pascal)
MSW or msw	**M**unicipal **S**olid **W**aste
n. d.	“not detectable”; “no data”, “not determined”

NATO/CCMS	**N**orth **A**tlantic **T**reaty **O**rganisation/**C**ommission for **C**hallenges of **M**odern **S**ociety
Ng	**n**ano**g**ram (10^{-9} g)
Nm³	Normalised cubic meter, volume of a gas at 1013 hPa and 0° Celsius
NOAEL	**N**on **o**bservable **a**dverse **e**ffect **l**evel
N-TEQ	**N**ordic **T**oxic **Eq**uivalent, commonly used in Scandinavian countries to express the toxicity of a mixture of PCDDs and PCDFs compared to the so-called Seveso dioxin
PCDD	**P**oly**c**hlorinated **d**ibenzo-para-**d**ioxins
PCDD/F	PCDD and PCDF
PCDF	**P**oly**c**hlorinated **d**ibenzo**f**urans
PCDT	**P**oly**c**hlorinated **d**ibenzothiophene (sulphur analogue compound of PCDF)
PCP	**P**enta**c**hloro**p**henol
PCTA	**P**oly**c**hlorinated thianthrene (sulphur analogue compound of PCDD)
pg	**P**ico**g**ram (10^{-12} g)
POPs	**P**ersistant **o**rganic **p**ollutant**s**, group of different chemicals known to accumulate in the environment; include PCDDs and PCDFs
PVC	**P**oly**v**inyl**c**hloride
Seveso dioxin	2,3,7,8 – tetrachlorodibenzo-p-dioxin
SNAP	**S**elected **N**omenclature for **A**ir **P**ollution
SO_2	Sulfur dioxide
Sorbalit®	class of adsorbents based on lime and activated coal components
TEF	**T**oxic **E**quivalence **F**actor, in general
TEQ	**T**oxic **Eq**uivalent, in general
Thianthrene	Heterocyclic compound with structure similar to the alicyclic anthracene but with 2 sulphur atoms bridging the outer carbon rings
Thiophene	Sulphur analogue compound of furan
throughburner	Operation principle of solid fuel heating stoves; flue gases generated from the burning layer at the bottom of the fuel load flow through the fuel load before entering the chimney
Underburner	Operation principle of solid fuel heating stoves; flue gases generated from the burning layer at the bottom of the fuel load are drawn away and do not flow through the fuel load before entering the chimney
Vol.	Volume
WHO	**W**orld **H**ealth **O**rganisation