IMPROVED INVENTORY FOR HEAVY METAL EMISSIONS FROM STATIONARY COMBUSTION PLANTS

1990-2009

Scientific Report from DCE – Danish Centre for Environment and Energy No. 68 2013

AARHUS UNIVERSITY
DCE – DANISH CENTRE FOR ENVIRONMENT AND ENERGY

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Data sheet

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Abstract: On behalf of the Ministry of the Environment DCE at Aarhus University annually reports heavy metals (HM) emissions to the UNECE CLRTAP (United Nations Economic Commission for Europe Convention on Long-Range Transboundary Air Pollution). This report presents updated heavy metal emission factors for stationary combustion plants and the corresponding improved emission inventories for the following HMs: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Nickel (Ni), Lead (Pb), Selenium (Se) and Zinc (Zn). The report presents data for the year 2009 and time series for 1990-2009. The report also include methodology, references and an uncertainty estimate. In Denmark, stationary combustion plants are among the most important emission sources for heavy metals. Emissions of all heavy metals have decreased considerably (73 % - 92 %) since 1990. The main HM emission sources are coal combustion, waste incineration, residual oil combustion and in 2009 also combustion of biomass. The emission from waste incineration plants has decreased profoundly also in recent years due to installation and improved performance of flue gas cleaning devices. The emission from power plants have also decreased considerably.

Keywords: Emission, combustion, heavy metal, HM, emission factor, stationary combustion, power plants, CHP, incineration, MSW, coal, emission inventory, As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn

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List of Abbreviations

AMS	Automatic Monitoring System
BAT	Best Available Technique
CHP	Combined Heat and Power
CLRTAP	Convention on Long-Range Transboundary Air Pollution
DEA	Danish Energy Agency
DEPA	Danish Environmental Protection Agency
EEA	European Environment Agency
EMEP	European Monitoring and Evaluation Programme
ESP	Electrostatic Precipitator
HM	Heavy Metal
IEF	Implied Emission Factor
TSP	Total Suspended Particulates
UNECE	United Nations Economic Commission for Europe
As	Arsenic
Cd	Cadmium
Cr	Chromium
Cu	Copper
Hg	Mercury
Ni	Nickel
Pb	Lead
Se	Selenium
Zn	Zinc

Preface

DCE (Danish Centre for Environment and Energy), Aarhus University is contracted by the Ministry of the Environment and the Ministry of Climate, Energy and Building to complete emission inventories for Denmark. Department of Environmental Science, Aarhus University is responsible for calculation and reporting of the Danish national emission inventory to EU and the UNFCCC (United Nations Framework Convention on Climate Change) and UNECE CLRTAP (Convention on Long Range Transboundary Air Pollution) conventions.

This report updates and improves the inventory for heavy metal emissions from stationary combustion plants. The work focuses on improvement of the emission factors and documentation, whereas plant specific emission data and fuel consumption data have not been recalculated.

Summary

On behalf of the Ministry of the Environment DCE at Aarhus University annually reports Heavy Metal (HM) emissions to the UNECE CLRTAP (United Nations Economic Commission for Europe Convention on Long-Range Transboundary Air Pollution). This report presents new heavy metal emission factors for stationary combustion plants and the corresponding improved emission inventories for the following HMs: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Nickel (Ni), Lead (Pb), Selenium (Se) and Zinc (Zn). The report presents data for the year 2009 and time series for 1990-2009.

Emission level

In 2009, the total fuel consumption for stationary combustion plants was 521 PJ of which 411 PJ was fossil fuels and 110 PJ was biomass. Coal and natural gas was the most utilised fuels for stationary combustion plants in 2009.

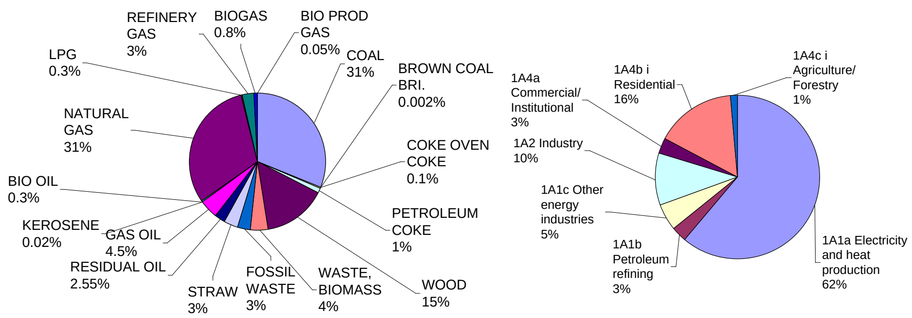


Figure s.1 Fuel consumption of stationary combustion 2009, disaggregated to fuel type and source category, respectively.

In Denmark, stationary combustion plants are among the most important emission sources for heavy metals. For Cu, Zn and Pb the emission share from stationary combustion plants is below 50 %, but for all other heavy metals, the emission share is above 50 %.

Table s.1 presents the Danish heavy metal emission inventory 2009 for the stationary combustion subcategories. The source categories *Public electricity and heat production, Residential* and *Industry* have the highest emission shares.

Table s.1 Heavy metal emission from stationary combustion plants, 2009[1].

	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	kg	kg	kg	kg	kg	kg	kg	kg	kg
1A1a Public electricity and heat production	89	31	197	157	236	929	351	880	493
1A1b Petroleum refining	31	23	24	46	22	285	67	106	96
1A1c Other energy industries	3	0	0	0	3	0	0	0	0
1A2 Industry	80	27	110	94	126	1312	644	261	1077
1A4a Commercial/Institutional	3	0	4	4	3	15	4	1	14
1A4b Residential	23	38	79	295	20	85	1455	19	3734
1A4c Agriculture/Forestry/Fisheries	11	5	25	41	12	249	242	36	520
Total	239	124	438	636	421	2875	2762	1304	5934
Emission share from stationary combustion, %	80	65	58	1	82	59	26	92	16

[1] Only emission from stationary combustion plants in the source categories is included.

Time series 1990 - 2009

Emissions of all heavy metals have decreased considerably (73 % - 92 %) since 1990. Time series are shown in Figure s.2.

The main HM emission sources are coal combustion, waste incineration, residual oil combustion and in 2009 also combustion of biomass.

Waste incineration plants was formerly a major emission source accounting for more than 50 % of Cd, Cr, Cu, Hg, Pb and Zn emissions in 1990. However, the emission share for waste incineration plants has decreased profoundly also in recent years due to installation and improved performance of gas cleaning devices in waste incineration plants. The emission share was below 15 % for all HMs in 2009. The improved flue gas cleaning is a result of lower emission limits for waste incineration plants (DEPA 2003). The emission of Hg has also been reduced as a result of installation of dioxin cleaning devices in all plants.

Combustion of coal was a large emission source for all HMs in 1990. The emission has decreased due to improved flue gas cleaning and also as a result of decreased consumption. However, coal combustion is still a major emission source for Hg and Se, and a considerable emission source for other HMs.

Residual oil combustion accounted for more than 80 % of the Ni emission in 2009 and was also the major emission source in 1990.

As a result of both the decrease of HM emissions from other sources and the increased wood consumption the emission of HMs from wood combustion has become one of the major emission sources for Cd, Cr, Cu, Pb and Zn in 2009.

The report includes time series for each source category.

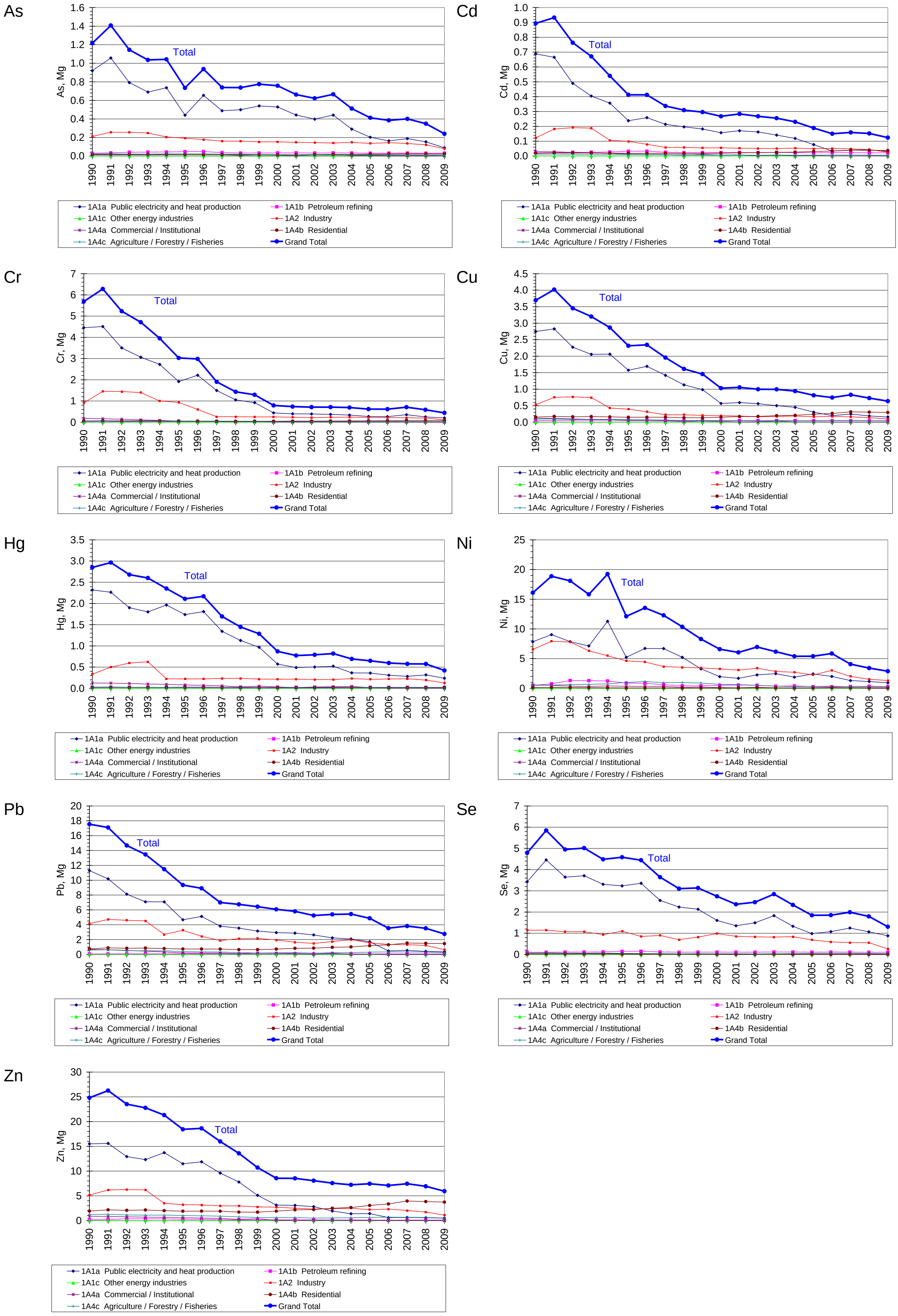


Figure s.2 Heavy metal emission time series, stationary combustion plants.

Methodology

The emission inventory for stationary combustion is based on activity rates from the Danish energy statistics.

Some large plants, such as power plants, waste incineration plants and large industries, are registered individually as large point sources and plant-specific emission data are used. Plant specific emission data for waste incineration plants are based on one or two annual emission measurements.

For large power plants, the annual emission data are based on the trace element emission model EMOK[1]. This HM flow data model includes separate models for fugitive and solid HM emissions. The model is based on power plant specific data (reduction efficiency), fuel analysis and plant specific operation statistics reported monthly including data from Automatic Monitoring Systems (AMS) for Total Suspended Particulates (TSP) emission. Due to fluctuation in emission level, the EMOK model that links the HM emission measurements to a constant measurement of TSP emissions gives a better estimate of the annual HM emission than a few direct emission measurements.

When plant specific emission data are not available, the inventories are based on emission factors. Emission factors have been determined for various fuels, plants and sectors.

Most emission factors refer to the EMEP/EEA Guidebook (EEA 2009). However, some country specific emission factors have been included:

- Emission factors for decentralised combined heat and power plants < 25 MW_e refer to three Danish studies including a large number of emission measurements: Nielsen et al. (2010), Nielsen & Illerup (2003) and Illerup et al. (1999).
- Country specific implied emission factors for large power plants/district heating plants combusting coal and/or residual oil.
- Heavy metal concentrations data for Danish natural gas have been included: Gruijthuijsen (2001) and Energinet.dk (2010),
- A CONCAWE study concerning HM concentrations in diesel oil (Denier van der Gon & Kuenen, 2009).

Uncertainty

The total emission uncertainties have been calculated based on the EMEP/EEA Guidebook Tier 1 approach (EEA 2009). The uncertainties have been estimated to be between 13 % and 96 %. The trend uncertainty is between 1.7 %-age point and 22 %-age point.

Table s.2 Danish uncertainty estimates, tier 1 approach, 2009.

HM	Uncertainty, Total emission, %	Trend, 1990-2009, %	Uncertainty Trend, %-age points
As	± 36	-80	± 6.5
Cd	± 50	-86	± 6.8
Cr	± 26	-92	± 1.9
Cu	± 53	-83	± 9.2
Hg	± 15	-85	± 2.0
Ni	± 30	-82	± 1.7
Pb	± 60	-84	± 9.5
Se	± 13	-73	± 2.7
Zn	± 96	-76	± 22

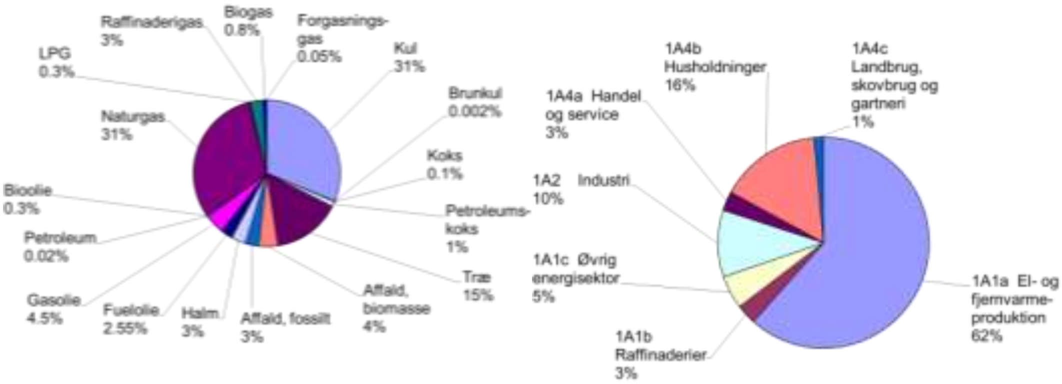
[1] EmissionsModel for Kraftværker.

Sammendrag

DCE - Nationalt Center for Miljø og Energi ved Aarhus Universitet udarbejder på vegne af Miljøministeriet årlige opgørelser for emissionen af tungmetal til luft. Disse emissionsopgørelser rapporteres til UNECE konventionen om langtransporteret grænseoverskridende luftforurening - CLRTAP (Convention on Long-Range Transboundary Air Pollution). Denne rapport præsenterer reviderede emissionsfaktorer for tungmetaller fra stationær forbrænding og de deraf følgende reviderede emissionsopgørelser for følgende metaller: Arsen (As), Kadmium (Cd), Krom (Cr), Kobber (Cu), Kviksølv (Hg), Nikkel (Ni), Bly (Pb), Selen (Se) og Zink (Zn). Rapporten viser data for år 2009 og tidsserier for 1990-2009.

Emission i 2009

I 2009 var brændselsforbruget for stationære forbrændingsanlæg i alt 521 PJ hvoraf 411 PJ var fossile brændsler og 110 PJ var biomasse. Kul og naturgas udgjorde hver 31 % af det samlede brændselsforbrug i 2009. Brændselsforbruget fra el- og fjernvarmeproduktion udgjorde 62 %.



Figur s.1 Brændselsforbrug for stationær forbrænding 2009. Opdelt efter henholdsvis brændselstype og sektor.

Stationær forbrænding er blandt de største kilder til tungmetalemission i Danmark. For kobber, zink og bly er emissionsandelen under 50 % af den samlede danske emission, men for alle øvrige tungmetaller er andelen højere end 50 %.

Tabel 1 nedenfor viser emissionen af tungmetaller fra de forskellige undersektorer for stationær forbrænding. Tungmetalemissionen er størst fra el- og fjernvarmeproduktion, beboelse og industri.

Tabel s.1 Tungmetalemission fra stationær forbrænding, 2009[1].

	As kg	Cd kg	Cr kg	Cu kg	Hg kg	Ni kg	Pb kg	Se kg	Zn kg
1A1a El- og fjernvarmeproduktion	89	31	197	157	236	929	351	880	493
1A1b Raffinaderier	31	23	24	46	22	285	67	106	96
1A1c Øvrig energisektor (off shore gasturbiner)	3	0	0	0	3	0	0	0	0
1A2 Industri	80	27	110	94	126	1312	644	261	1077
1A4a Handel og service	3	0	4	4	3	15	4	1	14
1A4b Husholdninger	23	38	79	295	20	85	1455	19	3734
1A4c Landbrug, skovbrug og gartneri	11	5	25	41	12	249	242	36	520
Total	239	124	438	636	421	2875	2762	1304	5934
Emissionsandel for stationær forbrænding, %	80	65	58	1	82	59	26	92	16

1) Kun emission fra stationær forbrænding inkluderet i tabellen. Nogle af sektorerne omfatter endvidere emission fra transport.

Tidsserier 1990 - 2009

Emissionen af alle tungmetaller er faldet betragteligt siden 1990 (73 % - 92 %). Tidsserier er vist i Figur s.2. Rapporten inkluderer endvidere tidsserier for alle undersektorer.

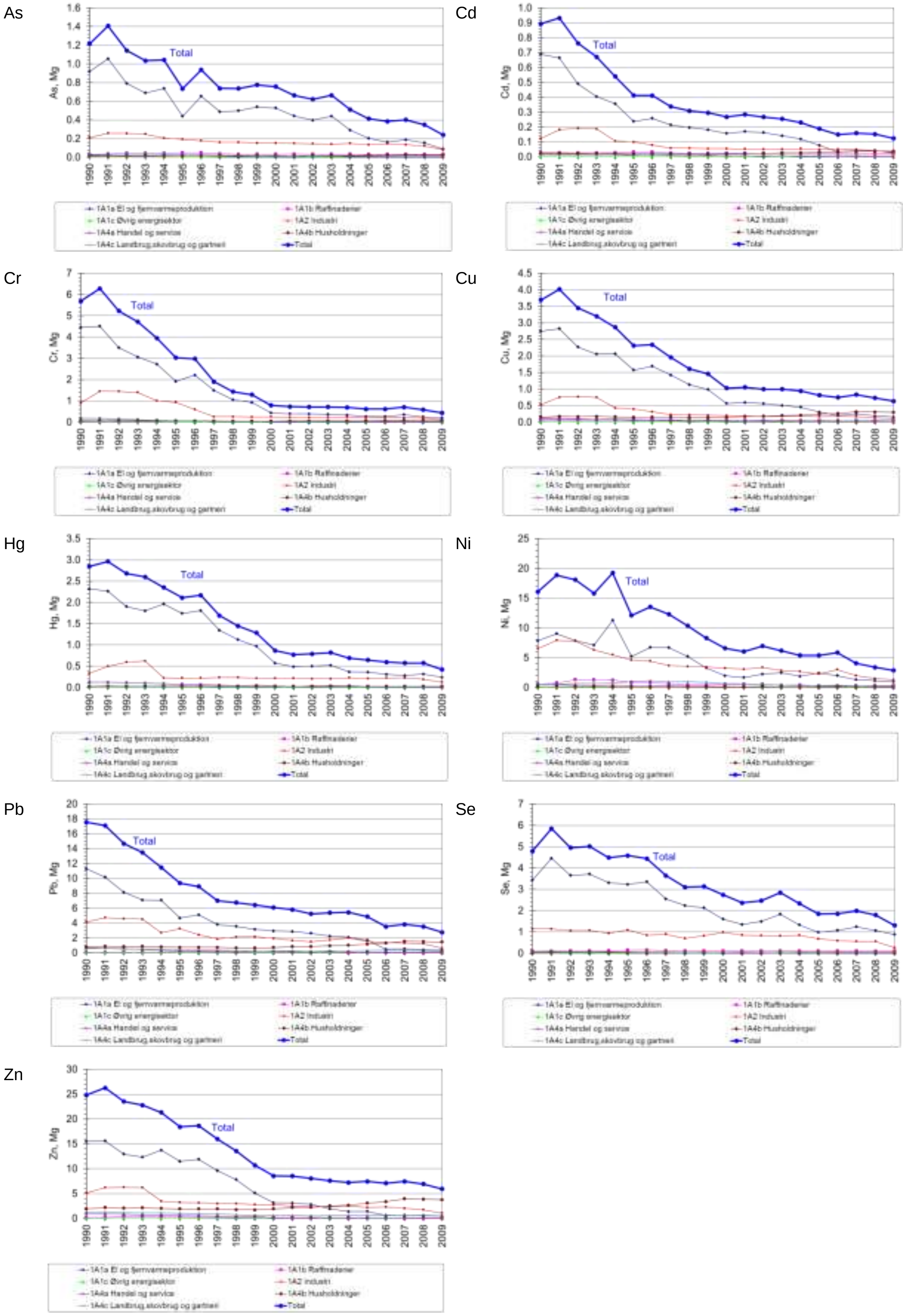
De største kilder til tungmetalemission er forbrænding af kul, affald og fuelolie samt i de senere år også forbrænding af biomasse.

Affaldsforbrænding var tidligere en stor emissionskilde for tungmetaller og emissionen herfra udgjorde i 1990 over 50 % af emissionen af Cd, Cr, Cu, Hg, Pb og Zn. Emissionen fra affaldsforbrænding er imidlertid faldet markant også i de seneste år som resultat af installering af forbedret røggasrensning. Den forbedrede røggasrensning er et resultat af skærpede emissionsgrænseværdier i lovgivningen (EPA 2003). Emissionen af Hg er endvidere faldet som resultat af de lavere grænseværdier for dioxin. I 2009 var emissionen fra affaldsforbrænding for alle metaller under 15 % af totalen for stationær forbrænding.

Kulforbrænding var en stor emissionskilde i 1990. Emissionen er faldet som resultat af den forbedrede røggasrensning og pga. det lavere forbrug af kul. Kul er dog stadig en relativt stor kilde til emission af Hg og Se og også en betydelig emissionskilde for andre tungmetaller.

Ni emissionen fra forbruget af fuelolie udgjorde i 2009 mere end 80 % af den samlede Ni emission. I 1990 var fuelolie ligeledes en dominerende kilde for Ni.

Forbrænding af træ er i de senere år blevet en af de største kilder til emission af Cd, Cr, Cu, Pb og Zn. Dette er et resultat af det store fald i tungmetalemissionen, der har været på andre kilder samt af det øgede forbrug af træ.



Figur s.2 Tidsserier for tungmetalemission, stationær forbrænding.

Metode

Emissionsopgørelsen er baseret på brændselsforbrug fra den danske energistatistik udarbejdet af Energistyrelsen.

Nogle af de større anlæg som fx kraftværker, affaldsforbrændingsanlæg og større industrianlæg opgøres selvstændigt og anlægsspecifikke emissionsdata inkluderes for disse.

For affaldsforbrændingsanlæg indarbejdes emissionsdata baseret på en eller to årlige emissionsmålinger for tungmetaller.

For kraftværker udarbejder DONG Energy og Vattenfall data for årlig emission baseret på en model for emission af sporstoffer. Denne model – EMOK[2] modellen – er en flow model, der omfatter separate beregningsmodeller for faste og flygtige fraktioner af tungmetaller. Modellen er baseret på anlægsspecifikke data for hvert enkelt kraftværk, brændselsanalyser og AMS data fra værkerne inkl. TSP emissionsdata. Pga. den store variation der er i emissionen af tungmetaller over tid kan EMOK-modellen, der kobler emissionsmålinger af tungmetaller med en konstant måling af TSP, give et bedre billede af den årlige emission end nogle enkelte direkte emissionsmålinger.

Når anlægsspecifikke emissionsdata ikke er til rådighed anvendes generelle emissionsfaktorer opdelt efter brændsel, sektor og teknologi.

Hovedparten af de anvendte emissionsfaktorer refererer til EMEP/EEA's Guidebook for emissionsopgørelser (EEA 2009). Nogle emissionsfaktorer refererer dog til andre kilder:

- Emissionsfaktorer for decentrale kraftvarmeværker < 25 MW_e refererer til tre danske projekter som inkluderede emissionsmålinger for bl.a. tungmetaller fra et stort antal anlæg, Nielsen et al. (2010), Nielsen & Illerup (2003) og Illerup et al. (1999).
- Danske emissionsfaktorer baseret på middelværdier for indsamlede anlægsspecifikke emissionsdata fra kraftværker og fjernvarmeværker, der anvender kul og/eller fuelolie.
- Emissionsfaktorerne for naturgas refererer til data fra Energinet.dk's hjemmeside (Energinet.dk 2010) og en rapport udarbejdet af Dansk Gasteknisk Center (Gruijthuijsen 2001).
- For gasolie refereres til et omfattende CONCAWE måleprogram for tungmetaller i dieselolie (Denier van der Gon & Kuenen, 2009).

Usikkerhed

Usikkerheden på de danske emissionsopgørelser er blevet beregnet baseret på Tier 1 metoden i EMEP/EEA's Guidebook (EEA 2009). Usikkerheden for de forskellige tungmetaller er fastlagt til mellem 13 % og 96 %. Usikkerheden på trend er beregnet til mellem 1,7 %-point og 22 %-point, se Tabel 2 nedenfor.

[2] <u>E</u>missions<u>M</u>odel for <u>K</u>raftværker

Tabel s.2 Usikkerhed for de danske emissionsopgørelser, 2009.

	Usikkerhed Total emission, %	Trend 1990-2009, %	Usikkerhed Trend, %-points
As	± 36	-80	± 6.5
Cd	± 50	-86	± 6.8
Cr	± 26	-92	± 1.9
Cu	± 53	-83	± 9.2
Hg	± 15	-85	± 2.0
Ni	± 30	-82	± 1.7
Pb	± 60	-84	± 9.5
Se	± 13	-73	± 2.7
Zn	± 96	-76	± 22

1 Introduction

On behalf of the Ministry of the Environment DCE at Aarhus University annually reports HM emissions to the UNECE CLRTAP (United Nations Economic Commission for Europe Convention on Long-Range Transboundary Air Pollution). This report presents new heavy metal emission factors for stationary combustion plants and the corresponding improved emission inventories for the following HMs: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Nickel (Ni), Lead (Pb), Selenium (Se) and Zinc (Zn). The report presents data for the year 2009 and time series for 1990-2009.

The emission inventories are based on fuel consumption data from the Danish energy statistics, fuel and technology specific emission factors and plant specific annual emission data.

In recent years, the emission from waste incineration plants and large power plants/CHP plants has decreased profoundly. Thus, the emission share from some other sources, e.g. residential wood combustion, that was previously minor sources, has now increased. Thus, improved emission factors for these emission source categories needed further focus.

Some of the HM emission factors applied in the emission inventories reported in 2010[3] had not been updated according to improved technology applied and/or improved knowledge. Thus, the improvements of the emission factors were the main focus in this work.

In addition, an improved uncertainty estimate was also needed owing to the fact that the former estimate was based on aggregated source categories not taking into account the dissimilar data references.

Finally, time series for HM emissions from subcategories to stationary combustion have not been presented in the annual Danish Informative Inventory Report (IIR). These time series are also included in this report.

[3] Emission inventories for 1990-2008. The improved emission factors determined and documented in this report were applied in the inventories reported in 2011.

2 Fuel consumption data

In 2009, the total fuel consumption for stationary combustion plants was 521 PJ of which 411 PJ was fossil fuels and 110 PJ was biomass.

Fuel consumption distributed according to the stationary combustion subcategories is shown in Figure 2.1 and Figure 2.2. The majority - 61 % - of all fuels is combusted in the source category, *Electricity and heat production*. Other source categories with high fuel consumption are *Residential* and *Industry*.

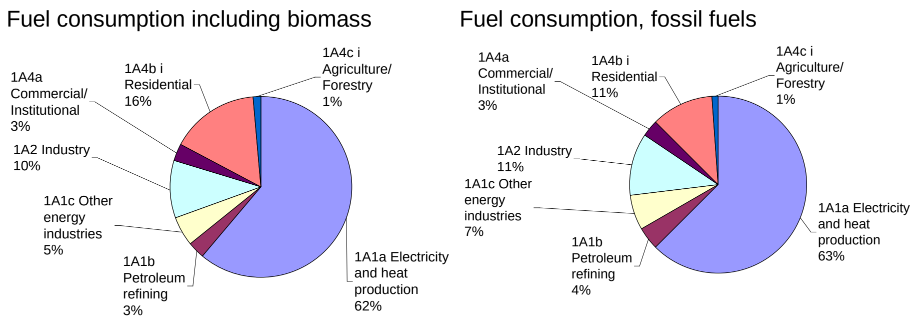


Figure 2.1 Fuel consumption of stationary combustion source categories, 2009. Based on DEA (2010a).

Coal and natural gas was the most utilised fuels for stationary combustion plants in 2009. Coal is mainly used in power plants and natural gas is used in power plants and decentralised combined heating and power (CHP) plants, as well as in industry, district heating, residential plants and offshore gas turbines[4] (see Figure 2.2).

Detailed fuel consumption rates are shown in Annex 2.

[4] Other energy industries

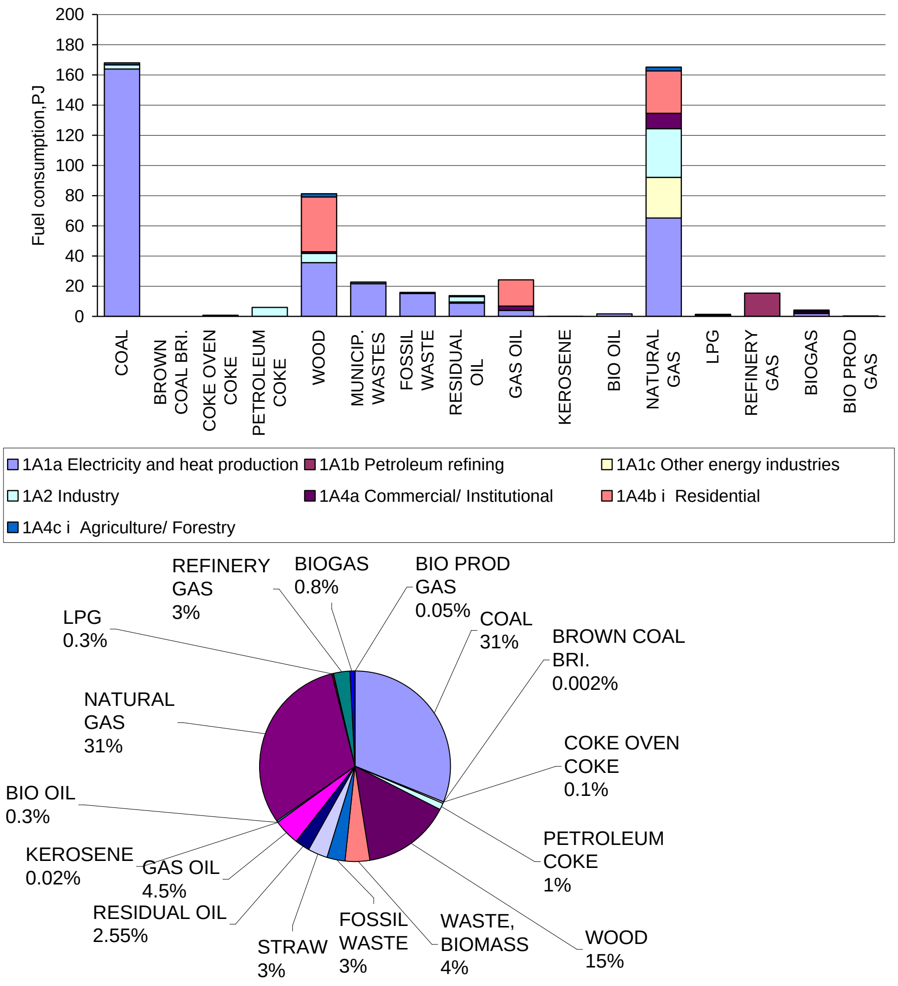


Figure 2.2 Fuel consumption of stationary combustion 2009, disaggregated to fuel type. Based on DEA (2010a).

Fuel consumption time series for stationary combustion plants are presented in Figure 2.3. The fuel consumption for stationary combustion was 5 % higher in 2009 than in 1990, while the fossil fuel consumption was 10 % lower and the biomass fuel consumption 158 % higher than in 1990.

The consumption of natural gas and biomass has increased since 1990 whereas coal consumption has decreased.

The fuels that account for the largest part of the HM emissions are coal, waste, residual oil and in recent years also wood. The consumption of coal and residual oil has decreased 34 % and 56 % respectively. The consumption of waste has increased to 2.5 times the 1990 level and wood to 3.5 times the 1990 level. Time series for these four fuels are shown in Figure 2.4.

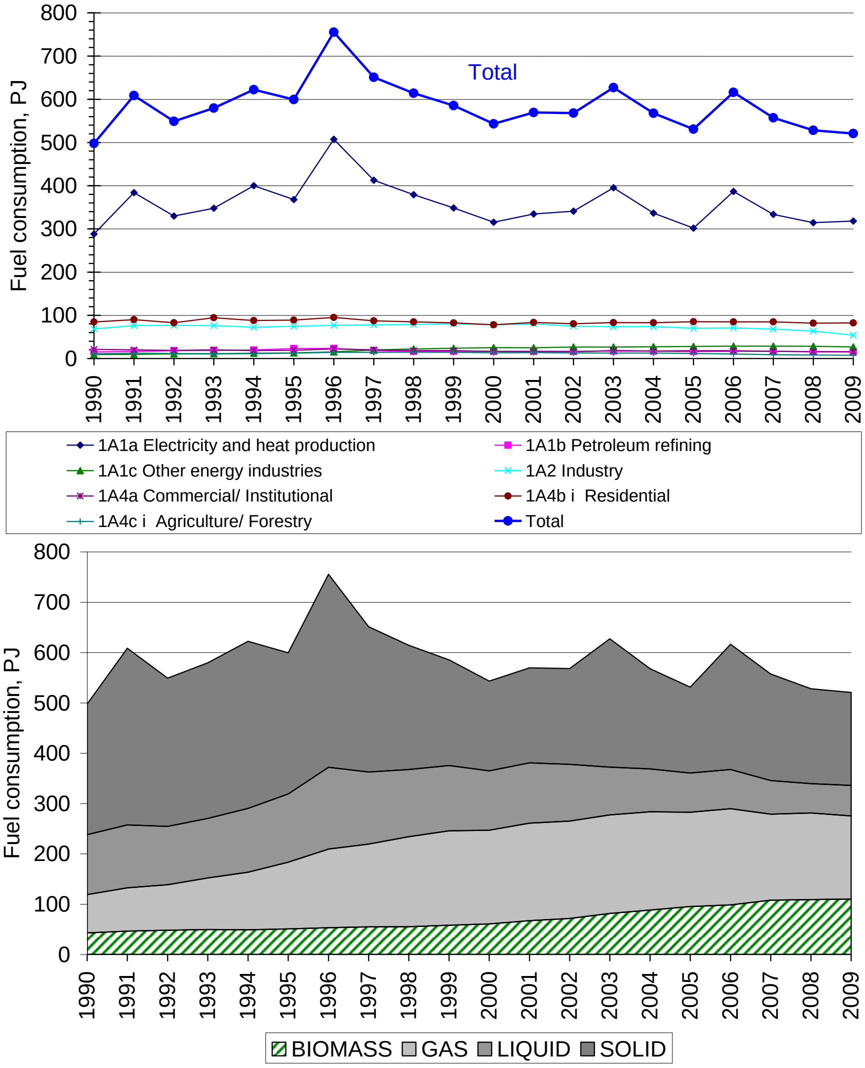


Figure 2.3 Fuel consumption time series, stationary combustion. Based on DEA (2010a).

