ISPRA
Institute for Environmental
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Italian Emission Inventory 1990-2008

Informative Inventory Report 2010

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EXECUTIVE SUMMARY

The *Italian Informative Inventory Report* (IIR) is edited in the framework of the *United Nations Economic Commission for Europe* (UNECE) *Convention on Long Range Transboundary Air Pollution* (CLRTAP). It contains information on the Italian inventory up to the year 2008, including an explanation of methodologies, data sources, QA/QC activities and verification processes carried out during the inventory compilation, with an analysis of emission trends and a description of key categories.

The aim of the document is to facilitate understanding of the calculation of the Italian air pollutant emission data, hence providing a common means for comparing the relative contribution of different emission sources and helping in the identification of reduction policies.

The Institute for Environmental Protection and Research (ISPRA) has the overall responsibility for the emission inventory submission to CLRTAP, as well as to the *United Nations Framework Convention on Climate Change* (UNFCCC), and is in charge of all work related to inventory compilation.
In particular, in compliance with the LRTAP Convention, Italy has to submit annually data on national emissions of SO_X, NO_X, NMVOC, CO and NH_3, and various heavy metals and POPs. The submission consists of the national emission inventory, communicated through compilation of the Nomenclature Reporting Format (NRF), and the informative inventory report (IIR) to ensure the properties of transparency, consistency, comparability, completeness and accuracy.

In the period 1990-2008, emissions from most pollutants described in this report show a downward trend. Reductions are especially relevant for the main pollutants (SO_X -84%; NO_X -48%; CO -58%; NMVOC -44%) and lead (-94%) whereas a significant raise is observed for polycyclic aromatic hydrocarbons (+51%).
The major drivers for the trend are reductions in the industrial and road transport sectors, due to the implementation of various European Directives which introduced new technologies, plant emission limits, the limitation of sulphur content in liquid fuels and the shift to cleaner fuels. Emissions have also decreased for the improvement of energy efficiency as well as the promotion of renewable energy.
The energy sector is the main source of emissions in Italy with a share of more than 80%, including fugitive emissions, in many pollutants (SO_X 92%; NO_X 98%; CO 86%; PM2.5 80%; Cd 83%). The industrial processes sector is an important source of emissions specifically related to the iron and steel production, at least for particulate matter, heavy metals and POPs, whereas significant emissions of SO_X and particulate matter derive from cement production; on the other hand, the solvent and other product use sector is characterized by NMVOC emissions. The agriculture sector is the main source of NH_3 emissions in Italy with a share of 95% in national total. Finally, the waste sector, specifically waste incineration, is a relevant source for HCB, PAH and dioxin emissions (46%, 21% and 12%, respectively).

Emission figures of the Italian emission inventory and other related documents are publicly available at http://www.sinanet.apat.it/it/sinanet/serie_storiche_emissioni.

1 INTRODUCTION

1.1 Background information on the Convention on Long-range Transboundary Air Pollution

The 1979 Geneva *Convention on Long-range Transboundary Air Pollution*, contributing to the development of international environmental law, is one of the fundamental international means for the protection of the human health and the environment through the intergovernmental cooperation.
The fact that air pollutants could travel several thousands of kilometres before deposition and damage occurred outlined the need for international cooperation.
In November 1979, in Geneva, 34 Governments and the European Community (EC) signed the Convention. The *Convention on Long-range Transboundary Air Pollution* was ratified by Italy in the year 1982 and entered into force in 1983. It has been extended by the following eight specific protocols:

- The 1984 Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP); 42 Parties. Entered into force on 28th January 1988.
- The 1985 Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent; 23 Parties. Entered into force on 2nd September 1987.
- The 1988 Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes; 31 Parties. Entered into force on 14th February 1991.
- The 1991 Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes; 22 Parties. Entered into force on 29th September 1997.
- The 1994 Protocol on Further Reduction of Sulphur Emissions; 27 Parties. Entered into force on 5th August 1998.
- The 1998 Protocol on Heavy Metals; 28 Parties. Entered into force on 29 December 2003.
- The 1998 Protocol on Persistent Organic Pollutants (POPs); 28 Parties. Entered into force on 23rd October 2003.
- The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone; 23 Parties. Entered into force on 17th May 2005. (Guidance documents to Protocol adopted by decision 1999/1).

As regards Italy, the following table shows the dates of signature and ratification of both Convention and Protocols.

	SIGNATURE	RATIFICATION
1979 Convention	14/11/1979	15/07/1982
1984 EMEP Protocol	28/09/1984	12/01/1989
1985 Sulphur Protocol	09/07/1985	05/02/1990
1988 NO_X Protocol	01/11/1988	19/05/1992
1991 VOC Protocol	19/11/1991	30/06/1995
1994 Sulphur Protocol	14/06/1994	14/09/1998
1998 Heavy Metals Protocol	24/06/1998	
1998 POPs Protocol	24/06/1998	20/06/2006
1999 Multi-effect Protocol	01/12/1999	

Table 1.1 Dates of signature and ratification of the UNECE Convention and Protocols

The following classes of pollutants should be included in the emission inventory:

Main Pollutants

- Sulphur oxides (SO_X), in mass of SO_2;
- Nitrous oxides (NO_X), in mass of NO_2;
- Carbon monoxide (CO);
- Non-methane volatile organic compounds (NMVOC);
- Ammonia (NH_3).

Particulate matter

- PM10, particulate matter less than 10 microns in diameter;
- PM2.5, particulate matter less than 2.5 microns in diameter.

Heavy Metals

- Priority Metals: Lead (Pb), Cadmium (Cd) and Mercury (Hg);
- Other metals: Arsenic (As), Chrome (Cr), Copper (Cu), Nickel (Ni), Selenium (Se) and Zinc (Zn).

Persistent organic pollutants (POPs)

- As specified in Annex I of the POPs Protocol;
- As specified in Annex II of the POPs Protocol, including Polychlorinated Biphenyls (PCBs);
- As specified in Annex III of the POPs Protocol: Dioxins (Diox), Polycyclic Aromatic Hydrocarbons (PAHs), Hexachlorobenzene (HCB);
- Other POPs.

1.2 National Inventory

As a Party to the *United Nations Economic Commission for Europe* (UNECE) *Convention on Long Range Transboundary Air Pollution* (CLRTAP), Italy has to submit annually data on emissions of air pollutants in order to fulfil obligations, in compliance with the implementation of Protocols under the Convention. Parties are required to report on annual national emissions of SO_X, NO_X, NMVOC, CO and NH_3, and various heavy metals and POPs according to the *Guidelines for Estimating and Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution* (UNECE, 2003).

Specifically, the submission consists of the national LRTAP emission inventory, communicated through compilation of the *Nomenclature Reporting Format* (NRF) and the *Informative Inventory Report* (IIR).

The Italian informative inventory report contains information on the national inventory for the year 2008, including descriptions of methods, data sources, QA/QC activities carried out and a trend analysis. The inventory accounts for anthropogenic emissions of the following substances: sulphur oxides (SO_X), nitrogen oxides (NO_X), ammonia (NH_3), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), particulate matter, particles of size <10 µm, (PM10), particulate matter, particles of size < 2.5µm, (PM2.5), lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), chromium (Cr), copper (Cu), nickel (Ni), selenium (Se), zinc (Zn), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAH), dioxins (Diox), hexachlorobenzene (HCB). Other pollutants are reported either as not estimated or not occurring, further investigation is planned to verify these emissions.

Detailed information on emission figures of primary pollutants, particulate matter, heavy metals and persistent organic pollutants as well as estimation procedures are provided in order to improve the transparency, consistency, comparability, accuracy and completeness of the inventory provided.

The national inventory is updated annually in order to reflect revisions and improvements in the methodology and the availability of new information. Changes are applied retrospectively to earlier years, which accounts for any difference in previously published data.
Total emissions by pollutant from 1990 to 2008 are reported in Table 1.2.

		1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
SO_X	*Gg*	1,794	1,319	749	697	616	518	480	401	379	335	293
NO_X	*Gg*	2,035	1,911	1,448	1,419	1,365	1,342	1,306	1,221	1,167	1,132	1,061
NMVOC	*Gg*	2,004	2,076	1,595	1,511	1,443	1,375	1,322	1,248	1,217	1,182	1,126
NH_3	*Gg*	466	447	446	448	436	431	425	413	408	417	406
CO	*Gg*	7,176	7,166	4,961	4,673	4,269	4,058	3,886	3,482	3,283	3,163	3,032
As	*Mg*	37	27	45	45	41	42	41	40	41	41	42
Cd	*Mg*	10	10	9	9	7	8	8	9	9	9	9
Cr	*Mg*	93	75	52	53	53	55	58	59	61	61	60
Cu	*Mg*	183	199	199	201	204	206	208	208	209	210	204
Hg	*Mg*	12	11	10	10	10	10	10	10	11	11	10
Ni	*Mg*	123	114	105	110	113	113	112	111	109	105	102
Pb	*Mg*	4,411	2,011	942	709	249	254	268	278	286	288	279
Se	*Mg*	10	10	11	11	11	12	12	12	12	12	12
Zn	*Mg*	930	912	875	877	878	895	942	948	1,019	1,015	995
PM10	*Gg*	232	227	192	190	178	174	176	163	159	158	154
PM2.5	*Gg*	198	194	160	157	146	142	144	131	128	127	122
PAH	*Mg*	103	121	128	129	118	123	141	138	143	155	156
Dioxin	*g* IT_q	473	462	375	299	289	288	296	300	308	320	311
HCB	*kg*	22	24	23	33	34	35	26	24	30	31	31
PCB	*kg*	279	289	252	258	261	264	269	266	273	269	263

Table 1.2 Emission time series by pollutant

The NRF files and other related documents can be found on website at the following address: http://www.sinanet.apat.it/it/sinanet/serie_storiche_emissioni.

1.3 Institutional arrangements

The Institute for Environmental Protection and Research (ISPRA) has the overall responsibility for the emission inventory and submissions to CLRTAP; the institute is also responsible for the

communication of the pollutants under the NEC directive as well as to carry out scenarios, jointly with the Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), as established by the Legislative Decree n. 171 of 21st May 2004. Moreover, ISPRA is the single entity in charge of the development and compilation of the national greenhouse gas emission inventory as indicated by the Legislative Decree n. 51 of 7th March 2008. The Ministry for the Environment, Land and Sea is responsible for the endorsement of the inventory and for the communication to the Secretariat of the different conventions.

The *Italian National System*, currently in place, is fully described in the document '*National Greenhouse Gas Inventory System in Italy*' (ISPRA, 2010[a]).

A specific unit of the Institute is responsible for the compilation of the *Italian Atmospheric Emission Inventory* and the *Italian Greenhouse Gas Inventory* in the framework of both the *Convention on Climate Change* and the *Convention on Long Range Transboundary Air Pollution*. The whole inventory is compiled by the institute; scientific and technical institutions and consultants may help in improving information both on activity data and emission factors of specific activities. All the measures to guarantee and improve the transparency, consistency, comparability, accuracy and completeness of the inventory are undertaken.

ISPRA bears the responsibility for the general administration of the inventory, co-ordinates participation in review processes, publishes and archives the inventory results.

Specifically, ISPRA is responsible for all aspects of national inventory preparation, reporting and quality management. Activities include the collection and processing of data from different data sources, the selection of appropriate emissions factors and estimation methods consistent with the EMEP/CORINAIR guidelines, the *IPCC 1996 Revised Guidelines*, the *IPCC Good Practice Guidance and Uncertainty management* and the *IPCC Good Practice Guidance for land use, land-use change and forestry*, and the *IPCC 2006 Guidelines*, the compilation of the inventory following the QA/QC procedures, the preparation of the *Informative Inventory Report* and the reporting through the *Nomenclature Reporting Format*, the response to review checks, the updating and data storage.

Different institutions are responsible for statistical basic data and data publication, which are primary to ISPRA for carrying out emission estimates. These institutions are part of the *National Statistical System* (Sistan), which provides national official statistics, and therefore are asked periodically to update statistics; moreover, the *National Statistical System* ensures the homogeneity of the methods used for official statistics data through a coordination plan, involving the entire public administration at central, regional and local levels.

The main Sistan products, which are primarily necessary for the inventory compilation, are:

- National Statistical Yearbooks, Monthly Statistical Bulletins, by ISTAT (National Institute of Statistics);
- Annual Report on the Energy and Environment, by ENEA (Agency for New Technologies, Energy and the Environment);
- National Energy Balance (annual), Petrochemical Bulletin (quarterly publication), by MSE (Ministry of Economic Development);
- Transport Statistics Yearbooks, by MINT (Ministry of Transportation);
- Annual Statistics on Electrical Energy in Italy, by TERNA (National Independent System Operator);
- Annual Report on Waste, by ISPRA;
- National Forestry Inventory, by MIPAAF (Ministry of Agriculture, Food and Forest Policies).