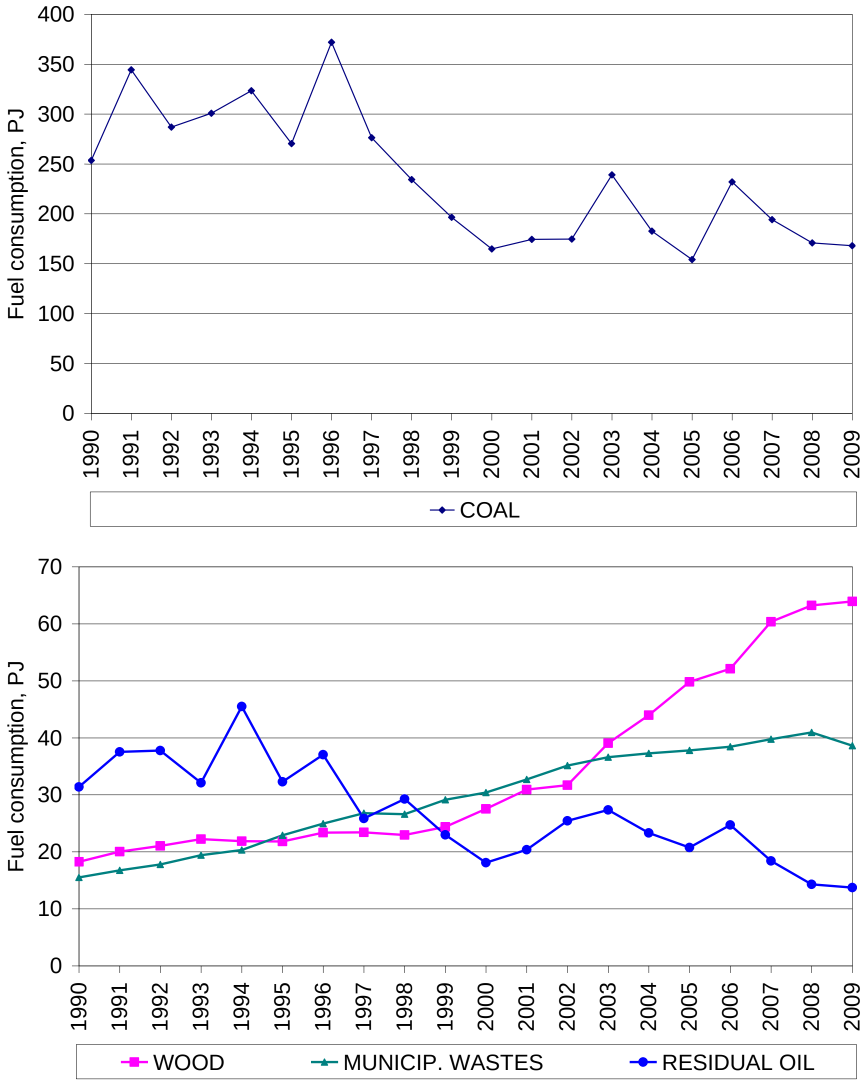


Figure 2.4 Fuel consumption time series for coal, residual oil, waste and wood, stationary combustion. Based on DEA (2010a).

The fluctuations in the time series for total fuel consumption are mainly a result of electricity import/export, but also of outdoor temperature variations from year to year. This, in turn, leads to fluctuations in emission levels. The fluctuations in electricity trade, fuel consumption and As emission are illustrated and compared in Figure 2.5. In 1990, the Danish electricity import was large causing relatively low fuel consumption, whereas the fuel consumption was high in 1996 due to a large electricity export. In 2009, the net electricity import was 1.2 PJ, whereas there was a 5.2 PJ electricity import in 2008. The large electricity export that occurs in some years is a result of low rainfall in Norway and Sweden causing insufficient hydropower production in both countries.

To be able to follow the national energy consumption as well as for statistical and reporting purposes, the (DEA) produces a correction of the actual fuel consumption without random variations in electricity imports/exports and in ambient temperature. This fuel consumption trend is also illustrated in Figure 2.5. The corrections are included here to explain the fluctuations in the time series for fuel rates and emissions.

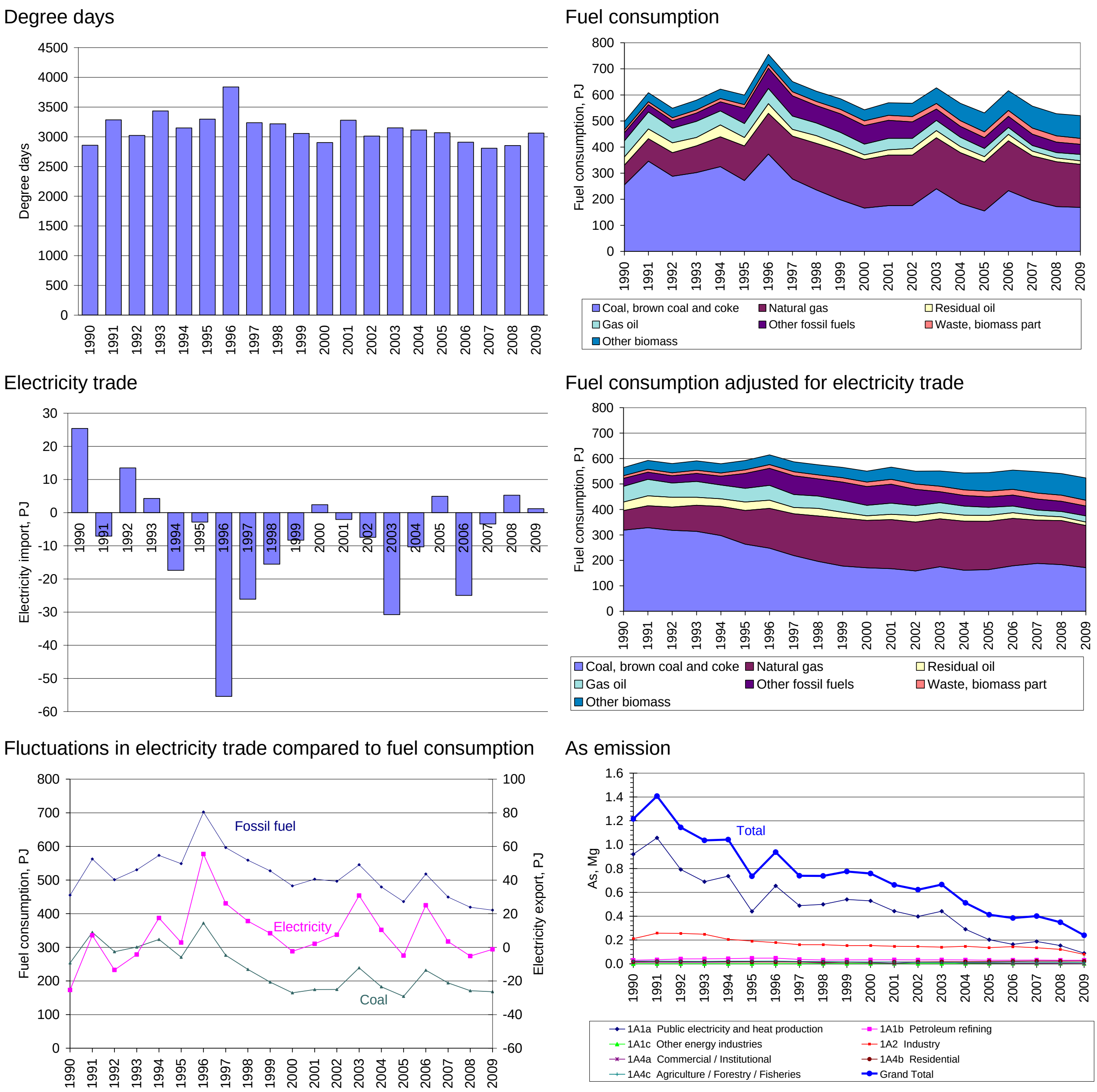


Figure 2.5 Comparison of time series fluctuations for electricity trade, fuel consumption and As emission. Based on DEA (2010a).

Fuel consumption time series for the subcategories to stationary combustion are shown in Figure 2.6, Figure 2.7 and Figure 2.8.

Fuel consumption for *Energy Industries* fluctuates due to electricity trade as discussed above. The fuel consumption in 2009 was 16 % higher than in 1990. The fluctuation in electricity production is based on fossil fuel consumption, mainly coal, in the subcategory *Electricity and Heat Production*. The energy consumption in *Other energy industries* is mainly natural gas used in gas turbines in the off-shore industry. The biomass fuel consumption in *Energy Industries* 2009 added up to 61 PJ, which is 3.5 times the level in 1990. The coal and residual oil consumption have decreased 31 % and 16 % respectively and the waste incineration increased to 2.7 times the 1990 level.

The fuel consumption in *Industry* was 21 % lower in 2009 than in 1990 (Figure 2.7). The fuel consumption in industrial plants has decreased considerably as a result of the financial crisis. The biomass fuel consumption in *In-*

dustry in 2009 added up to 8 PJ which is a 10 % increase since 1990. The coal and residual oil consumption both decreased 80 % since 1990 and the waste incineration increased 71 %.

The fuel consumption in *Other Sectors* decreased 10 % since 1990 (Figure 2.8). The biomass part of the fuel consumption has increased from 16 % in 1990 to 39 % in 2009. Wood consumption in residential plants in 2009 was 2.3 times the consumption in year 2000. The coal and residual oil consumption have decreased 58 % and 73 % respectively.

Time series for subcategories are shown in Chapter 4.

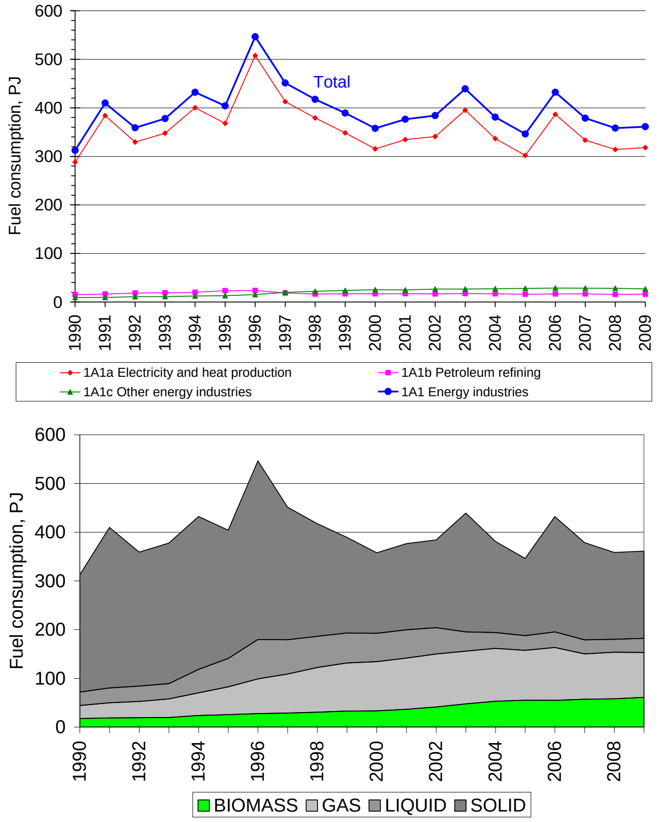


Figure 2.6 Fuel consumption time series for subcategories - 1A1 Energy Industries.

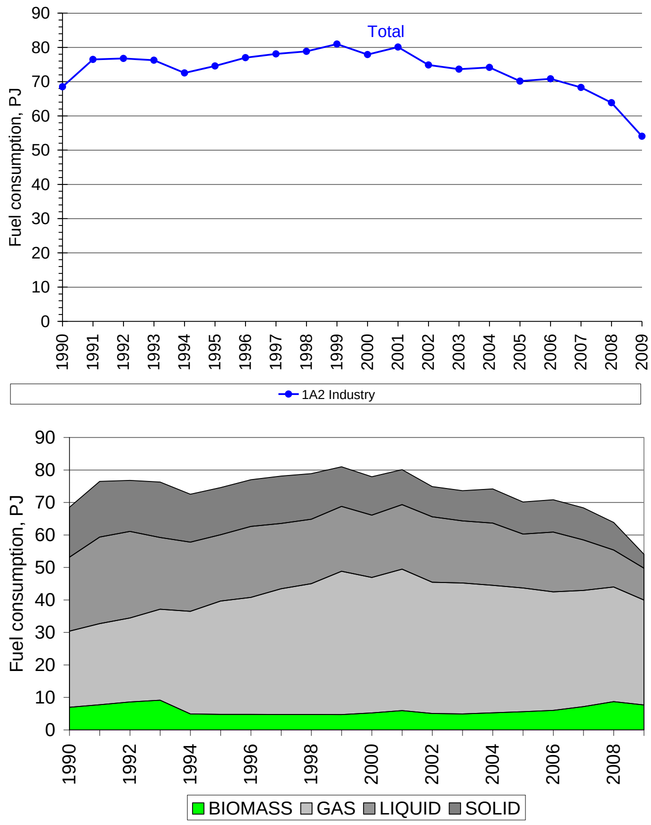


Figure 2.7 Fuel consumption time series for subcategories - 1A2 Industry.

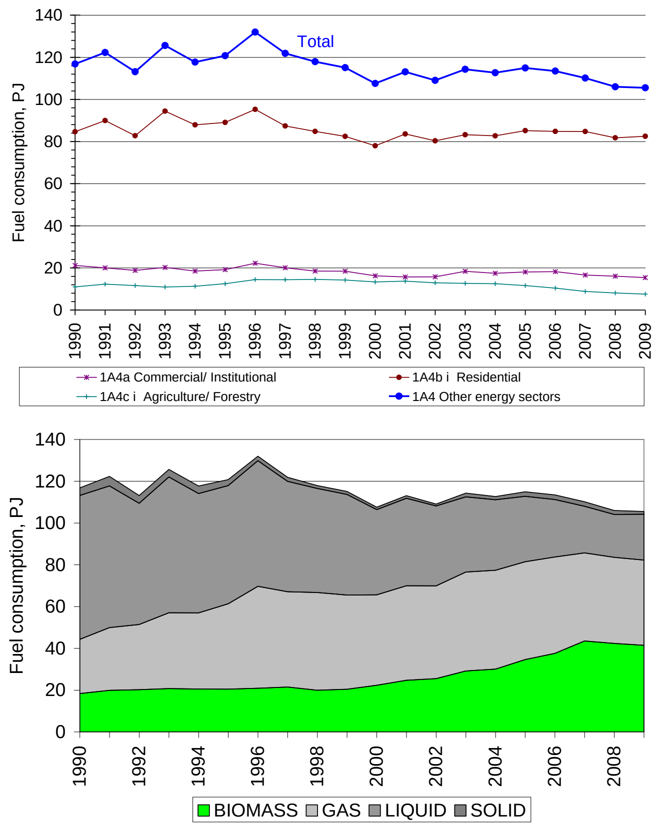


Figure 2.8 Fuel consumption time series for subcategories - 1A4 Other Sectors.

3 Emission inventory

3.1 Emission inventory for 2009

Stationary combustion plants are among the most important emission sources for heavy metals. For Cu, Zn and Pb the emission share from stationary combustion plants is below 50 %, but for all other heavy metals, the emission share is above 50 %.

Table 3.1 and Figure 3.1 present the heavy metal emission inventory for the stationary combustion subcategories. The source categories *Public electricity and heat production, Residential* and *Industry* have the highest emission shares.

Table 3.1 Heavy metal emission from stationary combustion plants, 2009[1].

	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	kg	kg	kg	kg	kg	kg	kg	kg	kg
1A1a Public electricity and heat production	89	31	197	157	236	929	351	880	493
1A1b Petroleum refining	31	23	24	46	22	285	67	106	96
1A1c Other energy industries	3	0	0	0	3	0	0	0	0
1A2 Industry	80	27	110	94	126	1312	644	261	1077
1A4a Commercial/Institutional	3	0	4	4	3	15	4	1	14
1A4b Residential	23	38	79	295	20	85	1455	19	3734
1A4c Agriculture/Forestry/Fisheries	11	5	25	41	12	249	242	36	520
Total	239	124	438	636	421	2875	2762	1304	5934
Emission share from stationary combustion, %	80	65	58	1	82	59	26	92	16

[1] Only emission from stationary combustion plants in the source categories is included.

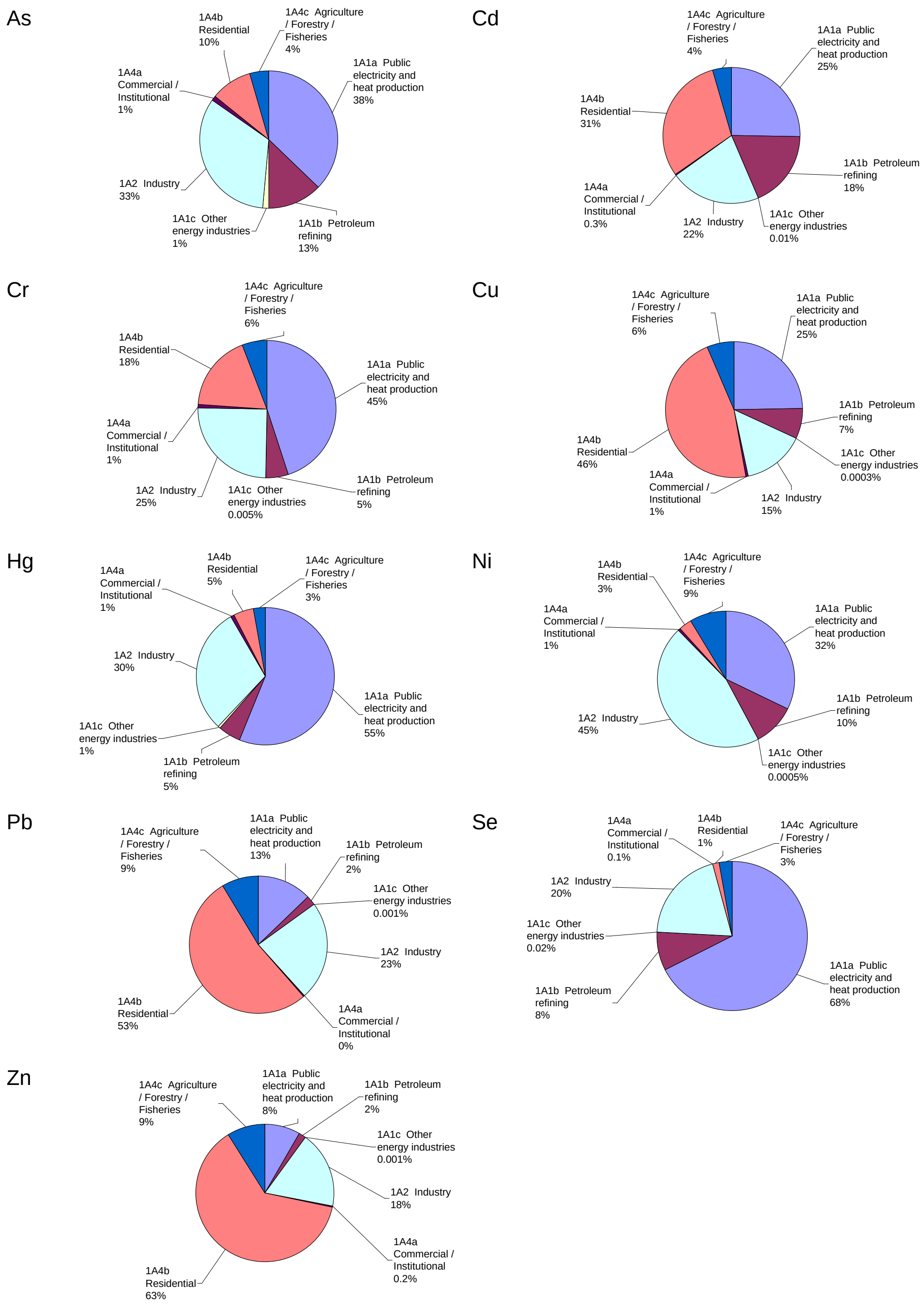


Figure 3.1 Heavy metal emission sources, stationary combustion plants, 2009.

3.2 Time series 1990-2009

Time series for heavy metal emissions are provided in Figure 3.2. Emissions of all heavy metals have decreased considerably (73 % - 92 %) since 1990, see Table 3.2.

The main HM emission sources are coal combustion, waste incineration, residual oil combustion and in 2009 also combustion of biomass.

Waste incineration plants were formerly a major emission source accounting for more than 50 % of Cd, Cr, Cu, Hg, Pb and Zn emissions in 1990. However, the emission share for waste incineration plants has decreased profoundly also in recent years due to installation and improved performance of flue gas cleaning devices in waste incineration plants. The emission share was below 15 % for all HMs in 2009. The improved flue gas cleaning is a result of lower emission limits for waste incineration plants (DEPA 2003). The emission of Hg has also been reduced as a result of installation of dioxin abatement in all plants.

Combustion of coal was a large emission source for all HMs in 1990. The emission has decreased due to improved flue gas cleaning and also as a result of decreased consumption. However, coal combustion is still a major emission source for Hg and Se, and a considerable emission source for other HMs.

Residual oil combustion accounted for more than 80 % of the Ni emission in 2009 and was also the major emission source in 1990.

As a result of the decrease in HM emissions from other sources and the increased residential wood consumption, the emission of HMs from residential wood combustion has become one of the major sources for Cd, Cr, Cu, Pb and Zn in 2009.

Table 3.2 Decrease in heavy metal emission 1990-2009.

Pollutant	Decrease since 1990, %
As	80
Cd	86
Cr	92
Cu	83
Hg	85
Ni	82
Pb	84
Se	73
Zn	76

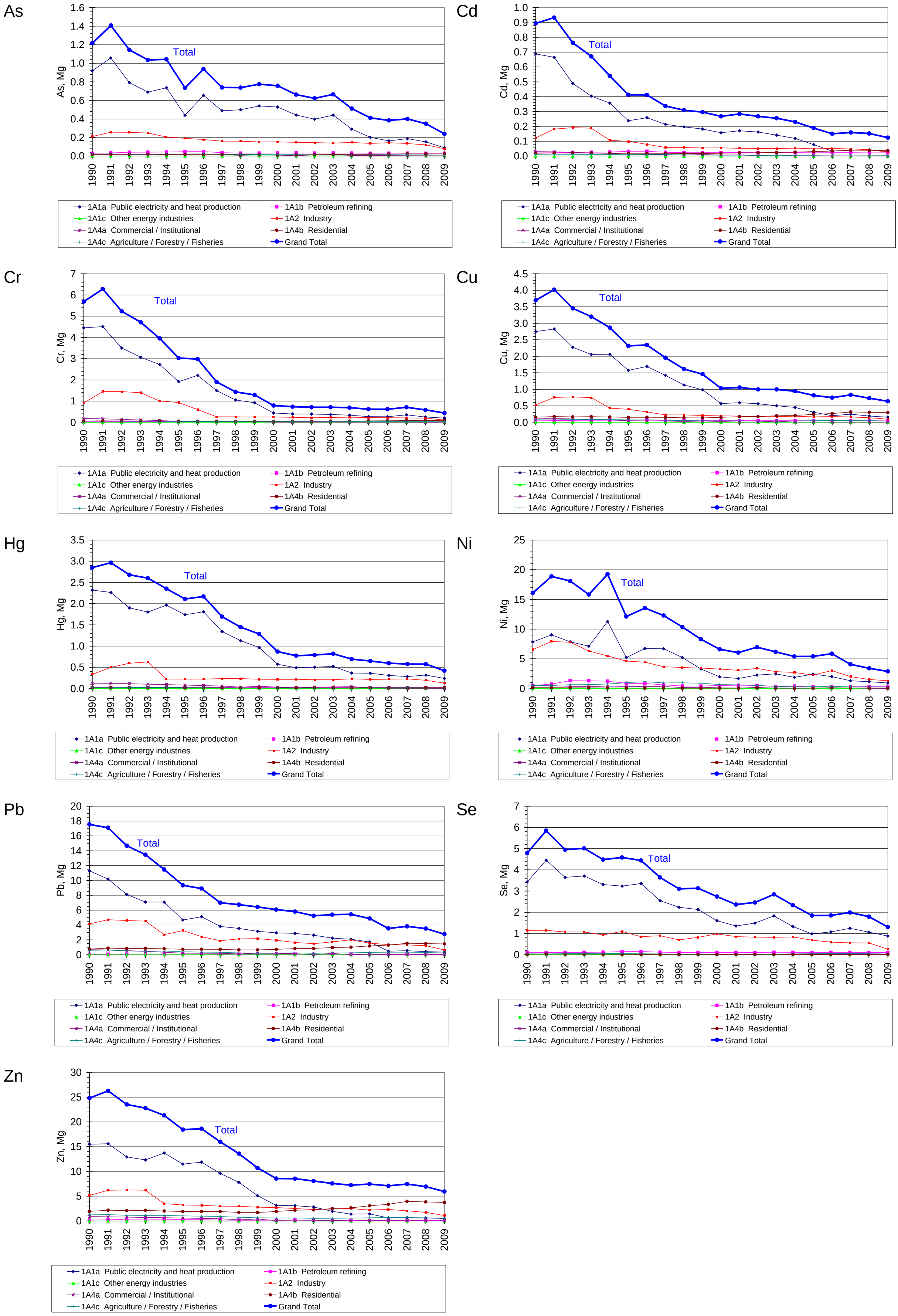


Figure 3.2 Heavy metal emission time series, stationary combustion plants.

4 Emission time series for subsectors

4.1 1A1 Energy Industries

The emission source category *1A1 Energy Industries* consists of the subcategories:

- 1A1a Electricity and heat production.
- 1A1b Petroleum refining.
- 1A1c Other energy industries.

Figure 4.1 present time series for fuel consumption in *Energy Industries* and Figure 4.2 presents time series for HM emissions. *Electricity and heat production* is the largest subcategory accounting for the main part of all HM emissions. Time series are discussed below for each subcategory.

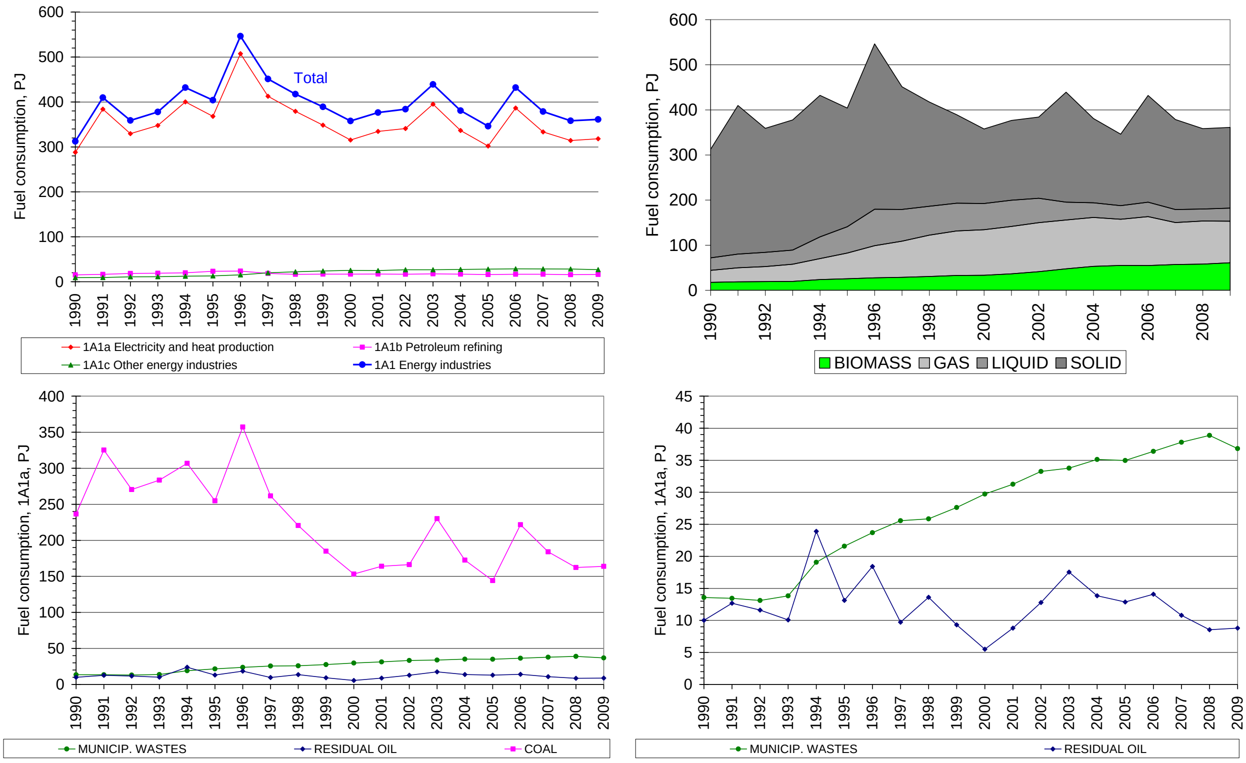


Figure 4.1 Time series for fuel consumption, 1A1 Energy industries.

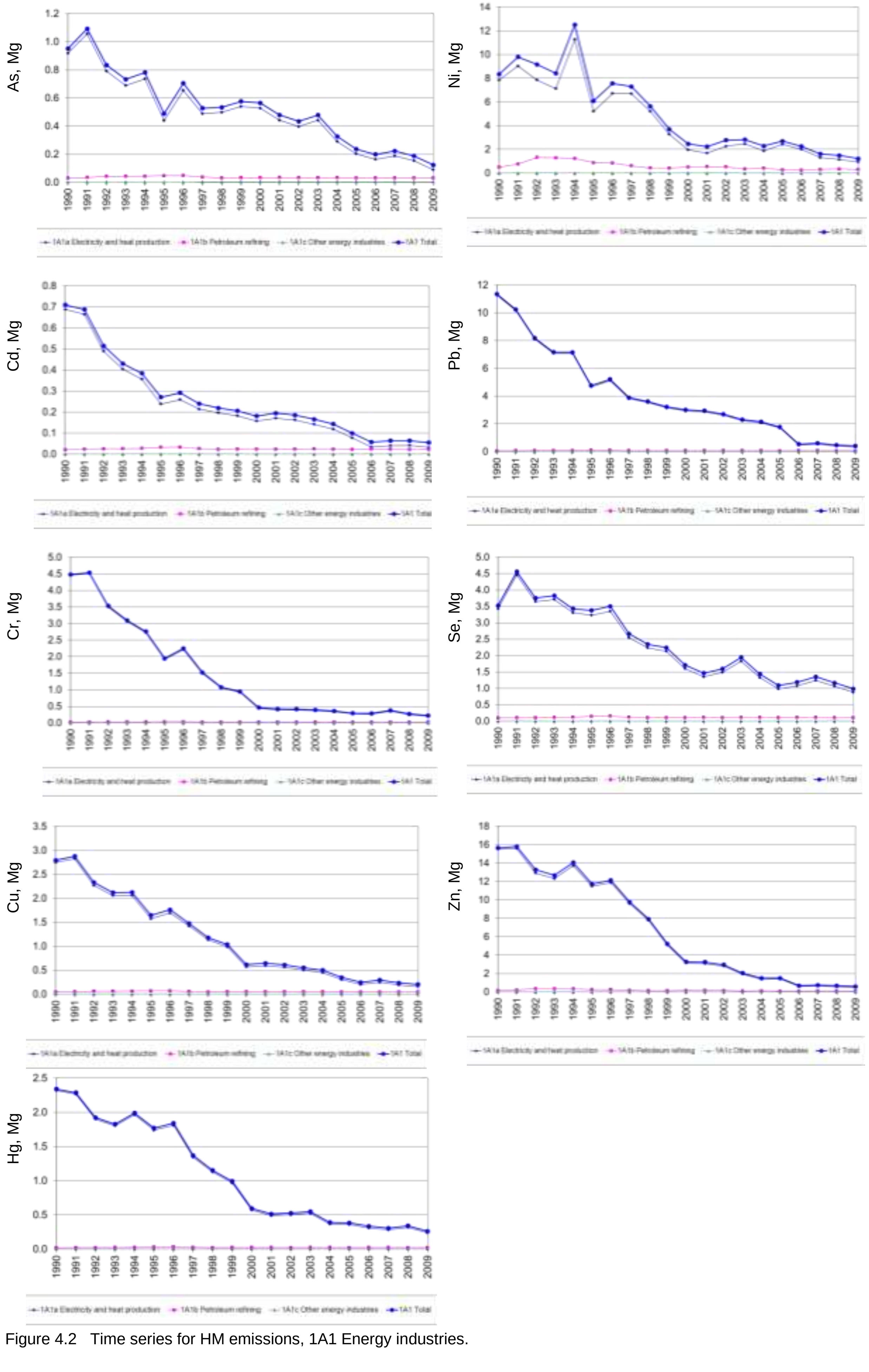


Figure 4.2 Time series for HM emissions, 1A1 Energy industries.

4.1.1 1A1a Electricity and district heat production

Public electricity and heat production is the largest source category regarding fuel consumption for stationary combustion. Figure 4.3 shows the time series for fuel consumption and emissions of HMs.

The fuel consumption in electricity and heat production was 10 % higher in 2009 than in 1990. As discussed in Chapter 2 the fuel consumption fluctuates mainly as a consequence of electricity trade. Coal is the fuel that is affected the most by the fluctuating electricity trade. Coal is the main fuel in the source category even in years with electricity import. The coal consumption in 2009 was 31 % lower than in 1990. The consumption of waste and biomass has increased.

The two largest emission sources in 1990 were coal combustion and incineration of waste accounting for more than 95 % of the emission, except for Ni where the emission from residual oil was almost 50 % in 1990.

In 2009, the emissions from coal combustion in power plants and from waste incineration plants have been reduced profoundly but are still among the main emission sources. Waste incineration is the largest emission source for Cd and Pb whereas coal combustion is larger for Hg and Se. However, other fuels also account for a considerable part of the emission in 2009. Thus, combustion of straw and wood is a considerable source for As, Cd, Cr, Cu and Pb. Combustion of residual oil is the main emission source for Ni in 2009.

The emissions of HMs have decreased 74 %- 97 % since 1990. The decrease is mainly a result of both the decrease of coal consumption and the improved flue gas cleaning devices installed in Danish power plants and waste incineration plants since 1990.

In the 1990s, the fluctuations of the time series follow the fluctuations of the coal consumption. However, as a result of the improved flue gas cleaning the high consumption of coal in 2003 and 2006 is hardly reflected in the time series for HM emissions.

Table 4.1 Heavy metal emissions from public electricity and heat production plants, 2009/1990 emission.

HM	2009 emission/1990 emission, %
As	10
Cd	5
Cr	4
Cu	6
Hg	10
Ni	12
Pb	3
Se	26
Zn	3

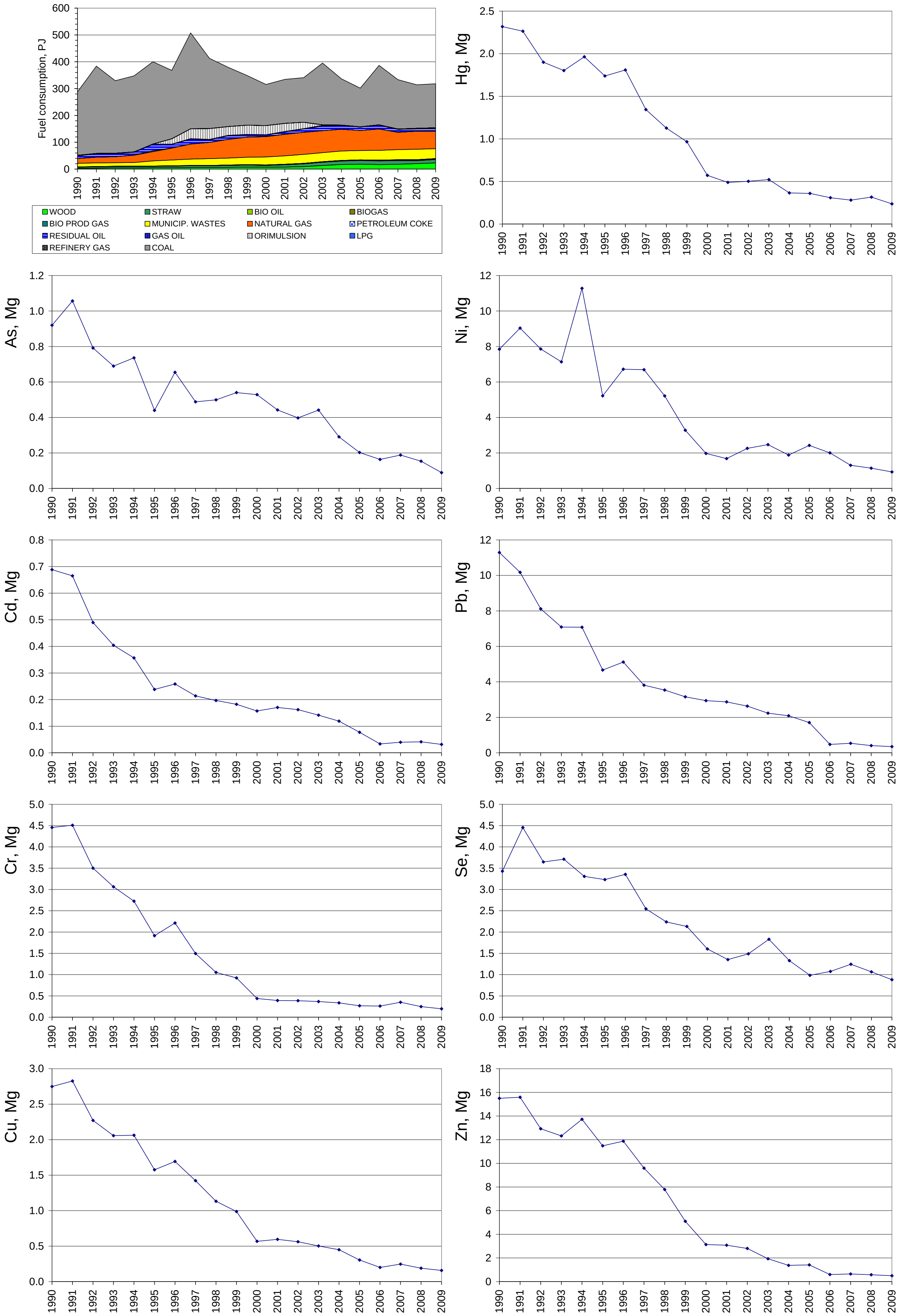


Figure 4.3 Time series for 1A1a Electricity and district heat production.

4.1.2 1A1b Petroleum refining

Petroleum refining is a small source category regarding both fuel consumption and emissions for stationary combustion. Presently, there are only two refineries in Denmark. Figure 4.4 shows the time series for fuel consumption and HM emissions.

The significant decrease in both fuel consumption and emissions in 1996 is a result of the closure of a third refinery.

The fuel consumption has increased 6 % since 1990. The consumption of refinery gas has increased 10 % and the consumption of residual oil decreased 45 %.

The emissions follow the fuel consumption time series. Ni and Zn are mainly dependent on the consumption of residual oil and the emissions have decreased 42 % and 35 % respectively. All other HMs are mainly dependent on the consumption of refinery gas and within + 10 % of the 1990 emission level.

A description of the Danish emission inventory for fugitive emissions from fuels is given in Plejdrup et al. (2009).

Table 4.2 Heavy metal emissions from petroleum refining, 2009/1990 emission.

HM	2009 emission/1990 emission, %
As	100
Cd	106
Cr	102
Cu	101
Hg	109
Ni	58
Pb	105
Se	109
Zn	65

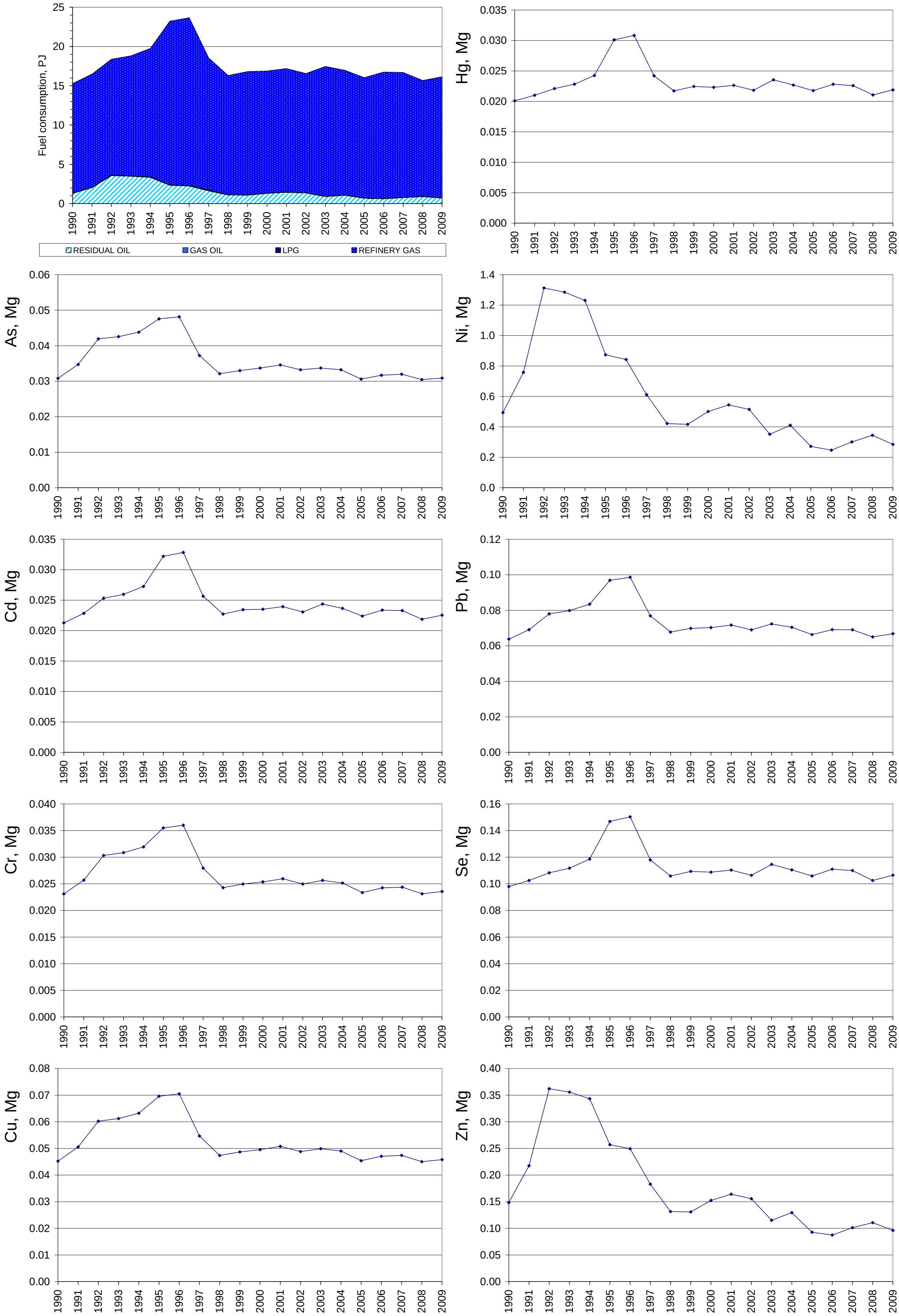


Figure 4.4 Time series for 1A1b Petroleum refining.

4.1.3 1A1c Other energy industries

The source category *Other energy industries* comprises natural gas consumption in the off-shore industry. Gas turbines are the main plant type. Figure 4.5 shows the time series for fuel consumption and emissions.

The fuel consumption in 2009 was three times the consumption in 1990.

The emissions follow the increase of fuel consumption and all HM emissions increased to almost three times the 1990 emission level, see Table 4.3.

Table 4.3 Heavy metal emissions from other energy industries, 2009/1990 emission.

HM	2009 emission/1990 emission, %
As	293
Cd	293
Cr	293
Cu	293
Hg	293
Ni	293
Pb	293
Se	293
Zn	293

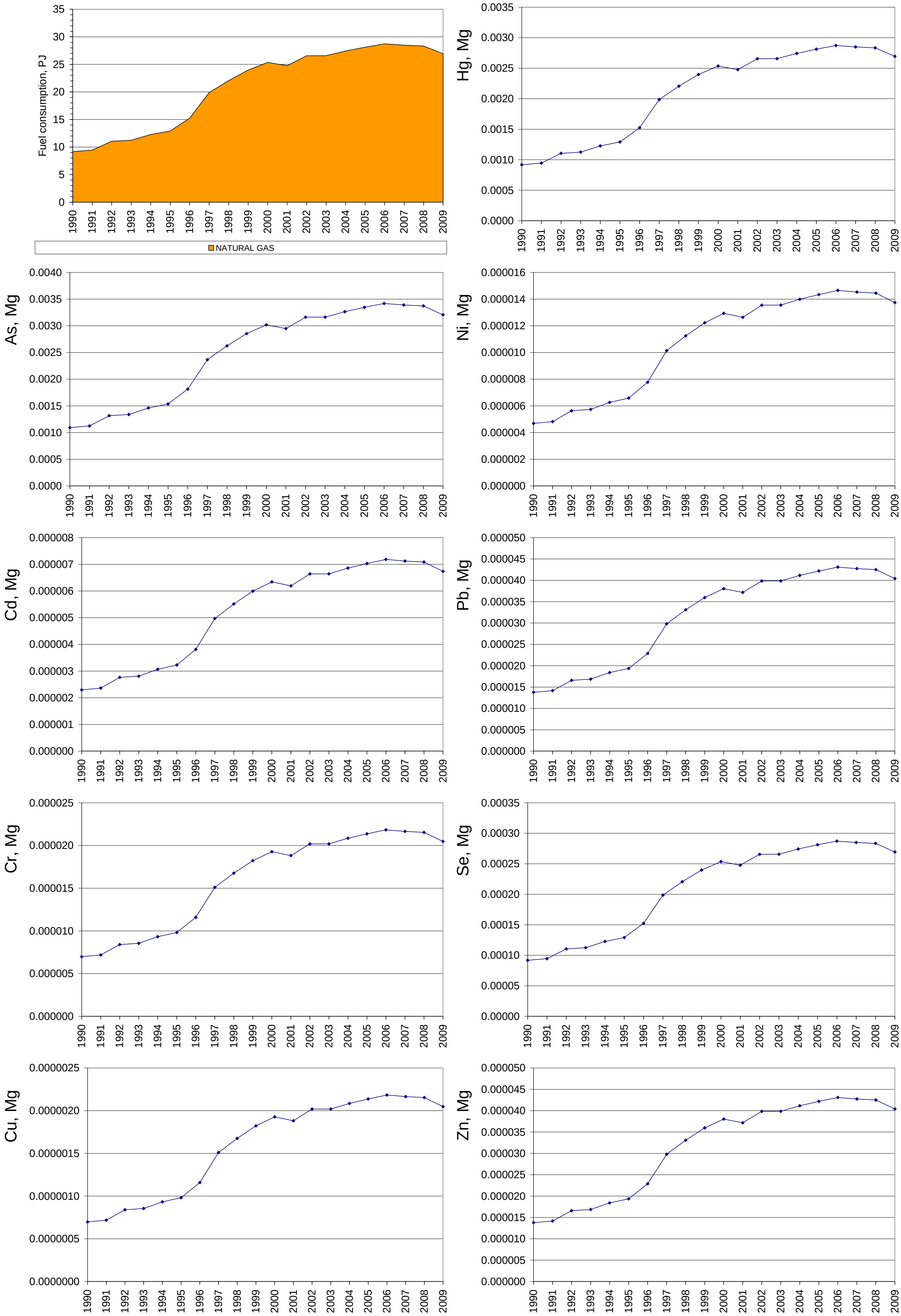


Figure 4.5 Time series for 1A1c Other energy industries.

4.2 1A2 Industry

Manufacturing industries and construction (Industry) consists of both stationary and mobile sources. In this report, only stationary sources are included.

Figure 4.6 and Figure 4.7 show the time series for fuel consumption and emissions. The data have not been disaggregated to industrial subcategories due to the fact that the Danish inventory is based on data for the industrial plants as a whole.

The total fuel consumption in industrial combustion was 21 % lower in 2009 than in 1990. The fuel consumption has decreased considerably (24 %) since 2006 and the financial crisis has resulted in a remarkable decrease in 2009. The consumption of gas has increased since 1990 whereas the consumptions of coal and residual oil have both decreased by 80 %.

Part of the consumption of waste for electricity and heat production has been included in source sector *Industry* in 1990-1993. This error cause incorrect time series for these two sectors. However, the total emission of HMs from stationary combustion is not affected by the error, which will be corrected in the next inventory.

Four industrial combustion subsectors with product contact are large emission sources: cement production, container glass production, gray iron foundries[5] and combustion of coke oven coke in mineral wool production[6].

In cement production a mix of fuels are applied: coal, petroleum coke, waste and residual oil. In container glass production natural gas and gas oil are the applied fuels. In mineral wool production, the applied fuels are coke oven coke and natural gas.

The main HM emission sources are:

- As: Cement production, residual oil combustion and gray iron foundries. In 1990 also coal combustion.
- Cd: Cement production, residual oil combustion and coal combustion. In 1990 also waste incineration, coal combustion and container glass production.
- Cr: Gray iron foundries, cement production and coal combustion. In 1990 also container glass production.
- Cu: Coal combustion and cement production. In addition, combustion of residual oil, combustion of coke oven coke in mineral wool production and combustion of wood are considerable emission sources. In 1990, container glass production and waste incineration were also large emission sources.
- Hg: Cement production. In 1990, waste incineration and coal combustion were also large emission sources.
- Ni: Combustion of residual oil is the main emission source in both 2009 and 1990.
- Pb: Gray iron foundries, coal combustion and combustion of coke oven coke in mineral wool production. In 1990 container glass production and waste incineration were also large emission sources.

[5] Will be allocated to industrial processes in future inventories.
[6] Except binding.

- Se: Gray iron foundries and coal combustion. In 1990 also container glass production.
- Zn: Combustion of coal and residual oil, combustion of coke oven coke in mineral wool production, and gray iron foundries. In 1990, waste incineration was also a large emission source.

The emissions have been reduced 62 % - 88 % since 1990. This is mainly a result of the lower consumption of coal and residual oil.

Table 4.4 Heavy metal emissions from industrial plants, 2009/1990 emission.

HM	2009 emission/1990 emission, %
As	38
Cd	22
Cr	12
Cu	18
Hg	38
Ni	20
Pb	16
Se	23
Zn	21

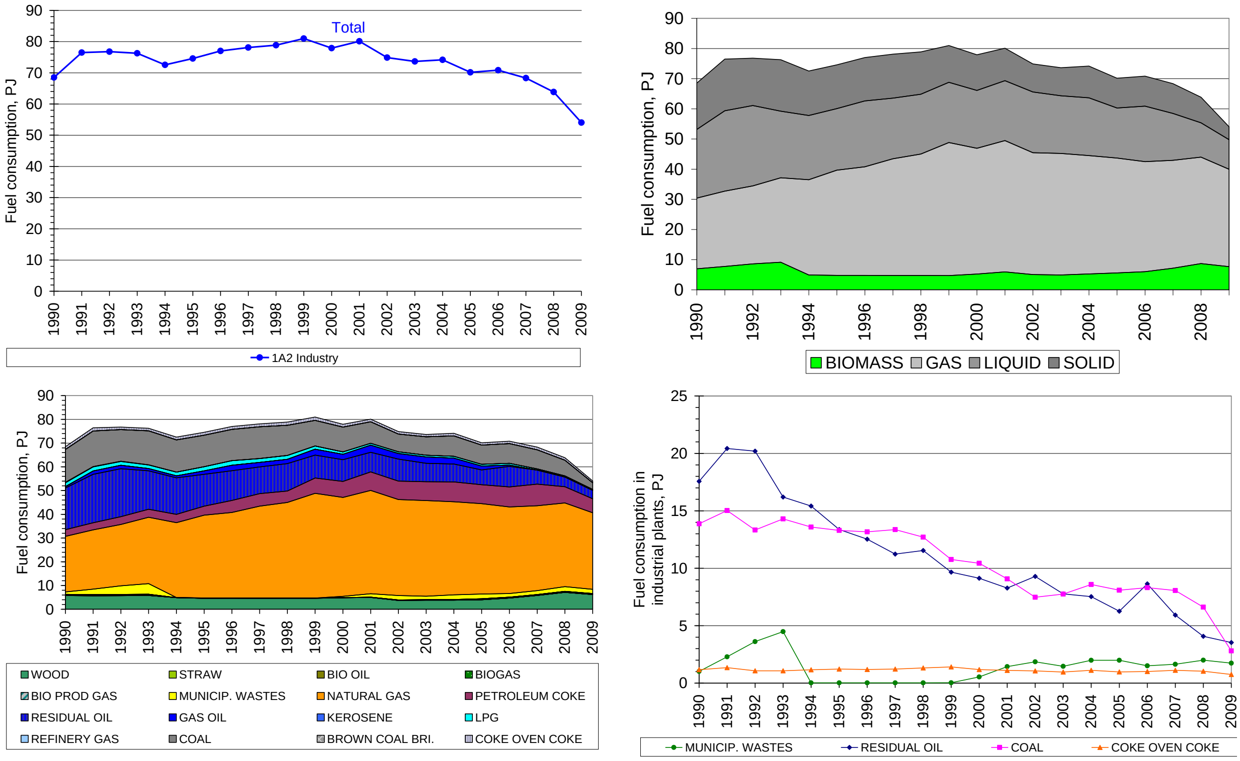


Figure 4.6 Time series for fuel consumption, 1A2 Industry.

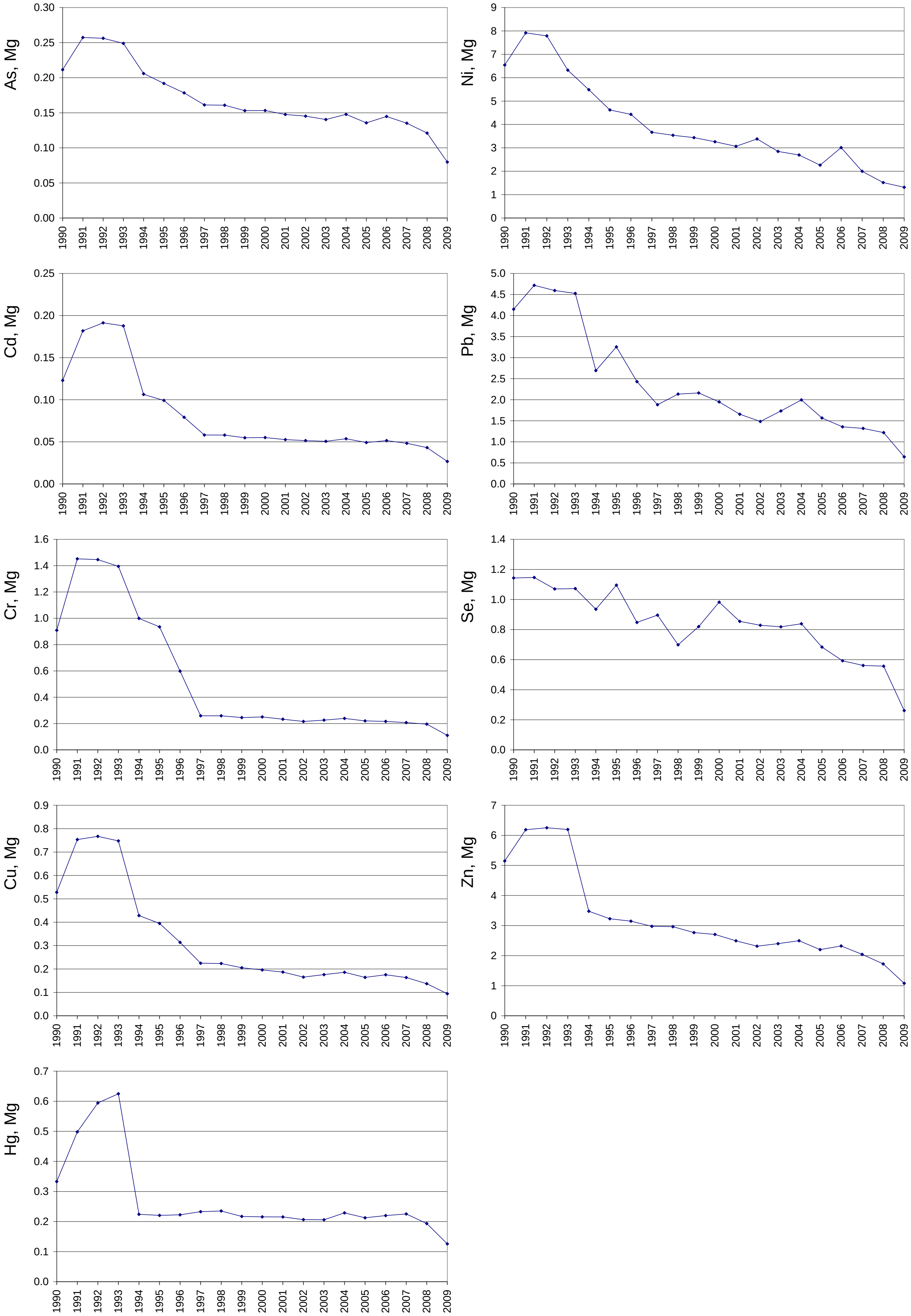


Figure 4.7 Time series for HM emissions, 1A2 Industry.

4.3 1A4 Other energy

The emission source category *1A4 Other Sectors* consists of the subcategories:

- 1A4a Commercial/Institutional plants.
- 1A4b Residential plants.
- 1A1c Agriculture/Forestry.

Figure 4.8 and Figure 4.9 present time series for fuel consumption and emissions respectively. *Residential plants* is the largest subcategory accounting for the largest part of all emissions. Time series are discussed below for each subcategory.

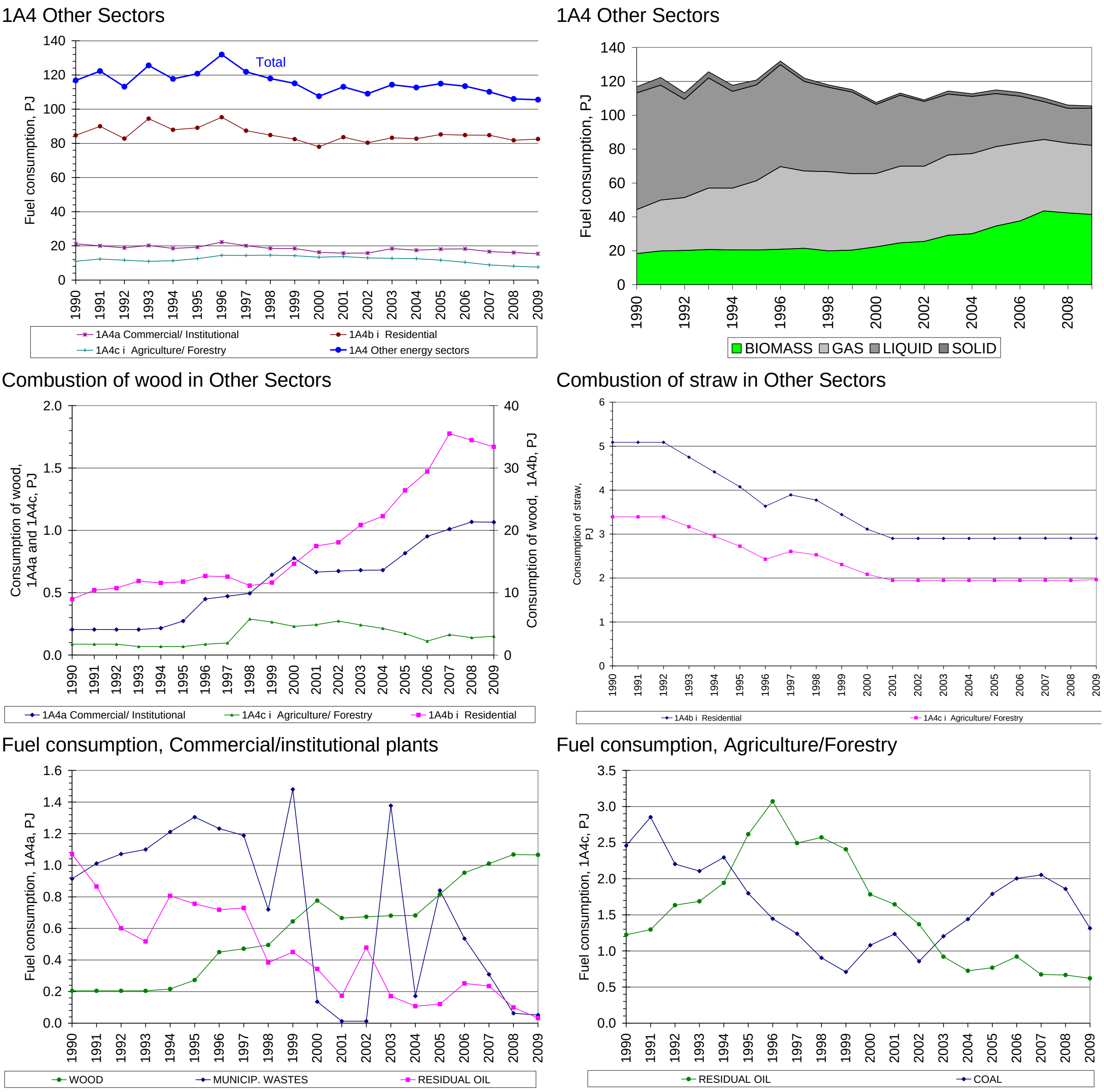


Figure 4.8 Time series for fuel consumption, 1A4 Other Sectors.

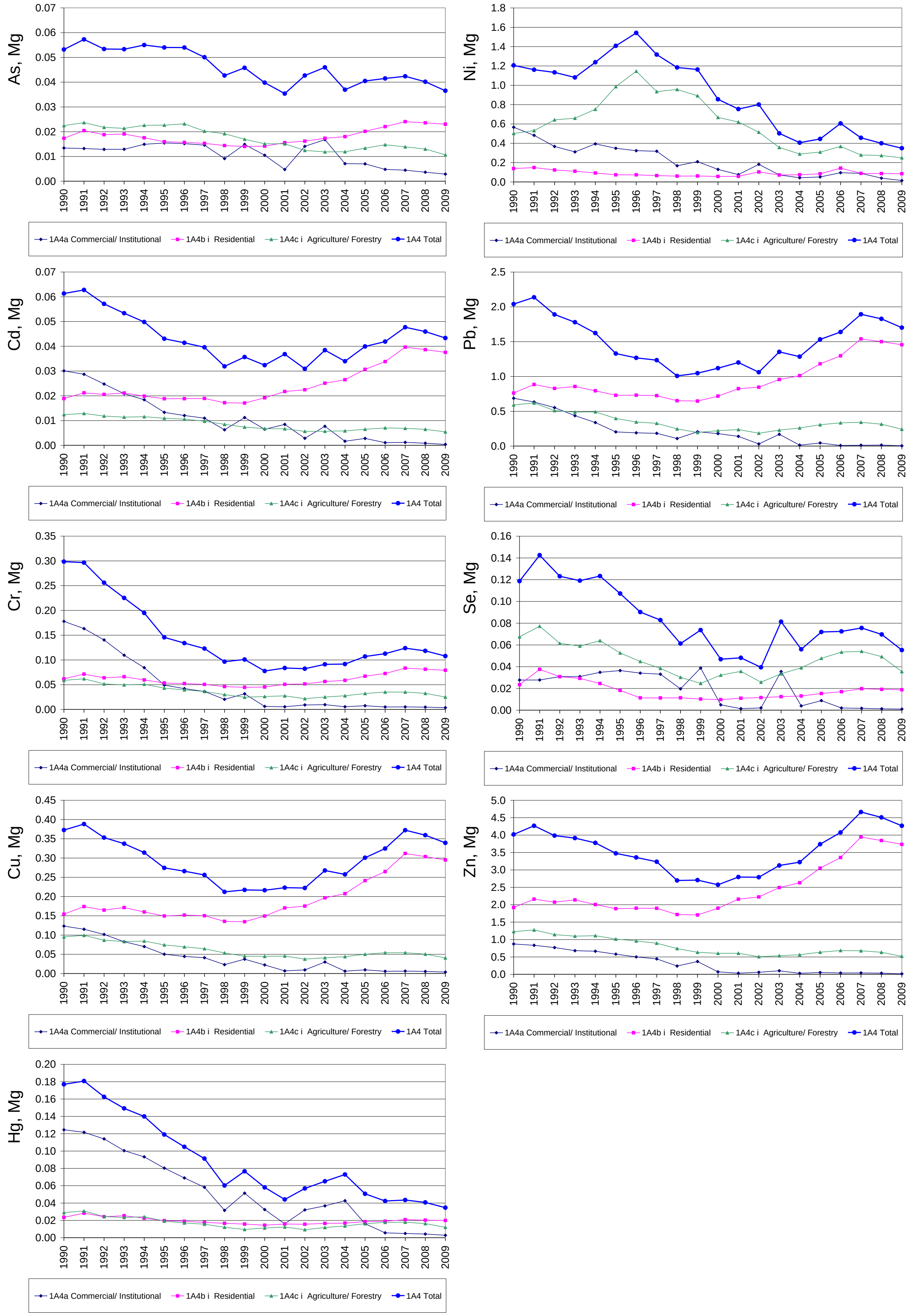


Figure 4.9 Time series for HM emissions, 1A4 Other Sectors.

4.3.1 1A4a Commercial/institutional plants

The emission source category *Commercial/institutional plants* consists of both stationary and mobile sources. In this chapter, only stationary sources are included.

Both fuel consumption and emissions from the subcategory *Commercial and institutional plants* are low compared to the other stationary combustion source categories. Figure 4.10 shows time series for fuel consumption and emissions.

The fuel consumption in commercial/institutional plants has decreased 27 % since 1990 and there has been a change of fuel type. The fuel consumption consists mainly of gas oil and natural gas. The consumption of gas oil has decreased and the consumption of natural gas has increased since 1990. The consumption of wood and biogas has also increased.

The consumptions of waste, residual oil and wood in commercial/institutional plants are shown in Figure 4.8 above. The consumption of residual oil has decreased to 9 % of the 1990 level. The wood consumption in 2009 was five times the consumption in 1990.

The consumption of waste fluctuates, and this is a result of the disaggregation of waste to subsectors. When the detailed site specific data for waste (from DEA plant specific database, DEA 2010c) applied in the emission inventory due to statistical differences do not add up to the correct total consumption in the Danish energy statistics (DEA 2010a) adjustment of consumption in the sector commercial/institutional is applied to make sure that the total consumption is in agreement with the total consumption in the energy statistics. Thus, the fluctuations in fuel consumption time series for waste incineration reflect a methodological issue, not actual time series fluctuations.

The emission of As has been reduced 79 % and all other HMs have been reduced more than 95 %, see Table 4.5. This is a result of the decreased consumption of residual oil and waste and also the decreasing emission factors for waste incineration. The time series fluctuations follow the time series for these two fuels, see Figure 4.8.

In 1990, the emission from waste incineration was the largest emission source for all HMs except Ni. The largest emission source for Ni was residual oil. For As, Se and Zn combustion of residual oil was also a considerable emission source in 1990. Both consumption and emission factors have decreased for waste incineration since 1990 and as mentioned above the residual oil consumption has also decreased. Thus, other emission sources are primary sources in 2009.

In 2009 combustion of wood is the main emission source for As, Cd, Cu, Cr, Pb and Se. For Hg natural gas combustion is the largest emission source and natural gas is also a considerable source for As. Residual oil combustion is still the main emission source for Ni, and for Zn both residual oil, waste and gas engines (including Zn from lubricants) are main sources.

Table 4.5 Heavy metal emissions from commercial/institutional plants, 2009/1990 emission.

HM	2009 emission/1990 emission, %
As	21
Cd	1
Cr	2
Cu	3
Hg	2
Ni	3
Pb	1
Se	4
Zn	2

Figure 4.10 Time series for 1A4a Commercial/institutional plants.

4.3.2 1A4b Residential plants

The emission source category *Residential plants* consists of both stationary and mobile sources. In this chapter, only stationary sources are included. Figure 4.11 shows the time series for fuel consumption and emissions.

For residential plants, the total fuel consumption has been rather stable, and in 2009, the consumption was 2 % lower than in 1990. However, the consumption of gas oil has decreased since 1990 whereas the consumption of wood has increased considerably (four times the 1990 level). The consumption of natural gas has also increased since 1990.