The national emission inventory itself is a Sistan product.

Other information and data sources are used to carry out emission estimates, which are generally referred to in Table 1.3 in the following section 1.5.

1.4 Inventory preparation process

ISPRA has established fruitful cooperation with a number of governmental and research institutions as well as industrial associations, which helps improving some leading categories of the inventory. Specifically, these activities aim at the improvement of provision and collection of basic data and emission factors, through plant-specific data, and exchange of information on scientific researches and new sources. Moreover, when in depth investigation is needed and a high uncertainty in the estimates is present, specific sector analyses are committed to ad hoc research teams or consultants.

ISPRA also coordinates with different national and regional authorities and private institutions for the cross-checking of parameters and estimates, as well as with ad hoc expert panels, in order to improve the completeness and transparency of the inventory.

The main basic data needed for the preparation of the national emission inventory are energy statistics, published by the Ministry of Economic Development (MSE) in the National Energy Balance (BEN), statistics on industrial and agricultural production, published by the National Institute of Statistics (ISTAT), statistics on transportation, provided by the Ministry of Transportation (MINT), and data supplied directly by the relevant professional associations.

Emission factors and methodologies used in the estimation process are consistent with the EMEP/CORINAIR Guidebook, the IPCC Guidelines and Good Practice Guidance as well as supported by national experiences and circumstances. Final decisions are up to inventory experts, taking into account all the information available.

For the industrial sector, emission data collected through the National Pollutant Emission Register (E-PRTR), the Large Combustion Plant (LCP) Directive and in the framework of the European Emissions Trading Scheme have yielded considerable developments in the inventory of the relative sectors. In fact, these data, even if not always directly used, are taken into account as a verification of emission estimates and improve national emissions factors as well as activity data figures.

In addition, final estimates are checked and verified also in view of annual environmental reports by industries.

For large industrial point sources, emissions are registered individually, when communicated, based upon detailed information such as fuel consumption.

Other small plants communicate their emissions which are also considered individually.

Emission estimates are drawn up for each sector. Final data are communicated to the UNECE Secretariat filling in the NRF files.

The process of the inventory preparation is carried out annually. In addition to a new year, the entire time series is checked and revised during the annual compilation of the inventory. In particular, recalculations are elaborated on account of changes in the methodologies used to carry out emission estimates, changes due to different allocation of emissions as compared to previous submissions and changes due to error corrections. The inventory may also be expanded by including categories not previously estimated if sufficient information on activity data and suitable emission factors have been identified and collected. Information on the major recalculations is provided in the sectoral chapter of the report.

All the reference material, estimates and calculation sheets, as well as the documentation on scientific papers and the basic data needed for the inventory compilation, are stored and archived at the Institute. After each reporting cycle, all database files, spreadsheets and electronic documents are archived as ‘read-only-files’ so that the documentation and estimates could be traced back

during the new year inventory compilation or a review process.
Technical reports and emission figures are publicly accessible on the web at the address http://www.sinanet.apat.it/it/sinanet/serie_storiche_emissioni.

1.5 Methods and data sources

An outline of methodologies and data sources used in the preparation of the emission inventory for each sector is provided in the following. In Table 1.3 a summary of the activity data and sources used in the inventory compilation is reported.
Methodologies are consistent with the *EMEP-CORINAIR Emission Inventory Guidebook, Revised 1996* and *2006 IPCC Guidelines*, and *IPCC Good Practice Guidance* (EMEP/CORINAIR, 2007; IPCC, 1997; IPCC, 2006; IPCC, 2000); national emission factors are used as well as default emission factors from international guidebooks, when national data are not available. The development of national methodologies is supported by background documents.
The most complete document describing national methodologies used in the emission inventory compilation is the *National Inventory Report*, submitted in the framework of the UN *Convention on Climate Change* and the *Kyoto Protocol* (ISPRA, 2010 [b]).

SECTOR	ACTIVITY DATA	SOURCE
1 Energy 1A1 Energy Industries	Fuel use	Energy Balance - Ministry of Economic Development Major national electricity producers European Emissions Trading Scheme
1A2 Manufacturing Industries and Construction	Fuel use	Energy Balance - Ministry of Economic Development Major National Industry Corporation European Emissions Trading Scheme
1A3 Transport	Fuel use Number of vehicles Aircraft landing and take-off cycles and maritime activities	Energy Balance - Ministry of Economic Development Statistical Yearbooks - National Statistical System Statistical Yearbooks - Ministry of Transportation Statistical Yearbooks - Italian Civil Aviation Authority (ENAC) Maritime and Airport local authorities
1A4 Residential-public-commercial sector	Fuel use	Energy Balance - Ministry of Economic Development
1B Fugitive Emissions from Fuel	Amount of fuel treated, stored, distributed	Energy Balance - Ministry of Economic Development Statistical Yearbooks - Ministry of Transportation Major National Industry Corporation
2 Industrial Processes	Production data	National Statistical Yearbooks- National Institute of Statistics International Statistical Yearbooks-UN European Emissions Trading Scheme European Pollutant Emission Registry Sectoral Industrial Associations
3 Solvent and Other Product Use	Amount of solvent use	National Environmental Publications - Sectoral Industrial Associations International Statistical Yearbooks - UN
4 Agriculture	Agricultural surfaces Production data Number of animals Fertiliser consumption	Agriculture Statistical Yearbooks - National Institute of Statistics Sectoral Agriculture Associations
5 Land Use, Land Use Change and Forestry	Forest and soil surfaces Amount of biomass Biomass burnt Biomass growth	Statistical Yearbooks - National Institute of Statistics State Forestry Corps National and Regional Forestry Inventory Universities and Research Institutes
6 Waste	Amount of waste	National Waste Cadastre - Institute for Environmental Protection and Research , National Waste Observatory

Table 1.3 Main activity data and sources for the Italian Emission Inventory

Activity data used in emission calculations and their sources are briefly described here below.
In general, for the energy sector, basic statistics for estimating emissions are fuel consumption published in the national Energy Balance by the Ministry of Economic Development. Additional information for electricity production is provided by the major national electricity producers and by the major national industry corporation. On the other hand, basic information for road transport, maritime and aviation, such as the number of vehicles, harbour statistics and aircraft landing and take-off cycles are provided in statistical yearbooks published both by the National Institute of Statistics and the Ministry of Transportation. Other data are communicated by different category associations.
Data from ETS are incorporated into the national inventory whenever the sectoral coverage is complete; in fact, not always do these figures entirely cover the energy categories whereas national statistics, such as the national energy balance and the energy production and consumption statistics, provide the complete basic data needed for the Italian emission inventory. However, the analysis of

data from the Italian Emissions Trading Scheme database is used to develop country-specific emission factors and check activity data levels. In this context, ISPRA is also responsible for developing, operating and maintaining the national registry under Directive 2003/87/CE as instituted by the Legislative Decree 51 of March 7th 2008; the Institute performs this tasks under the supervision of the national Competent Authority for the implementation of directive 2003/87/CE, jointly established by the Ministry for Environment, Land and Sea and the Ministry for Economic Development.

For the industrial sector, the annual production data are provided by national and international statistical yearbooks. Emission data collected through the National Pollutant Emission Register (E-PRTR) are also used in the development of emission estimates or taken into account as a verification of emission estimates for some specific categories. According to the Italian Decree of 23 November 2001, data from the Italian E-PRTR are validated and communicated by ISPRA to the Ministry for the Environment, Land and Sea and to the European Commission within October of the current year for data referring to the previous year. These data are used for the compilation of the inventory whenever they are complete in terms of sectoral information; in fact, industries communicate figures only if they exceed specific thresholds; furthermore, basic data such as fuel consumption are not supplied and production data are not split by product but reported as an overall value. Anyway, E-PRTR is a good basis for data checks and a way to facilitate contacts with industries which supply, under request, additional information as necessary for carrying out sectoral emission estimates.

In addition, final emissions are checked and verified also taking into account figures reported by industries in their annual environmental reports.

Both for energy and industrial processes, emissions of large industrial point sources are registered individually; communication also takes place in the framework of the European Directive on Large Combustion Plants, based upon detailed information such as fuel consumption. Other small plants communicate their emissions which are also considered individually.

For the other sectors, i.e. for solvents, the amount of solvent use is provided by environmental publications of sector industries and specific associations as well as international statistics.

For agriculture, annual production data and number of animals are provided by the National Institute of Statistics and other sectoral associations.

For waste, the main activity data are provided by the Institute for Environmental Protection and Research and the Waste Observatory.

In case basic data are not available proxy variables are considered; unpublished data are used only if supported by personal communication and confidentiality of data is respected.

All the material and documents used for the inventory emission estimates are stored at the Institute for Environmental Protection and Research. The inventory is composed by spreadsheets to calculate emission estimates; activity data and emission factors as well as methodologies are referenced to their data sources.

A ‘reference’ database has also been developed to increase the transparency of the inventory; at the moment, it is complete as far as references to greenhouse gas emissions are concerned.

1.6 Key categories

A key category analysis of the Italian inventory is carried out according to the Tier 1 method described in the IPCC Good Practice (IPCC, 2000). According to these guidelines, a key category is defined as an emission category that has a significant influence on a country’s inventory in terms of the absolute level in emissions. Key categories are those which, when summed together in

descending order of magnitude, add up to over 95% of the total emissions.
National emissions have been disaggregated into the categories reported in the *National Format Report*; details vary according to different pollutants in order to reflect specific national circumstances. The level analysis has been applied to the last submitted inventories, as for 2007 and 2008. Results are reported in the following table for the year 2008 by pollutant.

	Key categories												Total (%)
SO_x	1A2 (19.9%)	1A1a (19.8%)	1A3d ii (16.1%)	1A1b (15.5%)	1B2a iv (8.8%)	2A1 (4.4%)	1A4b i (3.3%)	1A1c (3.1%)	1B2c (2.8%)	2B5 a (2.5%)			96.1
NO_x	1A3b iii (24.1%)	1A3b i (19.5%)	1A2 (11.9%)	1A3 d ii (8.4%)	1A3b ii (7.2%)	1A1a (5.5%)	1A4c ii (5.3%)	1A4a i (3.7%)	1A4b i (3.4%)	1A2 (2.3%)	1A1b (2.2%)	6Ce (1.3%)	95.6
	1A3b iv (0.9%)												
NH_3	4 B1b (23.1%)	4B1a (21.9%)	4D1a (17.9%)	4B8 (12.1%)	4B9b (4.0%)	4B9d (3.4%)	4B2 (3.1%)	4B13 (2.7%)	1A3b i (2.6%)	4D2c (2.5%)	4B9a (2.5%)		95.6
NMVOC	1A3b iv (16.2%)	3A1 (12.9%)	3D2 (10.6%)	1A3d ii (8.2%)	3C (6.7%)	3A2 (6.4%)	1A3b i (6.1%)	1A4b i (4.4%)	3D3 (2.8%)	2D2 (2.5%)	1B2b (2.4%)	1B2a iv (2.0%)	95.0
	1A3b v (1.9%)	1B2a v (1.7%)	3D1 (1.7%)	3B1 (1.6%)	1A4a i (1.5%)	1A3b iii (1.4%)	6Ce (1.2%)	1A4c ii (1.2%)	1A3b ii (0.8%)	2A6 (0.8%)			
CO	1A3b i (22.1%)	1A4b i (19.6%)	1A3b iv (16.9%)	1A2 (9.3%)	6Ce (9.3%)	1A3d ii (6.1%)	2C1 (2.6%)	1A4c i (2.4%)	1A3b ii (2.3%)	1A3b iii (1.8%)	1A4c ii (1.6%)	1A1a (1.0%)	95.1
PM10	1A4b i (16.0%)	1A2 (11.6%)	6C e (8.1%)	1A3b i (6.4%)	1A3b vi (6.2%)	4B9b (5.7%)	1A3b iii (4.5%)	1A3b ii (4.5%)	2C1 (4.4%)	1A3d ii (4.3%)	1A4c ii (4.1%)	2A1 (3.6%)	95.5
	4B8 (2.4%)	1A4c i (2.0%)	1A3b iv (1.9%)	2A6 (1.6%)	4F (1.5%)	1A1a (1.3%)	1A2f ii (1.3%)	2A2 (1.1%)	4B1b (0.9%)	1A4a i (0.7%)	4B1a (0.7%)	1A5b (0.7%)	
PM2.5	1A4b i (19.1%)	1A2 (13.8%)	6Ce (8.7%)	1A3b i (8.1%)	1A3b iii (5.7%)	1A3b ii (5.6%)	1A3d ii (5.4%)	1A4c ii (5.2%)	2C1 (4.4%)	1A3b vi (4.3%)	1A4c i (2.5%)	1A3b iv (2.4%)	95.6
	4F (1.9%)	1A2f ii (1.6%)	1A1a (1.6%)	4B9b (0.9%)	1A4a i (0.9%)	1A5b (0.9%)	1A4c iii (0.8%)	4B1b (0.7%)	2A1 (0.7%)	1A1b (0.7%)			
Pb	1A2 (47.9%)	2C1 (27.6%)	1A4a i (15.7%)	1A3b vi (4.3%)									95.5
Cd	1A2 (36.8%)	1A4a i (25.6%)	2C1 (14.4%)	1A4b i (9.9%)	1B1b (2.6%)	1A3b i (2.4%)	6Cb (1.7%)	1A1a (1.4%)	1A4c i (1.1%)				95.8
Hg	1A2 (29.6%)	2C1 (28.4%)	1A4a i (18.1%)	1A4b i (8.3%)	1A1a (7.9%)	2B5a (2.1%)	1A1b (1.5%)						96.0
PAH	1A4b i (40.2%)	2C1 (25.8%)	6Ce (20.6%)	1A4c i (5.0%)	1A1c (3.7%)								95.4
Dioxin	1A2 (36.9%)	2C1 (28.1%)	1A4b i (13.0%)	6Ce (12.1%)	1A4a i (2.4%)	1A1a (1.8%)	1A3b i (1.8%)						96.2
HCB	6Cb (42.3%)	1A4a i (16.2%)	1A3b i (14.3%)	1A2 (13.2%)	1A3b ii (4.5%)	6Ca (3.4%)	1A3b iii (2.6%)						96.6
PCB	2C1 (41.9%)	1A1a (29.2%)	1A2 (15.5%)	1A4a i (10.2%)									96.8