All HM emission factors are the same in the time series 1990-2009 and thus the emission time series reflect time series for fuel consumption.

The HM emissions in 2009 were 61 % - 199 % of the 1990 emission level, see Table 4.6.

In general, combustion of mainly wood, but also straw, are the main emission sources and thus, the increased consumption of these fuels has caused the increase of emission level. However, for Ni residual oil combustion was the main source in 1990 and this consumption has decreased causing a decrease in Ni emission. The small consumption of coal was the major emission source for Se in 1990, but in 2009, this consumption had decreased to only 2 % of the 1990 level and this has caused the decrease for Se emission. For Hg gas oil was a considerable emission source in 1990 and due to the reduction of this fuel consumption, the Hg emission also decreased since 1990.

Table 4.6 Heavy metal emissions from residential plants, 2009/1990 emission.

HM	2009 emission/1990 emission, %
As	133
Cd	199
Cr	128
Cu	191
Hg	85
Ni	61
Pb	191
Se	80
Zn	195

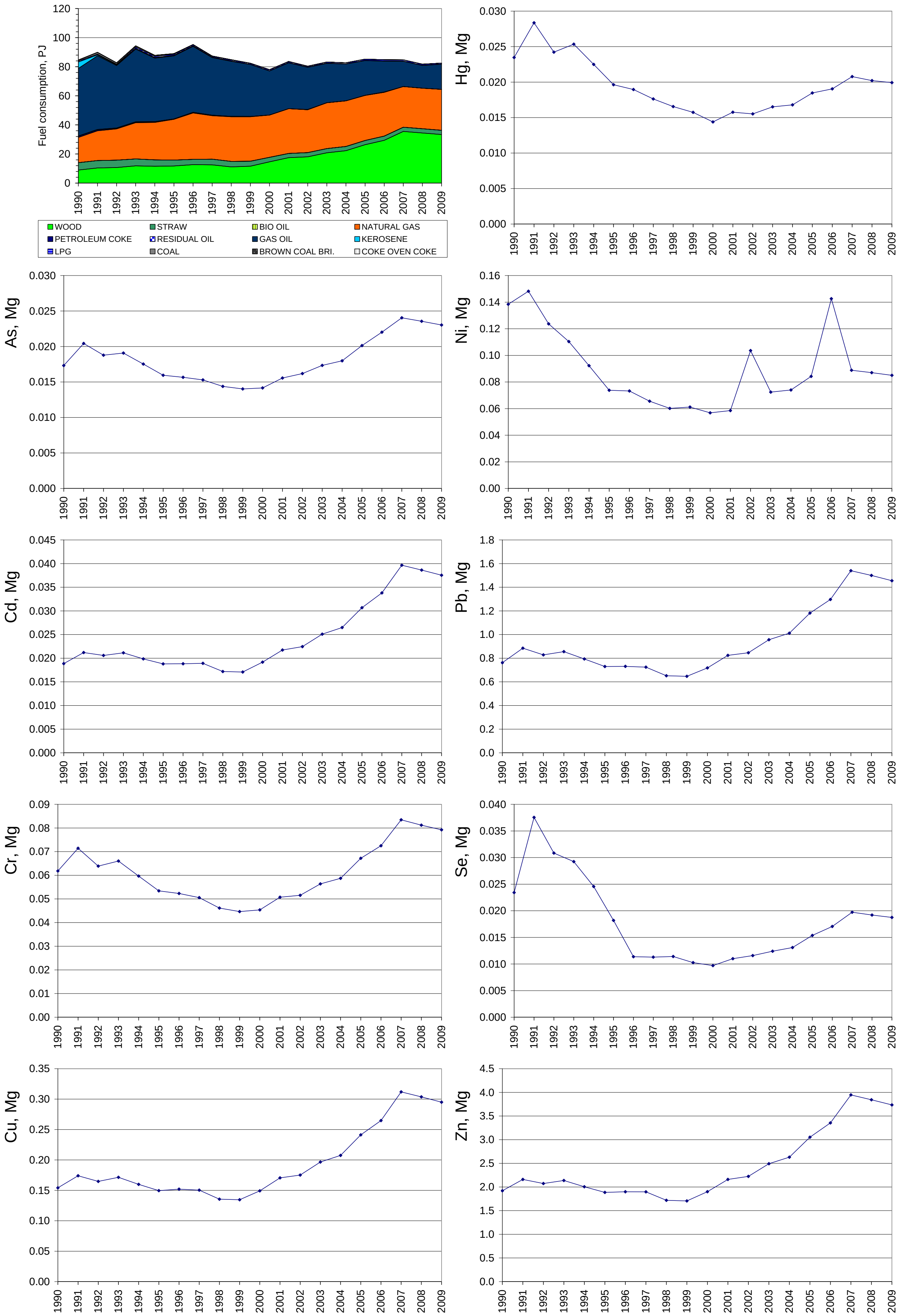


Figure 4.11 Time series for 1A4b Residential plants.

4.3.3 1A4c Agriculture/forestry

The emission source category *Agriculture/forestry* consists of both stationary and mobile sources. In this report, only stationary sources are included. Figure 4.12 shows the time series for fuel consumption and emissions.

For plants in agriculture and forestry, the fuel consumption has decreased 31 % since 1990. A remarkable decrease of fuel consumption has taken place since year 2000.

The type of fuel used has changed since 1990. In the years 1994-2004, the consumption of natural gas was high, but in recent years, the consumption decreased again. The decrease of natural gas consumption in later years is a result of the liberalisation of the electricity market that has caused lower production in CHP plants based on natural gas fuelled gas engines.

The consumption of straw has decreased since 1990. The consumption of both residual oil and gas oil has increased after 1990 but has decreased again in recent years. The coal and residual oil consumption has decreased 47 % and 49 % respectively.

In general, coal combustion is the main HM emission source. However, for Ni the main emission source is residual oil combustion. In addition, combustion of straw is a considerable emission source for Cd, Cu, Pb and Zn.

The HM emissions have decreased 47 %- 59 % since 1990, see Table 4.7. All emission factors are constant in the time series 1990-2009 and the HM emission time series reflect the fuel consumption time series. The decrease of HM emissions is mainly a result of the decrease of coal consumption (Figure 4.8) and the time series follows the time series for coal consumption closely. The Ni emission time series however follow the residual oil consumption time series (Figure 4.8).

Table 4.7 Heavy metal emissions from agriculture/forestry, 2009/1990 emission.

HM	2009 emission/1990 emission, %
As	47
Cd	44
Cr	43
Cu	43
Hg	41
Ni	50
Pb	41
Se	53
Zn	42

Figure 4.12 Time series for 1A4c Agriculture/forestry.

5 Methodology

The Danish emission inventory is based on the CORINAIR (CORe INventory on AIR emissions) system, which is a European program for air emission inventories. CORINAIR includes methodology, structure and software for inventories. The methodology is described in the EMEP/CORINAIR Emission Inventory Guidebook 3rd edition, 2007 update, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections (EEA 2007). Emission data are stored in an Access database from which data are transferred to the reporting formats.

The emission inventory for stationary combustion is based on activity rates from the Danish energy statistics. General emission factors for various fuels, plants and sectors have been determined. Some large plants, such as power plants, are registered individually as large point sources and plant-specific emission data are used.

5.1 Fuel consumption

The fuel consumption rates are based on the official Danish energy statistics prepared by the Danish Energy Agency (DEA). DCE aggregates fuel consumption rates to SNAP categories. Some fuel types in the official Danish energy statistics are added to a less detailed fuel aggregation level, see Annex 3.

The fuel consumption of the NFR category *Manufacturing industries and construction* (corresponding to SNAP category *03 Combustion in manufacturing industries)* is not disaggregated into specific industries in the DCE emission database[7]. So far, disaggregation into specific industries is only estimated for the reporting to the Climate Convention.

Non-traded fuels are included in the Danish energy statistics. Thus, for example, estimation of the annual consumption of non-traded wood is included. The consumption of non-traded wood is also included in the emission inventory.

Petroleum coke purchased abroad and combusted in Danish residential plants (border trade of 628 TJ in 2009) is not included in the Danish inventory. This is in agreement with the IPCC Guideline (IPCC, 1997).

For some large point sources, the CO_2 emission refers to the EU Emission Trading Scheme (EU ETS). For these plants, the fuel consumption also refers to EU ETS.

For all other large point sources, the fuel consumption refers to a DEA database (DEA 2010b). The DEA compiles a database for the fuel consumption of each district heating and power-producing plant, based on data reported by plant operators.

[7] Plant specific data are however disaggregated to industry specific SNAP levels. In 2009 the only HM emissions not included in NFR sector *1 A 2 f i Stationary combustion in manufacturing industries and construction: Other* is (part of) the emissions from iron foundries.

The fuel consumption of area sources is calculated as total fuel consumption minus fuel consumption of large point sources.

The Danish national energy statistics includes three fuels used for non-energy purposes, bitumen, white spirit and lubricants. The total consumption for non-energy purposes is relatively low, e.g. 10.6 PJ in 2009.

In Denmark all waste incineration are utilised for heat and power production. Thus, incineration of waste is included as stationary combustion in the source category *Energy* (subcategories *1A1*, *1A2* and *1A4)*.

Fuel consumption data are presented in Chapter 2.

5.2 Plant specific emission data

Plant specific HM emission data are collected annually from:

- The two major power plant owners (DONG Energy and Vattenfall). These data are based on the EMOK model presented below (Chapter 5.2.1). Unpublished data.
- Annual environmental reports/annual environmental reporting to a DEPA database published on the DEPA homepage (DEPA 2011) from remaining power plants > 25 MW_e.
- Annual environmental reports/annual environmental reporting to a DEPA database published on the DEPA homepage (DEPA 2011) from waste incineration plants.
- Plant specific emission data for the cement production plant Aalborg Portland performed in 1997. These emission data have been applied to estimate emission factors based on production data.
- Annual environmental report from a container glass production plant including Pb and Se emissions. Zn emission data were included in former environmental reports and calculated emission data for recent years have been based on historic data. Other HM emission data are based on fuel consumption and default emission factors for industrial combustion.
- Emission data for gray iron foundries are based on production data and emission factors from a former update of the EMEP/EEA Guidebook.

5.2.1 EMOK model

The two large power plant owners in Denmark DONG Energy and Vattenfall both apply the trace element emission model EMOK[8]. The model includes separate models for fugitive and solid HM emissions. The model is based on HM flow data in each power plant unit as shown in Figure 5.1 and Figure 5.2.

The EMOK model calculations are based on data for:

- Plant configuration including type of filter, type of desulphurisation unit and refuelling of ash.
- Fuel consumption and fuel data.
- Constant measurement data for TSP emission and flue gas flow available from the Automatic Monitoring System (AMS).
- A continuously updated fuel quality database including HM concentrations.

[8] EmissionsModel for Kraftværker.

The TSP reduction in the electrostatic filter (ESP) is usually > 99.9 % for Danish power plants (Knudsen 2008). Thus, particle bound HMs are also reduced efficiently. For fugitive HMs only the part bound to particles are reduced in the electrostatic filter. However, fugitive emissions are also reduced in the desulphurisation unit.

The reduction efficiencies have been measured for each trace element.

An example showing the EMOK model diagram, and data for particle bound emissions, is shown in Figure 5.1. The particle bound HM emissions are calculated based on measurements of particulate matter emissions and data for the increased HM concentration of small size fly ash particulates:

Emission = Flue gas flow · TSP concentration · HM concentration in ash · enrichment factor

where the enrichment factor express the higher concentration of HMs in the fly ash than in bottom ash fraction.

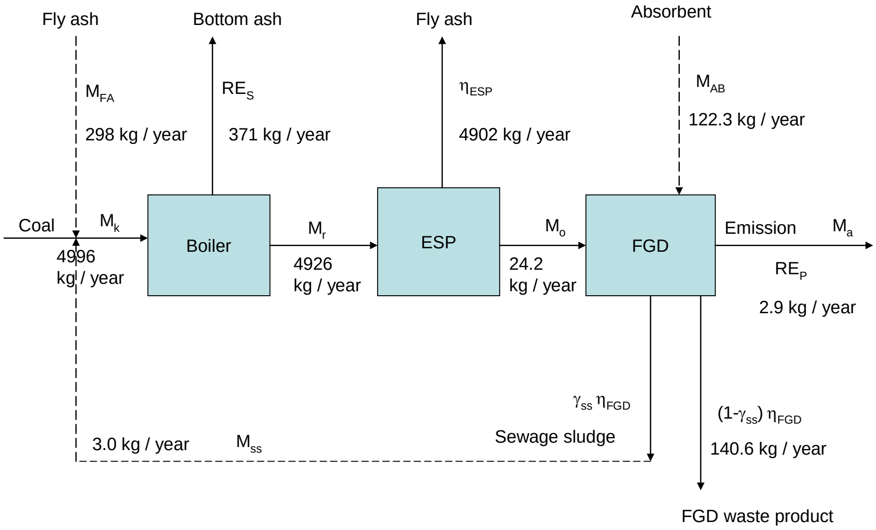


Figure 5.1 The EMOK model for particle bound trace metal emissions, example (Knudsen, 2008).

An example showing the EMOK model diagram and data for fugitive emissions is shown in Figure 5.2. Emissions are determined based on reduction efficiency in the particle filter and the desulphurisation unit. The emission of fugitive HMs is calculated as:

Emission = Fuel input · concentration · (1- slag fraction) · (1- η_{ESP}) · (1- η_{FGD})

where

η_{ESP} is the reduction efficiency of the electrostatic filter (ESP)

η_{FGD} is the reduction efficiency of the flue gas desulphurisation unit (FGD)

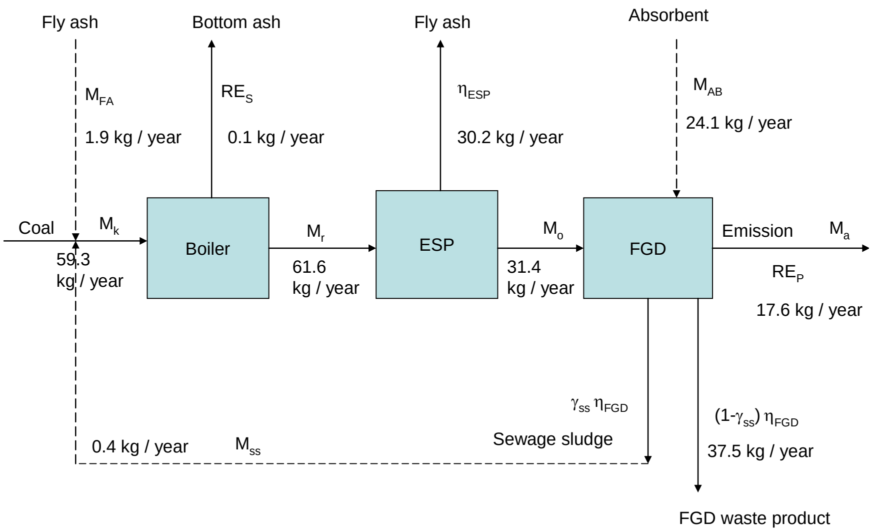


Figure 5.2 The EMOK model for fugitive trace metal emissions, example (Knudsen 2008).

The TSP and HM emission varies hugely even in stable operation, see Figure 5.3. Thus, in spite of the fact that direct HM emission measurements gives an accurate emission value at the time of measurement, a few random HM emission measurements are unsuited for estimates of the annual emission or an average emission factor. The EMOK model on the other hand is based on power plant specific data (reduction efficiency), fuel analysis, constant TSP emission measurements and plant specific operation statistics reported monthly. Thus, the power plant owners have assessed that the EMOK model gives a better estimate of the annual HM emission than an emission estimate that is only based on a few emission measurements annually.

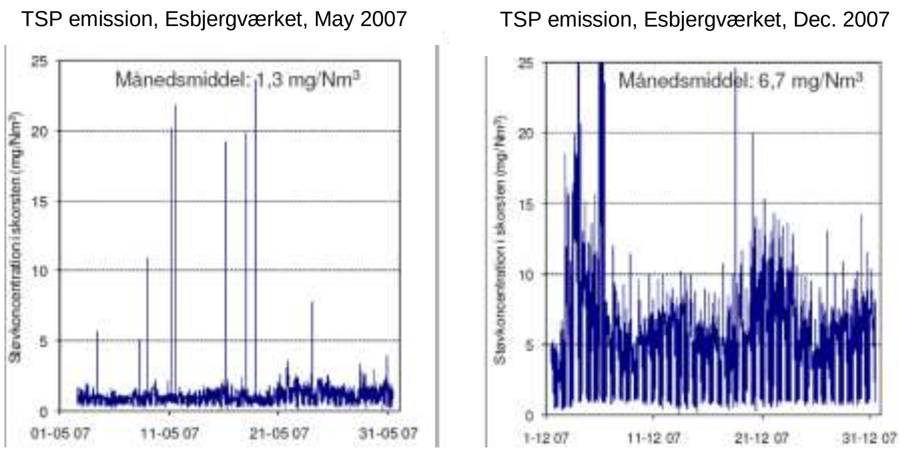


Figure 5.3 Two TSP emission measurements time series for the power plant Esbjergvaerket (Knudsen 2008).

5.3 Former HM emission factors

The HM emission factors applied in the emission inventory reported in 2010 are presented in Annex 1. The Annex includes references and time series. The former emission factors refer to:

- Research concerning heavy metal emission factors representative for Denmark (Illerup et al. 1999).
- Two emission measurement programs carried out on Danish decentralised CHP plants (Nielsen et al. 2010; Nielsen & Illerup, 2003).

Time series was estimated for waste incineration. For all other sources, the same emission factors were applied for 1990-2009.

6 Emission factors

Most of the applied HM emission factors refer to the EMEP/EEA Guidebook (EEA 2009). However, some additional data sources have been included:

- Emission factors for decentralised combined heat and power plants < 25 MW_e refer to three Danish studies including a large number of emission measurements: Nielsen et al. (2010), Nielsen & Illerup (2003) and Illerup et al. (1999).
- Country specific implied emission factors for large power plants/district heating plants combusting coal and/or residual oil.
- Heavy metal concentrations data for Danish natural gas have been included: Gruijthuijsen (2001) and Energinet.dk (2010),
- A CONCAWE study concerning HM concentrations in diesel oil (Denier van der Gon & Kuenen, 2009).

6.1 Solid fossil

6.1.1 Coal

Coal is mainly applied in large power plants from which plant specific emission factors are available from 1994 onwards. Thus, in recent years the main part of the emission from coal consumption is not based on the default emission factors for coal combustion. The plant specific Zn emission data have, however, only been reported since the year 2000. The coal consumption not covered by plant specific emission data has decreased since 1994.

91-96 % of the coal consumption is used in large power plants. Further 3-6 % is used in industrial plants. The consumption in district heating plants has decreased from 2% in 1990 to no consumption in 2008. Finally, 0-1 % is applied in agricultural plants and other energy sectors.

Power plants and large district heating plants

Country specific emission factors for the year 1990 have been estimated by Illerup et al. (1999). These country specific emission factors have been based on emission measurements performed at Danish plants. The Zn emission factor, however, refers to an older version of the EMEP/EEA Guidebook. Two datasets are presented in the report: Emission factors for point sources (large power plants) and Emission factors for coal combustion in general. Both datasets are shown in Table 6.1.

The EMEP/EEA Guidebook (EEA 2009) states the emission factors shown in Table 6.1. The Guidebook refers to US EPA (1998), chapter 1.1 for both the tier 1 and the tier 2 dataset, except the factors for Cu and Zn that refer to expert judgements based on the 2006 update of the Guidebook. The US EPA data are based on emission data at eleven facilities installed with both desulphurisation and electrostatic precipitators (ESP)/fabric filters (FF). Due to the lack of a recent update, the emission factors could be overestimated for recent years for plants using the best available technology.

Plant specific emission data have been reported annually by the plant owners DONG Energy and Vattenfall (Elsam[9], Elkraft[10] and Energi E2[11] in the beginning of the time series) since 1994. Thus, in recent years the main part of the emission from coal consumption is not based on the default emission factors for coal combustion. The plant specific Zn emission data have, however, only been reported since the year 2000. The plant specific data are based on mass balance model calculations for each production unit (*EMOK model* calculations).

Implied emission factors (IEF) for large power plants based on the plant specific data reported by the plant owners are also shown in Table 6.1. Detailed data for these IEFs are shown in Table 6.2. Only power plants for which more than 90 % of the fuel consumption is coal have been included in the estimates. All heavy metal emissions have been allocated to the coal consumption. The IEFs have been estimated for the years 1995, 2000, 2005 and 2008. The implied emission factors are below the emission level stated in the EMEP/EEA Guidebook (EEA 2009).

The IEFs have been reduced 36-90 % since 1995. The reduction efficiency of Hg and Se in the flue gas cleaning systems is less than for the other heavy metals (Meij & Winkel 2007). This is reflected in the time series of the IEFs that has been reduced less than for the other metals as a result of the improved flue gas cleaning implemented in Danish plants since 1995.

Model improvements have been implemented since 2005 (Møller 2006). This improvement has caused some inconsistencies in the time series, mainly for Zn. However, the data for previous years have not been recalculated by the plant owners and thus recalculated data are not available. DCE has decided that data based on the former model version is still relevant to apply.

Emission factors for coal fired power plants in the Netherlands reported by Meij & Winkel (2007) are shown in Table 6.1. These emission factors are in good agreement with the Danish implied emission factors for 2008.

The emission factors applied for the inventories for Sweden have been estimated by Kindbom et al. (2004). These emission factors[12] are above the implied emission factors for Danish power plants 1995.

[9] 1990-2006.
[10] 1990-1998.
[11] 1999-2006.
[12] Except for Se.

Table 6.1 Emission factors for coal combustion, power plants and district heating plants.

	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ
Illerup et al. (1999) Former EMF for area sources	3.2	0.1[5)]	2.3	3.1	1.7	4.4	6.0	0.5[5)]	10.5[6)]
Illerup et al (1999) Former EMF for power plants, point sources[1)]	3.3	0.1[5)]	8.02	4.41	2.20	6.81	6.0	13.0	10.5[6)]
EMEP/EEA (2009) GB tier 1, 1A1a, Table 3-3	8.0 (4.8-11)	1.0 (0.6-1.4)	5.0 (3.0-7.1)	4.8 (0.2-16)	1.6 (1.0-2.3)	5.4 (3.3-7.6)	8.1 (4.9-11.4)	25 (15-35)	19 (0.39-155)
EMEP/EEA (2009) GB tier 2, 1A1a, Table 3-16 (wet bottom boilers)	8.0 (5.0-12)	1.1 (0.6-1.5)	5.3 (3.2-7.5)	4.8 (0.2-16)	1.7 (3.4-8.0)	5.7 (3.4-8.0)	8.6 (5.2-12)	27 (16-37)	19 (0.4-155)
Kindbom et al. (2004)[7)]	3	0.5	10	10	3	8	24	3	10
Meij & Winkel (2007)	0.5	0.01	0.57	0.36	0.303[2)]	0.77	0.42	5.78[3)]	1.3
Implied emission factor 1995[4)]	0.93	0.12	4.7	3.3	1.8	6.8	6.0	11	-
Implied emission factor 2000[4)]	0.77	0.070	1.7	1.0	1.1	4.4	1.6	4.9	0.66
Implied emission factor 2005[4)]	0.53	0.047	1.0	0.60	1.3	1.3	1.0	4.4	2.1
Implied emission factor 2008[4)]	0.51	0.066	0.86	0.48	1.1	0.97	0.62	5.9	1.9

1) Based on plants installed with ESP

2) Dust: 0.003 mg/GJ, Gas: 0.3 mg/GJ

3) Dust: 2.18 mg/GJ, Gas: 3.6 mg/GJ

4) Detailed data are shown in Table 6.2 below

5) Based on the IEFs for 1995 onwards this emission factor is considered incorrect

6) Not included in the Danish dataset. The emission factor refers to an earlier update of the EMEP/EEA Guidebook.

7) Emission factors applied in the emission inventory for Sweden

Table 6.2 Implied emission factors (IEF) for power plants combusting coal.

	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn[2)]
	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ
IEF 1995	0.93	0.12	4.7	3.3	1.8	6.8	6.0	11	-
Stdev. IEF	1.37	0.10	5.05	3.48	1.28	6.05	5.84	11.28	-
Min IEF	0.02	0.02	0.50	0.38	0.83	0.84	0.75	0.03	-
Max IEF	4.35	0.44	19.23	9.58	6.74	22.32	21.16	48.07	-
Number of power plant units	23	23	23	9	23	23	23	23	-
Annual fuel consumption [PJ]	230	230	230	72	230	230	230	230	-
Annual fuel consumption [%][1)]	90%	90%	90%	28%	90%	90%	90%	90%	0%
IEF 2000	0.77	0.070	1.7	1.0	1.1	4.4	1.6	4.9	0.66
Stdev. IEF	0.87	0.06	2.91	1.56	0.71	6.05	2.46	4.48	1.22
Min IEF	0.13	0.01	0.44	0.28	0.77	1.41	0.50	0.10	-
Max IEF	3.37	0.18	11.80	6.40	2.80	21.06	10.11	16.97	3.04
Number of power plant units	14	14	14	14	14	14	14	14	10
Annual fuel consumption [PJ]	146	146	146	146	146	146	146	146	73
Annual fuel consumption [%][1)]	95%	95%	95%	95%	95%	95%	95%	95%	48%
IEF 2005	0.53	0.047	1.0	0.60	1.3	1.3	1.0	4.4	2.1
Stdev. IEF	0.52	0.05	1.49	1.04	1.03	2.42	2.19	3.91	2.30
Min IEF	0.04	0.00	0.01	0.10	0.74	0.17	0.11	0.04	0.20
Max IEF	1.64	0.18	5.20	3.66	4.70	8.98	8.03	10.56	8.13
Number of power plant units	13	13	13	13	13	13	13	13	13
Annual fuel consumption [PJ]	139	139	139	139	139	139	139	139	139
Annual fuel consumption [%][1)]	96%	96%	96%	96%	96%	96%	96%	96%	96%
IEF 2008	0.51	0.066	0.86	0.48	1.1	0.97	0.62	5.9	1.9
Stdev. IEF	0.58	0.08	0.71	0.39	1.10	0.73	0.46	4.03	1.65
Min IEF	0.01	0.01	0.16	0.10	0.71	0.23	0.13	0.04	0.40
Max IEF	2.19	0.27	2.49	1.33	4.79	2.27	1.46	9.82	5.70
Number of power plant units	13	13	13	13	13	13	13	11	13
Annual fuel consumption [PJ]	159	159	159	159	159	159	159	141	159
Annual fuel consumption [%][1)]	98%	98%	98%	98%	98%	98%	98%	87%	98%

[1)] % of the Danish coal consumption in power plants and district heating plants.

[2)] Model improvements implemented since 2005 has caused considerable inconsistency of the time series.

The emission factors for power plants[13] estimated by Illerup et al. (1999) will be applied for 1990 in future inventories. The implied emission factors estimated for 1995, 2000, 2005 and 2008 will be applied for these years. A constant decrease between these five emission factor datasets has been assumed. Some exceptions have been made as a result of the analysis of the collected data in Table 6.1 and Table 6.2.

The Cd emission factor for 1990 is considered incorrect. Instead, the emission factor 1.1 mg/GJ referring to EMEP/EEA Guidebook (EEA 2009) for wet bottom boilers will be applied for 1990.

The Zn implied emission factors has been influenced considerably by the model improvements in 2005 onwards. The implied emission factor for the year 2000 will be ignored. The emission factor 19 mg/GJ referring to the

[13] Point sources.

EMEP/EEA Guidebook (EEA 2009) will be applied for 1990 and a linear development assumed from 1990 to 2005.

The IEFs for Cd fluctuate for the years 2000-2008. The emission factor 0.070 mg/GJ will be applied for 2000-2008.

The IEFs for Hg fluctuate for the years 2000-2008. The emission factor 1.3 mg/GJ will be applied for 2000-2008.

The IEFs for Se fluctuate for the years 2000-2008. The emission factor 5.9 mg/GJ will be applied for 2000-2008.

The emission factors applied for future inventories are shown in Table 6.3.

Table 6.3 Future emission factors for coal combustion in power plants and district heating[1)].

Pollutant	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ
1990	3.3	1.1	8.0	4.4	2.2	6.8	6.0	13	19
1995	0.93	0.12	4.7	3.3	1.8	6.8	6.0	11	-
2000	0.77	0.070	1.7	1.0	1.3	4.4	1.6	5.9	-
2005	0.53	0.070	1.0	0.60	1.3	1.3	1.0	5.9	2.1
2008	0.51	0.070	0.86	0.48	1.3	0.97	0.62	5.9	1.9

[1)] Linear development between the stated emission factors assumed.

Other plants combusting coal

As mentioned above 4-6 % of the coal consumption is applied in industrial plants (1A2) and 0-1 % is applied in agricultural plants and other energy sectors (1A4).

For industrial (boiler) plants, the EMEP/EEA Guidebook (EEA 2009) refers to the emission factors for other boiler plants. The Danish industrial boiler plants are considered to be similar to the boilers in other energy sectors (1A4).

The emission factors for other energy sectors (1A4) from the EMPE/EEA Guidebook (EEA 2009) are shown in Table 6.4. These factors refer to earlier versions of the Guidebook. The Guidebook values for power plants are also shown in the table. The Se emission factor for other energy sectors is lower than the emission factor applied for Danish power plants in 2008. This is considered unlikely and the Guidebook emission factor for power plants has been applied instead. Further the As emission factor for residential plants is lower than the emission factor for power plants in the same update of the Guidebook.

The Guidebook values for commercial/institutional/agricultural plants (1A4a/c) have been applied for the source categories industry (1A2) and other energy (1A4). For Se, however, the emission factor for the sector electricity and district heat production (1A1a) has been applied.

Table 6.4 Emission factors for coal combustion, other.

	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ
EMEP/EEA (2009) GB tier 1, 1A1a, Table 3-3	8.0 (4.8-11)	1.0 (0.6-1.4)	5.0 (3.0-7.1)	4.8 (0.2-16)	1.6 (1.0-2.3)	5.4 (3.3-7.6)	8.1 (4.9-11.4)	25 (15-35)	19 (0.39-155)
EMEP/EEA (2009) GB tier 2, 1A1a, Table 3-16 (wet bottom boilers)	8.0 (5.0-12)	1.1 (0.6-1.5)	5.3 (3.2-7.5)	4.8 (0.2-16)	1.7 (3.4-8.0)	5.7 (3.4-8.0)	8.6 (5.2-12)	27 (16-37)	19 (0.4-155)
EMEP/EEA (2009) GB tier 1, 1A4a/c, Table 3-7	4 (0.2-8)	1.8 (0.2-5)	13.5 (0.5-20)	17.5 (5-50)	7.9 (5-10)	13 (0.5-30)	134 (50-300)	1.8 (0.2-3)	200 (50-500)
EMEP/EEA (2009) GB tier 1, 1A4b, Table 3-3	2.5 (1.5-5)	1.5 (0.5-3)	11.2 (10-15)	22.3 (20-30)	5.1 (3-6)	12.7 (10-20)	130 (100-200)	1 (1-2.4)	220 (120-300)
EMEP/EEA (2009) GB tier 2, 1A4a/c, Table 3-27: Non-residential, 50-1000 kW_{th} boilers burning coal fuels	5 (0.5-8)	3 (1-5)	15 (1-20)	30 (8-50)	7 (5-9)	20 (2-30)	200 (80-300)	2 (0.5-3)	300 (100-500)
Kindbom et al. (2004)[1)]	3	4	10	10	4	8	24	3	210
Häsänen et al. (1986)	5.3	0.38	26	-	0.028	25	21	-	57

[1)] Emission factors applied in the emission inventory for Sweden.

6.1.2 Brown coal briquettes

Brown coal briquettes have not been applied in Denmark since 2003. Before that, the consumption was also low, below 0.2 PJ all years. The main part of the consumption takes place in *Residential plants* and in *Agriculture/forestry*. In addition, there is a small consumption in *Industry* and in *Commercial/Institutional*.

Emission factors refer to the EMEP/EEA Guidebook (EEA 2009). The tier 1 emission factors for brown coal are identical to the hard coal emission factors for both *Residential plants* and *Agriculture/forestry* and *Commercial/Institutional*. Both emission factor datasets refer to an earlier update of the Guidebook.

For industrial plants, the emission factors for *Agriculture/forestry* will be applied. This is in accordance with the EMEP/EEA Guidebook (EEA 2009).

Time series have not been estimated.

Table 6.5 Emission factors for brown coal combustion.

	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ
EMEP/EEA (2009) Small combustion, Table 3-7 Tier 1, 1A4a/c Hard coal and brown coal	4 (0.2-8)	1.8 (0.2-5)	13.5 (0.5-20)	17.5 (5-50)	7.9 (5-10)	13 (0.5-30)	134 (50-300)	1.8 (0.2-3)	200 (50-500)
EMEP/EEA (2009) Small combustion, Table 3-3 Tier 1, 1A4b, Hard coal and brown coal	2.5 (1.5-5)	1.5 (0.5-3)	11.2 (10-15)	22.3 (20-30)	5.1 (3-6)	12.7 (10-20)	130 (100-200)	1 (1-2.4)	220 (120-300)

6.1.3 Coke oven coke

Coke oven coke is mainly applied in industrial plants. In addition, a small consumption occurs in residential plants. The total consumption of coke oven coke has been below 1.5 PJ all years.

Emission factors refer to the EMEP/EEA Guidebook (EEA 2009). Coke is included in the fuel category hard coal.

Time series have not been estimated.

Table 6.6 Emission factors for coke oven coke.

	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ
EEA (2009) tier 1, 1A4a/c,	4	1.8	13.5	17.5	7.9	13	134	1.8	200
Table 3-7	(0.2-8)	(0.2-5)	(0.5-20)	(5-50)	(5-10)	(0.5-30)	(50-300)	(0.2-3)	(50-500)
Hard coal and brown coal									
EEA (2009) tier 1, 1A4b,	2.5	1.5	11.2	22.3	5.1	12.7	130	1	220
Table 3-3	(1.5-5)	(0.5-3)	(10-15)	(20-30)	(3-6)	(10-20)	(100-200)	(1-2.4)	(120-300)
Hard coal and brown coal									

6.2 Liquid fossil

6.2.1 Petroleum coke

Petroleum coke is mainly applied in industrial plants, primarily cement industry. For the cement industry, plant specific data are included and thus, the emission factors are only applied to a minor part of the consumption. Petroleum coke is also applied in residential plants and to a lesser degree in other stationary combustion plant categories. The total consumption is below 10 PJ.

The EMEP/EEA Guidebook (EEA 2009) includes petroleum coke as part of the fuel category heavy fuel oil. This fuel category also includes residual oil that is further discussed in Chapter 6.2.2.

The emission factors for residual oil will be applied for petroleum coke in future inventories.

6.2.2 Residual oil

The consumption of residual oil has decreased from 39 PJ in 1990 to 17 PJ in 2008. Residual oil is mainly applied in electricity and heat production and in industrial plants.

Plant specific emission data are available for the large power plants. Data have been stated by the plant owners DONG Energy and Vattenfall (Elsam, Elkraft and Energi E2 in the beginning of the time series) from 1994 onwards. The plant specific Zn emission data have, however, only been reported since the year 2000. The plant specific data are based on mass balance model calculations for each production unit (*EMOK model*[14] calculations).

Implied emission factors (IEF) for large power plants based on the plant specific data reported by the plant owners have been estimated for the plants

[14] See Chapter 5.2.1.

that mainly apply residual oil. Only power plants for which more than 90 % of the fuel consumption is residual oil have been included in the estimates. All heavy metal emissions have been allocated to the residual oil consumption. The estimated IEFs fluctuate but show no significant increase/decrease. As a result, only average IEFs for 1994-2008 are applied and shown in Table 6.7. These IEFs have been applied for *Electricity and district heat production* in 1990 onwards.

The EMEP/EEA Guidebook (EEA 2009) includes emission factors for *Energy Industries* shown in Table 6.7. Both emission factor datasets refer to US EPA (1998). The chapters on small combustion and industry do not include emission factors for residual oil combustion but only for liquid fuel. These emission factors are not considered applicable for residual oil.

Emission factors stated by Illerup et al. (1999) based on data from Denmark are also shown in Table 6.7. Emission factors for fuel oil combustion in power plants are based on data from Danish plants equipped with ESP, ESP + SD or ESP + WET, respectively. The emission factors for fuel oil combustion in plants with ESP were based on the assumption that 60 % of all heavy metal content of the fuel oil is emitted. The emission factors for area sources refer to an earlier update of the EMEP/EEA Guidebook and are not considered valid.

Finally, emission factors stated by US EPA (2010), Sippula et al. (2009), Reddy et al. (2005), and Häsänen et al. (1986) are also shown in Table 6.7. The estimated implied emission factors[15] are remarkably high compared to data for power plants with ESP stated by Illerup et al. (1999).

In future inventories the EMEP/EEA (2009) emission factors will be applied for all other sectors than *Electricity and district heat production*. To ensure that the emission from large industrial plants equipped with ESP is not overestimated plant specific data will be included if available.

A considerable part of the fuel oil consumption is related to starting the waste incineration units. It is likely that the HM emission related to this fuel oil consumption is not fully included in the stated annual emission data from the waste plants that is based on emission measurements at full load. This problem has not been addressed in the inventory.

[15] Except Cd.

Table 6.7 Emission factors for residual oil combustion, power plants and district heating plants.

	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ
Illerup et al. (1999) Area sources	14.07	13.5	33.33	12.96	4.3	642	23.46	12.3	2.72
Illerup et al. (1999) Power plants with ESP Point sources[1)]	1.48	4.43	1.33	1.48	0.15	191	1.48	0.59	11.7[2)]
Illerup et al. (1999) Power plants with ESP + SD	0.13	3.5	0.72	0.86	0.074	92.10	1.48	0.006	-
Illerup et al. (1999) Power plants with ESP + WET	0.52	2.88	0.66	0.75	0.083	138.16	0.66	0.19	-
Implied emission factor	2.1	0.53	2.6	2.4	0.21	362	2.6	1.2	7.4
EMEP/EEA (2009) Tier 1, 1A1a, Table 3-7 Heavy fuel oil	4.3 (2.1-8.5)	1.3 (0.6-3.0)	2.7 (1.4-5.5)	5.7 (2.8-11)	0.4 (0.2-1.0)	273 (140-550)	4.9 (2.4-10)	2.2 (1.1-4.4)	94 (47-190)
EMEP/EEA (2009) Tier 2, 1A1a, Table 3-13 (Residual oil, dry bottom boilers)	4.0 (2.0-8.0)	1.2 (0.6-2.4)	2.5 (1.3-5.1)	5.3 (2.7-11)	0.3 (0.2-0.7)	255 (127-510)	4.6 (2.3-9.1)	2.1 (1.0-4.1)	88 (44-176)
Kindbom et al. (2004)[3)]	1.2	0.4	0.7	5	0.06	240	15	1.5	12
Sippula et al. (2009) 4 MW heavy fuel oil burner, unabated	0.12	-	27	1.5	-	130-200	0.91	-	7.2
Häsänen et al. (1986)	1.48	0.0076	3.0	-	0.00136	420	4.9	-	15.0
Reddy et al. (2005)	0.126-0.437	0.00612-0.0117	0.0012-0.0525	0.0758-0.217	0.000201-0.283	0.0311-0.0330	0.00122-0.0126	0.0117-0.0501	0.248-0.408
US EPA (2010) Distillate fuel oil combustion	1.8	1.4	1.4	2.7	1.4	1.4	4.1	6.8	1.8
US EPA (2010) Uncontrolled fuel oil combustion	3.8	1.2	2.4	5.1	0.3	244	4.4	2.0	84
Fontelle 2009	4.5	1.25	8.5	6.5	2	700	9.2	4	25

1) Based on plants installed with ESP.

2) Not included in the Danish dataset. The emission factor refers to an earlier update of the EMEP/EEA Guidebook.

3) Emission factors applied in the emission inventory for Sweden.

6.2.3 Gas oil

The gas oil consumption has decreased from 56 TJ in 1990 to 21 PJ in 2008. Gas oil is mainly applied in residential plants that accounts for more than 70 % of the consumption. Commercial/institutional plants also account for a considerable consumption.

The former emission factors shown in Table 6.8 all refer to a former update of the EMEP/EEA Guidebook as cited by Illerup et al. (1999). Emission factors from the updated EMEP/EEA Guidebook (EEA 2009) are also shown in Table 6.8. The tier 1 emission factors refer to US EPA (1998). Tier 2 emission factors for gas turbines and gas engines refer to US EPA 2000 and US EPA 1998 respectively.

The Danish emission measurement programme for decentralised CHP plants (Nielsen et al. 2010) included a HM emission measurement from a gas oil fuelled engine. The emission factors measured in this study were in general lower than the Guidebook values, but this might be a result of the lower detection limits that has been attained in recent years. However, the Zn emission is much higher than the Guidebook values. This might partly be a result of the additional emission from lubricant use in reciprocating engines. Zn is an additive applied for lube oil (Jørgensen et al. 2010).

The European CONCAWE research organisation recently analysed metal content in diesel available from gas filling stations (Denier van der Gon & Kuenen, 2009). 110 samples collected in nine European countries were analysed. Emission factors estimated on the HM content assuming full emission of all metals are shown in Table 6.8. This study is considered the most comprehensive dataset and representative for gas oil consumption in Danish stationary combustion. A Danish refinery has confirmed that the HM content is the same for both stationary and mobile combustion of gasoil (Holst 2010).

For engines the emission factors will refer to Nielsen et al. (2010) whereas the emission factors for other technologies will refer to the CONCAWE study (Denier van der Gon & Kuenen, 2009).

Table 6.8 Emission factors for gas oil combustion.

	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ
Illerup et al. (1999)[1)]	1.17	0.23	0.94	1.17	1.17	0.64	2.34	4.68	11.7
Nielsen et al. 2010, reciprocating engines[2)]	<0.055	<0.011	0.2	0.3	<0.11	0.013	0.15	<0.22	58[4)]
EMEP/EEA (2009) Energy Industries, Table 3-8 Tier 1, Other liquid fuels	1.8 (0.2-20)	1.4 (0.1-15)	1.4 (0.1-15)	2.7 (0.3-30)	1.4 (0.1-15)	1.4 (0.1-15)	4.1 (0.4-40)	6.8 (0.7-70)	1.8 (0.2-20)
EMEP/EEA (2009) Energy industries, Table 3-21 Tier 2, 1A1a, Gas oil, gas turbines	-	2.2 (0.7-6.5)	5.0 (1.7-14.9)	-	0.5 (0.2-1.6)	-	6.3 (2.1-19)	-	-
EMEP/EEA (2009) Energy industries, Table 3-22 Tier 2, 1A1a, Gas oil, reciprocating engines	1.8 (0.2-18)	1.4 (0.1-14)	1.4 (0.1-14)	2.7 (0.3-27)	1.4 (0.1-14)	1.4 (0.1-14)	4.1 (0.4-41)	6.8 (0.7-68)	1.8 (0.2-18)
EMEP/EEA (2009) Small combustion, Table 3-36 Gas turbines	-	2.17	4.98	-	0.543	-	6.34	-	-
Kindbom et al. (2004)	0.4	0.2	0.5	2	0.1	0.8	2.4	0.16	1.6
CONCAWE (Denier van der Gon & Kuenen, 2009) Based on diesel oil concentrations[3)]	<0.002	<0.001	0.20	0.13	<0.12	0.005	0.012	<0.002	0.42

[1)] Refers to an earlier update of the EMEP/EEA Guidebook (EEA 2009).

[2)] Based on one measurement.

[3)] Based on fuel concentration. Data shown in the table are estimated by NERI assuming that all metals are emitted in flue gas.

[4)] The emission factor for Zn is remarkably high. This might partly be a result of the emission originating from lube oil.

6.2.4 Kerosene

In 1990, the consumption of kerosene was 5 PJ, but for all other years, the consumption was below 1 PJ. Kerosene is mainly used in residential plants. The emission factors for gas oil will be applied in future inventories.

6.2.5 Orimulsion

Orimulsion have only been applied in one power plant unit (Asnaes 5) in Denmark and only in the years 1995-2004. Plant specific emission factors are available for all years. Implied emission factors shown in Table 6.9 have been estimated based on emission data for year 2000.

The emission factors are not applied in the Danish inventories but only estimated for information.

Table 6.9 Emission factors for orimulsion (after flue gas cleaning).

	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ
Implied emission factors[16] year 2000	0.13	0.03	0.13	0.24	0.12	2.0	0.32	1.1	2.1

6.2.6 LPG

The LPG consumption is below 3 PJ for all years. LPG is mainly applied in industrial and residential plants.

The EMEP/EEA Guidebook (EEA 2009) includes LPG as part of the fuel category *Other liquid fuels* that also includes gas oil.

The emission factors for gas oil will be applied in future inventories.

6.2.7 Refinery gas

The consumption of refinery gas is approximately 15 TJ per year. Refinery gas is mainly applied in petroleum refining.

The emission factors for other liquid fuels stated by EMEP/EEA (2009) will be applied in future inventories. The emission factors are shown in Table 6.10. The EMEP/EEA emission factors all refer to US EPA (1998).

Time series have not been estimated.

Table 6.10 Emission factors for refinery gas.

	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ
EMEP/EEA (2009), Tier 1, Table 3-8, 1A1a, Other liquid fuels	1.8 (0.2-20)	1.4 (0.1-15)	1.4 (0.1-15)	2.7 (0.3-30)	1.4 (0.1-15)	1.4 (0.1-15)	4.1 (0.4-40)	6.8 (0.7-70)	1.8 (0.2-20)

6.3 Gaseous fossil

6.3.1 Natural gas

The natural gas consumption increased from 76 PJ in 1990 to 172 PJ in 2008. Natural gas is applied in all sectors but the largest consumptions are in energy industries, industrial plants and residential plants.

In recent years, a considerable part of natural gas is applied in gas engines and in 2008, the consumption in gas engines was 18 PJ. The gas engines use

16 All HM emissions have been allocated to orimulsion. Consumption of residual oil adds up to less than 1 %.

lubricants that also contain metals. The emission from lube oil is included in the emission factors for the gas engines.

The tier 1 emission factors for natural gas stated in the EMEP/EEA Guidebook (EEA 2009) are shown in Table 6.11. These emission factors refer to US EPA (1998). The Hg emission factor for *Energy Industries*, however, refers to van der Most & Veldt (1992)[17].

The heavy metal content of Danish natural gas have been measured in 2001 (Gruijthuijsen 2001) and are also shown in Table 6.11. An additional Hg analysis is also shown (Larsen 2009).

The Hg content of natural gas varies considerably over time (Ryzhov et al. 2002). Thus, the few measurements performed for Danish natural gas are considered insufficient for estimating a valid emission factor. The interval stated by Ryzhov et al. (2002) is also shown in Table 6.11.

The As content of Danish natural gas have been reported by the Danish gas transmission company Energinet.dk (2010). The As content was measured in 2002 and the emission factor is shown in Table 6.11.

Table 6.11 Emission factors for natural gas.

Pollutant	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ
EEA (2009), tier 1, 1A1a, Table 3-5 Energy industries Ref: US EPA (1998)	0.09 (0.03-0.3)	0.5 (0.2-1.5)	0.7 (0.2-2)	0.4 (0.2-0.8)	0.10 (0.05-0.15)	1.0 (0.5-2.0)	0.2 (0.1-0.7)	0.01 (0.004-0.03)	14 (4.5-40)
EEA (2009), tier 1, 1A4b.i, Table 3-4 Residential plants Ref: US EPA (1998)	0.0937 (0.0312-0.281)	0.515 (0.172-1.55)	0.656 (0.219-1.97)	0.398 (0.199-0.796)	0.234 (0.0781-0.703)	0.984 (0.492-1.97)	0.984 (0.492-1.97)	0.0112 (0.00375-0.0337)	13.6 (4.53-40.7)
Energinet.dk (2010)[2)]	0.119	-	-	-	-	-	-	-	-
Gruijthuijsen (2001)[3)]	-	0.00025	0.00076	0.000076	0.68	0.00051	0.0015	-	0.0015
Larsen (2009)[4)]	-	-	-	-	0.0013	-	-	-	-
Ryzhov et al. (2002)[5)]	-	-	-	-	0.03-5	-	-	-	-
Nielsen et. al. (2010) Natural gas fuelled engines[1)]	0.05	0.003	0.05	0.01	0.1	0.05	0.04	0.01	2.9

[1)] Including the emission from lube oil (but not including emissions from oil in dual fuel engines).
[2)] Measurements on Danish natural gas. Based on measurements performed in 2002: 4.7 µg/m_n^3 , 39,419 MJ/m_n^3 (gas quality data for 2009).
[3)] Measurements on Danish natural gas. All measurements below the detection limit. Gas quality data for 2009 have been applied for conversion from µg/Nm^3 to mg/GJ.
[4)] Measurement performed in 2003, reported by Danish Gas Technology Centre.
[5)] 1-200 ng/l. Refers to Shafawi A, Ebdon L, Foulkes M, Stockwell P, Corns W. Determination of total mercury in hydrocarbons and natural gas condensate by atomic fluorescence spectrometry. Analyst 1999;124:788 –796.

The emission factors for Cd, Cr, Cu, Ni, Pb and Zn will all be based on the measurements on Danish natural gas reported by Gruijthuijsen (2001). These emission factors are all below the emission factors suggested in the EMEP/EEA Guidebook (EEA 2009). This might be due to the lower detection limit for the more recent Danish measurements.

[17] The US EPA (1998) emission factor for Hg (0.105 mg/GJ) is however almost identical to the emission factor in the EMEP/EEA Guidebook value.

The emission factor for As will be based on the data from the Danish gas transmission company Energinet.dk (2010). This emission factor is slightly higher than the Guidebook factor (EEA 2009).

The Hg data from Danish natural gas are considered insufficient due to the high variability of this concentration. The EEA (2009) emission factor for *Energy Industries* will be applied for all sectors.

The concentration of Se in Danish natural gas has not been measured. The EEA (2009) emission factor for *Energy Industries* will be applied for all sectors.

Time series have not been estimated for natural gas HM emission factors.

The emission factors for natural gas fuelled engines will be applied for natural gas fuelled engines in all sectors and all years.

6.4 Biomass

6.4.1 Wood

The consumption of wood has increased from 18 PJ in 1990 to 63 PJ in 2008. Wood is mainly applied in residential plants and in electricity and district heat production plants. However, wood is also applied in industrial plants and in commercial/agricultural plants.

Residential wood combustion

The consumption in residential plants has increased from 9 PJ in 1990 to 36 TJ in 2008. In 1990, almost all wood consumption was wood log whereas the consumption of wood pellets was 8 PJ and the consumption of wood logs was 27 PJ in 2008. Wood chips accounts for a small consumption through the time series.

Technology specific time series for the Danish consumption of wood in residential plants has been estimated by Aarhus University based on information from Danish studies (Illerup et al. 2007). The time series for the ten different technologies are shown in Figure 6.1.

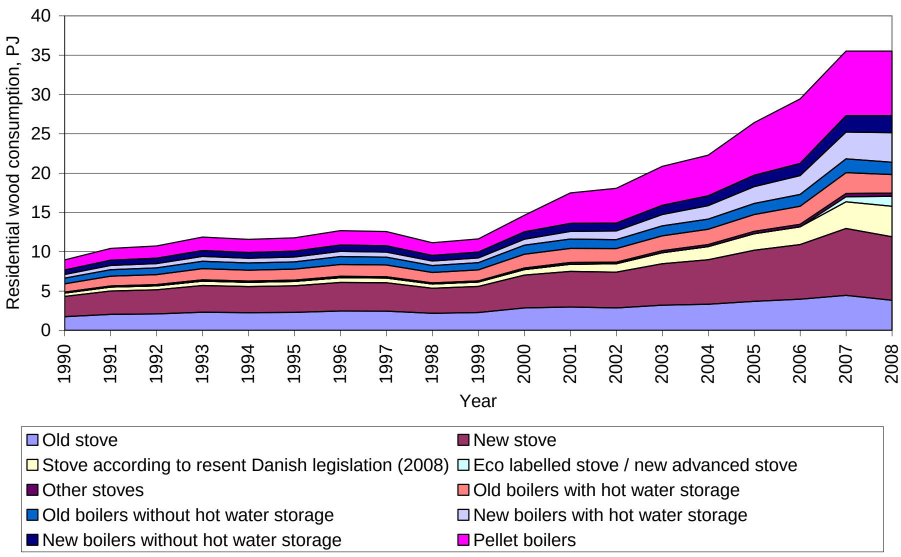


Figure 6.1 Time series for residential wood combustion, technology specific.

The EMEP/EEA Guidebook (EEA 2009) includes emission factors for a number of different technologies as shown in Table 6.12. However, only a very limited number of the heavy metal emission factors differ between technologies. The EMEP/EEA Guidebook (EEA 2009) refers to an earlier update of the Guidebook.

Emission factors referring to Tissari et al. (2007), Schmidl et al. (2008), Haakonsen & Kvingedal (2001), Palrud et al. (2010) and Hedberg et al. (2002) are also shown in Table 6.12.

Heavy metal emissions have not been included in the Danish emission measurement programmes.

As expected the emission factors for Hg seems independent of technology whereas the emission factors for the metals that are usually released as compounds associated and/or adsorbed with particles differ between references/technologies.

Other Danish emission factors for residential wood combustion are estimated based on emission factors for different technologies. However, the collected data are considered insufficient for a technology specific approach for estimating the emission factors for heavy metals from residential wood combustion. Instead, the Guidebook values (EEA 2009) for combustion of wood in stoves will be applied.

Table 6.12 Emission factors for residential wood combustion.

	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ
EEA (2009) Small combustion, Table 3-6 Tier 1, 1A4b Residential, biomass	1 (0.3-2.5)	1.4 (0.1-2.5)	2.9 (1-10)	8.6 (0.5-11.2)	0.5 (0.2-0.6)	4.4 (1-250)	40 (10-60)	0.5 (0.25-0.75)	130 (60-250)
EEA (2009) Small combustion, Table 3-14 Tier 2, 1A4b Fireplaces, biomass	0.5 (0.3-0.7)	2 (1.2-2.8)	1 (0.6-1.4)	8 (4.8-11.2)	0.4 (0.24-0.56)	2 (1.2-2.8)	40 (24-56)	0.5 (0.3-0.7)	100 (60-140)
EEA (2009) Small combustion, Table 3-17 Tier 2, 1A4b Stoves, wood and wood waste	0.5 (0.3-2.5)	1 (0.6-2.5)	2 (1.2-2.8)	8 (4.8-11.2)	0.4 (0.24-0.56)	2 (1.2-2.8)	40 (24-56)	0.5 (0.3-0.7)	100 (60-250)
EEA (2009) Small combustion, Table 3-18 Tier 2, 1A4b Boilers, wood and wood waste	2 (0.3-2.5)	2 (0.6-2.5)	5 (1.2-6)	10 (4.8-11.2)	0.6 (0.24-1)	10 (1.2-15)	40 (24-56)	0.5 (0.3-0.7)	200 (60-250)
EEA (2009) Small combustion, Table 3-24 Tier 2, 1A4b Advanced fireplaces, wood	0.5 (0.3-2.5)	1 (0.5-2.5)	8 (1-10)	2 (1-11.2)	0.4 (0.2-0.6)	2 (0.1-200)	30 (20-60)	0.5 (0.25-0.75)	80 (60-250)
EEA (2009) Small combustion, Table 3-25 Tier 2, 1A4b Advanced stoves, wood	0.5 (0.3-2.5)	1 (0.5-2.5)	8 (1-10)	2 (1-11.2)	0.4 (0.2-0.6)	2 (1-200)	30 (20-60)	0.5 (0.25-0.75)	80 (60-250)
EEA (2009) Small combustion, Table 3-26 Tier 2, 1A4b Pellet stoves, wood	0.5 (0.3-2.5)	0.5 (0.1-2.5)	3 (1-10)	1 (0.5-11.2)	0.4 (0.2-0.6)	2 (1-200)	40 (10-60)	0.5 (0.25-0.75)	80 (60-250)
Tissari et al. (2007) Stove	<5.2	<26	<26	6.3	-	<26	63	-	105
Tissari et al. (2007) All residential units	<5.2	<26	<26	4.7-89	-	<26	0.5-118	-	105-568
Schmidl et al (2008)	<5.2	<5.2-28	135-271	18-339	-	5-68	5-63	-	99-521
Haakonsen & Kvingedal (2001)[1)]	-	5.2	-	-	-	-	-	-	-
Palrud et al. (2010) -Small scale boilers -Small scale boilers chips/saw dust - stoves -open fireplace log	-	3	3	5	0.5	2.5	15	2.2	400
Hedberg et al. (2002) Stoves birch logs	<16	38	40	4	<119	4	21	1	471

[1)] Applied in the inventory for Norway.

Other wood combustion

Emission factors for CHP plants < 25 MW_e have been estimated as part of two Danish emission measurement programmes for CHP plants. The emission factors are applied for all non-residential wood combustion.

The emission factor for As estimated by Nielsen et al. (2003) might be overestimated as this factor is based on two measurements (from two plants) both below detection limit. The emission factor is above the Guidebook value (EEA 2009) and this reference will applied for the As emission factor. Se was not included in the two Danish studies and will also be based on the EMEP/EEA Guidebook (EEA 2009).

Table 6.13 Emission factors for other wood combustion.

	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ
EEA (2009) Small combustion, Table 3-6 Tier 1, 1A4a/c Commercial, biomass	1.4 (0.25-2)	1.8 (0.1-3)	6.5 (1-10)	4.6 (1-5)	0.7 (0.4-1.5)	2 (0.1-300)	24.8 (5-30)	0.5 (0.1-2)	114 (1-150)
Nielsen et al. (2003)	<2.34	<1	<2.34	<2.6	<0.8	<2.34	<3.62	-	-
Nielsen et al. (2010) CHP plants with fabric filter/ electrostatic precipitator	-	0.27	-	-	<0.4	-	-	-	2.3

6.4.2 Straw

The consumption of straw has increased from 12 PJ in 1990 to 15 PJ in 2008. In 1990 straw was applied equally in electricity and heat production, residential plants and agricultural plants. Since then the consumption in residential plants and agricultural plants have decreased to 3 PJ and 2 PJ respectively. The consumption in electricity and heat production plants has increased to 11 PJ in 2008.

CHP, district heating and industry

Emission factors for CHP plants < 25 MW_e have been estimated as part of two Danish emission measurement programmes for CHP plants. The As emission factor estimated by Nielsen & Illerup (2003) is based on 3 measurements below the detection limit and thus the emission factor might be overestimated. Instead, the emission factor will refer to the EEA (2009) values for commercial biomass combustion. Se was not included in the Danish studies and this emission factor will also refer to the EMEP/EEA Guidebook (EEA 2009) for commercial biomass combustion.

The Guidebook also includes emission factors for biomass combustion in public electricity and heat production. However, these emission factors refer to US EPA (1998) whereas the Guidebook values for both residential and commercial plants refer to an earlier update of the Guidebook. The emission factors referring to US EPA (1998) are higher[18] than the other emission factors and the emission factors from the Danish studies are closer to the emission factors for biomass combustion in commercial/institutional plants than for biomass combustion in public electricity and heat production.

Consistency of emission factors has led to the decision to apply the As and Se emission factors for commercial/institutional plants rather than for public electricity and heat production.

Emission factors for CHP plants will be applied for district heating plants and for the – very small – consumption in industrial plants.

[18] Except Pb.

Residential plants and agriculture/forestry

The EMEP/EEA Guidebook (EEA 2009) emission factors for residential plants will be applied for both residential plants and agricultural plants.

Table 6.14 Emission factors for straw combustion.

	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ
EEA (2009) Small combustion, Table 3-6 Tier 1, 1A4b Residential, biomass[1)]	1 (0.3-2.5)	1.4 (0.1-2.5)	2.9 (1-10)	8.6 (0.5-11.2)	0.5 (0.2-0.6)	4.4 (1-250)	40 (10-60)	0.5 (0.25-0.75)	130 (60-250)
EEA (2009) Small combustion, Table 3-10 Tier 1, 1A4a/c Commercial, biomass[1)]	1.4 (0.25-2)	1.8 (0.1-3)	6.5 (1-10)	4.6 (1-5)	0.7 (0.4-1.5)	2 (0.1-300)	24.8 (5-30)	0.5 (0.1-2)	114 (1-150)
EEA (2009) Energy industries, Table 3-9 Tier 1, 1A1a Public electricity and heat production[2)]	9.5 (5.7-13.2)	1.8 (1.1-2.5)	9.0 (5.4-12.6)	21 (13-29)	1.5 (0.9-2.1)	14 (8.5-20)	21 (12-29)	1.2 (0.7-1.7)	181 (108-253)
Nielsen Illerup (2003) CHP plants	<2.1	<0.8	<1.6	<1.7	<0.6	<1.7	<6.2	-	-
Nielsen et al. (2010) CHP plants with fabric filter/ electrostatic precipitator	-	<0.32	-	-	<0.31	-	-	-	0.41

[1)] Refer to an earlier update of the EMEP/EEA Guidebook (EEA 2009).

[2)] Refer to US EPA (1998).

6.4.3 Sewage sludge

Sewage sludge is included in the fuel category waste in the Danish energy statistics and in general also in the Danish emission inventory.

However, in 2000-2005 the cement production company in Denmark (Aalborg Portland) combusted sewage sludge (<0.4 PJ) and this consumption has not been included in waste fuel category in the Danish inventory[19].

The emission factors for waste will be applied for sewage sludge, see Chapter 6.5.1.

6.4.4 Bio oil

The consumption of bio oil has increased from 0.7 PJ in 1990 to 2 PJ in 2008. Bio oil is mainly used in electricity and heat production, but is applied in all sector categories.

Emission factors for bio oil are not available. The emission factors for gas oil (Chapter 6.2.3) will be applied.

[19] Sewage sludge have now been included as part of the fuel category waste.

6.4.5 Biogas

The consumption of biogas has increased from 0.7 PJ in 1990 to 4 PJ in 2008. Biogas is mainly used in electricity and heat production, but with considerable consumption in both commercial/institutional, agricultural/forestry and industrial plants.

Biogas includes manure gas, landfill gas and sludge gas with a consumption of 2.8 PJ, 0.3 PJ and 0.8 PJ respectively in 2008.

In recent years, a considerable part of biogas is applied in gas engines and in 2008 the consumption in gas engines was 2.3 PJ. The gas engines use lubricants that also contain metals. The emission from lubricants (in the flue gas) is included in the emission factors for the gas engines.

The EMEP/EEA Guidebook (EEA 2009) does not contain emission factors for metals from biogas.

Nielsen et al. (2010) includes emission factors for biogas engines. The emission factors are, however, based on a single measurement from an engine using landfill gas. Several of the emission factors are below the detection limit and may be overestimated. All emission factors are however relatively low and will be applied for all biogas consumption in Denmark in spite of the fact that additives from lubricants might have influenced the emission factors.

Table 6.15 Emission factors for biogas.

	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ	mg/GJ
Nielsen et al. 2010 Biogas fuelled engines	< 0.04	0.002	0.18	0.31	< 0.12	0.23	0.005	< 0.21	3.95

6.4.6 Gasification gas

A consumption of biomass gasification gas has been specified in the Danish emission inventories since 2008. Before that, gasification gas was included in the fuel category wood. The gasification gas is based on wood and used in gas engines. The consumption in 2008 was only 0.1 PJ, but the consumption will increase in coming years.

Gasification gas is used in gas engines in several different sectors and the same emission factor will be applied for all source categories.

The EMEP/EEA Guidebook (EEA 2009) does not contain emission factors for metals from biogas.

A gas engine combusting gasification gas was included in the Danish emission measurement programme for CHP plants (Nielsen et al. 2010). The emission factors are, however, based on a measurement from only one engine. Several of the emission factors are below the detection limit and may be overestimated. All emission factors are, however, relatively low. Additives in the lubricants used might have influenced the emission factors.

Table 6.16 Emission factors for gasification gas.

	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ
Nielsen et al. 2010 Gas engines combusting gasification gas based on wood	0.12	< 0.009	0.029	< 0.045	0.54	0.014	0.022	< 0.18	0.058

6.5 Other (Waste)

6.5.1 Waste

The incineration of solid waste increased from 15 PJ in 1990 to 41 PJ[20] in 2008. Almost all (> 90 %) waste is combusted in the emission source category electricity and district heat production. However, combustion also takes place in industry and commercial/institutional plants. The consumption in CHP plants has increased from ~ 6 % of the total waste consumption in 1990 to 88 % in 2008.

The fuel category *Waste* includes all waste incinerated for energy production. Municipal solid waste accounted for 46 % (w/w) in 2006 (DEPA 2010).

Plant specific HM emission data are available for a considerable number of waste incineration plants since year 2000. However, these data often only include some of the HMs.

Only one industrial plant (cement producer Aalborg Portland) incinerates a considerable amount of waste and plant specific HM emission data are available for this plant since 1990[21].

Emission factors for waste incineration are based on three Danish emission measurement programmes including waste incineration in CHP plants; Nielsen et al. (2010), Nielsen & Illerup (2003) and Illerup et al. (1999).

The emission factors estimated in these three Danish studies are shown in Table 6.17.

Table 6.17 Emission factors for waste incineration.

	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ
Illerup et al. (1999) Emission factors for 1990	7.82	31.32	186.1	123.49	132.42	191.96	722.60	-	804.88
Illerup et al. (1999) Emission factors for 1995	3.53[1)]	9.21	32.97	31.80	58.70	55.40	137.57	-	359.5
Nielsen & Illerup (2003) Emission factors for year 2000, based on 8-16 incineration units	6.8 (2.2-34)	4.8 (1-10.5)	2.5 (2.0-2.6)	10.1 (2.6-29)	7.4 (0.7-34)	4.8 (2.2-16)	123 (3-2855)	-	-
Nielsen et al. 2010 Emission factors for year 2006 onwards	0.59 (0.04-2.65)	0.44 (0.00-1.05)	1.56 (0.19-8.12)	1.30 (0.26-4.62)	1.79 (0.10-4.45)	2.06 (0.04-10.08)	5.52 (0.22-28.81)	1.11 (0.16-4.71)	2.33 (0.18-14.52)

[1)] Not applied.

[20] 3.9 · 10^6 tonnes.

[21] The plant specific HM emission data for Aalborg Portland are based on production rate. The emission factors might not be fully updated.

Nielsen et al. (2010) includes estimates of emission factor time series. The time series are based on two Danish studies: Nielsen & Illerup (2003) and Illerup et al. (1999).

2006 onwards

The emission factors referring to Nielsen et al. (2010) have been applied for all waste incineration plants in 2006 and onwards. Thus, the HM emission factors for the limited incineration of waste in industrial plants and district heating plants have been assumed equal to the emission from CHP plants. The legislation for the plant categories is the same.

CHP plants 2000-2006

The emission factors for CHP plants year 2000 refer to Nielsen & Illerup (2003). The emission factors have been applied for the years 2000-2003.

New emission limit values came into force for waste incineration plants in 2006. Modifications of the plants are assumed to have taken place over several years prior to 2006; therefore, a linear reduction of emission factors has been assumed between 2003 and 2006.

Nielsen et al. (2010) included emission measurements of selenium and zinc that were not part of the previous Danish studies. For selenium and zinc it has been assumed that the reduction since year 2000 for these two pollutants have been similar to that of lead. The choice of the lead emission factor as surrogate data is based on the high number of measurements for lead and that only a few of the measurements are below the detection limit.

Non-CHP plants 1995 – 2006

The plant/flue gas cleaning improvements documented for CHP plants in year 2000 were not fully implemented in the non-power producing waste incineration units. These units were in general older and smaller units. Thus, the emission factors estimated for CHP plants in year 2000 were below the emission level for district heating plants at that time. DCE has assumed that the emission level was implemented for non-power producing units in year 2003 and that the emission factor followed a linear reduction rate in 1995-2003.

1990-2000

The emission factors are discussed in Nielsen et Illerup (2003). Most data refer to Illerup et al. (1999). The emission factor for Se refers to the EMEP/EEA Guidebook (EEA 2009).

Table 6.18 Emission factor time series for waste incineration.