1 Energy	3 Solvent and product use	6 Waste
2 Industry	4 Agriculture	7 Other

Table 1.4 Key categories for the Italian Emission Inventory in 2008

1.7 QA/QC and Verification methods

ISPRA has elaborated an inventory QA/QC procedures manual which describes specific QC procedures to be implemented during the inventory development process, facilitates the overall QA procedures to be conducted, as far as possible, on the entire inventory and establishes quality objectives (APAT, 2006). Specific QA/QC procedures and different verification activities implemented thoroughly the current inventory compilation are figured out in the annual QA/QC plans (ISPRA, 2010 [c]).

Quality control checks and quality assurance procedures together with some verification activities are applied both to the national inventory as a whole and at sectoral level. Future planned improvements are prepared for each sector by the relevant inventory compiler; each expert identifies areas for sectoral improvement based on his own knowledge and in response to different inventory review processes.

In addition to *routine* general checks, source specific quality control procedures are applied on a case by case basis, focusing on key categories and on categories where significant methodological and data revision have taken place or new sources.

Checklists are compiled annually by the inventory experts and collected by the QA/QC coordinator. These lists are also registered in the 'reference' database.

General QC procedures also include data and documentation gathering. Specifically, the inventory analyst for a source category maintains a complete and separate project archive for that source category; the archive includes all the materials needed to develop the inventory for that year and is kept in a transparent manner.

Quality assurance procedures regard different verification activities of the inventory.

Feedbacks for the Italian inventory derive from communication of data to different institutions and/or at local level. Emission figures are also subjected to a process of re-examination once the inventory, the inventory related publications and the national inventory reports are posted on website, specifically www.isprambiente.it.

The preparation of environmental reports where data are needed at different aggregation levels or refer to different contexts, such as environmental and economic accountings, is also a check for emission trends. At national level, for instance, emission time series are reported in the Environmental Data Yearbooks published by the Institute, in the Reports on the State of the Environment by the Ministry for the Environment, Land and Sea and, moreover, figures are communicated to the National Institute of Statistics to be published in the relevant Environmental Statistics Yearbooks as well as used in the framework of the EUROSTAT NAMEA Project.

Comparisons between national activity data and data from international databases are usually carried out in order to find out the main differences and an explanation to them. Emission intensity indicators among countries (e.g. emissions per capita, industrial emissions per unit of added value, road transport emissions per passenger car, emissions from power generation per kWh of electricity produced, emissions from dairy cows per tonne of milk produced) can also be useful to provide a preliminary check and verification of the order of magnitude of the emissions. Additional comparisons between emission estimates from industrial sectors and those published by the industry itself in the Environmental reports are carried out annually in order to assess the quality and the uncertainty of the estimates.

The quality of the inventory has also improved by the organization and participation in sector specific workshops.

A specific procedure undertaken for improving the inventory regards the establishment of national expert panels (in particular, in road transport, land use change and forestry and energy sectors)

which involve, on a voluntary basis, different institutions, local agencies and industrial associations cooperating for improving activity data and emission factors accuracy.
Furthermore, activities in the framework of the improvement of local inventories are carried out together with local authorities concentrating on the comparison between top down and bottom up approaches and identifying the main critical issues. In 2008, ISPRA finalised the provincial inventory at local scale for the years 1990, 1995, 2000 and 2005 (ISPRA, 2009) applying a top down approach. Methodologies and results were checked out by regional and local environmental agencies and authorities, and are also available at ISPRA web address http://www.sinanet.apat.it/it/inventaria. This work is also relevant to carry out regional scenarios, for the main pollutants, within the Rains Italy project implemented by ENEA and supported by ISPRA and the regional authorities.
In addition to these expert panels, ISPRA participates in technical working groups within the National Statistical System. These groups, named *Circoli di qualità*, coordinated by the National Institute of Statistics, are constituted by both producers and users of statistical information with the aim of improving and monitoring statistical information in specific sectors such as transport, industry, agriculture, forest and fishing. These activities should improve the quality and details of basic data, as well as enable a more organized and timely communication.
Other specific activities relating to improvements of the inventory and QA/QC practises in the last year regarded the progress on the building of a unique database where information collected in the framework of different European directives, Large Combustion Plant, E-PRTR and Emissions Trading, are gathered together thus highlighting the main discrepancies in information and detecting potential errors. In fact, ISPRA personally collects these data from the industrial associations and the inventory team manages all this information and makes use of it in the preparation of the national inventory ensuring the consistency of the time series. The database is still under finalization but all the figures are considered in an overall approach and used in the compilation of the inventory.

A proper archiving and reporting of the documentation related to the inventory compilation process is also part of the national QA/QC programme.
All the material and documents used for the inventory preparation are stored at the Institute for Environmental Protection and Research.
Information relating to the planning, preparation, and management of inventory activities are documented and archived. The archive is organised so that any skilled analyst could obtain relevant data sources and spreadsheets, reproduce the inventory and review all decisions about assumptions and methodologies undertaken. A master documentation catalogue is generated for each inventory year and it is possible to track changes in data and methodologies over time. Specifically, the documentation includes:

- electronic copies of each of the draft and final inventory report, electronic copies of the draft and final NFR tables;
- electronic copies of all the final, linked source category spreadsheets for the inventory estimates (including all spreadsheets that feed the emission spreadsheets);
- results of the reviews and, in general, all documentation related to the corresponding inventory year submission.

After each reporting cycle, all database files, spreadsheets and electronic documents are archived as ‘read-only’ mode.
A ‘reference’ database is also compiled every year to increase the transparency of the inventory. This database consists of a number of records that references all documentation used during the

inventory compilation, for each sector and submission year, the link to the electronically available documents and the place where they are stored as well as internal documentation on QA/QC procedures.

1.8 General uncertainty evaluation

An overall uncertainty analysis for the Italian inventory related to the pollutants described in this report has not been assessed yet. Nevertheless, different studies on uncertainty have been carried out (Romano et al., 2004) and a quantitative assessment of the Italian GHG inventory is performed by the Tier 1 method defined in the IPCC Good Practice Guidance (IPCC, 2000) which provides a calculation based on the error propagation equations. Details on the results of the GHG inventory uncertainty figures can be found in the *National Inventory Report* 2009 (ISPRA, 2010 [b]).

It should be noted that different levels of uncertainty pertain to different pollutants. Estimates of the main pollutants are generally of high level, but PM emissions, especially those of small particle sizes, heavy metal and POP estimates are more uncertain. For this reason, even though not quantified in terms of uncertainty, improvements are planned especially for the specified pollutants.

Nevertheless, since quantitative uncertainty assessments constitute a means to either provide the inventory users with a quantitative assessment of the inventory quality or to direct the inventory preparation team to priority areas, a planned improvement for next submissions is the completion of such analysis.

1.9 General Assessment of Completeness

The inventory covers all major sources, as well as all main pollutants, included in the EMEP CORINAIR guidelines.
NFR sheets are complete as far as the details of basic information are available.
Allocation of emissions is not consistent with the guidelines only where there are no sufficient data available to split the information. For instance, emissions from combustion in manufacturing industries and construction are not split among the relevant production sectors but included in category 1.A.2.f i as a total; emissions from category 1.A.5.a other stationary are reported and included under category 1.A.4.a i commercial and institutional emission estimates. PAH emissions are not detailed in the four indicator compounds but accounted for as a total. Non exhaust emissions, both from automobile tyre and brake wear and road abrasion, are reported under 1.A.3.b vi automobile tyre and brake wear. Emissions from 4.B.9.c turkeys are included in 4.B.9.d other poultry.
There are a few emission sources not assessed yet: NO_X emissions from manure management, from cattle, buffalo, swine and other livestock categories, and NO_X emissions from direct soil emission, from the use of fertilizers in soils.
TSP emissions from all the relevant categories are not accounted for in the inventory.
Other not estimated emissions are PCPs and SCCP from solvent use, deriving from wood preservation and some manufacturing industries, and pesticides in agriculture. No information on activity data and emission factors are available for these sources at the moment and verification is needed to assess if these emissions actually occur within the national area.
Category 6.C.d cremation is not estimated for all relevant pollutants since no information on activity data is available.
Emissions from the new categories reported in the NFR under 2.A.7, quarrying and mining of

minerals other than coal, construction and demolition and storage, handling and transport of mineral products, are not estimated because no information on activity data is still available.
Further investigation will be carried out about these source categories and pollutants in order to calculate and improve figures.

2 ANALYSIS OF KEY TRENDS BY POLLUTANT

2.1 Main pollutants

In the following sections, Italian emission series of sulphur oxides, nitrogen oxides, non-methane volatile organic compounds, carbon monoxide and ammonia are presented.

2.1.1 Sulphur dioxide (SO_X)

The national atmospheric emissions of sulphur oxides have significantly decreased in recent years, as occurred in almost all countries of the UNECE.