Year	As		Cd		Cr		Cu		Hg		Ni		Pb		Se		Zn	
	mg/GJ		mg/GJ		mg/GJ		mg/GJ		mg/GJ		mg/GJ		mg/GJ		mg/GJ		mg/GJ	
	CHP	Other	CHP	Other	CHP	Other	CHP	Other	CHP	Other	CHP	Other	CHP	Other	CHP	Other	CHP	Other
1990	7.8	7.8	31	31	186	186	123	123	132	132	192	192	723	723	25	25	805	805
1991	7.8	7.8	27	27	155	155	105	105	117	117	165	165	606	606	25	25	716	716
1992	7.8	7.8	22	22	125	125	87	87	103	103	137	137	489	489	25	25	627	627
1993	7.8	7.8	18	18	94	94	68	68	88	88	110	110	372	372	25	25	538	538
1994	7.8	7.8	14	14	64	64	50	50	74	74	82	82	255	255	25	25	449	449
1995	7.8	7.8	9.2	9.2	33	33	32	32	59	59	55	55	138	138	25	25	360	360
1996	7.6	7.7	8.3	8.7	27	29	28	29	49	53	45	49	135	136	25	25	298	322
1997	7.4	7.6	7.4	8.1	21	25	23	27	38	46	35	42	132	134	25	25	237	283
1998	7.2	7.4	6.6	7.6	15	22	19	24	28	40	25	36	129	132	25	25	175	245
1999	7	7.3	5.7	7	8.6	18	14	21	18	33	15	30	126	131	25	25	114	206
2000	6.8	7.2	4.8	6.5	2.5	14	10.1	18	7.4	27	4.8	24	123	129	25	25	52	168
2001	6.8	7.1	4.8	5.9	2.5	10	10.1	16	7.4	20	4.8	17	123	127	25	25	52	129
2002	6.8	6.9	4.8	5.4	2.5	6.3	10.1	13	7.4	14	4.8	11	123	125	25	25	52	91
2003	6.8	6.8	4.8	4.8	2.5	2.5	10.1	10.1	7.4	7.4	4.8	4.8	123	123	25	25	52	52
2004	4.7	4.7	3.3	3.3	2.2	2.2	7.2	7.2	5.5	5.5	3.9	3.9	84	84	17	17	35	35
2005	2.7	2.7	1.9	1.9	1.9	1.9	4.2	4.2	3.7	3.7	3	3	45	45	9.1	9.1	19	19
2006	0.59	0.59	0.44	0.44	1.56	1.56	1.3	1.3	1.79	1.79	2.06	2.06	5.52	5.52	1.11	1.11	2.33	2.33
2007	0.59	0.59	0.44	0.44	1.56	1.56	1.3	1.3	1.79	1.79	2.06	2.06	5.52	5.52	1.11	1.11	2.33	2.33
2008	0.59	0.59	0.44	0.44	1.56	1.56	1.3	1.3	1.79	1.79	2.06	2.06	5.52	5.52	1.11	1.11	2.33	2.33

6.6 Emission factors based on production data

The emission factors for some industrial plants are based on production data rather than fuel consumption. Thus:

- Plant specific emission data for the cement production plant Aalborg Portland refer to emission measurements performed in 1997. These emission data have been applied to estimate emission factors based on production data.
- Annual environmental report from a container glass production plant including Pb and Se emissions. Zn emission data were included in former environmental reports and calculated emission data for recent years have been based on historic data and emission factors related to production data. Other HM emission data are based on fuel consumption and default emission factors for industrial combustion.
- Emission data for gray iron foundries are based on emission factors relating to production data. The emission factors refer to a former update of the EMEP/EEA Guidebook.

7 QA/QC and validation

The QA/QC and validation for the HM emission inventory for stationary combustion is discussed in the sector report for stationary combustion: Nielsen et al. (2010b).

8 Planned improvements

Planned improvements for the HM emission inventory include:

- An update of the Guidebook will be published in 2013. Emission factors that are not nationally referenced will be revised accordingly.
- Emissions factors for refinery gas, LPG and kerosene might be overestimated.
- HM emissions from some industrial processes have been allocated from stationary combustion to industrial processes in the emission inventories reported in 2012 and 2013.

9 Uncertainty

According to the Good Practice Guidance for LRTAP Emission Inventories (Pulles & Aardenne, 2004) uncertainty estimates should be part of the LRTAP Convention reporting. Uncertainty estimates include uncertainty with regard to the total emission inventory as well as uncertainty with regard to trends.

9.1 Methodology

The Danish uncertainty estimates are based on the Tier 1 approach.

The uncertainty estimates are based on emission data for the base year 1990 and for the year 2009 as well as on uncertainties for fuel consumption and emission factors for each of the aggregated source categories.

In general, the source aggregation level follows the five fuel categories[22] and the NFR source categories[23]. However, a few exceptions are made to reflect the different data sources and related uncertainties.

- Plant specific annual emission data for large emission sources are considered independently. These data are based on emission measurements and/or model calculations with lower uncertainties than other emission sources. Data are disaggregated into power plants, waste incineration plants, industrial plants and remaining plants.
- The NFR sectors 1A4a and 1A4c are added to one source category due to the fact that the same emission factors have been applied to both categories and the source categories are not statistically independent.
- The emissions from residential wood combustion are considered individually. This is mainly due to the fact that this is a considerable source category in recent years.

The uncertainty for fuel consumption in stationary combustion plants refer to either IPCC (2000) default values or to national estimates.

Most of the applied uncertainties for emission factors are default values referring to the EEA Guidelines, 2009 update (EEA 2009). The default uncertainties for emission factors are given in letter codes representing an uncertainty range. It has been assumed that the uncertainties were in the lower end of the range for all sources and pollutants. Some of the uncertainties are however, DCE estimates or refer to other sources:

- The annual emission data available for large plants are considered separately. The total uncertainty has been estimated by DCE.
- For a minor part of the solid fuel consumption in electricity and district heat producing plants, plant specific annual data are not available. However, the emission factors are based on a large number of measurements and the uncertainty is estimated by DCE to be ± 10%.
- The uncertainty for waste incineration is relatively low due to the considerable number of emission measurements performed as part of the research programmes for CHP plants (Nielsen et al. 2010).

[22] Solid fuel, liquid fuel, gaseous fuel, waste and biomass fuels.
[23] 1A1a, 1A1b, 1A1c, 1A2, 1A4a, 1A4b and 1A4c.

- The uncertainty for non-industrial combustion has been assumed lower than the default value (1000 %), 300 % for biomass and 100 % for other fuels.
- The uncertainty for residential plants has also been assumed somewhat lower than the default value.
- The uncertainties for residential wood combustion have been based on the values in EMEP/EEA Guidebook (EEA 2009), Small combustion, Table 3-17.

The applied uncertainties for emission factors are listed in Table 9.1.

Table 9.1 Uncertainty rates for fuel rate and emission factors, %.

Source sector	Fuel rate uncertainty %	Reference	Emission factor uncertainty %	Reference
1A1a Annual emission values for LPS power plants	0	1)	5	NERI 2011
1A1a Annual emission values for LPS waste incineration	0	1)	10	NERI 2011
1A2 Annual emission values for LPS industrial plants	0	1)	50	NERI 2011
Annual emissions for other LPS	0	1)	50	NERI 2011
1A1a Solid fuel	1	IPCC 2000	10	NERI 2011
1A1a Liquid fuel	1	IPCC 2000	100/55[3)]	EEA 2009
1A1a Gaseous fuel	1	Lindgren 2010	100	EEA 2009
1A1a waste incineration	5	NERI 2011	10	NERI 2011
1A1a Biomass fuels	1	IPCC 2000	100	EEA 2009
1A1b Liquid fuels	1	IPCC 2000	100	EEA 2009
1A1c Gaseous fuel	1	Lindgren 2010	100	EEA 2009
1A2 Solid fuel	2	IPCC 2000	100	EEA 2009
1A2 Liquid fuel	2	IPCC 2000	100/55[3)]	EEA 2009
1A2 Gaseous fuel	1	IPCC 2000	100	EEA 2009
1A2 waste incineration	5	NERI 2011	30	NERI 2011
1A2 Biomass fuels	2	IPCC 2000	100	EEA 2009
1A4a and 1A4c Solid fuel	3	IPCC 2000	100	EEA 2009
1A4a and 1A4c Liquid fuel	3	IPCC 2000	100	EEA 2009
1A4a and 1A4c Gaseous fuel	1	IPCC 2000	100	EEA 2009
1A4a and 1A4c Waste incineration	5	NERI 2011	30	NERI 2011
1A4a and 1A4c Biomass fuels	10	NERI 2011	300	NERI 2011
1A4b Solid fuel	3	IPCC 2000	500	NERI 2011
1A4b Liquid fuel	3	IPCC 2000	500	NERI 2011
1A4b Gaseous fuel	3	IPCC 2000	100	EEA 2009
1A4b Waste incineration	5	NERI 2011	30	NERI 2011
1A4b Wood combustion	50	NERI 2011	100 - 400[2)]	EEA 2009, Small combustion, Table 3-17
1A4b Other biomass fuels	30	NERI 2011	500	NERI 2011

[1)] Included in the uncertainty of the annual emission value stated in the emission factor uncertainty column.

[2)] As 400 %, Cd 150 %, Cr 100 %, Cu 100 %, Hg 100 %, Ni 100 %, Pb 100 %, Se 100 % and Zn 150 %. Based on EMEP/EEA Guidebook (EEA 2009), Small combustion, Table 3.17: Tier 2 emission factors for residential plants, stoves, combusting wood.

[3)] 55 % for Ni. Calculation based on the interval given in the EMEP/EEA Guidebook (EEA 2009) for residual oil. Residual oil is the main liquid fuel in the sectors 1A1a and 1A2.

9.2 Results

The uncertainty estimates for stationary combustion emission inventories are shown in Table 9.2. Detailed calculation sheets are provided in Annex 4.

The total emission uncertainties are between 13 % and 96 %. The trend uncertainty is between 1.7 %-age point and 22 %-age point.

In general, the uncertainty for residential wood combustion contributes most to the total uncertainty for year 2009. However, for Hg the emission from large industrial plants is the sector that contributes most to the uncertainty. For Ni it is the combustion of liquid fuel in industry and for Se it is the combustion of liquid fuel in refineries that contributes most to the uncertainty.

Table 9.2 Danish uncertainty estimates, tier 1 approach, 2009.

HM	Uncertainty Total emission, %	Trend 1990-2009, %	Uncertainty Trend, %-age points
As	± 36	-80	± 6.5
Cd	± 50	-86	± 6.8
Cr	± 26	-92	± 1.9
Cu	± 53	-83	± 9.2
Hg	± 15	-85	± 2.0
Ni	± 30	-82	± 1.7
Pb	± 60	-84	± 9.5
Se	± 13	-73	± 2.7
Zn	± 96	-76	± 22

10 Conclusion

In 2009, the total fuel consumption for stationary combustion plants was 521 PJ of which 411 PJ was fossil fuels and 110 PJ was biomass. Coal and natural gas was the most utilised fuels for stationary combustion plants in 2009.

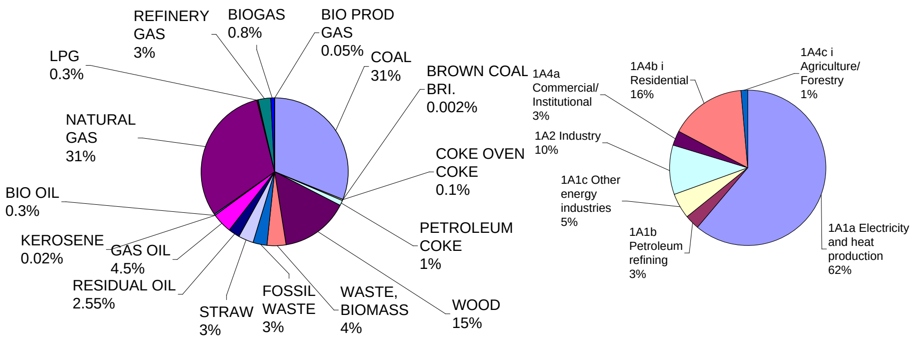


Figure 10.1 Fuel consumption of stationary combustion 2009, disaggregated to fuel type and source category, respectively.

In Denmark, stationary combustion plants are among the most important emission sources for heavy metals. For Cu, Zn and Pb the emission share from stationary combustion plants is below 50 %, but for all other heavy metals, the emission share is above 50 %.

Table 10.1 presents the Danish heavy metal emission inventory 2009 for the stationary combustion subcategories. The source categories *Public electricity and heat production, Residential* and *Industry* have the highest emission shares.

Table 10.1 Heavy metal emission from stationary combustion plants, 2009[1)].

	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
	kg	kg	kg	kg	kg	kg	kg	kg	kg
1A1a Public electricity and heat production	89	31	197	157	236	929	351	880	493
1A1b Petroleum refining	31	23	24	46	22	285	67	106	96
1A1c Other energy industries	3	0	0	0	3	0	0	0	0
1A2 Industry	80	27	110	94	126	1312	644	261	1077
1A4a Commercial/Institutional	3	0	4	4	3	15	4	1	14
1A4b Residential	23	38	79	295	20	85	1455	19	3734
1A4c Agriculture/Forestry/Fisheries	11	5	25	41	12	249	242	36	520
Total	239	124	438	636	421	2875	2762	1304	5934
Emission share from stationary combustion	80%	65%	58%	1%	82%	59%	26%	92%	16%

[1)] Only emission from stationary combustion plants in the source categories is included.

Emissions of all heavy metals have decreased considerably (73 % - 92 %) since 1990, see Table 10.2.

Table 10.2 Decrease in heavy metal emission 1990-2009.

Pollutant	Decrease since 1990, %
As	80
Cd	86
Cr	92
Cu	83
Hg	85
Ni	82
Pb	84
Se	73
Zn	76

The main HM emission sources are coal combustion, waste incineration, residual oil combustion and in 2009 also combustion of biomass.

Waste incineration plants was formerly a major emission source accounting for more than 50 % of Cd, Cr, Cu, Hg, Pb and Zn emissions in 1990. However, the emission share for waste incineration plants has decreased profoundly also in recent years due to installation and improved performance of gas cleaning devices in waste incineration plants. The emission share was below 15 % for all HMs in 2009. The improved flue gas cleaning is a result of lower emission limits for waste incineration plants (DEPA 2003). The emission of Hg has been reduced as a result of installation of dioxin cleaning devices in all plants.

Combustion of coal was a large emission source for all HMs in 1990. The emission has decreased due to improved flue gas cleaning and also as a result of decreased consumption. However, coal combustion is still a major emission source for Hg and Se, and a considerable emission source for other HMs.

Residual oil combustion accounted for more than 80 % of the Ni emission in 2009 and was also the major emission source in 1990.

As a result of the decrease of HM emissions from other sources and of the increased wood consumption the emission of HMs from wood combustion has become one of the major emission sources for Cd, Cr, Cu, Pb and Zn emissions in 2009.

The report includes time series for each source category.

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Annex

Annex 1 Former emission factors

Table A-1 HM emission factors and references 2008.

Fuel	IPCC sector	SNAP	As, mg/GJ	Reference	Cd, mg/GJ	Reference	Cr , mg/GJ	Reference	Cu, mg/GJ	Reference	Hg, mg/GJ	Reference	Ni, mg/GJ	Reference	Pb, mg/GJ	Reference	Se, mg/GJ	Reference	Zn, mg/GJ	Reference
COAL	all	all	3.2	1	0.1	1	2.3	1	3.1	1	1.7	1	4.4	1	6	1	0.5	1	10.5	1
COKE OV.COKE	all	all	3.2	1	0.1	1	2.3	1	3.1	1	1.7	1	4.4	1	6	1	0.5	1	10.5	1
PETROLE-UM COKE	all	all	3.2	1	0.1	1	2.3	1	3.1	1	1.7	1	4.4	1	6	1	0.5	1	10.5	1
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	2.34	2	0.27	4	2.34	2	2.6	2	0.4	4	2.34	2	3.62	2	1.2	4	2.3	4
WOOD AND SIMIL.	1A1a 1A2 1A4a 1A4b 1A4c	010202, 010203, 030100, 030102, 020100, 020200, 020300	-	-	6.8	1	-	-	6.8	1	6.8	1	-	-	3.4	1	1.2	4	136	1
MUNICIP. WASTES	1A1a	010102, 010103	0.59	4	0.44	4	1.56	4	1.3	4	1.79	4	2.06	4	5.52	4	1.11	4	2.33	4
MUNICIP. WASTES	1A1a 1A4a	010203, 030102, 020103	3.53	1	9.21	1	32.97	1	31.8	1	58.7	1	55.4	1	137.57	1	1.11	4	2.33	4
STRAW	1A1a	010101, 010102, 010103, 010104	2	2	0.32	4	1.52	2	1.66	2	0.31	4	1.62	2	6.12	2	1.2	4	0.41	4
STRAW	1A1a, 1A4b, 1A4c	010202, 010203, 020200, 020300	-	-	0.62	1	0.62	1	1.06	1	6.8	1	0.53	1	3.22	1	1.2	4	8.39	1
RESIDUAL OIL	all	all	14.07	1	13.5	1	33.33	1	12.96	1	4.3	1	642	1	23.46	1	12.3	1	2.72	1
GAS OIL	all	Not engines	1.17	1	0.23	1	0.94	1	1.17	1	1.17	1	0.64	1	2.34	1	4.68	1	11.7	1
GAS OIL	all	Engines	0.055	4	0.011	4	0.2	4	0.3	4	0.11	4	0.013	4	0.15	4	0.22	4	58	4
FISH & RAPE OIL	All	all	1.17	3	0.23	3	0.94	3	1.17	3	1.17	3	0.64	3	2.34	3	4.68	3	11.7	3
NATURAL GAS	All	Engines	0.05	4	0.003	4	0.05	4	0.01	4	0.1	4	0.05	4	0.04	4	0.01	4	2.9	4
BIOGAS	all	all	0.04	4	0.002	4	0.18	4	0.31	4	0.12	4	0.23	4	0.005	4	0.21	4	3.95	4
BIO PROD GAS	all	all	0.12	4	0.009	4	0.029	4	0.045	4	0.54	4	0.014	4	0.022	4	0.18	4	0.058	4

[1)] Illerup, J.B., Geertinger, A., Hoffmann, L. & Christiansen, K., 1999. Emissionsfaktorer for tungmetaller 1990-1996. Danmarks Miljøundersøgelser. 66 s. – Faglig rapport fra DMU nr. 301. (In Danish) Available at: http://www.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/fr301.pdf (26-02-2009).

[2)] Nielsen, M. & Illerup, J.B. 2003. Emissionsfaktorer og emissionsopgørelse for decentral kraftvarme. Eltra PSO projekt 3141. Kortlægning af emissioner fra decentrale kraftvarmeværker. Delrapport 6. Danmarks Miljøundersøgelser. 116 s. – Faglig rapport fra DMU nr. 442.(In Danish, with an English summary). Available at : http://www.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR442.pdf (26-02-2009).

[3)] Assumed same emission factors as for gas oil boilers (NERI assumption).

[4)] Nielsen, M., Nielsen, O.K. & Thomsen, M. 2010: Emissionskortlægning for decentral kraftvarme, Energinet.dk miljøprojekt nr. 07/1882. Delrapport 5. Emissionsfaktorer og emissionsopgørelse for decentral kraftvarme, 2006. National Environmental Research Institute, University of Aarhus.

For large power plants combusting coal or residual oil, other emission factors are applied for point sources than for area sources. The emission inventories are however mainly based on plants specific emission data from each plant. The large point source emission factors that differ from the area source emission factors are shown below.

Table A-2 HM emission factors 2008 for large point sources, mg per GJ. Only emission factors that differ from the area source emission factors are included.

Fuel	SNAP	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Coal	010102	3.3	0.1	8.02	4.41	2.2	6.81	6	13	10.5
Residual oil	010101, 010102	1.48	4.43	1.33	1.48	0.15	191	1.48	0.59	11.7

Time series for emission factors for heavy metals is not constant for waste. Time series are shown in Table A-3. All other factors are constant in 1990-2008.

Table A-3 HM emission factors time series for waste, mg per GJ.

						1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
pol_abbr	fuel_type	fuel_gr_abbr	nfr_id_EA	nfr_name	snap_id	Sum of 1990	Sum of 1991	Sum of 1992	Sum of 1993	Sum of 1994	Sum of 1995	Sum of 1996	Sum of 1997	Sum of 1998	Sum of 1999
As	BIO-MASS	STRAW	1A4b i	Residential	020200	2	0	0	0	0	0	0	2	2	2
	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100	7.82	7.207	6.74	6.74						
					010102					6.74	6.74			6.74	6.74
					010103					6.74	6.74	6.74	6.74	6.74	6.74
					010104					6.74	6.74	6.74	6.74	6.74	6.74
					010200	7.82	7.207	6.594	5.981						
			1A2	Industry	030100	7.82	7.207	6.594	5.981	5.369	4.756	4.143	3.53	3.53	3.53
			1A4a	Commercial/ Institutional	020100	7.82	7.207	6.594	5.981	5.369	4.756	4.143	3.53	3.53	3.53
Cd	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100	31.32	28.161	25.003	21.844						
					010102					18.686	15.527			9.21	9.21
					010103					18.686	15.527	12.369	9.21	9.21	9.21
					010104					4.73	4.73	4.73	4.73	4.73	4.73
					010200	31.32	28.161	25.003	21.844						
			1A2	Industry	030100	31.32	28.161	25.003	21.844	18.686	15.527	12.369	9.21	9.21	9.21
			1A4a	Commercial/Institutional	020100	31.32	28.161	25.003	21.844	18.686	15.527	12.369	9.21	9.21	9.21
Cr	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100	186.1	164.224	142.349	120.473						
					010102					98.597	76.721			32.97	32.97
					010103					98.597	76.721	54.846	32.97	32.97	32.97
					010104					2.43	98.6	54.846	32.97	32.97	32.97
					010200	186.1	164.224	142.349	120.473						
			1A2	Industry	030100	186.1	164.224	142.349	120.473	98.597	76.721	54.846	32.97	32.97	32.97
			1A4a	Commercial/Institutional	020100	186.1	164.224	142.349	120.473	98.597	76.721	54.846	32.97	32.97	32.97
Cu	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100	123.49	110.391	97.293	84.194						
					010102					71.096	57.997			31.8	31.8
					010103					71.096	57.997	44.899	31.8	31.8	31.8
					010104					71.096	57.997	44.899	31.8	31.8	31.8
Continued															
					010200	123.49	110.391	97.293	84.194						
			1A2	Industry	030100	123.49	110.391	97.293	84.194	71.096	57.997	44.899	31.8	31.8	31.8
			1A4a	Commercial/Institutional	020100	123.49	110.391	97.293	84.194	71.096	57.997	44.899	31.8	31.8	31.8
Hg	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100	132.42	121.889	111.357	100.826						
					010102					90.294	79.763			58.7	58.7
					010103					90.294	79.763	69.231	58.7	58.7	58.7
					010104					90.294	79.763	69.231	58.7	58.7	58.7
					010200	132.42	121.889	111.357	100.826						
			1A2	Industry	030100	132.42	121.889	111.357	100.826	90.294	79.763	69.231	58.7	58.7	58.7

						1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
			1A4a	Commercial/Institutional	020100	132.42	121.889	111.357	100.826	90.294	79.763	69.231	58.7	58.7	58.7
Ni	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100	191.96	172.451	152.943	133.434						
					010102					113.926	94.417			55.4	55.4
					010103					113.926	94.417	74.909	55.4	55.4	55.4
					010104					113.926	94.417	74.909	55.4	55.4	55.4
					010200	191.96	172.451	152.943	133.434						
			1A2	Industry	030100	191.96	172.451	152.943	133.434	113.926	94.417	74.909	55.4	55.4	55.4
			1A4a	Commercial/Institutional	020100	191.96	172.451	152.943	133.434	113.926	94.417	74.909	55.4	55.4	55.4
Pb	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100	639.024	639.024	555.449	471.873						
					010102					388.297	304.721			137.57	137.57
					010103					388.297	304.721	221.146	137.57	137.57	137.57
					010104					388.297	304.721	221.146	137.57	137.57	137.57
					010200	722.6	639.024	555.449	471.873						
			1A2	Industry	030100	722.6	639.024	555.449	471.873	388.297	304.721	221.146	137.57	137.57	137.57
			1A4a	Commercial/Institutional	020100	722.6	639.024	555.449	471.873	388.297	304.721	221.146	137.57	137.57	137.57
Se	BIO-MASS	STRAW	1A1a	Electricity and heat production	010102					1.2	1.2	1.2	1		1.2
			1A4b i	Residential	020200	1.2	0	0	0	1.2	1.2	1.2	1.2	1.2	1.2
			1A4c i	Agriculture/Forestry	020300		0	0	0	1.2	1.2	1.2			
		WOOD	1A2	Industry	030100		0	0	0	1.2	1.2				
			1A4a	Commercial/Institutional	020100		0	0	0	1.2	1.2				
Continued															
			1A4c i	Agriculture/Forestry	020300		0	0	0	1.2	1.2				
	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010102					25	25			25	25
					010103					25	25	25	25	25	25
					010104					25	25	25	25	25	25
					010203					25	25	25	25	25	25
			1A2	Industry	030102										
			1A4a	Commercial/Institutional	020100	25	25	25	25	25	25	25	25	25	25
					020103					25	25	25	25	25	25
Zn	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010102					52	52			52	52
					010103					52	52	52	52	52	52
					010104					52	52	52	52	52	52
					010203					52	52	52	52	52	52
			1A2	Industry	030102										
			1A4a	Commercial/Institutional	020100	52	52	52	52	52	52	52	52	52	52
					020103					52	52	52	52	52	52

Continued						2000	2001	2002	2003	2004	2005	2006	2007	2008
pol_abbr	fuel_type	fuel_gr_abbr	nfr_id_EA	nfr_name	snap_id	Sum of 2000	Sum of 2001	Sum of 2002	Sum of 2003	Sum of 2004	Sum of 2005	Sum of 2006	Sum of 2007	Sum of 2008
As	BIO-MASS	STRAW	1A4b i	Residential	020200	0	0	0	0	0	0	0	0	0
	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100									
					010102	6.8	6.8	6.8	6.8	4.7	2.7	0.59	0.59	0.59
					010103	6.8	6.8	6.8	6.8	4.7	2.7	0.59	0.59	0.59
					010104	6.8			6.8			0.59		
					010200									
			1A2	Industry	030100									
			1A4a	Commercial/Institutional	020100	3.53			3.53	3.53	3.53	3.53		
Cd	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100									
					010102	4.8	4.8	4.8	4.8	3.3	1.9	0.44	0.44	0.44
					010103	4.8	4.8	4.8	4.8	3.3	1.9	0.44	0.44	0.44
					010104	4.8			4.8			0.44		
					010200									
			1A2	Industry	030100									
			1A4a	Commercial/Institutional	020100	9.21			9.21	9.21	9.21	9.21		
Cr	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100									
					010102	2.5	2.5	2.5	2.5	2.2	1.9	1.56	1.56	1.56
					010103	2.5	2.5	2.5	2.5	2.2	1.9	1.56	1.56	1.56
					010104	2.5			2.5			1.56		
					010200									
			1A2	Industry	030100									
			1A4a	Commercial/Institutional	020100	32.97			32.97	32.97	32.97	32.97		
Cu	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100									
					010102	10.1	10.1	10.1	10.1	7.2	4.2	1.3	1.3	1.3
					010103	10.1	10.1	10.1	10.1	7.2	4.2	1.3	1.3	1.3
					010104	10.1			10.1			1.3		
					010200									
			1A2	Industry	030100									
			1A4a	Commercial/Institutional	020100	31.8			31.8	31.8	31.8	31.8		
Hg	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100									
					010102	7.4	7.4	7.4	7.4	5.5	3.7	1.79	1.79	1.79
					010103	7.4	7.4	7.4	7.4	5.5	3.7	1.79	1.79	1.79
					010104	7.4			7.4			1.79		
					010200									
			1A2	Industry	030100									
			1A4a	Commercial/Institutional	020100	58.7			58.7	58.7	58.7	58.7		
Ni	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100									

Continued						2000	2001	2002	2003	2004	2005	2006	2007	2008
					010102	4.8	4.8	4.8	4.8	3.9	3	2.06	2.06	2.06
					010103	4.8	4.8	4.8	4.8	3.9	3	2.06	2.06	2.06
					010104	4.8			4.8			2.06		
					010200									
			1A2	Industry	030100									
			1A4a	Commercial/Institutional	020100	55.4			55.4	55.4	55.4	55.4		
Pb	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100									
					010102	123	123	123	123	84	45	5.52	5.52	5.52
					010103	123	123	123	123	84	45	5.52	5.52	5.52
					010104	123			123			5.52		
					010200									
			1A2	Industry	030100									
			1A4a	Commercial/Institutional	020100	137.57			137.57	137.57	137.57	137.57		
Se	BIO-MASS	STRAW	1A1a	Electricity and heat production	010102	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
			1A4b i	Residential	020200	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
			1A4c i	Agriculture/Forestry	020300	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
		WOOD	1A2	Industry	030100	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
			1A4a	Commercial/Institutional	020100	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
			1A4c i	Agriculture/Forestry	020300	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010102	25	25	25	25	17	9	1.11	1.11	1.11
					010103	25	25	25	25	17	9	1.11	1.11	1.11
					010104	25			25			1.11		
					010203	25	25	25	25	17	9	1.11	1.11	1.11
			1A2	Industry	030102				25	17	9	1.11		1.11
			1A4a	Commercial/Institutional	020100	25			25	17	9	1.11		
					020103	25	25	25	25	17	9	1.11	1.11	1.11
Zn	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010102	52	52	52	52	35	19	2.33	2.33	2.33
					010103	52	52	52	52	35	19	2.33	2.33	2.33
					010104	52			52			2.33		
					010203	52	52	52	52	35	19	2.33	2.33	2.33
			1A2	Industry	030102				52	35	19	2.33		2.33
			1A4a	Commercial/Institutional	020100	52			52	35	19	2.33		
					020103	52	52	52	52	35	19	2.33	2.33	2.33

Annex 2 Detailed fuel consumption rates

Table A-4 Fuel consumption data for stationary combustion plants in PJ, 1990 – 2009.

fuel_type	fuel_gr_abbr	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
BIOMASS	BIO OIL	0.74	0.74	0.74	0.80	0.25	0.25	0.06	0.01	0.01	0.03
	BIO PROD GAS					0.08	0.02	0.03	0.04	0.04	0.05
	BIOGAS	0.75	0.75	0.75	0.75	1.28	1.75	1.99	2.39	2.64	2.61
	STRAW	12.48	13.31	13.88	13.37	12.66	12.97	12.94	13.17	13.90	13.67
	WOOD	18.25	20.04	21.03	22.22	21.86	21.82	23.36	23.42	22.95	24.38
WASTE	MUNICIP. WASTES	15.50	16.74	17.80	19.41	20.31	22.91	24.95	26.77	26.59	29.14
GAS	NATURAL GAS	76.10	86.11	90.48	102.48	114.60	132.71	156.26	164.50	178.72	187.95
LIQUID	GAS OIL	61.44	64.99	56.09	62.02	53.92	53.69	58.01	51.06	48.41	47.49
	KEROSENE	5.09	0.94	0.78	0.77	0.65	0.58	0.54	0.44	0.42	0.26
	LPG	2.60	2.55	2.32	2.56	2.60	2.74	2.98	2.49	2.54	2.21
	NAPHTA										
	ORIMULSION						19.91	36.77	40.49	32.58	34.19
	PETROLEUM COKE	4.46	4.40	4.31	5.68	7.55	5.27	5.88	6.02	5.30	6.78
	REFINERY GAS	14.17	14.54	14.87	15.41	16.36	20.84	21.44	16.91	15.23	15.72
	RESIDUAL OIL	31.39	37.52	37.78	32.09	45.50	32.28	37.04	25.85	29.26	22.97
SOLID	BROWN COAL BRI.	0.12	0.17	0.10	0.13	0.09	0.07	0.06	0.05	0.05	0.04
	COAL	253.44	344.30	286.84	300.80	323.40	270.35	371.91	276.28	234.28	196.47
	COKE OVEN COKE	1.28	1.45	1.18	1.15	1.23	1.27	1.23	1.25	1.35	1.42
Total		497.80	608.57	548.94	579.64	622.33	599.44	755.43	651.14	614.27	585.38

Continued

fuel_type	fuel_gr_abbr	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
BIOMASS	BIO OIL	0.05	0.19	0.13	0.42	0.65	0.76	1.13	1.21	1.84	1.66
	BIO PROD GAS	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.09	0.08	0.25
	BIOGAS	2.87	3.02	3.33	3.54	3.71	3.83	3.92	3.91	3.93	4.17
	STRAW	12.22	13.70	15.65	16.88	17.94	18.49	18.54	18.76	15.84	17.34
	WOOD	27.53	30.91	31.69	39.06	43.97	49.80	52.12	60.35	63.21	63.94
WASTE	MUNICIP. WASTES	30.39	32.70	35.12	36.60	37.27	37.79	38.43	39.75	40.94	38.62
GAS	NATURAL GAS	186.13	193.84	193.62	195.94	195.08	187.41	191.08	170.98	172.12	165.19
LIQUID	GAS OIL	41.25	43.63	38.60	38.83	35.76	31.65	26.52	21.53	20.71	24.19
	KEROSENE	0.17	0.29	0.26	0.34	0.21	0.28	0.22	0.12	0.12	0.11
	LPG	1.99	1.70	1.50	1.66	1.76	1.84	1.97	1.66	1.53	1.39
	NAPHTA										
	ORIMULSION	34.15	30.24	23.85	1.92	0.02					
	PETROLEUM COKE	6.79	7.81	7.78	7.96	8.38	8.08	8.46	9.16	6.92	5.92
	REFINERY GAS	15.56	15.76	15.20	16.55	15.89	15.35	16.12	15.92	14.78	15.42
	RESIDUAL OIL	18.11	20.36	25.43	27.35	23.33	20.76	24.72	18.42	14.29	13.72
SOLID	BROWN COAL BRI.	0.03	0.03	0.02	0.00					0.01	0.01
	COAL	164.71	174.31	174.65	238.97	182.50	154.01	231.97	194.13	170.74	168.00
	COKE OVEN COKE	1.19	1.11	1.07	1.00	1.14	0.98	1.01	1.12	1.04	0.75
Total		543.18	569.65	567.96	627.11	567.69	531.11	616.29	557.11	528.09	520.68

Table A-5 Detailed fuel consumption data for stationary combustion plants, PJ. 1990 – 2009.

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
BIOMASS	BIOGAS	1A1	Electricity and heat production	010100	0.24	0.24								
				010101					0.02	0.00		0.02		
				010102					0.01		0.09	0.04	0.05	0.03
				010104					0.00	0.02				
				010105			0.27	0.27	0.49	0.58	0.65	0.82	0.98	1.06
				010200	0.03	0.03								
				010203					0.21	0.25	0.25	0.25	0.25	0.22
		1A2	Industry	030100	0.49	0.49	0.49	0.49	0.01	0.13	0.10	0.12	0.07	0.03
				030103					0.01	0.02	0.02	0.02	0.02	0.02
		1A4	Commercial/ Institutional	020100					0.11	0.17	0.17	0.27	0.23	0.29
				020103						0.00	0.01	0.04	0.07	0.07
				020105					0.41	0.57	0.54	0.77	0.90	0.81
			Agriculture/ Forestry	020300					0.00	0.00	0.13	0.03	0.03	0.03
				020304					0.01	0.02	0.02	0.02	0.03	0.05
	STRAW	1A1	Electricity and heat production	010100	0.48	0.99	1.49	1.64						
				010101					0.10	0.08	0.22	0.74	1.01	1.34
				010102					0.61	1.13	1.50	1.31	1.25	1.31
				010103					0.72	0.99	1.32	1.14	1.46	1.34
				010200	3.52	3.84	3.92	3.81						
				010203					3.87	3.97	3.83	3.49	3.88	3.92
		1A2	Industry	030103						0.00				
				030105									0.00	0.00
		1A4	Residential	020200	5.09	5.09	5.09	4.75	4.41	4.08	3.63	3.89	3.77	3.44
			Agriculture/ Forestry	020300	3.39	3.39	3.39	3.17	2.94	2.72	2.42	2.59	2.03	1.80
				020302					0.01	0.01	0.01	0.01	0.50	0.51
	WOOD	1A1	Electricity and heat production	010100			0.17	0.52						
				010101					0.04				0.26	
				010102					1.74	1.60	1.60	1.57	1.95	2.86
				010103					0.05	0.04	0.03	0.06	0.06	0.34
				010104						0.00				
				010200	3.22	3.65	4.10	3.75						
				010203					3.32	3.48	3.89	4.06	4.14	4.04
		1A2	Industry	030100	5.78	5.69	5.75	5.82	4.46	4.23	4.10	4.17	4.27	4.25
				030102									0.00	0.00
				030103					0.41	0.37	0.53	0.43	0.35	0.37
		1A4	Commercial/ Institutional	020100	0.20	0.20	0.20	0.20	0.22	0.27	0.45	0.47	0.49	0.64
				020105									0.00	0.00
			Residential	020200	8.95	10.41	10.72	11.86	11.56	11.76	12.67	12.57	11.13	11.62
			Agriculture/ Forestry	020300	0.09	0.09	0.09	0.07	0.07	0.07	0.09	0.10	0.23	0.23
				020302									0.06	0.03
	BIO PROD GAS	1A1	Electricity and heat production	010105					0.08	0.02	0.03	0.04	0.04	0.04
		1A4	Agriculture/ Forestry	020304								0.00	0.00	0.01
	BIO OIL	1A1	Electricity and heat production	010200	0.74	0.74	0.74	0.80						
				010203					0.25	0.25	0.06	0.01	0.01	0.03
WASTE	MUNICIP. WASTES	1A1	Electricity and heat production	010100		0.88	1.30	2.52						
				010101									0.76	0.75

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
				010102					3.20	2.67	3.72	4.54	4.76	8.54
				010103					2.62	3.20	3.54	3.30	2.78	0.67
				010104					0.37	0.54	1.14	1.10	0.91	0.91
				010200	9.20	8.23	7.18	6.21						
				010202						1.98	2.73	2.73	2.72	
				010203					5.85	4.71	2.79	3.35	3.27	5.38
		1A2	Industry	030100	0.69	1.55	2.33	2.83	0.02	0.02	0.02	0.01	0.02	0.02
		1A4	Commercial/ Institutional	020100	0.62	0.69	0.69	0.69	0.75	0.77	0.72	0.69	0.42	0.87
				020103					0.02	0.02	0.01	0.00	0.01	0.00
			Agriculture/ Forestry	020302									0.00	0.00
P_WASTE	FOSSIL WASTE	1A1	Electricity and heat production	010100		0.42	0.71	1.47						
				010101									0.53	0.53
				010102					1.87	1.73	2.61	3.18	3.34	5.98
				010103					1.53	2.07	2.48	2.31	1.95	0.47
				010104					0.21	0.35	0.80	0.77	0.64	0.64
				010200	4.37	3.91	3.93	3.63						
				010202						1.28	1.91	1.92	1.90	
				010203					3.42	3.05	1.96	2.35	2.29	3.77
		1A2	Industry	030100	0.33	0.74	1.28	1.65	0.01	0.01	0.01	0.01	0.01	0.01
		1A4	Commercial/Institutional	020100	0.29	0.33	0.38	0.41	0.44	0.50	0.50	0.49	0.29	0.61
				020103					0.01	0.01	0.00	0.00	0.00	0.00
GAS	NATURAL GAS	1A1	Electricity and heat production	010100			0.80	3.21						
				010101	4.01	4.39	3.28	4.42	6.45	7.81	9.48	8.44	17.50	17.27
				010102					2.01	2.85	4.08	8.14	9.30	6.45
				010103					0.02	0.05				
				010104	2.51	3.95	5.67	7.52	7.59	8.23	13.94	15.81	12.76	21.45
				010105	0.09	0.18	0.25	0.41	8.59	16.78	21.93	23.46	26.39	26.61
				010200	10.92	13.13	12.35	11.42						
				010202					0.26	0.38	0.38	0.47	0.54	0.20
				010203					9.39	7.95	6.40	4.01	3.14	2.74
			Other energy industries	010504	9.18	9.44	11.05	11.24	12.26	12.91	15.24	19.87	22.05	23.97
		1A2	Industry	030100	22.78	24.34	25.15	27.18	29.24	29.66	28.82	29.18	28.66	31.02
				030102					0.71	2.66	2.46	2.97	2.96	3.10
				030103					0.77	0.81	1.07	0.98	1.09	0.90
				030104	0.51	0.61	0.66	0.73	0.76	0.91	2.15	3.04	4.77	6.14
				030105					0.02	0.19	0.88	0.97	1.17	1.17
				030106	0.14	0.03	0.05	0.07	0.06	0.03	0.02	0.01	0.05	0.11
				030315								0.92	0.90	1.01
				030318						0.62	0.59	0.62	0.67	0.69
		1A4	Commercial/Institutional	020100	6.38	6.93	7.38	8.91	7.34	8.44	11.25	9.11	8.66	7.53
				020103					0.00	0.00	0.00	0.00	0.20	0.01
				020104						0.00		0.00		
				020105					0.58	0.71	0.79	0.97	1.04	1.08
			Residential	020200	17.36	20.43	21.44	24.90	24.74	26.95	30.41	28.36	29.14	28.98
				020202					0.05	0.01	0.05	0.04	0.03	0.04
				020204					0.96	1.04	1.41	1.46	1.53	1.52
			Agriculture/Forestry	020300	2.22	2.68	2.39	2.46	2.49	2.56	2.67	2.64	2.48	2.24

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
				020304					0.28	1.16	2.22	3.03	3.71	3.72
LIQUID	GAS OIL	1A1	Electricity and heat production	010100	0.30	0.47	0.70	0.29						
				010101					0.01	0.05	0.04	0.09	0.11	0.26
				010102					0.01	0.01	0.03	0.03	0.03	0.05
				010103						0.00	0.04	0.03	0.01	0.03
				010104		0.02	0.02	0.03	0.04	0.08	0.05	0.03	0.14	0.03
				010105					0.12	0.14	0.10	0.10	0.12	0.11
				010200	1.94	0.81	0.74	0.95						
				010202					0.15	0.20	0.15	0.07	0.12	0.05
				010203					0.99	0.68	1.40	1.18	1.06	0.67
			Petroleum refining	010306		0.04	0.04	0.03	0.05	0.03	0.02	0.09		
		1A2	Industry	030100	0.54	1.37	1.43	0.95	0.81	1.46	2.25	1.90	1.80	2.48
				030102					0.00	0.00	0.00	0.00	0.00	0.00
				030103					0.00	0.00	0.01	0.00	0.00	0.00
				030104								0.00	0.00	0.01
				030105					0.00				0.00	0.00
				030315								0.00	0.00	0.00
		1A4	Commercial/Institutional	020100	11.79	10.62	9.06	9.01	7.16	6.56	6.62	6.09	5.44	5.78
				020102					0.19		0.00		0.00	
				020103					0.00		0.06	0.06	0.06	0.04
				020105					0.00	0.02	0.00	0.00	0.00	0.00
			Residential	020200	46.46	50.64	42.91	49.97	43.68	43.29	45.30	39.60	37.85	35.68
			Agriculture/Forestry	020300	0.41	1.01	1.18	0.79	0.71	1.18	1.94	1.80	1.68	2.29
				020302								0.00		
				020304							0.00	0.00		0.01
	KEROSENE	1A2	Industry	030100	0.07	0.05	0.04	0.04	0.03	0.02	0.03	0.03	0.02	0.01
		1A4	Commercial/Institutional	020100	0.57	0.21	0.21	0.19	0.15	0.12	0.10	0.10	0.13	0.12
			Residential	020200	4.40	0.66	0.51	0.52	0.44	0.41	0.38	0.29	0.25	0.12
			Agriculture/Forestry	020300	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.02	0.01
	LPG	1A1	Electricity and heat production	010100		0.00	0.00	0.00						
				010200	0.01	0.01	0.01							
				010203					0.00	0.00				0.00
			Petroleum refining	010306			0.00		0.01	0.02	0.02	0.02		
		1A2	Industry	030100	1.58	1.69	1.59	1.45	1.56	1.74	1.92	1.60	1.62	1.36
		1A4	Commercial/Institutional	020100	0.08	0.08	0.08	0.12	0.13	0.13	0.14	0.13	0.12	0.11
				020105										0.00
			Residential	020200	0.67	0.52	0.44	0.86	0.79	0.73	0.77	0.64	0.68	0.66
			Agriculture/Forestry	020300	0.26	0.25	0.19	0.12	0.12	0.13	0.14	0.11	0.13	0.09
	ORIMULSION	1A1	Electricity and heat production	010101						19.91	36.77	40.49	32.58	34.19
	PETROLEUM COKE	1A1	Electricity and heat production	010100				1.24						
				010102					3.18	0.92				
		1A2	Industry	030100	0.30		0.06	0.12		0.10	0.11	0.03	0.03	0.04
				030311	2.50	2.99	3.23	3.23	3.47	3.71	4.97	5.23	4.77	6.40
		1A4	Commercial/Institutional	020100	0.06	0.10	0.09	0.10	0.09	0.07	0.09	0.10	0.07	0.05
			Residential	020200	0.76	0.70	0.46	0.49	0.40	0.23	0.43	0.34	0.22	0.20
			Agriculture/Forestry	020300	0.84	0.61	0.47	0.50	0.41	0.24	0.29	0.32	0.20	0.09

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	REFINERY GAS	1A1	Electricity and heat production	010203							0.03	0.04		
			Petroleum refining	010300	0.46	0.93	1.53	2.08						
				010304					2.36	2.29	2.67	2.28	2.48	2.65
				010306	13.52	13.49	13.24	13.21	14.00	18.55	18.70	14.54	12.71	13.07
		1A2	Industry	030100	0.19	0.13	0.10	0.11			0.03	0.05	0.03	
	RESIDUAL OIL	1A1	Electricity and heat production	010100	0.78	0.37	1.75	0.75						
				010101	6.51	9.63	8.26	7.78	21.50	8.49	11.61	5.15	8.87	6.00
				010102	0.70	0.44	0.45	0.66	0.76	2.53	4.57	2.63	2.78	1.58
				010103					0.21	0.36	0.04	0.20	0.16	
				010104										0.01
				010105					0.01	0.00	0.00	0.00	0.01	0.00
				010200	2.01	2.24	1.14	0.88						
				010202					0.24	0.46	0.52	0.41	0.23	0.28
				010203					1.19	1.29	1.66	1.33	1.54	1.43
			Petroleum refining	010306	1.31	2.04	3.57	3.49	3.34	2.33	2.24	1.62	1.11	1.09
		1A2	Industry	030100	15.80	18.27	17.83	13.80	11.86	9.48	9.88	8.49	8.39	7.95
				030102					0.79	0.85	0.77	0.68	0.55	0.58
				030103					0.15	0.22	0.10	0.14	0.07	0.24
				030104								0.05		
				030311	1.76	2.15	2.37	2.40	2.62	2.84	1.77	1.86	2.54	0.89
		1A4	Commercial/ Institutional	020100	1.07	0.87	0.60	0.52	0.72	0.68	0.72	0.73	0.38	0.45
				020103					0.09	0.08				
			Residential	020200	0.22	0.22	0.17	0.13	0.10	0.06	0.07	0.05	0.04	0.05
			Agriculture/ Forestry	020300	1.22	1.30	1.63	1.69	1.94	2.62	3.07	2.49	2.56	2.39
				020302									0.00	0.00
				020304									0.01	0.01
SOLID	BROWN COAL BRI.	1A2	Industry	030100	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00		
		1A4	Commercial/ Institutional	020100	0.00	0.00		0.01	0.00	0.00	0.00	0.00		
			Residential	020200	0.05	0.07	0.04	0.08	0.08	0.06	0.05	0.05	0.04	0.04
			Agriculture/ Forestry	020300	0.06	0.09	0.05	0.02	0.01	0.01	0.01	0.00	0.00	
	COAL	1A1	Electricity and heat production	010100	8.52	12.89	10.18	8.22						
				010101	207.92	294.72	241.79	256.32	284.66	233.17	333.57	244.26	206.22	172.04
				010102	13.98	11.03	13.21	15.41	18.91	19.37	22.59	17.06	14.23	12.84
				010103					0.49	0.37	0.06			
				010104					0.27	0.27	0.30	0.07		
				010105					0.02					
				010200	6.02	6.64	5.17	3.58						
				010202					1.08	0.68				
				010203					1.38	0.95	0.65	0.15	0.09	0.04
		1A2	Industry	030100	8.85	8.98	6.75	7.70	5.87	4.63	4.24	4.14	4.40	3.52
				030102					0.47	1.05	1.45	1.47	1.41	1.41
				030103					0.34	0.39	0.41	0.55	0.27	0.19
				030311	5.02	6.05	6.58	6.60	6.91	7.22	7.07	7.21	6.63	5.64
		1A4	Commercial/ Institutional	020100	0.09	0.01	0.10	0.08	0.09	0.07	0.04	0.04	0.00	
			Residential	020200	0.59	1.13	0.87	0.79	0.62	0.38	0.09	0.09	0.13	0.08
			Agriculture/ Forestry	020300	2.46	2.85	2.20	2.11	2.29	1.80	1.45	1.24	0.90	0.71
	COKE OVEN COKE	1A2	Industry	030100	1.17	1.35	1.08	1.07	1.16	0.29	0.30	0.30	0.32	0.38

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
				030318						0.94	0.89	0.93	1.01	1.03
		1A4	Residential	020200	0.11	0.10	0.10	0.08	0.06	0.05	0.04	0.03	0.02	0.01
Grand Total					497.80	608.57	548.94	579.64	622.33	599.44	755.43	651.14	614.27	585.38

Continued

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
BIOMASS	BIOGAS	1A1	Electricity and heat production	010102	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
				010105	1.07	1.15	1.27	1.34	1.38	1.45	1.45	1.57	1.58	1.69
				010203	0.30	0.28	0.25	0.26	0.14	0.09	0.12	0.15	0.16	0.13
		1A2	Industry	030100	0.02	0.01	0.01	0.04	0.04	0.11	0.12	0.12	0.09	0.08
				030102	0.02	0.02	0.02	0.04	0.05	0.05	0.04	0.03	0.05	0.06
				030103	0.02	0.06	0.07	0.06	0.06	0.01	0.01	0.01	0.05	0.06
				030105		0.02	0.06	0.08	0.09	0.25	0.22	0.22	0.23	0.25
		1A4	Commercial/ Institutional	020100	0.31	0.35	0.43	0.32	0.44	0.44	0.47	0.37	0.36	0.31
				020103	0.09	0.08	0.07	0.09	0.11	0.11	0.14	0.10	0.11	0.11
				020105	0.87	0.83	0.82	0.79	0.79	0.76	0.59	0.58	0.56	0.62
			Agriculture/ Forestry	020300	0.08	0.08	0.10	0.13	0.17	0.08	0.33	0.28	0.27	0.34
				020304	0.08	0.11	0.20	0.37	0.42	0.46	0.41	0.47	0.46	0.51
	STRAW	1A1	Electricity and heat production	010101	1.12	1.59	2.64	3.16	3.66	3.33	3.69	3.59	2.42	2.82
				010102	1.33	1.26	1.17	1.29	2.06	2.04	1.70	1.87	1.74	1.89
				010103	0.73	2.09	1.94	2.07	2.11	2.13	2.06	2.14	2.13	2.16
				010104		0.10	1.22	1.71	1.86	2.45	2.54	2.51	0.82	1.52
				010203	3.84	3.81	3.83	3.81	3.40	3.69	3.69	3.79	3.89	4.07
		1A2	Industry	030105	0.00	0.00								
		1A4	Residential	020200	3.11	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90
			Agriculture/ Forestry	020300	1.59	1.46	1.48	1.48	1.48	1.48	1.43	1.49	1.46	1.47
				020302	0.50	0.48	0.47	0.47	0.47	0.47	0.52	0.46	0.48	0.50
	WOOD	1A1	Electricity and heat production	010101		0.00	0.07	0.31	0.23	0.17	0.29	0.17	0.26	0.52
				010102	2.73	2.52	3.19	5.36	5.43	6.62	6.49	6.29	5.80	7.11
				010103	0.44	0.53	0.64	0.60	0.67	0.57	0.51	0.56	0.56	0.66
				010104			0.12	1.58	4.49	4.48	2.61	3.77	5.96	6.26
				010203	3.90	4.49	4.96	5.62	6.15	6.55	7.02	7.07	7.86	8.59
		1A2	Industry	030100	4.45	4.60	3.31	3.53	3.43	3.67	4.26	4.35	5.48	4.51
				030102	0.00	0.00					0.01	1.06	1.18	1.21
				030103	0.39	0.39	0.40	0.28	0.40	0.34	0.44	0.39	0.45	0.48
		1A4	Commercial/ Institutional	020100	0.78	0.67	0.67	0.68	0.68	0.82	0.95	1.01	1.07	1.06
				020105		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00
			Residential	020200	14.62	17.48	18.07	20.86	22.27	26.40	29.42	35.51	34.45	33.38
				020202						0.00	0.00	0.00	0.00	0.00
				020204									0.00	0.00
			Agriculture/ Forestry	020300	0.17	0.15	0.15	0.11	0.10	0.09	0.08	0.08	0.08	0.08
				020302	0.06	0.10	0.13	0.13	0.12	0.09	0.03	0.09	0.06	0.07
	BIO PROD GAS	1A1	Electricity and heat production	010105	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.09	0.08	0.25
		1A2	Industry	030105								0.00	0.00	0.00
		1A4	Agriculture/ Forestry	020304	0.00	0.00								
	BIO OIL	1A1	Electricity and heat production	010101				0.10				0.01	0.01	
				010105					0.00			0.00	0.00	0.00

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
				010202				0.01	0.00	0.02	0.02	0.05	0.40	0.19
				010203	0.05	0.19	0.07	0.30	0.64	0.74	1.10	1.14	1.39	1.43
		1A2	Industry	030103			0.06							
				030105			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1A4	Commercial/ Institutional	020105								0.00		
			Residential	020200								0.00	0.04	0.04
			Agriculture/ Forestry	020304	0.00	0.00	0.00							
WASTE	MUNICIP. WASTES	1A1	Electricity and heat production	010101		0.11	0.52	0.08					0.02	0.03
				010102	7.09	7.66	8.17	8.30	9.77	11.33	11.71	11.93	12.31	12.18
				010103	5.30	5.28	5.42	5.37	5.36	5.16	5.62	5.56	5.66	5.16
				010104	1.30	1.45	1.54	1.75	1.71	1.52	1.81	1.95	1.95	1.91
				010203	3.78	3.88	3.89	4.36	3.81	2.55	2.25	2.79	2.92	2.38
		1A2	Industry	030102					0.00	0.00			0.02	
				030311	0.32	0.85	1.09	0.86	1.17	1.17	0.89	0.97	1.15	1.03
		1A4	Commercial/ Institutional	020100	0.07			0.77	0.06	0.39	0.21	0.15		
				020103	0.01	0.01	0.01	0.04	0.04	0.10	0.11	0.03	0.04	0.03
P_WASTE	FOSSIL WASTE	1A1	Electricity and heat production	010101		0.08	0.37	0.06					0.01	0.02
				010102	4.97	5.37	5.73	5.81	6.84	7.94	8.21	8.36	8.63	8.54
				010103	3.71	3.70	3.80	3.76	3.75	3.61	3.94	3.89	3.97	3.61
				010104	0.91	1.01	1.08	1.22	1.20	1.06	1.27	1.37	1.37	1.34
				010203	2.65	2.72	2.73	3.05	2.67	1.79	1.58	1.95	2.05	1.67
		1A2	Industry	030102					0.00	0.00			0.02	
				030311	0.22	0.59	0.76	0.60	0.82	0.82	0.62	0.68	0.81	0.72
		1A4	Commercial/ Institutional	020100	0.05			0.54	0.04	0.28	0.15	0.11		
				020103	0.01	0.01	0.01	0.03	0.03	0.07	0.08	0.02	0.03	0.02
GAS	NATURAL GAS	1A1	Electricity and heat production	010101	18.44	18.19	16.52	17.88	17.30	17.24	18.96	13.89	10.91	13.38
				010102	6.54	6.37	5.52	3.94	3.34	2.96	2.60	0.94	3.82	2.73
				010103	0.05	0.03	0.02	0.04	0.04	0.01	0.05	0.06	0.06	0.05
				010104	22.81	24.87	30.04	29.66	30.53	25.50	32.05	26.22	27.83	24.59
				010105	25.51	27.85	27.59	26.74	26.92	24.03	21.47	17.10	18.30	15.43
				010202	0.14	0.08	0.21	0.21	0.28	0.22	0.06	0.23	0.38	2.10
				010203	2.32	2.94	2.36	3.23	2.72	4.42	4.57	6.12	6.03	6.91
			Other energy industries	010504	25.36	24.76	26.56	26.57	27.42	28.11	28.72	28.48	28.33	26.93
		1A2	Industry	030100	28.53	30.89	28.91	27.88	26.40	26.65	26.54	27.08	27.27	25.74
				030102	2.69	2.87	1.19	2.27	2.30	2.20	2.29	1.57	1.50	0.81
				030103	0.68	0.18	0.46	0.59	0.60	0.57	0.58	0.62	0.52	0.56
				030104	6.42	6.19	6.72	6.48	6.81	5.88	4.64	4.47	3.82	3.33
				030105	1.57	1.66	1.57	1.56	1.59	1.34	1.02	0.53	0.59	0.63
				030106	0.06	0.06	0.03	0.02	0.03	0.01	0.01	0.02	0.12	0.08
				030315	1.10	1.09	1.02	0.95	0.91	0.87	0.83	0.83	0.87	0.72
				030318	0.63	0.59	0.52	0.55	0.61	0.56	0.56	0.63	0.57	0.41
		1A4	Commercial/ Institutional	020100	7.23	7.32	7.62	9.22	9.20	9.74	10.76	10.10	9.73	9.21
				020103	0.16	0.19	0.17	0.01	0.09	0.01	0.08	0.02	0.05	0.03
				020104	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00		
				020105	1.11	1.14	1.17	1.14	1.10	1.02	1.03	0.92	0.88	0.85
			Residential	020200	27.57	29.26	28.08	30.02	29.86	29.52	28.59	26.57	26.52	26.84
				020202	0.06	0.08	0.03	0.07	0.07	0.03	0.06	0.07	0.10	0.10

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
				020204	1.40	1.41	1.36	1.38	1.42	1.41	1.44	1.31	1.20	1.15
			Agriculture/ Forestry	020300	2.38	2.69	2.54	2.32	2.26	2.25	2.24	1.87	1.66	1.71
				020304	3.34	3.12	3.39	3.20	3.30	2.85	1.92	1.33	1.06	0.90
LIQUID	GAS OIL	1A1	Electricity and heat production	010101	0.05	0.08	0.09	0.96	0.21	0.18	0.45	0.52	0.92	2.29
				010102	0.11	0.10	0.09	0.03	0.05	0.03	0.04	0.06	0.04	0.08
				010103	0.05	0.02	0.03	0.03	0.02	0.02	0.01	0.02	0.02	0.02
				010104	0.07	0.04	0.03	0.03	0.07	0.09	0.08	0.05	0.04	0.06
				010105	0.08	0.10	0.09	0.09	0.11	0.08	0.07	0.15	0.14	0.09
				010202	0.54	0.94	0.24	0.35	0.49	0.26	0.24	0.36	0.31	0.51
				010203	0.61	0.54	0.44	0.05	0.61	0.46	0.37	0.33	0.72	0.95
				010204				1.04						
			Petroleum refining	010306				0.00	0.01	0.00	0.01	0.01	0.00	0.01
		1A2	Industry	030100	2.18	2.99	2.34	2.61	2.47	1.58	0.52	0.00	0.00	0.00
				030102				0.00	0.00	0.00	0.01	0.01	0.02	0.00
				030103	0.08	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	
				030104	0.00		0.00			0.00	0.00	0.00	0.00	0.00
				030105	0.00	0.00							0.00	0.00
				030315	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
		1A4	Commercial/ Institutional	020100	4.96	4.69	4.04	4.30	4.41	3.75	3.03	2.61	2.80	2.78
				020103	0.07	0.05	0.04	0.03	0.02	0.05	0.03	0.02	0.03	0.06
				020105	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Residential	020200	30.28	31.51	29.00	27.03	25.29	23.86	21.20	17.38	15.61	17.28
				020204									0.01	0.02
			Agriculture/ Forestry	020300	2.15	2.55	2.15	2.25	1.97	1.22	0.45			
				020302	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00
				020304	0.01	0.01	0.02	0.02	0.01	0.03	0.02	0.02	0.03	0.02
	KEROSENE	1A2	Industry	030100	0.01	0.03	0.07	0.05	0.02	0.01	0.02	0.01	0.02	0.01
		1A4	Commercial/ Institutional	020100	0.06	0.08	0.07	0.07	0.08	0.10	0.06	0.02	0.01	0.02
			Residential	020200	0.09	0.16	0.11	0.21	0.11	0.16	0.14	0.09	0.09	0.07
			Agriculture/ Forestry	020300	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
	LPG	1A1	Electricity and heat production	010101							0.00		0.00	0.00
				010102									0.00	0.00
				010202						0.00	0.00	0.00		
				010203	0.00					0.00		0.00	0.00	0.00
		1A2	Industry	030100	1.02	0.76	0.68	0.73	0.75	0.74	0.77	0.49	0.45	0.39
		1A4	Commercial/ Institutional	020100	0.12	0.12	0.14	0.17	0.21	0.25	0.27	0.27	0.27	0.27
				020105						0.00	0.00	0.00	0.00	0.00
			Residential	020200	0.76	0.74	0.63	0.70	0.75	0.80	0.88	0.88	0.78	0.70
			Agriculture/ Forestry	020300	0.09	0.08	0.06	0.06	0.05	0.05	0.05	0.03	0.03	0.04
	ORIMULSION	1A1	Electricity and heat production	010101	34.15	30.24	23.85	1.92	0.02					
	PETROLEUM COKE	1A1	Electricity and heat production	010102					0.01	0.00				0.03
		1A2	Industry	030100	0.29	0.13	0.22	0.23	0.18	0.16	0.16			
				030311	6.47	7.66	7.54	7.71	8.19	7.80	8.28	9.11	6.84	5.89
		1A4	Commercial/ Institutional	020100	0.01	0.01	0.01	0.01		0.07	0.01	0.04	0.06	0.00
			Residential	020200	0.01	0.01	0.01	0.01		0.06	0.01	0.01	0.02	
			Agriculture/ Forestry	020300	0.01	0.00	0.00	0.00						

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	REFINERY GAS	1A1	Petroleum refining	010304	2.40	2.45	2.46	2.67	2.44	2.00	2.25	2.31	1.83	1.94
				010306	13.16	13.31	12.74	13.88	13.45	13.35	13.87	13.61	12.95	13.48
	RESIDUAL OIL	1A1	Electricity and heat production	010101	3.44	3.51	3.75	5.76	4.60	4.33	3.34	5.44	2.81	3.62
				010102	0.66	2.31	1.25	1.66	1.33	1.46	1.79	0.26	0.91	1.86
				010103	0.27	0.09	0.13	0.10	0.18	0.20	0.11	0.60	0.23	0.08
				010104		1.72	6.62	9.32	7.39	6.34	8.40	4.50	4.47	2.88
				010105	0.02	0.00	0.00	0.01	0.00	0.02	0.02	0.00	0.01	0.01
				010202										0.01
				010203	1.11	1.17	1.04	0.69	0.34	0.53	0.45		0.11	0.32
			Petroleum refining	010306	1.32	1.44	1.36	0.91	1.07	0.69	0.62	0.77	0.89	0.73
		1A2	Industry	030100	7.43	6.90	7.89	5.54	5.02	3.66	6.06	3.45	0.66	0.22
				030102	0.63	0.57	0.46	0.92	0.92	1.06	0.82	0.61	1.90	1.97
				030103	0.21	0.31	0.35	0.73	0.77	0.84	0.79	0.81	1.01	1.10
				030105		0.00	0.00	0.00	0.00	0.01	0.00		0.00	
				030311	0.86	0.50	0.59	0.59	0.82	0.69	0.98	1.06	0.51	0.25
		1A4	Commercial/ Institutional	020100	0.34	0.17	0.48	0.17	0.11	0.12	0.25	0.23	0.10	0.03
			Residential	020200	0.04	0.03	0.15	0.05	0.04	0.05	0.20	0.01	0.01	0.01
			Agriculture/ Forestry	020300	1.78	1.64	1.37	0.91	0.72	0.76	0.90	0.64	0.64	0.60
				020302				0.01	0.01	0.01	0.02	0.03	0.03	0.02
				020304	0.00	0.00	0.00	0.00						
SOLID	BROWN COAL BRI.	1A4	Residential	020200	0.03	0.03	0.02	0.00					0.01	0.01
	COAL	1A1	Electricity and heat production	010101	143.84	156.22	158.32	223.55	167.93	140.02	218.36	180.90	159.44	161.87
				010102	9.30	7.74	7.98	6.43	4.51	4.05	3.29	3.05	2.81	1.99
				010104										0.02
				010203	0.04	0.03	0.02	0.03	0.02	0.05		0.06	0.01	
		1A2	Industry	030100	3.23	3.12	2.01	2.72	3.25	2.58	2.52	2.66	1.60	0.14
				030102	1.06	1.00	1.00	1.57	1.50	1.50	1.23	1.16	1.22	1.21
				030103	0.43	0.44	0.12	0.10	0.09	0.10	0.20	0.21	0.25	0.32
				030311	5.71	4.52	4.35	3.37	3.75	3.92	4.36	4.03	3.54	1.14
		1A4	Commercial/ Institutional	020100					0.00					
			Residential	020200	0.01	0.01	0.02	0.00	0.00	0.01	0.00	0.01	0.01	0.01
			Agriculture/ Forestry	020300	1.08	1.23	0.86	1.20	1.44	1.79	2.00	2.05	1.86	1.31
				020304					0.00	0.00				0.00
	COKE OVEN COKE	1A2	Industry	030100	0.24	0.22	0.28	0.28	0.30	0.24	0.25	0.21	0.15	0.02
				030102									0.06	0.06
				030103								0.04	0.05	0.06
				030318	0.94	0.88	0.79	0.69	0.81	0.74	0.76	0.88	0.78	0.61
		1A4	Residential	020200	0.01	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00
Grand Total					543.18	569.65	567.96	627.11	567.69	531.11	616.29	557.11	528.09	520.68

Annex 3 Fuel correspondence lists

Table A-6   Fuel category correspondence list, DEA, DCE and Climate Convention reportings (IPCC).

Danish Energy Agency	NERI Emission database	IPCC fuel category
Other Hard Coal	Coal	Solid
Coke	Coke oven coke	Solid
Electricity Plant Coal	Coal	Solid
Brown Coal Briquettes	Brown coal briq.	Solid
Orimulsion	Orimulsion	Liquid
Petroleum Coke	Petroleum coke	Liquid
Fuel Oil	Residual oil	Liquid
Waste Oil	Residual oil	Liquid
Gas/Diesel Oil	Gas oil	Liquid
Other Kerosene	Kerosene	Liquid
LPG	LPG	Liquid
Refinery Gas	Refinery gas	Liquid
Town Gas	Natural gas	Gas
Natural Gas	Natural gas	Gas
Straw	Straw	Biomass
Wood Waste	Wood and simil.	Biomass
Wood Pellets	Wood and simil.	Biomass
Wood Chips	Wood and simil.	Biomass
Firewood, Hardwood & Conifer	Wood and simil.	Biomass
Waste Combustion (biomass)	Municip. wastes	Biomass
Bio Oil	Bio oil	Biomass
Biogas	Biogas	Biomass
Biogas, other	Biogas	Biomass
Biogas, landfill	Biogas	Biomass
Biogas, sewage sludge	Biogas	Biomass
(Wood applied in gas engines)	Gasification gas	Biomass
Waste Combustion (fossil)	Fossil waste	Other fuel

Annex A3.2 Uncertainty.