Figure 2.1 and Table 2.1 show the emission trend from 1990 to 2008. Figure 2.1 also illustrates the share of SO_X emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

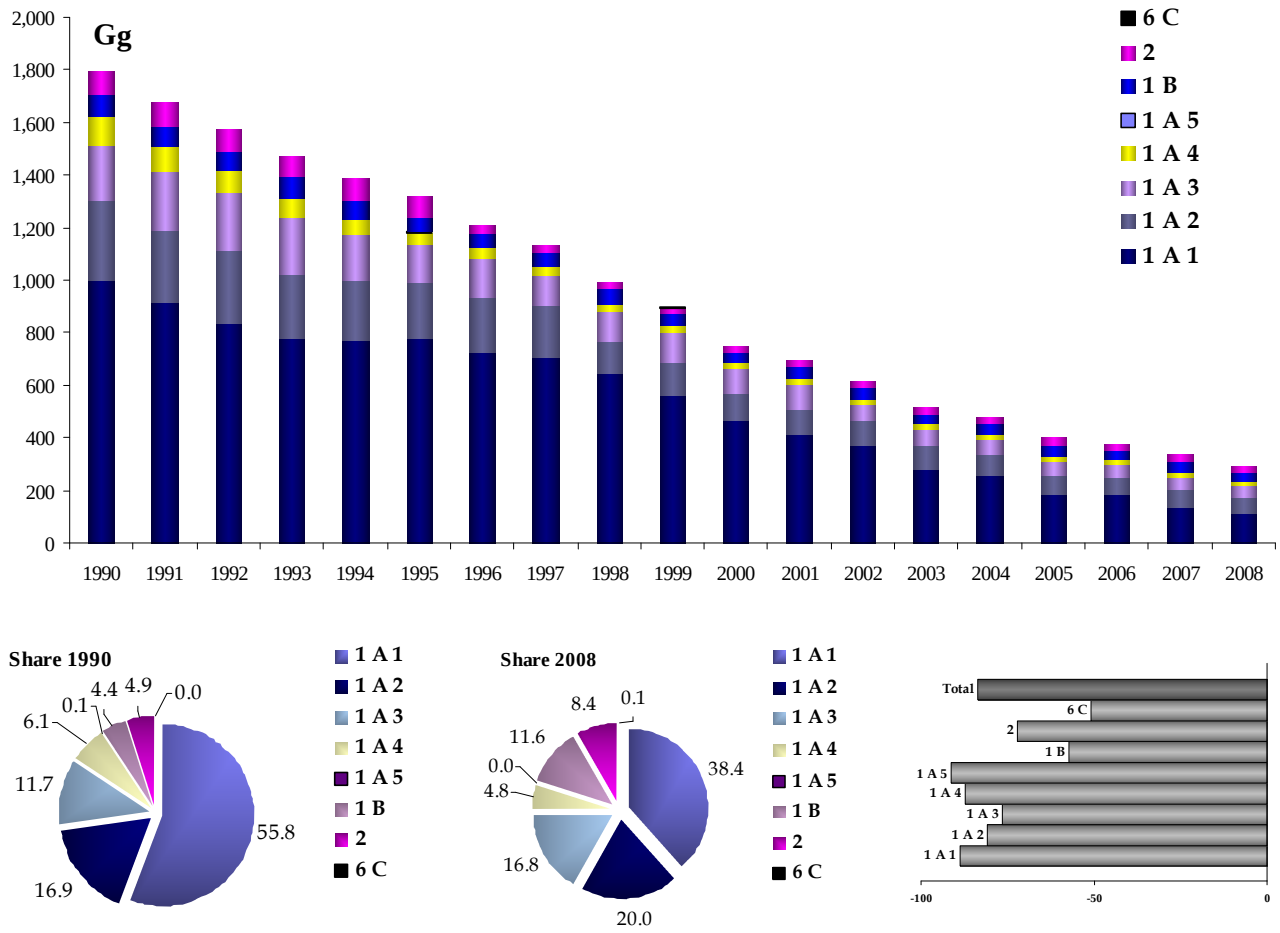

Figure 2.1 SO_X emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2001	2005	2006	2007	2008
			Gg					
Combustion in energy and transformation industries	1,001	776	467	415	187	184	139	112
Non industrial combustion plants	96	35	22	23	19	17	14	14
Combustion - Industry	299	215	104	95	73	66	67	58
Production processes	156	125	50	60	59	53	58	50
Road transport	130	72	12	13	2	2	2	2
Other mobile sources and machinery	100	86	84	82	51	48	46	48
Waste treatment and disposal	13	11	10	10	11	9	9	8
Total	***1,794***	***1,319***	***749***	***697***	***401***	***379***	***335***	***293***

Table 2.1 SO_X emission trend from 1990 to 2008 (Gg)

Figures show a general decline of SO_X emissions during the period, from 1,794 Gg in 1990 to 293 Gg in 2008. The national target of SO_X emissions amounts to 475 Gg for 2010, as set by the National Emission Ceilings Directive.
The decreasing trend is determined mainly by the reduction in emissions from *combustion in energy* (-89%) and in *industry* (-80%), representing in 2008 about 38%, and 20% of the total, respectively. Emissions deriving from *non industrial combustion plants* (-85%) and *road transport* (-99%) show a strong decrease too, but these emissions represent only about 5% and 1% of the total in 2008, respectively. *Production processes* and *other mobile sources and machiner*y also present a significant decreasing trend, showing an influence on the total of 17% and 16% and dropping by about -68% and -52%, respectively.
Since SO_X emissions are included in the NEC directive, an explanation of the sectoral decreasing trend, starting from the early eighties, is outlined more in details in the following.

Combustion in energy and transformation industries
The trend of emissions of this sector shows a reduction in the early eighties mainly due to the use, in the energy production, of natural gas in place of coal, and to the implementation of the Directive EEC 75/716 which introduces more restrictive constraints in the sulphur content of liquid fuels.
During the years 1985-1990, there was an increase of energy consumption that, not sufficiently hampered by additional measures, led to an increase in the emissions of the sector and consequently of total SO_X levels.
However in the nineties, there was an inverse trend due to the introduction of two regulatory instruments: the DPR 203/88, laying down rules concerning the authorisation of plants, and the DM of 12th July 1990, which introduced plant emission limits. Also the European Directive 88/609/EEC concerning the limitation of specific pollutants originated from large combustion plants (transposed

in Italy by the DM of 8th May 1989), gave a contribution to the reduction of emissions in the sector. Finally, in recent years, a further shift to natural gas in place of fuel oil has contributed to a decrease in emissions.

Non industrial combustion plants

The declining of the emissions occurred mainly as a result of the increase in natural gas and LPG as fuel alternative to coal and fuel oil for heating; furthermore, a number of European Directives on the sulphur content in fuels were adopted. In accordance with national legislation, the sulphur content allowed in diesel fuel has decreased from 0.8% in 1980 to 0.2% in 1995, while in fuel oil for heating from 3% in 1980 to 0.3% in 1998.

Combustion in industry

Emissions from this sector show the same trend of reduction in the area previously analyzed, as both submitted to the same rules.

Production processes

Emissions from refineries have been reduced as a result of compliance with the DM 12th July 1990, which introduces limit values. The reduction of emissions from chemical industry is due to the drop off of the sulphuric acid production and to the decrease of emissions in the production of carbon black. Furthermore, there was a reduction in emissions in the production of cement with regard to the type of fuel used in the process and the respective sulphur content.

Road transport

The reduction of emissions is mainly due to the introduction of Directives regulating the sulphur content in liquid fuels.

Other mobile sources and machinery

As regards off roads, emissions mainly derive from maritime transport, which shows a decrease due the introduction of Directives regulating the sulphur content in fuels.

2.1.2 Nitrogen oxides (NO_x)

The national atmospheric emissions of nitrogen oxides show a decreasing trend in the period 1990-2008, from 2,005 Gg to 1,661 Gg. Figure 2.2 and Table 2.2 show the emission figures from 1990 to 2008. Figure 2.2 also illustrates the share of NO_X emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

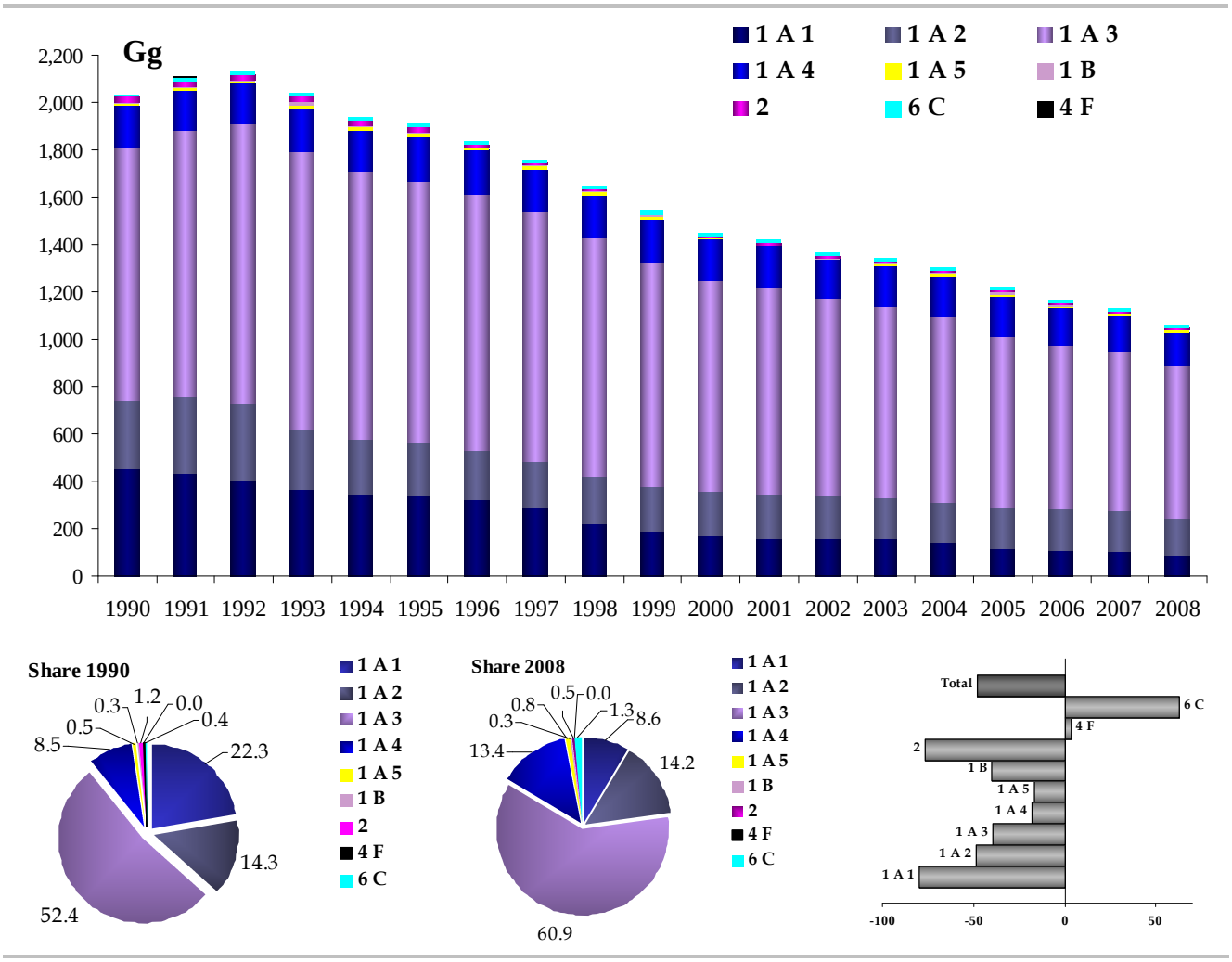

Figure 2.2 NO_X emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2005	2006	2007	2008
			Gg				
Combustion in energy and transformation industries	457	344	173	117	114	102	92
Non industrial combustion plants	62	62	65	76	74	73	77
Combustion - Industry	246	177	148	148	146	147	126
Production processes	30	31	9	16	13	11	9
Road transport	961	1008	773	617	589	583	549
Other mobile sources and machinery	270	275	268	231	216	201	193
Waste treatment and disposal	9	14	13	15	14	14	14
Agriculture	0	1	0	0	0	0	0
Total	***2,035***	***1,911***	***1,448***	***1,221***	***1,167***	***1,132***	***1,061***

Table 2.2 NO_X emission trend from 1990 to 2008 (Gg)

Total emissions show a reduction of about 48% from 1990 to 2008, with a marked decrease between 1995 and 2000, especially in the road transport and energy combustion sectors. The target value of emissions, fixed for 2010 by the National Emission Ceilings Directive, amounts to 990 Gg.
The main source of emissions is *road transport* (about 52% in 2008), which shows a reduction of 43% between 1990 and 2008; *other mobile sources and machinery* in 2008 contributes to the total emissions for 18% and have reduced by 28% from 1990. Combustion in energy and in industry shows a decrease of about 80% and 49%, respectively, having a share on the total of about 9% and 12%, respectively. Among the sectors concerned, the only ones which highlight an increase in emissions are: *waste treatment and disposal* and *non industrial combustion plants*, showing an increase by 61% and 24%, respectively, but accounting only for 1% and 7% of the total, respectively.
As SO_X, NO_X emissions are also included in the NEC directive. Details on the sectoral emission trend and respective variation are outlined in the following sections, starting from the early eighties.

Combustion in energy and transformation industries
Emissions from this sector show an upward trend until 1988 due to an increase in energy consumption, not prevented by reduction measures. From 1988 onwards, emissions present a gradual reduction due, mainly, to the introduction of the two regulatory instruments already mentioned for sulphur dioxide: the DPR 203/88, laying down rules for the authorization of facilities and the DM of 12th July 1990, which introduces plant emission limits. The adoption of these regulations, as the DM 8th May 1989 on large combustion plants, has led to a shift in energy consumption from oil with high sulphur content to oil with lower sulphur content and to natural gas.
In recent years, the conversion to the use of natural gas to replace fuel oil has intensified, thanks to

incentives granted for the improvement of energy efficiency. These measures, together with those of promoting renewable energy and energy saving, have led to a further reduction of emissions in the sector.

Non industrial combustion plants

The increase in emissions is explained by the growing trend of energy consumption during the period considered. This is due the fact that from the last twenty years all the new buildings are equipped with heating system and old buildings were modernized.

Combustion in industry

Emissions from this sector show a decreasing trend, motivated by the same reasons as the energy industry, having undergone the same legislation.

Road transport

The decrease is the result of two opposing trends: an increase in emissions in the early years of the historical series, with a peak in 1992, due to the increase in the fleet and in the total mileage of both passengers and goods transported by road, and a subsequent reduction in emissions. This decrease is, once more, the result of two opposing trends: on the one hand, the growth of both the fleet and the mileage, on the other the introduction of technologies to reduce vehicle emissions, as the catalytic converter, provided by European Directives, in particular the Directives 91/441/EC, 94/12/EC and 98/69/EC on light vehicles.

To encourage the reduction of emissions, different policies have also been implemented, including incentives to renew the public and private fleet and for the purchase of electric vehicles, promotion for the integrated expansion of rail, maritime and urban transport system, and programmes of sustainable mobility.

Other mobile sources and machinery

From 1980, emissions have a slightly rising trend until 1998 and then decrease slightly until arriving in 2008 to lower levels. Emissions in the sector are characterized predominantly by maritime transport, by machinery used in agriculture and industry and to a lesser extent, by air transport. Regarding mobile machinery used in agriculture and industry, these sectors were not governed by any legislation until the Directive 97/68/EC, which provides for a reduction in NO_X limits from 1st January 1999, with a following decreasing trend particularly in recent years. Regarding aviation, in the absence of specific legislation up to now, emissions have increased in relation to the growth in air traffic.

2.1.3 Ammonia (NH_3)

The national atmospheric emissions of ammonia show a slight decline in the period 1990-2008, from 466 Gg to 406 Gg. Figure 2.3 and Table 2.3 report the emission figures from 1990 to 2008. Figure 2.3 also illustrates the share of NH_3 emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

According to the National Emission Ceilings Directive, the target value of emissions for 2010 amounts to 419 Gg.

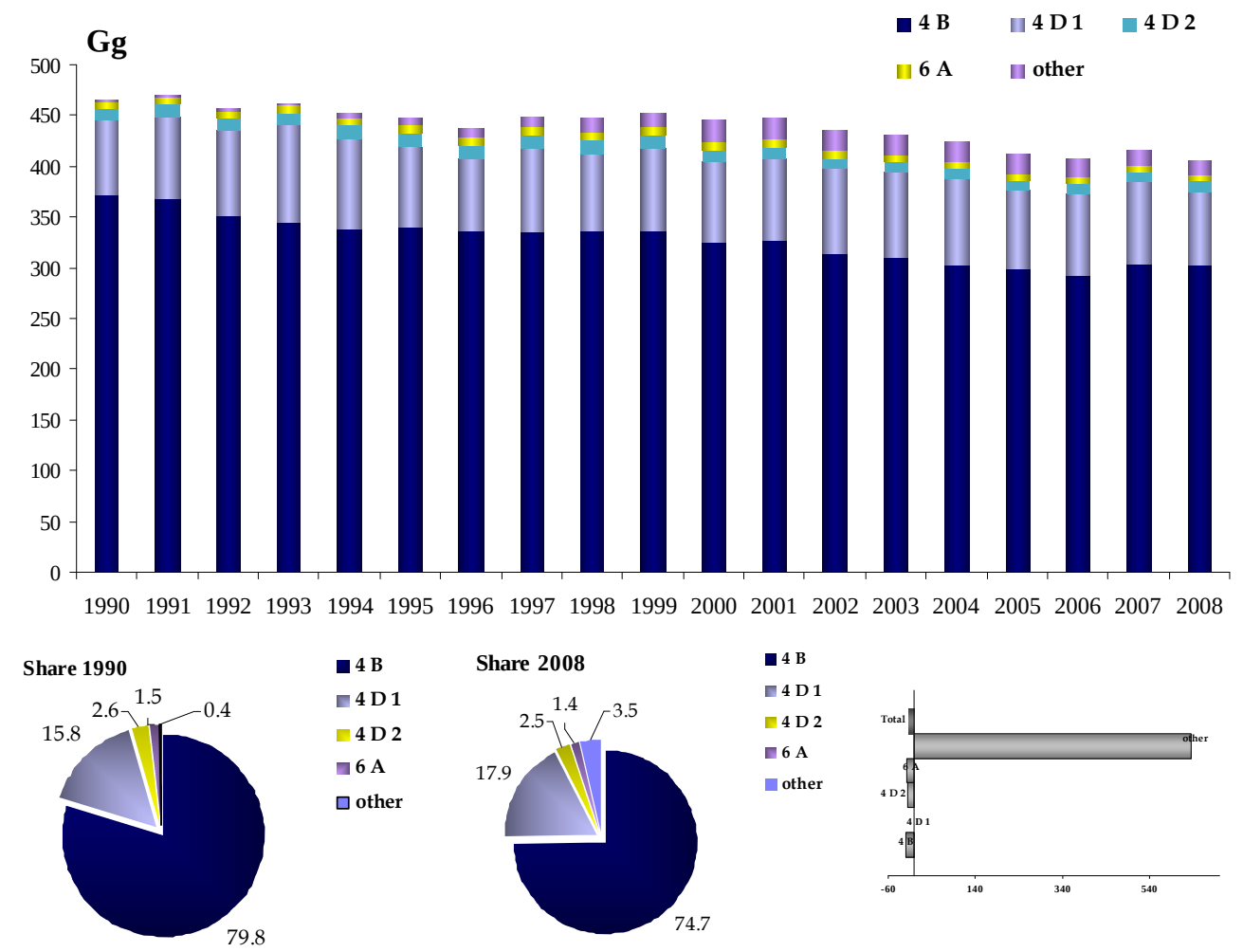

Figure 2.3 NH_3 emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2005	2006	2007	2008
			Gg				
Combustion in energy and transformation industries	0.1	0.1	0.1	0.2	0.2	0.2	0.2
Non industrial combustion plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Combustion - Industry	0.1	0.1	0.1	3.4	2.3	1.6	1.8
Production processes	0.8	0.4	0.3	0.5	0.6	0.5	0.4
Road transport	0.7	5.5	19.4	14.8	14.2	12.6	10.9
Other mobile sources and machinery	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste treatment and disposal	7.0	8.2	9.0	7.3	6.8	6.7	6.5
Agriculture	457.5	432.5	416.7	386.6	383.9	395.0	385.8
Total	***466.2***	***447.0***	***445.6***	***412.9***	***407.9***	***416.6***	***405.7***

Table 2.3 NH_3 emission trend from 1990 to 2008 (Gg)

In 2008 *agriculture* is the main source of emissions, with a contribution by 95% out of the total NH_3 emissions; from 1990 to 2008 emissions from this sector decrease of about 16%. Emissions from *road transport* show a strong increase, but the share on the total is only about 3%. Emissions from *waste treatment and disposa*l, accounting only for 2% of the total, decrease of about 7%. Emissions from *combustion in energy* and *transformation industries* show an increase of about 41%, but in 2008 the contribution to total emissions is almost zero. Emissions from *non industrial combustion plants* decrease of about 88%, but the contribution to total emissions is negligible. Emissions from *combustion in industry* show a significant increase, but the contribution to total emissions is negligible. Emissions from *production processes* show a reduction of about 41%, but also this contribution is insignificant.

Specifically, emissions from *agriculture* have decreased because of the reduction in the number of animals and the trend in agricultural production, and the introduction of abatement technologies due to the implementation of the EU IPPC Directive. Emissions related to *production processes*, mainly the production of nitrogenous fertilizers and ammonia, dropped as a result of a lower production, whereas emissions from the *waste* sector have increased as a result of the greater amount of waste disposed in landfills. Emissions from *road transport* have increased as a result of the introduction of catalytic converter.

2.1.4 Non methane volatile organic compounds (NMVOC)

The national atmospheric emissions of NMVOC show a decreasing trend in the period 1990-2008. Figure 2.4 and Table 2.4 illustrate the emissions values from 1990 to 2008. Figure 2.4 also illustrates the share of NMVOC emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

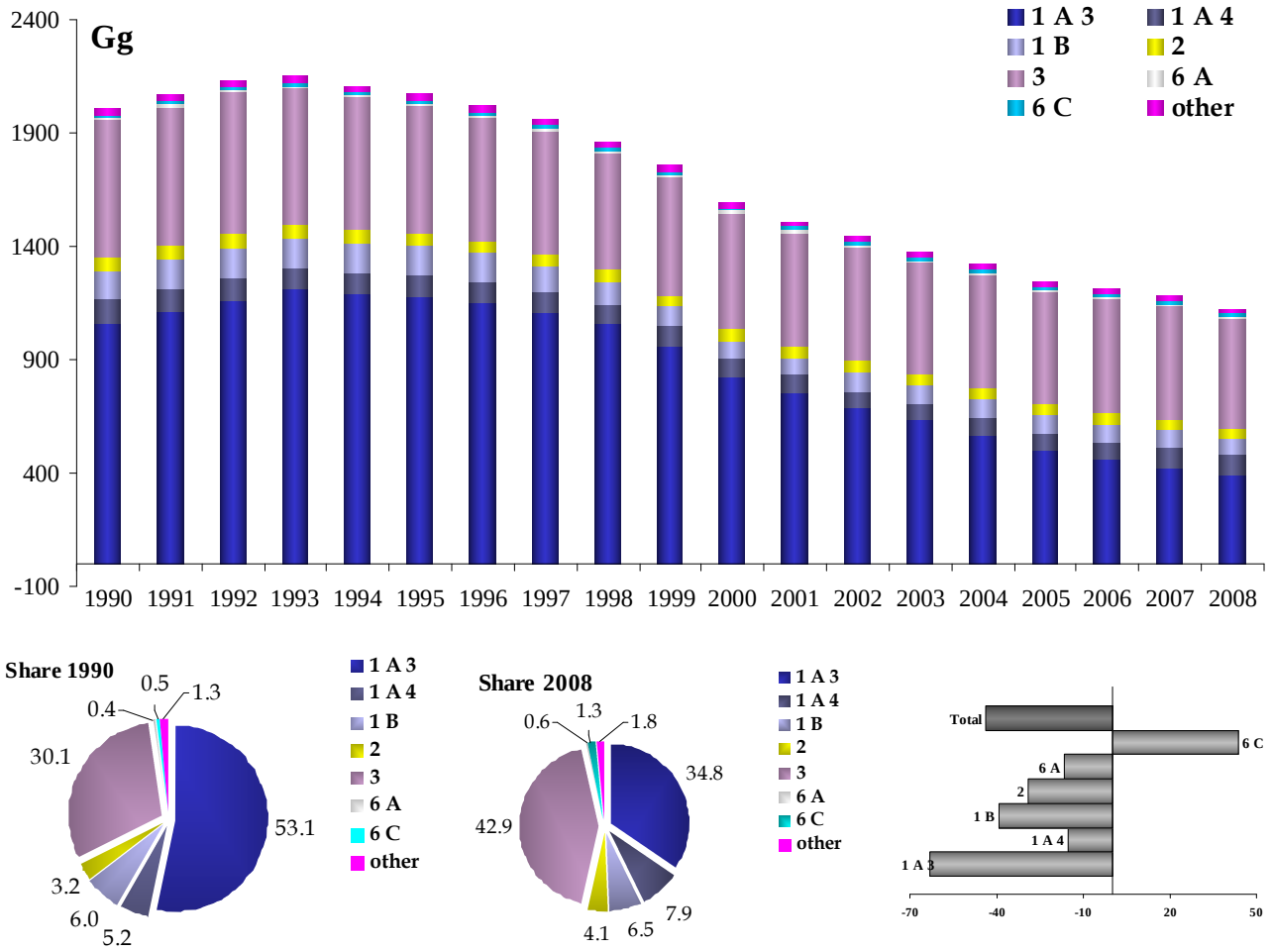

Figure 2.4 NMVOC emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2005	2006	2007	2008
			Gg				
Combustion in energy and transformation industries	7.6	7.4	6.3	5.6	5.6	5.6	5.4
Non industrial combustion plants	24.9	33.0	43.4	55.0	58.5	69.6	72.8
Combustion - Industry	7.3	8.1	8.2	8.0	8.3	8.2	7.5
Production processes	95.0	85.6	70.7	76.1	76.9	76.2	70.4
Extraction and distrib. of fossil fuels / geothermal energy	90.4	103.7	56.2	53.6	50.7	47.5	48.7
Solvent and other product use	604.3	559.0	513.0	494.7	505.6	501.6	483.1
Road transport	967.5	1,068.6	718.0	398.6	359.8	326.9	298.0
Other mobile sources and machinery	187.3	183.7	154.6	130.4	126.5	123.0	116.2
Waste treatment and disposal	19.0	25.6	23.8	24.4	23.4	22.4	22.5
Agriculture	1.3	1.3	1.2	1.2	1.2	1.2	1.3
Total	***2,004***	***2,076***	***1,595***	***1,248***	***1,217***	***1,182***	***1,126***

Table 2.4 NMVOC emission trend from 1990 to 2008 (Gg)

The global emission trend shows a reduction of about 44% between 1990 and 2008, from 2,004 Gg to 1,126 Gg. In the framework of the *National Emission Ceilings Directive*, the target value of NMVOC for 2010 has been fixed to 1,159 Gg.