Emission source sector	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		kg	kg	%	%	%	%	%	%	%	%	%
1A1a Annual emission values for LPS power plants	As		32.348		5.000	5.000	0.676	0.027	0.027	0.133		0.133
1A1a Annual emission values for LPS MSW incineration	As		2.309		10.000	10.000	0.096	0.002	0.002	0.019		0.019
1A2 Annual emission values for LPS industrial plants	As	82.980	43.525		50.000	50.000	9.090	0.022	0.036	1.117		1.117
Annual emissions for other LPS	As		0.584		50.000	50.000	0.122	0.000	0.000	0.024		0.024
1A1a Solid fuel	As	780.252	0.775	1.000	10.000	10.050	0.033	-0.125	0.001	-1.249	0.001	1.249
1A1a Liquid fuel	As	21.013	4.211	1.000	100.000	100.005	1.759	0.000	0.003	0.006	0.005	0.008
1A1a Gaseous fuel	As	2.079	4.269	1.000	100.000	100.005	1.783	0.003	0.004	0.317	0.005	0.317
1A1a Waste incineration	As	105.823	15.764	5.000	10.000	11.180	0.736	-0.004	0.013	-0.042	0.092	0.101
1A1a Biomass fuels	As	10.120	28.812	1.000	100.000	100.005	12.035	0.022	0.024	2.206	0.034	2.206
1A1b Liquid fuels	As	30.790	30.878	1.000	100.000	100.005	12.898	0.020	0.025	2.041	0.036	2.041
1A1c Gaseous fuel	As	1.092	3.205	1.000	100.000	100.005	1.339	0.002	0.003	0.246	0.004	0.246
1A2 Solid fuel	As	40.096	9.597	2.000	100.000	100.020	4.009	0.001	0.008	0.140	0.022	0.142
1A2 Liquid fuel	As	69.500	14.126	2.000	100.000	100.020	5.901	0.000	0.012	0.036	0.033	0.049
1A2 Gaseous fuel	As	2.788	3.798	2.000	100.000	100.020	1.587	0.003	0.003	0.267	0.009	0.267
1A2 Waste incineration	As	7.941		5.000	30.000	30.414		-0.001		-0.039		0.039
1A2 Biomass fuels	As	8.117	8.689	2.000	100.000	100.020	3.630	0.006	0.007	0.583	0.020	0.584
1A4a and 1A4c Solid fuel	As	10.426	5.257	3.000	100.000	100.045	2.197	0.003	0.004	0.264	0.018	0.264
1A4a and 1A4c Liquid fuel	As	13.488	2.813	3.000	100.000	100.045	1.175	0.000	0.002	0.013	0.010	0.016
1A4a and 1A4c Gaseous fuel	As	1.023	1.391	3.000	100.000	100.045	0.581	0.001	0.001	0.098	0.005	0.098
1A4a and 1A4c Waste incineration	As	7.129	0.031	5.000	30.000	30.414	0.004	-0.001	0.000	-0.034	0.000	0.034
1A4a and 1A4c Biomass fuels	As	3.800	4.011	10.000	300.000	300.167	5.029	0.003	0.003	0.805	0.047	0.806
1A4b Solid fuel	As	2.749	0.068	3.000	500.000	500.009	0.142	-0.000	0.000	-0.195	0.000	0.195
1A4b Liquid fuel	As	2.938	0.097	3.000	500.000	500.009	0.202	-0.000	0.000	-0.198	0.000	0.198
1A4b Gaseous fuel	As	2.066	3.263	3.000	100.000	100.045	1.364	0.002	0.003	0.235	0.011	0.235
1A4b Waste incineration	As			5.000	30.000	30.414						
1A4b Wood combustion	As	4.477	16.693	50.000	400.000	403.113	28.107	0.013	0.014	5.202	0.971	5.292
1A4b Other biomass fuels	As	5.087	2.905	30.000	500.000	500.899	6.078	0.002	0.002	0.783	0.101	0.789
Total	As	1215.773	239.419				1330.172					41.957
Total uncertainties		Overall uncertainty i the year (%):				36.472		Trend uncertainty (%):			6.477	

Emission source sector	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
Continued…		Input data	Input data	Input data	Input data							
		kg	kg	%	%	%	%	%	%	%	%	%
1A1a Annual emission values for LPS power plants	Cd		11.231		5.000	5.000	0.453	0.013	0.013	0.063		0.063
1A1a Annual emission values for LPS MSW incineration	Cd		1.112		10.000	10.000	0.090	0.001	0.001	0.012		0.012
1A2 Annual emission values for LPS industrial plants	Cd	50.360	16.431		50.000	50.000	6.627	0.011	0.018	0.528		0.528
Annual emissions for other LPS	Cd		0.233		50.000	50.000	0.094	0.000	0.000	0.013		0.013
1A1a Solid fuel	Cd	260.084	0.106	1.000	10.000	10.050	0.009	-0.040	0.000	-0.401	0.000	0.401
1A1a Liquid fuel	Cd	5.304	1.087	1.000	100.000	100.005	0.877	0.000	0.001	0.039	0.002	0.039
1A1a Gaseous fuel	Cd	0.005	0.054	1.000	100.000	100.005	0.043	0.000	0.000	0.006	0.000	0.006
1A1a Waste incineration	Cd	420.577	11.756	5.000	10.000	11.180	1.060	-0.052	0.013	-0.519	0.093	0.527
1A1a Biomass fuels	Cd	2.151	5.900	1.000	100.000	100.005	4.760	0.006	0.007	0.627	0.009	0.627
1A1b Liquid fuels	Cd	21.271	22.531	1.000	100.000	100.005	18.175	0.022	0.025	2.191	0.036	2.191
1A1c Gaseous fuel	Cd	0.002	0.007	1.000	100.000	100.005	0.005	0.000	0.000	0.001	0.000	0.001
1A2 Solid fuel	Cd	18.043	4.242	2.000	100.000	100.020	3.423	0.002	0.005	0.195	0.013	0.195
1A2 Liquid fuel	Cd	21.353	4.271	2.000	100.000	100.020	3.446	0.001	0.005	0.146	0.014	0.147
1A2 Gaseous fuel	Cd	0.006	0.010	2.000	100.000	100.020	0.008	0.000	0.000	0.001	0.000	0.001
1A2 Waste incineration	Cd	31.559		5.000	30.000	30.414		-0.005		-0.147		0.147
1A2 Biomass fuels	Cd	1.563	1.673	2.000	100.000	100.020	1.350	0.002	0.002	0.163	0.005	0.163
1A4a and 1A4c Solid fuel	Cd	4.691	2.366	3.000	100.000	100.045	1.909	0.002	0.003	0.192	0.011	0.192
1A4a and 1A4c Liquid fuel	Cd	4.614	0.852	3.000	100.000	100.045	0.687	0.000	0.001	0.024	0.004	0.024
1A4a and 1A4c Gaseous fuel	Cd	0.002	0.008	3.000	100.000	100.045	0.006	0.000	0.000	0.001	0.000	0.001
1A4a and 1A4c Waste incineration	Cd	28.334	0.023	5.000	30.000	30.414	0.006	-0.004	0.000	-0.131	0.000	0.131
1A4a and 1A4c Biomass fuels	Cd	4.827	2.545	10.000	300.000	300.167	6.162	0.002	0.003	0.630	0.040	0.631
1A4b Solid fuel	Cd	1.296	0.035	3.000	500.000	500.009	0.142	-0.000	0.000	-0.081	0.000	0.081
1A4b Liquid fuel	Cd	1.475	0.036	3.000	500.000	500.009	0.146	-0.000	0.000	-0.094	0.000	0.094
1A4b Gaseous fuel	Cd	0.004	0.010	3.000	100.000	100.045	0.008	0.000	0.000	0.001	0.000	0.001
1A4b Waste incineration	Cd			5.000	30.000	30.414						
1A4b Wood combustion	Cd	8.954	33.387	50.000	150.000	158.114	42.581	0.036	0.037	5.395	2.642	6.007
1A4b Other biomass fuels	Cd	7.122	4.067	30.000	500.000	500.899	16.432	0.003	0.005	1.723	0.193	1.733
Total	Cd	893.598	123.972				2549.750					45.586
Total uncertainties				Overall uncertainty i the year (%):			50.495				Trend uncertainty (%):	6.752

Emission source sector	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
Continued…		Input data	Input data	Input data	Input data							
		kg	kg	%	%	%	%	%	%	%	%	%
1A1a Annual emission values for LPS power plants	Cr		87.607		5.000	5.000	1.000	0.015	0.015	0.077		0.077
1A1a Annual emission values for LPS MSW incineration	Cr		16.700		10.000	10.000	0.381	0.003	0.003	0.029		0.029
1A2 Annual emission values for LPS industrial plants	Cr	523.100	54.259		50.000	50.000	6.193	0.002	0.010	0.123		0.123
Annual emissions for other LPS	Cr		1.660		50.000	50.000	0.189	0.000	0.000	0.015		0.015
1A1a Solid fuel	Cr	1891.520	1.307	1.000	10.000	10.050	0.030	-0.025	0.000	-0.253	0.000	0.253
1A1a Liquid fuel	Cr	26.460	5.792	1.000	100.000	100.005	1.322	0.001	0.001	0.066	0.001	0.066
1A1a Gaseous fuel	Cr	0.018	0.794	1.000	100.000	100.005	0.181	0.000	0.000	0.014	0.000	0.014
1A1a Waste incineration	Cr	2523.462	39.787	5.000	10.000	11.180	1.015	-0.027	0.007	-0.271	0.049	0.275
1A1a Biomass fuels	Cr	14.129	43.360	1.000	100.000	100.005	9.898	0.007	0.008	0.743	0.011	0.743
1A1b Liquid fuels	Cr	23.104	23.549	1.000	100.000	100.005	5.376	0.004	0.004	0.383	0.006	0.383
1A1c Gaseous fuel	Cr	0.007	0.020	1.000	100.000	100.005	0.005	0.000	0.000	0.000	0.000	0.000
1A2 Solid fuel	Cr	135.324	31.905	2.000	100.000	100.020	7.284	0.004	0.006	0.378	0.016	0.378
1A2 Liquid fuel	Cr	47.424	8.950	2.000	100.000	100.020	2.044	0.001	0.002	0.093	0.004	0.093
1A2 Gaseous fuel	Cr	0.018	0.056	2.000	100.000	100.020	0.013	0.000	0.000	0.001	0.000	0.001
1A2 Waste incineration	Cr	189.354		5.000	30.000	30.414		-0.003		-0.077		0.077
1A2 Biomass fuels	Cr	13.621	14.573	2.000	100.000	100.020	3.327	0.002	0.003	0.238	0.007	0.238
1A4a and 1A4c Solid fuel	Cr	35.186	17.743	3.000	100.000	100.045	4.052	0.003	0.003	0.264	0.013	0.265
1A4a and 1A4c Liquid fuel	Cr	20.964	2.402	3.000	100.000	100.045	0.548	0.000	0.000	0.014	0.002	0.014
1A4a and 1A4c Gaseous fuel	Cr	0.007	0.096	3.000	100.000	100.045	0.022	0.000	0.000	0.002	0.000	0.002
1A4a and 1A4c Waste incineration	Cr	170.004	0.081	5.000	30.000	30.414	0.006	-0.002	0.000	-0.069	0.000	0.069
1A4a and 1A4c Biomass fuels	Cr	10.517	8.236	10.000	300.000	300.167	5.643	0.001	0.001	0.392	0.020	0.392
1A4b Solid fuel	Cr	9.713	0.263	3.000	500.000	500.009	0.300	-0.000	0.000	-0.043	0.000	0.043
1A4b Liquid fuel	Cr	19.415	3.651	3.000	500.000	500.009	4.167	0.000	0.001	0.189	0.003	0.190
1A4b Gaseous fuel	Cr	0.013	0.078	3.000	100.000	100.045	0.018	0.000	0.000	0.001	0.000	0.001
1A4b Waste incineration	Cr			5.000	30.000	30.414						
1A4b Wood combustion	Cr	17.909	66.773	50.000	100.000	111.803	17.042	0.012	0.012	1.150	0.830	1.418
1A4b Other biomass fuels	Cr	14.752	8.433	30.000	500.000	500.899	9.642	0.001	0.001	0.642	0.063	0.645
Total	Cr	5686.021	438.076				686.934					3.774
Total uncertainties				Overall uncertainty i the year (%):			26.209			Trend uncertainty (%):		1.943

Emission source sector	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
Continued…		Input data	Input data	Input data	Input data							
		kg	kg	%	%	%	%	%	%	%	%	%
1A1a Annual emission values for LPS power plants	Cu		53.423		5.000	5.000	0.421	0.014	0.014	0.072		0.072
1A1a Annual emission values for LPS MSW incineration	Cu		14.908		10.000	10.000	0.235	0.004	0.004	0.040		0.040
1A2 Annual emission values for LPS industrial plants	Cu	114.600	16.631		50.000	50.000	1.309	-0.001	0.005	-0.042		0.042
Annual emissions for other LPS	Cu		1.561		50.000	50.000	0.123	0.000	0.000	0.021		0.021
1A1a Solid fuel	Cu	1040.336	0.730	1.000	10.000	10.050	0.012	-0.048	0.000	-0.481	0.000	0.481
1A1a Liquid fuel	Cu	24.302	5.419	1.000	100.000	100.005	0.853	0.000	0.001	0.034	0.002	0.034
1A1a Gaseous fuel	Cu	0.002	0.157	1.000	100.000	100.005	0.025	0.000	0.000	0.004	0.000	0.004
1A1a Waste incineration	Cu	1668.741	33.156	5.000	10.000	11.180	0.584	-0.068	0.009	-0.684	0.063	0.687
1A1a Biomass fuels	Cu	15.348	47.678	1.000	100.000	100.005	7.506	0.012	0.013	1.219	0.018	1.220
1A1b Liquid fuels	Cu	45.203	45.773	1.000	100.000	100.005	7.206	0.010	0.012	1.029	0.018	1.029
1A1c Gaseous fuel	Cu	0.001	0.002	1.000	100.000	100.005	0.000	0.000	0.000	0.000	0.000	0.000
1A2 Solid fuel	Cu	175.420	41.365	2.000	100.000	100.020	6.513	0.003	0.011	0.303	0.032	0.305
1A2 Liquid fuel	Cu	96.128	18.777	2.000	100.000	100.020	2.956	0.001	0.005	0.061	0.014	0.062
1A2 Gaseous fuel	Cu	0.002	0.009	2.000	100.000	100.020	0.001	0.000	0.000	0.000	0.000	0.000
1A2 Waste incineration	Cu	125.218		5.000	30.000	30.414		-0.006		-0.175		0.175
1A2 Biomass fuels	Cu	15.188	16.242	2.000	100.000	100.020	2.557	0.004	0.004	0.369	0.012	0.369
1A4a and 1A4c Solid fuel	Cu	45.612	23.001	3.000	100.000	100.045	3.622	0.004	0.006	0.410	0.026	0.411
1A4a and 1A4c Liquid fuel	Cu	30.522	4.139	3.000	100.000	100.045	0.652	-0.000	0.001	-0.030	0.005	0.030
1A4a and 1A4c Gaseous fuel	Cu	0.001	0.018	3.000	100.000	100.045	0.003	0.000	0.000	0.000	0.000	0.000
1A4a and 1A4c Waste incineration	Cu	112.422	0.068	5.000	30.000	30.414	0.003	-0.005	0.000	-0.156	0.000	0.156
1A4a and 1A4c Biomass fuels	Cu	29.923	17.209	10.000	300.000	300.167	8.132	0.003	0.005	0.980	0.066	0.982
1A4b Solid fuel	Cu	13.814	0.436	3.000	500.000	500.009	0.343	-0.001	0.000	-0.263	0.001	0.263
1A4b Liquid fuel	Cu	24.904	2.431	3.000	500.000	500.009	1.914	-0.001	0.001	-0.251	0.003	0.251
1A4b Gaseous fuel	Cu	0.001	0.014	3.000	100.000	100.045	0.002	0.000	0.000	0.000	0.000	0.000
1A4b Waste incineration	Cu			5.000	30.000	30.414						
1A4b Wood combustion	Cu	71.635	267.094	50.000	100.000	111.803	47.010	0.069	0.072	6.897	5.114	8.586
1A4b Other biomass fuels	Cu	43.747	24.988	30.000	500.000	500.899	19.704	0.005	0.007	2.364	0.287	2.381
Total	Cu	3693.071	635.226				2850.633					84.211
Total uncertainties				Overall uncertainty i the year (%):			53.391			Trend uncertainty (%):		9.177

Emission source sector	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
Continued…		Input data	Input data	Input data	Input data							
		kg	kg	%	%	%	%	%	%	%	%	%
1A1a Annual emission values for LPS power plants	Hg		163.730		5.000	5.000	1.944	0.057	0.057	0.287		0.287
1A1a Annual emission values for LPS MSW incineration	Hg		27.562		10.000	10.000	0.654	0.010	0.010	0.097		0.097
1A2 Annual emission values for LPS industrial plants	Hg	105.399	99.788		50.000	50.000	11.846	0.030	0.035	1.477		1.477
Annual emissions for other LPS	Hg		2.061		50.000	50.000	0.245	0.001	0.001	0.036		0.036
1A1a Solid fuel	Hg	520.168	1.976	1.000	10.000	10.050	0.047	-0.026	0.001	-0.263	0.001	0.263
1A1a Liquid fuel	Hg	2.371	0.821	1.000	100.000	100.005	0.195	0.000	0.000	0.017	0.000	0.017
1A1a Gaseous fuel	Hg	1.753	4.481	1.000	100.000	100.005	1.064	0.001	0.002	0.148	0.002	0.148
1A1a Waste incineration	Hg	1790.844	28.464	5.000	10.000	11.180	0.756	-0.082	0.010	-0.824	0.071	0.827
1A1a Biomass fuels	Hg	2.649	8.090	1.000	100.000	100.005	1.921	0.003	0.003	0.270	0.004	0.270
1A1b Liquid fuels	Hg	20.093	21.878	1.000	100.000	100.005	5.195	0.007	0.008	0.664	0.011	0.664
1A1c Gaseous fuel	Hg	0.918	2.693	1.000	100.000	100.005	0.640	0.001	0.001	0.090	0.001	0.090
1A2 Solid fuel	Hg	79.190	18.691	2.000	100.000	100.020	4.439	0.002	0.007	0.245	0.019	0.246
1A2 Liquid fuel	Hg	9.222	1.363	2.000	100.000	100.020	0.324	-0.000	0.000	-0.000	0.001	0.001
1A2 Gaseous fuel	Hg	2.343	3.228	2.000	100.000	100.020	0.767	0.001	0.001	0.101	0.003	0.101
1A2 Waste incineration	Hg	134.380		5.000	30.000	30.414		-0.007		-0.209		0.209
1A2 Biomass fuels	Hg	2.372	2.532	2.000	100.000	100.020	0.601	0.001	0.001	0.077	0.003	0.077
1A4a and 1A4c Solid fuel	Hg	20.590	10.383	3.000	100.000	100.045	2.466	0.003	0.004	0.258	0.015	0.258
1A4a and 1A4c Liquid fuel	Hg	9.599	0.643	3.000	100.000	100.045	0.153	-0.000	0.000	-0.027	0.001	0.027
1A4a and 1A4c Gaseous fuel	Hg	0.860	1.271	3.000	100.000	100.045	0.302	0.000	0.000	0.040	0.002	0.040
1A4a and 1A4c Waste incineration	Hg	120.648		5.000	30.000	30.414		-0.006		-0.188		0.188
1A4a and 1A4c Biomass fuels	Hg	1.812	1.588	10.000	300.000	300.167	1.132	0.000	0.001	0.139	0.008	0.139
1A4b Solid fuel	Hg	5.455	0.136	3.000	500.000	500.009	0.162	-0.000	0.000	-0.118	0.000	0.118
1A4b Liquid fuel	Hg	10.152	2.173	3.000	500.000	500.009	2.580	0.000	0.001	0.118	0.003	0.118
1A4b Gaseous fuel	Hg	1.736	2.809	3.000	100.000	100.045	0.667	0.001	0.001	0.090	0.004	0.090
1A4b Waste incineration	Hg			5.000	30.000	30.414						
1A4b Wood combustion	Hg	3.582	13.355	50.000	100.000	111.803	3.545	0.005	0.005	0.450	0.331	0.559
1A4b Other biomass fuels	Hg	2.543	1.457	30.000	500.000	500.899	1.733	0.000	0.001	0.190	0.022	0.191
Total	Hg	2848.679	421.173				228.367					4.202
Total uncertainties			Overall uncertainty i the year (%):				15.112			Trend uncertainty (%):		2.050

Emission source sector	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
Continued…		Input data	Input data	Input data	Input data							
		kg	kg	%	%	%	%	%	%	%	%	%
1A1a Annual emission values for LPS power plants	Ni		105.212		5.000	5.000	0.183	0.007	0.007	0.033		0.033
1A1a Annual emission values for LPS MSW incineration	Ni		18.283		10.000	10.000	0.064	0.001	0.001	0.011		0.011
1A2 Annual emission values for LPS industrial plants	Ni	477.900	77.732		50.000	50.000	1.352	-0.000	0.005	-0.024		0.024
Annual emissions for other LPS	Ni		1.918		50.000	50.000	0.033	0.000	0.000	0.006		0.006
1A1a Solid fuel	Ni	1607.792	1.475	1.000	10.000	10.050	0.005	-0.018	0.000	-0.177	0.000	0.177
1A1a Liquid fuel	Ni	3621.459	704.599	1.000	55.000	55.009	13.484	0.004	0.044	0.196	0.062	0.206
1A1a Gaseous fuel	Ni	0.014	0.787	1.000	100.000	100.005	0.027	0.000	0.000	0.005	0.000	0.005
1A1a Waste incineration	Ni	2604.864	52.539	5.000	10.000	11.180	0.204	-0.026	0.003	-0.256	0.023	0.257
1A1a Biomass fuels	Ni	14.398	43.845	1.000	100.000	100.005	1.525	0.003	0.003	0.257	0.004	0.257
1A1b Liquid fuels	Ni	493.501	284.503	1.000	100.000	100.005	9.898	0.012	0.018	1.220	0.025	1.220
1A1c Gaseous fuel	Ni	0.005	0.014	1.000	100.000	100.005	0.000	0.000	0.000	0.000	0.000	0.000
1A2 Solid fuel	Ni	130.312	30.848	2.000	100.000	100.020	1.073	0.000	0.002	0.047	0.005	0.047
1A2 Liquid fuel	Ni	5724.696	1189.121	2.000	55.000	55.036	22.767	0.010	0.074	0.567	0.209	0.604
1A2 Gaseous fuel	Ni	0.012	0.048	2.000	100.000	100.020	0.002	0.000	0.000	0.000	0.000	0.000
1A2 Waste incineration	Ni	195.462		5.000	30.000	30.414		-0.002		-0.065		0.065
1A2 Biomass fuels	Ni	13.646	14.596	2.000	100.000	100.020	0.508	0.001	0.001	0.076	0.003	0.076
1A4a and 1A4c Solid fuel	Ni	33.883	17.086	3.000	100.000	100.045	0.595	0.001	0.001	0.069	0.005	0.069
1A4a and 1A4c Liquid fuel	Ni	842.259	236.161	3.000	100.000	100.045	8.219	0.005	0.015	0.532	0.062	0.536
1A4a and 1A4c Gaseous fuel	Ni	0.004	0.093	3.000	100.000	100.045	0.003	0.000	0.000	0.001	0.000	0.001
1A4a and 1A4c Waste incineration	Ni	175.488	0.107	5.000	30.000	30.414	0.001	-0.002	0.000	-0.058	0.000	0.058
1A4a and 1A4c Biomass fuels	Ni	15.604	10.580	10.000	300.000	300.167	1.105	0.000	0.001	0.145	0.009	0.146
1A4b Solid fuel	Ni	9.654	0.277	3.000	500.000	500.009	0.048	-0.000	0.000	-0.045	0.000	0.045
1A4b Liquid fuel	Ni	88.448	5.091	3.000	500.000	500.009	0.886	-0.001	0.000	-0.333	0.001	0.333
1A4b Gaseous fuel	Ni	0.009	0.071	3.000	100.000	100.045	0.002	0.000	0.000	0.000	0.000	0.000
1A4b Waste incineration	Ni			5.000	30.000	30.414						
1A4b Wood combustion	Ni	17.909	66.773	50.000	100.000	111.803	2.597	0.004	0.004	0.395	0.293	0.492
1A4b Other biomass fuels	Ni	22.382	12.782	30.000	500.000	500.899	2.227	0.001	0.001	0.273	0.034	0.275
Total	Ni	16089.699	2874.540				885.386					2.821
Total uncertainties				Overall uncertainty i the year (%):			29.755			Trend uncertainty (%):		1.679

Emission source sector	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
Continued…		Input data	Input data	Input data	Input data							
		kg	kg	%	%	%	%	%	%	%	%	%
1A1a Annual emission values for LPS power plants	Pb		58.859		5.000	5.000	0.107	0.003	0.003	0.017		0.017
1A1a Annual emission values for LPS MSW incineration	Pb		51.165		10.000	10.000	0.186	0.003	0.003	0.029		0.029
1A2 Annual emission values for LPS industrial plants	Pb	1921.800	280.922		50.000	50.000	5.101	-0.001	0.016	-0.059		0.059
Annual emissions for other LPS	Pb		0.877		50.000	50.000	0.016	0.000	0.000	0.003		0.003
1A1a Solid fuel	Pb	1418.640	0.943	1.000	10.000	10.050	0.003	-0.013	0.000	-0.126	0.000	0.126
1A1a Liquid fuel	Pb	26.037	9.046	1.000	100.000	100.005	0.329	0.000	0.001	0.028	0.001	0.028
1A1a Gaseous fuel	Pb	0.030	0.660	1.000	100.000	100.005	0.024	0.000	0.000	0.004	0.000	0.004
1A1a Waste incineration	Pb	9808.941	136.355	5.000	10.000	11.180	0.554	-0.080	0.008	-0.796	0.055	0.798
1A1a Biomass fuels	Pb	36.474	92.630	1.000	100.000	100.005	3.364	0.005	0.005	0.496	0.007	0.496
1A1b Liquid fuels	Pb	63.725	66.778	1.000	100.000	100.005	2.425	0.003	0.004	0.324	0.005	0.324
1A1c Gaseous fuel	Pb	0.014	0.040	1.000	100.000	100.005	0.001	0.000	0.000	0.000	0.000	0.000
1A2 Solid fuel	Pb	1343.215	315.728	2.000	100.000	100.020	11.469	0.006	0.018	0.597	0.051	0.599
1A2 Liquid fuel	Pb	118.474	16.101	2.000	100.000	100.020	0.585	-0.000	0.001	-0.014	0.003	0.015
1A2 Gaseous fuel	Pb	0.035	0.072	2.000	100.000	100.020	0.003	0.000	0.000	0.000	0.000	0.000
1A2 Waste incineration	Pb	736.038		5.000	30.000	30.414		-0.007		-0.198		0.198
1A2 Biomass fuels	Pb	20.940	22.424	2.000	100.000	100.020	0.815	0.001	0.001	0.109	0.004	0.109
1A4a and 1A4c Solid fuel	Pb	349.256	176.118	3.000	100.000	100.045	6.399	0.007	0.010	0.691	0.043	0.693
1A4a and 1A4c Liquid fuel	Pb	131.885	3.247	3.000	100.000	100.045	0.118	-0.001	0.000	-0.100	0.001	0.100
1A4a and 1A4c Gaseous fuel	Pb	0.013	0.086	3.000	100.000	100.045	0.003	0.000	0.000	0.000	0.000	0.000
1A4a and 1A4c Waste incineration	Pb	660.822	0.287	5.000	30.000	30.414	0.003	-0.006	0.000	-0.177	0.000	0.177
1A4a and 1A4c Biomass fuels	Pb	136.706	66.173	10.000	300.000	300.167	7.214	0.003	0.004	0.765	0.053	0.767
1A4b Solid fuel	Pb	99.368	2.841	3.000	500.000	500.009	0.516	-0.001	0.000	-0.364	0.001	0.364
1A4b Liquid fuel	Pb	100.595	0.287	3.000	500.000	500.009	0.052	-0.001	0.000	-0.442	0.000	0.442
1A4b Gaseous fuel	Pb	0.026	0.086	3.000	100.000	100.045	0.003	0.000	0.000	0.000	0.000	0.000
1A4b Waste incineration	Pb			5.000	30.000	30.414						
1A4b Wood combustion	Pb	358.177	1335.468	50.000	100.000	111.803	54.228	0.073	0.076	7.294	5.385	9.067
1A4b Other biomass fuels	Pb	203.476	116.198	30.000	500.000	500.899	21.139	0.005	0.007	2.402	0.281	2.418
Total	Pb	17534.687	2753.391				3656.996					90.909
Total uncertainties				Overall uncertainty i the year (%):			60.473			Trend uncertainty (%):		9.535

Emission source sector	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
Continued…		Input data	Input data	Input data	Input data							
		kg	kg	%	%	%	%	%	%	%	%	%
1A1a Annual emission values for LPS power plants	Se		796.063		5.000	5.000	3.053	0.166	0.166	0.831		0.831
1A1a Annual emission values for LPS MSW incineration	Se				10.000	10.000						
1A2 Annual emission values for LPS industrial plants	Se	854.340	207.677		50.000	50.000	7.965	-0.005	0.043	-0.260		0.260
Annual emissions for other LPS	Se		21.090		50.000	50.000	0.809	0.004	0.004	0.220		0.220
1A1a Solid fuel	Se	3073.720	8.970	1.000	10.000	10.050	0.069	-0.172	0.002	-1.718	0.003	1.718
1A1a Liquid fuel	Se	12.009	2.411	1.000	100.000	100.005	0.185	-0.000	0.001	-0.018	0.001	0.018
1A1a Gaseous fuel	Se	0.175	0.448	1.000	100.000	100.005	0.034	0.000	0.000	0.008	0.000	0.008
1A1a Waste incineration	Se	339.175	40.821	5.000	10.000	11.180	0.350	-0.011	0.009	-0.108	0.060	0.123
1A1a Biomass fuels	Se	3.667	10.691	1.000	100.000	100.005	0.820	0.002	0.002	0.202	0.003	0.202
1A1b Liquid fuels	Se	97.931	106.449	1.000	100.000	100.005	8.166	0.017	0.022	1.666	0.031	1.666
1A1c Gaseous fuel	Se	0.092	0.269	1.000	100.000	100.005	0.021	0.000	0.000	0.005	0.000	0.005
1A2 Solid fuel	Se	223.370	42.758	2.000	100.000	100.020	3.281	-0.004	0.009	-0.377	0.025	0.378
1A2 Liquid fuel	Se	36.608	7.228	2.000	100.000	100.020	0.555	-0.001	0.002	-0.057	0.004	0.057
1A2 Gaseous fuel	Se	0.234	0.316	2.000	100.000	100.020	0.024	0.000	0.000	0.005	0.000	0.005
1A2 Waste incineration	Se	25.451		5.000	30.000	30.414		-0.001		-0.043		0.043
1A2 Biomass fuels	Se	2.994	3.191	2.000	100.000	100.020	0.245	0.000	0.001	0.050	0.002	0.050
1A4a and 1A4c Solid fuel	Se	63.745	32.858	3.000	100.000	100.045	2.522	0.003	0.007	0.324	0.029	0.325
1A4a and 1A4c Liquid fuel	Se	6.692	1.447	3.000	100.000	100.045	0.111	-0.000	0.000	-0.008	0.001	0.008
1A4a and 1A4c Gaseous fuel	Se	0.086	0.127	3.000	100.000	100.045	0.010	0.000	0.000	0.002	0.000	0.002
1A4a and 1A4c Waste incineration	Se	22.850	0.058	5.000	30.000	30.414	0.001	-0.001	0.000	-0.039	0.000	0.039
1A4a and 1A4c Biomass fuels	Se	1.841	2.039	10.000	300.000	300.167	0.469	0.000	0.000	0.096	0.006	0.096
1A4b Solid fuel	Se	14.883	0.247	3.000	500.000	500.009	0.095	-0.001	0.000	-0.397	0.000	0.397
1A4b Liquid fuel	Se	1.341	0.071	3.000	500.000	500.009	0.027	-0.000	0.000	-0.031	0.000	0.031
1A4b Gaseous fuel	Se	0.174	0.281	3.000	100.000	100.045	0.022	0.000	0.000	0.005	0.000	0.005
1A4b Waste incineration	Se			5.000	30.000	30.414						
1A4b Wood combustion	Se	4.477	16.693	50.000	100.000	111.803	1.432	0.003	0.003	0.323	0.247	0.406
1A4b Other biomass fuels	Se	2.543	1.453	30.000	500.000	500.899	0.558	0.000	0.000	0.079	0.013	0.080
Total	Se	4788.401	1303.654				161.030					7.188
Total uncertainties				Overall uncertainty i the year (%):			12.690			Trend uncertainty (%):		2.681

Emission source sector	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
Continued…		Input data	Input data	Input data	Input data							
		kg	kg	%	%	%	%	%	%	%	%	%
1A1a Annual emission values for LPS power plants	Zn		287.009		5.000	5.000	0.242	0.012	0.012	0.058		0.058
1A1a Annual emission values for LPS MSW incineration	Zn				10.000	10.000						
1A2 Annual emission values for LPS industrial plants	Zn	759.999	279.191		50.000	50.000	2.352	0.004	0.011	0.196		0.196
Annual emissions for other LPS	Zn		4.726		50.000	50.000	0.040	0.000	0.000	0.010		0.010
1A1a Solid fuel	Zn	4492.360	2.889	1.000	10.000	10.050	0.005	-0.043	0.000	-0.431	0.000	0.431
1A1a Liquid fuel	Zn	74.975	26.321	1.000	100.000	100.005	0.444	0.000	0.001	0.034	0.002	0.034
1A1a Gaseous fuel	Zn	0.301	44.798	1.000	100.000	100.005	0.755	0.002	0.002	0.180	0.003	0.180
1A1a Waste incineration	Zn	10921.435	85.687	5.000	10.000	11.180	0.161	-0.101	0.003	-1.014	0.024	1.014
1A1a Biomass fuels	Zn	10.404	41.763	1.000	100.000	100.005	0.704	0.002	0.002	0.158	0.002	0.158
1A1b Liquid fuels	Zn	148.226	96.028	1.000	100.000	100.005	1.618	0.002	0.004	0.244	0.005	0.244
1A1c Gaseous fuel	Zn	0.014	0.040	1.000	100.000	100.005	0.001	0.000	0.000	0.000	0.000	0.000
1A2 Solid fuel	Zn	2004.799	471.324	2.000	100.000	100.020	7.944	-0.000	0.019	-0.033	0.054	0.063
1A2 Liquid fuel	Zn	1546.748	308.959	2.000	100.000	100.020	5.207	-0.002	0.012	-0.246	0.035	0.248
1A2 Gaseous fuel	Zn	0.035	1.884	2.000	100.000	100.020	0.032	0.000	0.000	0.008	0.000	0.008
1A2 Waste incineration	Zn	819.516		5.000	30.000	30.414		-0.008		-0.237		0.237
1A2 Biomass fuels	Zn	15.222	16.006	2.000	100.000	100.020	0.270	0.000	0.001	0.050	0.002	0.050
1A4a and 1A4c Solid fuel	Zn	521.277	262.863	3.000	100.000	100.045	4.432	0.006	0.011	0.557	0.045	0.559
1A4a and 1A4c Liquid fuel	Zn	401.010	64.066	3.000	100.000	100.045	1.080	-0.001	0.003	-0.128	0.011	0.129
1A4a and 1A4c Gaseous fuel	Zn	0.013	5.082	3.000	100.000	100.045	0.086	0.000	0.000	0.020	0.001	0.020
1A4a and 1A4c Waste incineration	Zn	735.770	0.121	5.000	30.000	30.414	0.001	-0.007	0.000	-0.213	0.000	0.213
1A4a and 1A4c Biomass fuels	Zn	441.535	201.156	10.000	300.000	300.167	10.175	0.004	0.008	1.155	0.115	1.161
1A4b Solid fuel	Zn	152.393	4.556	3.000	500.000	500.009	0.384	-0.001	0.000	-0.643	0.001	0.643
1A4b Liquid fuel	Zn	209.430	10.047	3.000	500.000	500.009	0.847	-0.002	0.000	-0.807	0.002	0.807
1A4b Gaseous fuel	Zn	0.026	3.381	3.000	100.000	100.045	0.057	0.000	0.000	0.014	0.001	0.014
1A4b Waste incineration	Zn			5.000	30.000	30.414						
1A4b Wood combustion	Zn	895.443	3338.670	50.000	150.000	158.114	88.957	0.126	0.135	18.882	9.515	21.144
1A4b Other biomass fuels	Zn	661.296	377.658	30.000	500.000	500.899	31.878	0.009	0.015	4.422	0.646	4.469
Total	Zn	24812.224	5934.225				9154.513					471.319
Total uncertainties				Overall uncertainty i the year (%):			95.679			Trend uncertainty (%):		21.710

IMPROVED INVENTORY FOR HEAVY METAL EMISSIONS FROM STATIONARY COMBUSTION PLANTS

1990-2009

On behalf of the Ministry of the Environment DCE at Aarhus University annually reports heavy metals (HM) emissions to the UNECE CLRTAP (United Nations Economic Commission for Europe Convention on Long-Range Transboundary Air Pollution). This report presents updated heavy metal emission factors for stationary combustion plants and the corresponding improved emission inventories for the following HMs: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Nickel (Ni), Lead (Pb), Selenium (Se) and Zinc (Zn). The report presents data for the year 2009 and time series for 1990-2009. The report also include methodology, references and an uncertainty estimate. In Denmark, stationary combustion plants are among the most important emission sources for heavy metals. Emissions of all heavy metals have decreased considerably (73 % - 92 %) since 1990. The main HM emission sources are coal combustion, waste incineration, residual oil combustion and in 2009 also combustion of biomass. The emission from waste incineration plants has decreased profoundly also in recent years due to installation and improved performance of flue gas cleaning devices. The emission from power plants have also decreased considerably.

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