Solvent and other product use is the main source of emissions, contributing to the total with 43% and showing a decrease of about 20%. The biggest reductions relate to the sector of *road transport* (-69%), accounting for 26% of the total and the sector of *extraction and distribution of fossil fuels/geothermal energy* (-46%), accounting only for 4%. Emissions from *other mobile sources and machinery*, accounting for 10% of the total, decrease of about 38%. Emissions from *non industrial combustion plants* show the biggest increase, but this is not relevant on total emissions, accounting only for 6%. Emissions from *waste treatment and disposal*, and from *combustion in industry*, accounting only for 2% and 1% of the total, show increase of about 18% and 3% respectively.

Details on the sectoral emission trend and respective variation are outlined in the following sections.

Solvent and other product use

Emissions from this sector stem from numerous activities such as painting both domestic and industrial, degreasing and dry cleaning, manufacturing and processing chemicals, other use of solvents and related activities including the use of household products that contain solvents, such as cosmetics, household products and toiletries.

Significant reductions occurred in the nineties by the introduction in the market of products with low solvent content in paints, and the reduction of the total amount of organic solvent used for metal degreasing and in glues and adhesives; furthermore, there was a replacement of open loop

with closed loop laundry machines. The gradual application of the EU Directive 99/13/EC will lead to further reductions in the coming years.

Road transport

The trend of emissions in this sector is characterized by a first stage of reduction in the early eighties, occurred despite the increase of consumption and mileage because of the gradual adjustment of the fleet to Community legislation, ECE Regulation 15 and subsequent amendments, which introduced stricter emission limits for passenger cars. Subsequently, in the early nineties, an increase in emissions is observed, with a peak in 1992, due to a high increase in gasoline consumption not efficiently opposed by the replacement of the fleet. With the introduction of Directive 91/441/EC and following, which provide for cars the catalytic device to reduce exhaust and evaporative emissions, NMVOC emissions were gradually reduced.

A different explanation of the emission trend pertains to the nineties. In fact, in this period an increase of the fleet and of the mileage is observed in Italy, especially for the emergent use of mopeds for urban mobility, which, until 1999, were not subject to any national emission regulation. Thereafter, various measures were introduced in order to facilitate the reduction of NMVOC emissions, including incentives for replacement of both the fleet of passenger cars and of mopeds and motorcycles with low-emission vehicles; incentives were also provided for the use of fuels different from gasoline, such as LPG and natural gas. In addition, funds were allocated for the implementation of urban traffic plans, for the establishment of restricted traffic areas and car-free days, for checks on exhaust pipes of cars, for the implementation of voluntary agreements with manufacturers of mopeds and motorcycles in order to anticipate the timing provided by the European Directive 97/24/EC as regards the placing on the market of mopeds with low emissions.

Other mobile sources and machinery

The reduction in emissions is explained by the reduction of gasoline consumption in the sector, largely for two-stroke engines used in agriculture and in maritime activities.

As regards the other sectors, a decrease in emissions from production processes is observed, mainly in the food industries, in the chemical sector and in the processes in the refineries. The emissions concerning the extraction and distribution of fuels, even in the presence of an increase in quantity treated, have been reduced as a result of the application of the DM 16th May 1996, concerning the adoption of devices for the recovery of vapours and of the applications of measures on deposits of gasoline provided by the DM 21st January 2000.

Emissions from the other sectors are not subject to specific regulations.

2.1.5 Carbon monoxide (CO)

The national CO emissions show a decreasing trend in the period 1990-2008, from 7,176 Gg to 3,032 Gg. The emission figures from 1990 to 2008 are shown in Figure 2.5 and Table 2.5. Figure 2.5 also illustrates the share of CO emissions by category in 1990 and 2008, as well as the total and sectoral variation from 1990 to 2008.

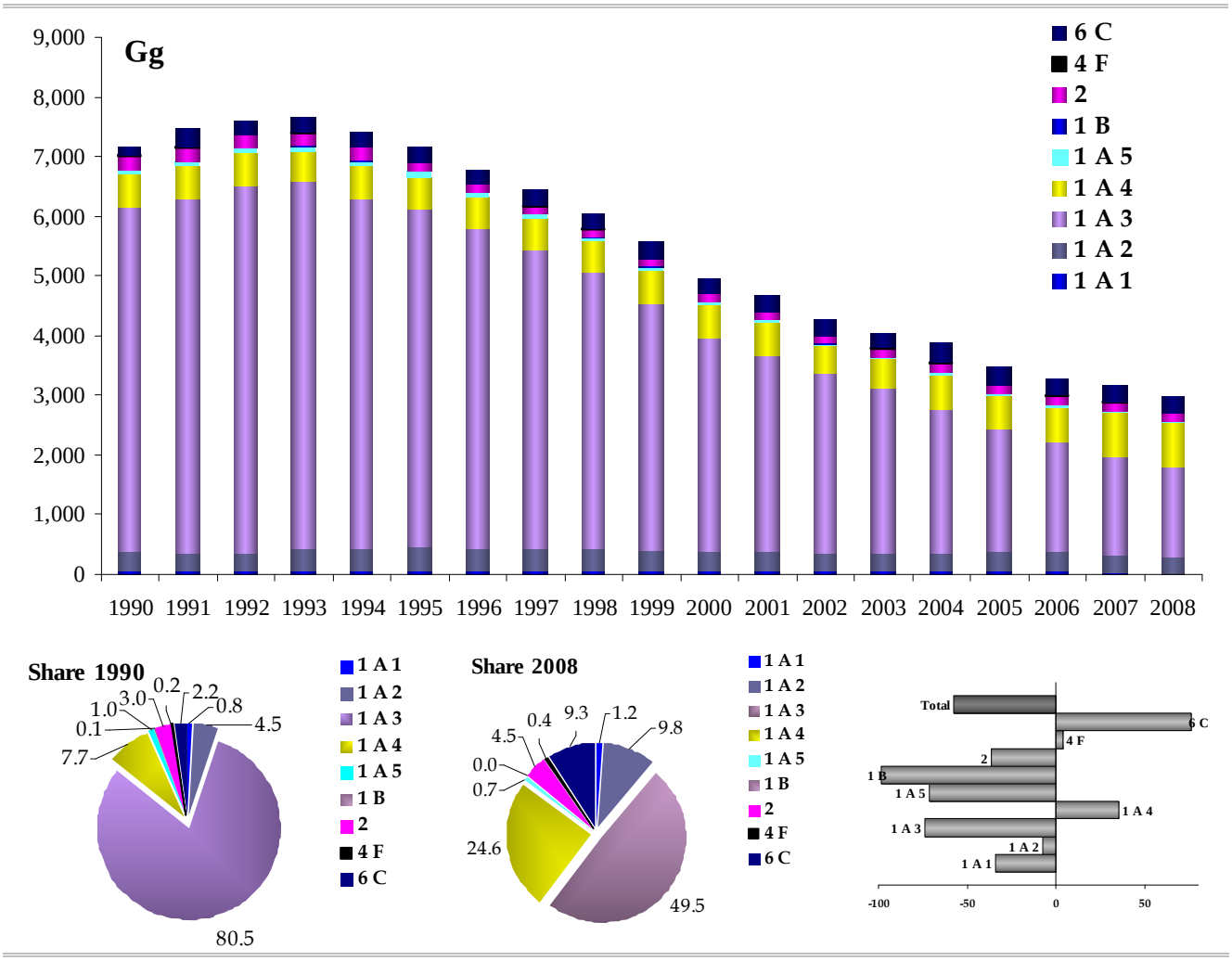

Figure 2.5 CO emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2001	2005	2006	2007	2008
			Gg					
Combustion in energy and transformation industries	59	54	56	58	54	54	40	38
Non industrial combustion plants	256	348	450	469	479	524	658	689
Combustion - Industry	306	411	312	309	326	323	267	281
Production processes	224	140	129	125	145	149	140	136
Road transport	5,593	5,428	3,357	3,055	1,825	1,612	1,460	1,309
Other mobile sources and machinery	567	503	396	375	346	327	315	284
Waste treatment and disposal	159	269	249	271	296	281	269	281
Agriculture	13	13	12	11	13	12	13	13
Total	***7,176***	***7,166***	***4,961***	***4,673***	***3,482***	***3,283***	***3,163***	***3,032***

Table 2.5 CO emission trend from 1990 to 2008 (Gg)

The decrease in emissions (-58%) is mostly due to the trend observed for the transport sector (including road, railways, air and maritime transport) which show a total reduction from 1990 to 2008 of about 74%. Specifically by sector, emissions from *road transport* and *other mobile sources and machinery*, accounting in 2008 for 43% and 9% of the total, respectively, show a decrease from 1990 to 2008 of about 77% and 50%. On the other hand, emissions from *non industrial combustion plants*, representing about 23% of the total, show a strong increase between 1990 and 2008, equal to 169% due to the increase of wood combustion for heating; figures show a strong increase in emissions from *waste treatment and disposal* too (76%), which share 9% of the total.

2.2 Particulate matter

2.2.1 PM10

The national atmospheric emissions of PM10 show a slight decreasing trend in the period 1990-2008, from 232 Gg to 154 Gg. Figure 2.6 and Table 2.6 illustrate the emission trend from 1990 to 2008. Figure 2.6 also illustrates the share of PM10 emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

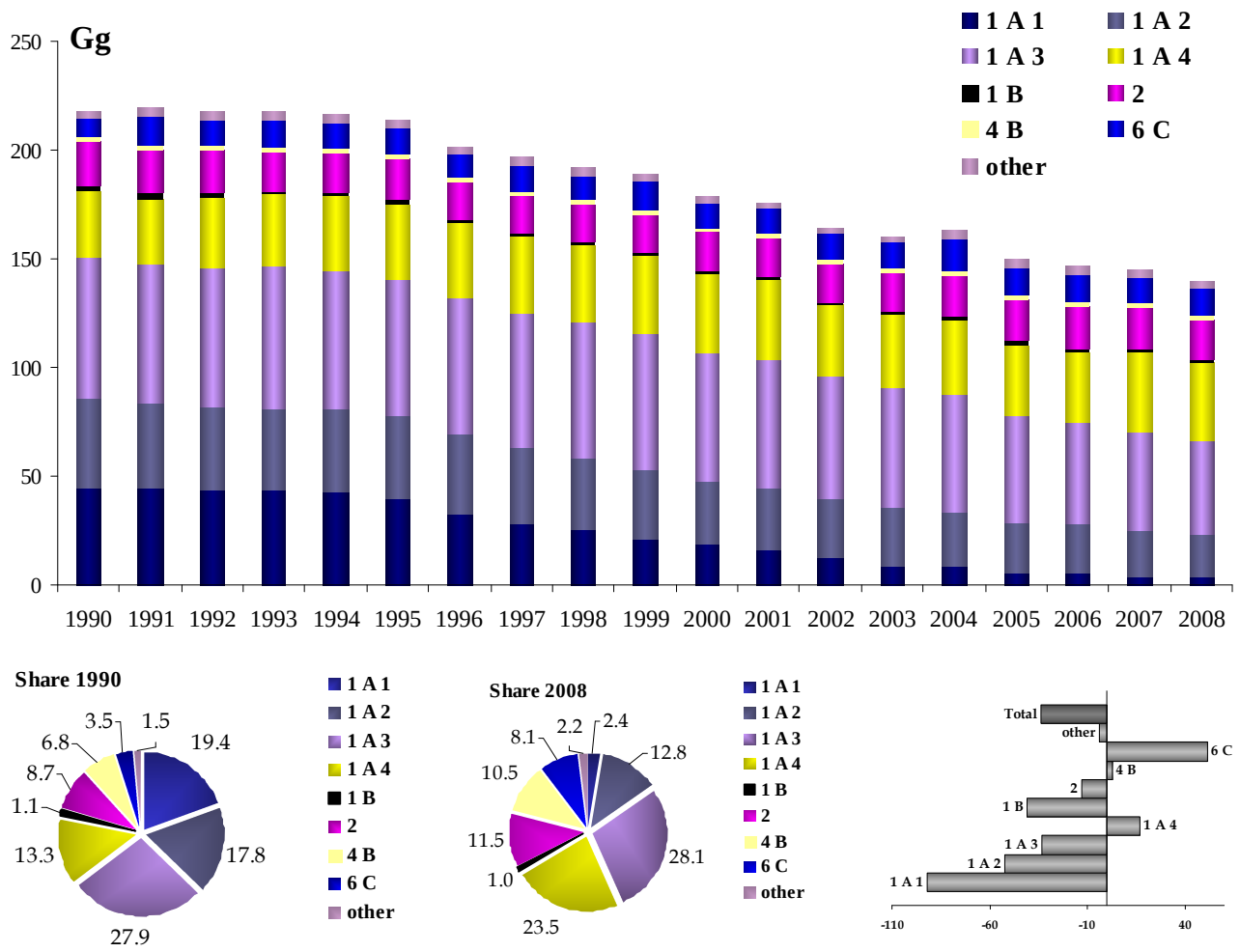

Figure 2.6 PM10 emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2005	2006	2007	2008
			Gg				
Combustion in energy and transformation industries	45	40	18	6	6	4	4
Non industrial combustion plants	14	16	20	20	22	28	29
Combustion - Industry	36	33	24	20	20	18	18
Production processes	22	20	19	20	20	20	18
Extraction and distribution of fossil fuels / geothermal energy	1	1	1	1	1	1	1
Solvent and other product use	0	0	0	0	0	0	0
Road transport	57	55	51	42	39	39	36
Other mobile sources and machinery	32	33	30	24	21	19	17
Waste treatment and disposal	8	12	11	13	13	12	12
Agriculture	18	18	17	18	17	18	18
Total	***232***	***227***	***192***	***163***	***159***	***158***	***154***

Table 2.6 PM10 emission trend from 1990 to 2008 (Gg)

A considerable amount of emissions is mostly to be attributed to *road transport* (24% in 2008); from 1990 to 2008 the trend shows a reduction of about 36%. In 2008 *other mobile sources and machinery*, accounting for 11% of the total, show a reduction of about 45%. Emissions from *non industrial combustion plants* and from *combustion in industry* account for about 19% and 12% of the total, respectively, but while the former show an increase of about 106%, the latter decrease of about 50%. Emissions from *production processes* accounting for 12% of the total in 2008 decrease of about 17% between 1990 and 2008. The largest decrease (-92%) is observed in emissions deriving from *combustion in energy and transformation industries*, which contribution to total emissions is equal to 2%.

2.2.2 PM2.5

The trend of the national atmospheric emissions of PM2.5 is slightly decreasing between 1990 and 2008, with a variation from 198 Gg to 122 Gg. Figure 2.7 and Table 2.7 illustrate the emission trend from 1990 to 2008. Figure 2.7 also illustrates the share of $PM_{2.5}$ emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

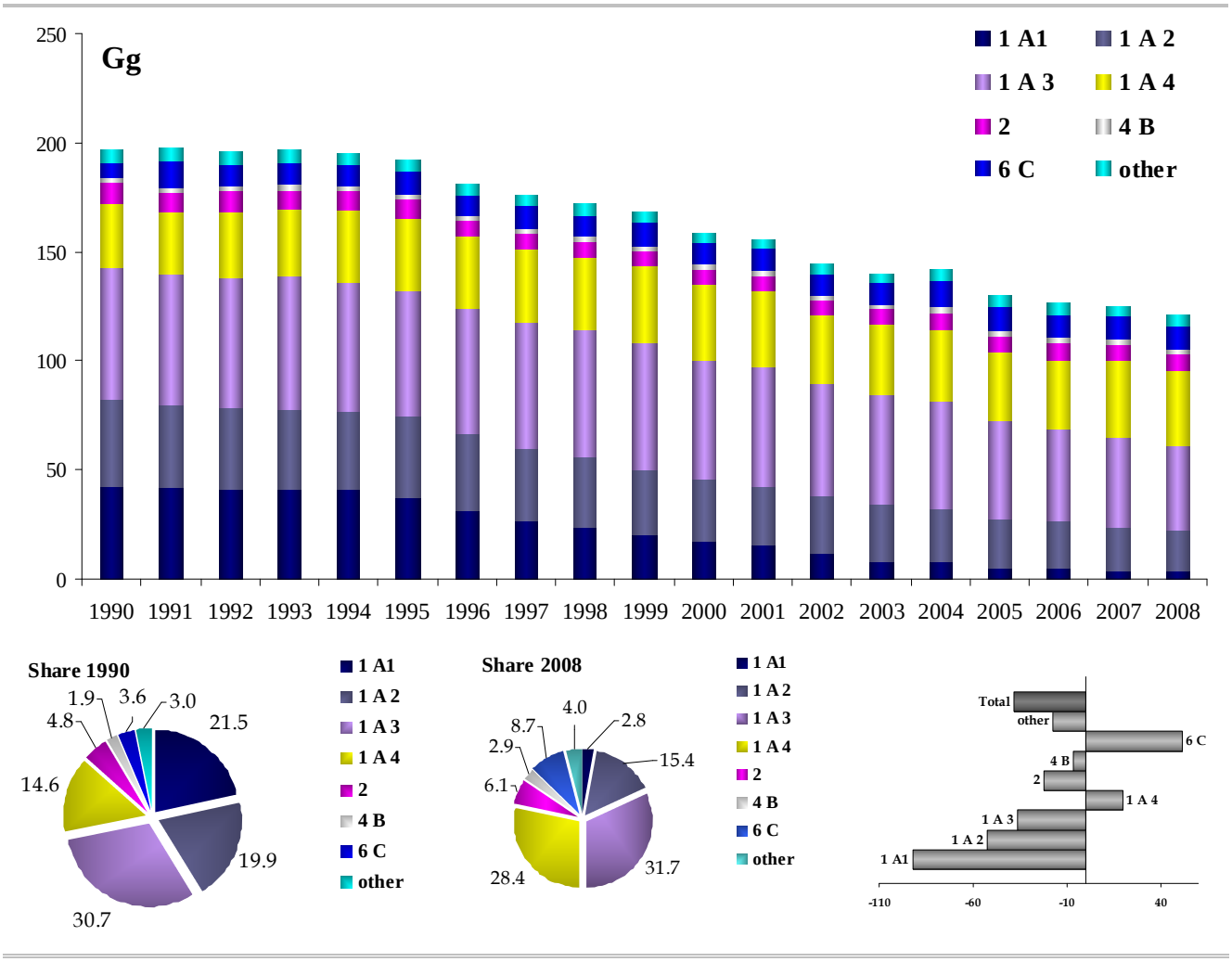

Figure 2.7 PM2.5 emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2005	2006	2007	2008
			Gg				
Combustion in energy and transformation industries	43	38	18	6	5	4	3
Non industrial combustion plants	12	14	19	19	21	26	27
Combustion - Industry	34	32	23	19	19	17	17
Production processes	11	10	8	8	9	9	8
Extraction and distribution of fossil fuels / geothermal energy	1	1	1	1	1	1	1
Solvent and other product use	0	0	0	0	0	0	0
Road transport	53	51	47	37	35	34	32
Other mobile sources and machinery	32	33	30	24	21	19	17
Waste treatment and disposal	7	10	10	11	11	10	11
Agriculture	6	6	6	6	6	6	6
Total	**198**	**194**	**160**	**131**	**128**	**127**	**122**

Table 2.7 PM2.5 emission trend from 1990 to 2008 (Gg)

Total emissions show a global reduction from 1990 to 2008 of about 38%.
Specifically, emissions from *road transport*, accounting for 26% of total emissions, decrease of about 40%. Emissions from *other mobile sources and machinery* show a reduction of 45%, accounting in 2008 for 14% of total emissions. Emissions from *non industrial combustion plants* and from *combustion in industry* account for 22% and 14% of the total, but while the former show an increase of about 125%, the latter decrease of about 50%. Emissions from *waste treatment and disposal*, accounting for 9% of the total in 2008, show an increase of about 51%. The largest decrease is observed for *combustion in energy* and *transformation industries* (-92%), being the influence on the total in 2008 equal to 3%.

2.3 Heavy metals (Pb, Cd, Hg)

This section provides an illustration of the most significant developments between 1990 and 2008 of lead, cadmium and mercury emissions.

2.3.1 Lead (Pb)

The national atmospheric emissions of lead show a strong decreasing trend (-94%) between 1990 and 2008, varying from 4,411 Mg to 279 Mg. Figure 2.8 and Table 2.8 illustrate the emission trend from 1990 to 2008. Figure 2.8 also illustrates the share of Pb emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

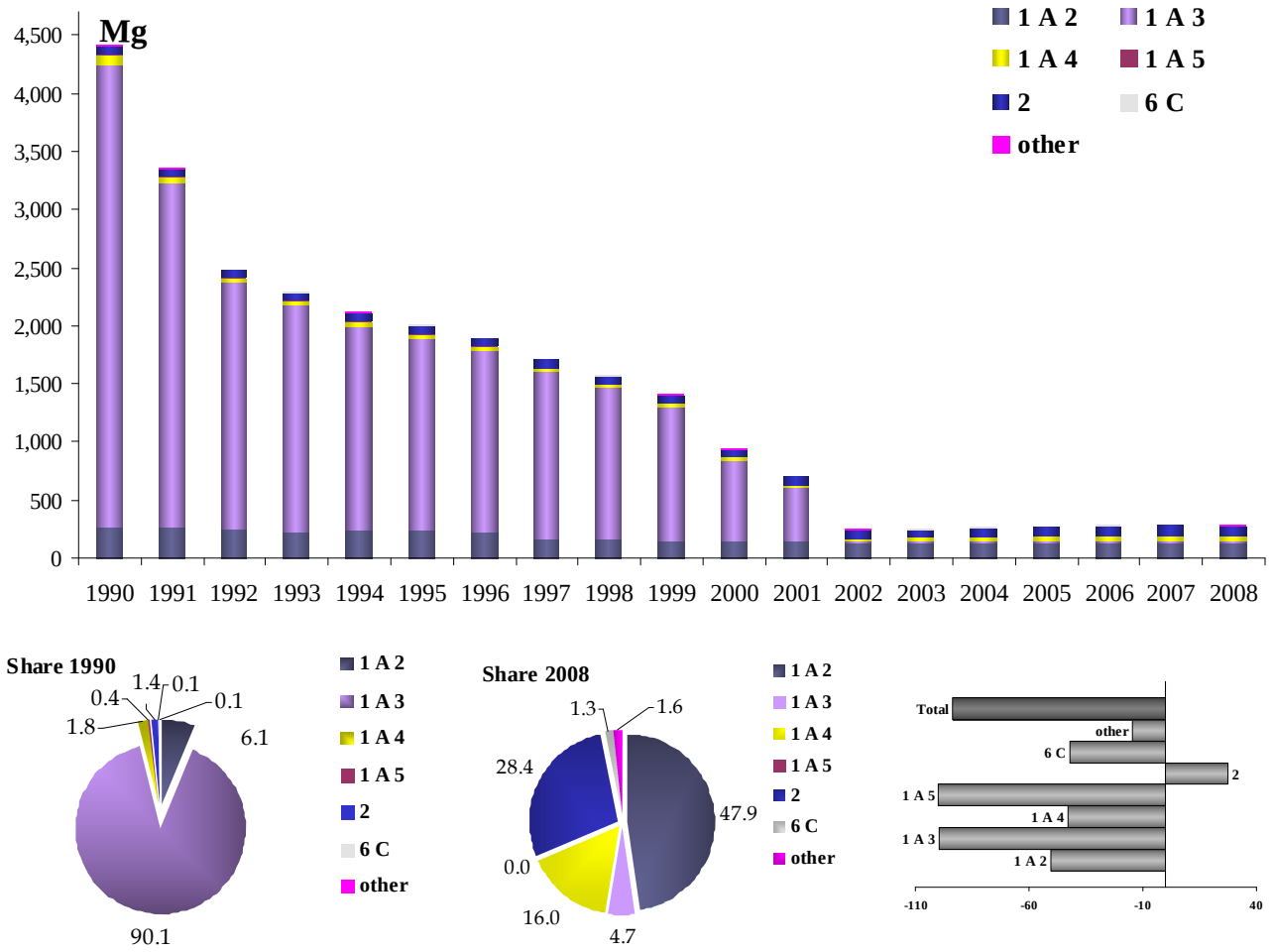

Figure 2.8 Pb emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2005	2006	2007	2008
		Mg					
Combustion in energy and transformation industries	4	4	4	4	4	4	4
Non-industrial combustion plants	11	12	17	41	41	43	45
Combustion - industry	263	235	153	142	142	142	134
Production processes	64	68	67	74	82	82	80
Road transport	3,909	1,629	673	0	0	0	0
Other mobile sources and machinery	144	46	13	1	1	1	1
Waste treatment and disposal	6	6	3	4	4	3	4
Total	***4,411***	***2,011***	***942***	***278***	***286***	***288***	***279***

Table 2.8 Pb emission trend from 1990 to 2008 (Mg)

In 2008 emissions from *processes with contact* have the most significant impact on the total (47%) and show a reduction of about 38%. Emissions from *production processes*, and in particular processes in iron and steel industries and collieries, increased of about 26%, and represent 29% of the total. Emissions from *non industrial combustion plants* show a strong increase and represent, in 2008, the 16% of the total. As regard emissions from *transport* activities, because of changes occurred in the legislation regarding fuels, trends show a sharp reduction in emissions from 2002 onwards. Emissions from *process furnaces without contact* show a strong decrease (-97%) but the contribution to total emissions in 2008 is negligible (equal to 0.4%).

2.3.2 Cadmium (Cd)

The national atmospheric emissions of cadmium show a slight decreasing trend. Figure 2.9 and Table 2.9 illustrate the emission trend from 1990 to 2008. Figure 2.9 also illustrates the share of Cd emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

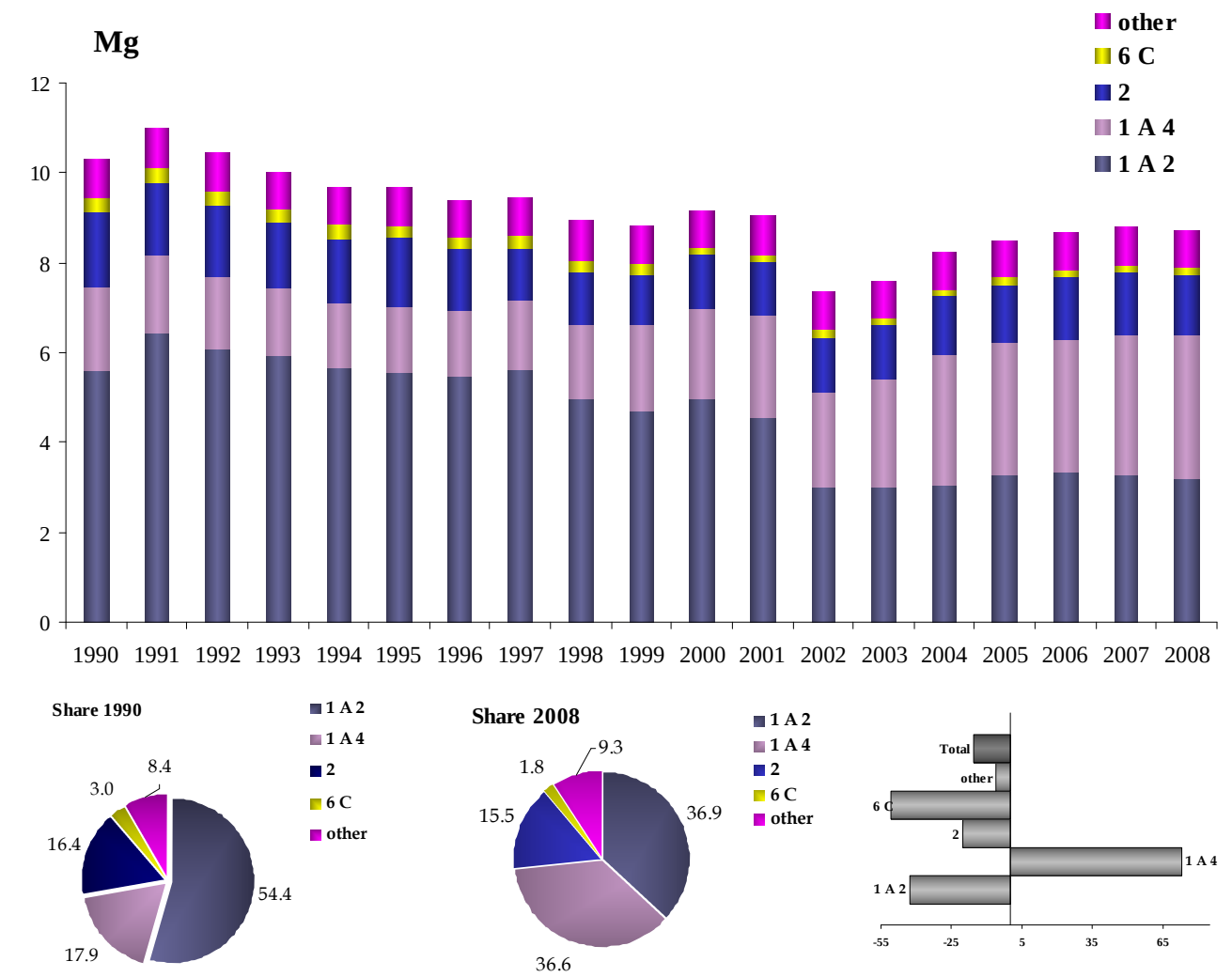

Figure 2.9 Cd emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2005	2006	2007	2008
			Mg				
Combustion in energy and transformation industries	0.19	0.20	0.18	0.17	0.17	0.16	0.15
Non-industrial combustion plants	1.84	1.47	2.02	2.94	2.92	3.11	3.18
Combustion - industry	5.61	5.56	4.98	3.28	3.36	3.28	3.21
Production processes	2.01	1.78	1.42	1.52	1.63	1.64	1.57
Road transport	0.28	0.32	0.34	0.36	0.37	0.37	0.36
Other mobile sources and machinery	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Waste treatment and disposal	0.31	0.27	0.14	0.16	0.17	0.15	0.15
Total	***10.32***	***9.69***	***9.16***	***8.52***	***8.70***	***8.79***	***8.71***

Table 2.9 Cd emission trend from 1990 to 2008 (Mg)

Emissions show a global reduction of 16% between 1990 and 2008, from 10.3 Mg to 8.7 Mg. Among the most significant variations, emissions from *combustion in industry* and from *non industrial combustion plants* represent the 37% of the total each one, showing the former a decrease (-43%) and the latter a strong increase (73%). Emissions from *production processes* decrease of about 22% and represent the 18% of the total. Emissions from *waste treatment and disposal*, waste incineration, accounting for 2% of the total, register a reduction of about 51%. The share of other subsectors on the total is irrelevant.

2.3.3 Mercury (Hg)

The national atmospheric emissions of mercury show a quite stable trend in the period 1990-2008. Figure 2.10 and Table 2.10 illustrate the emission trend from 1990 to 2008. Figure 2.10 also illustrates the share of Hg emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

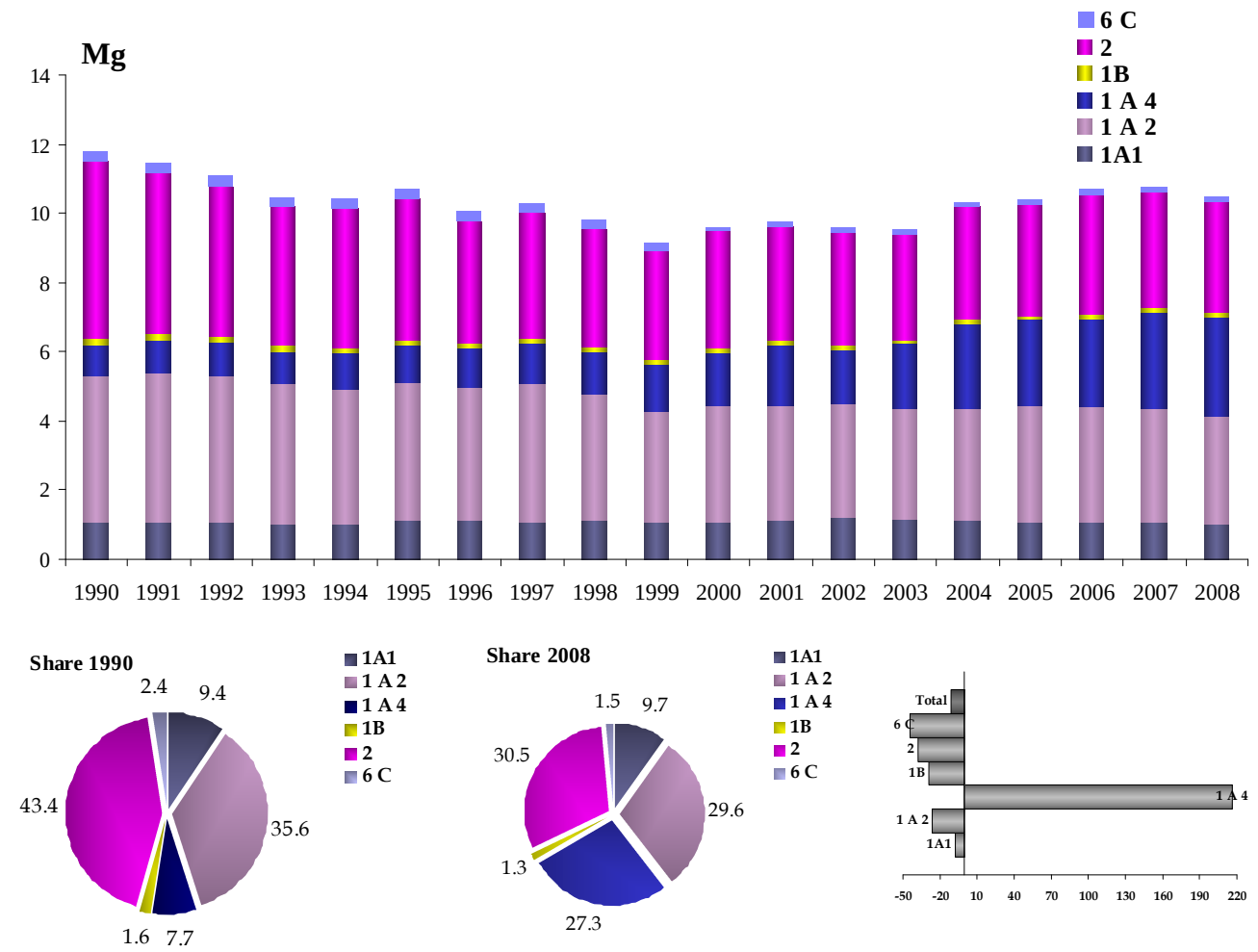

Figure 2.10 Hg emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2005	2006	2007	2008
		Mg					
Combustion in energy and transformation industries	1.10	1.15	1.10	1.10	1.09	1.06	1.02
Non-industrial combustion plants	0.90	1.08	1.50	2.48	2.52	2.76	2.86
Combustion - industry	4.19	3.95	3.37	3.35	3.32	3.30	3.11
Production processes	5.31	4.26	3.50	3.31	3.59	3.51	3.34
Waste treatment and disposal	0.28	0.25	0.12	0.15	0.17	0.15	0.15
Total	***11.79***	***10.70***	***9.59***	***10.39***	***10.70***	***10.77***	***10.48***

Table 2.10 Hg emission trend from 1990 to 2008 (Mg)

Emission trend shows a global reduction of about 11% from 1990 to 2008, varying from 11.8 Mg to 10.5 Mg. The main variations concern: emissions from *processes in iron and steel industries and collieries*, representing 30% of the total and increasing of 25%; emissions from *processes with contact*, accounting for 25% and decreasing of 26%; emissions from *non industrial combustion plants* which represent 27% of the total and showing the strongest increase (217%). Emissions deriving from *combustion in energy and transformation industries*, accounting for 10%, show a reduction of 7%. Emissions from *processes in inorganic chemical industries*, contributing to the total only for 2%, show the largest reduction, equal to 92%.

2.4 Persistent organic pollutants (POPs)

In this section, the most significant peculiarities of polycyclic aromatic hydrocarbons and dioxins, occurred between 1990 and 2008, will be presented.

2.4.1 Polycyclic aromatic hydrocarbons (PAH)

The national atmospheric emissions of polycyclic aromatic hydrocarbons show an increasing trend between 1990 and 2008, from 103 Mg to 156 Mg. Figure 2.11 and Table 2.11 illustrate the emission trend from 1990 to 2008. Figure 2.11 also illustrates the share of PAH emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

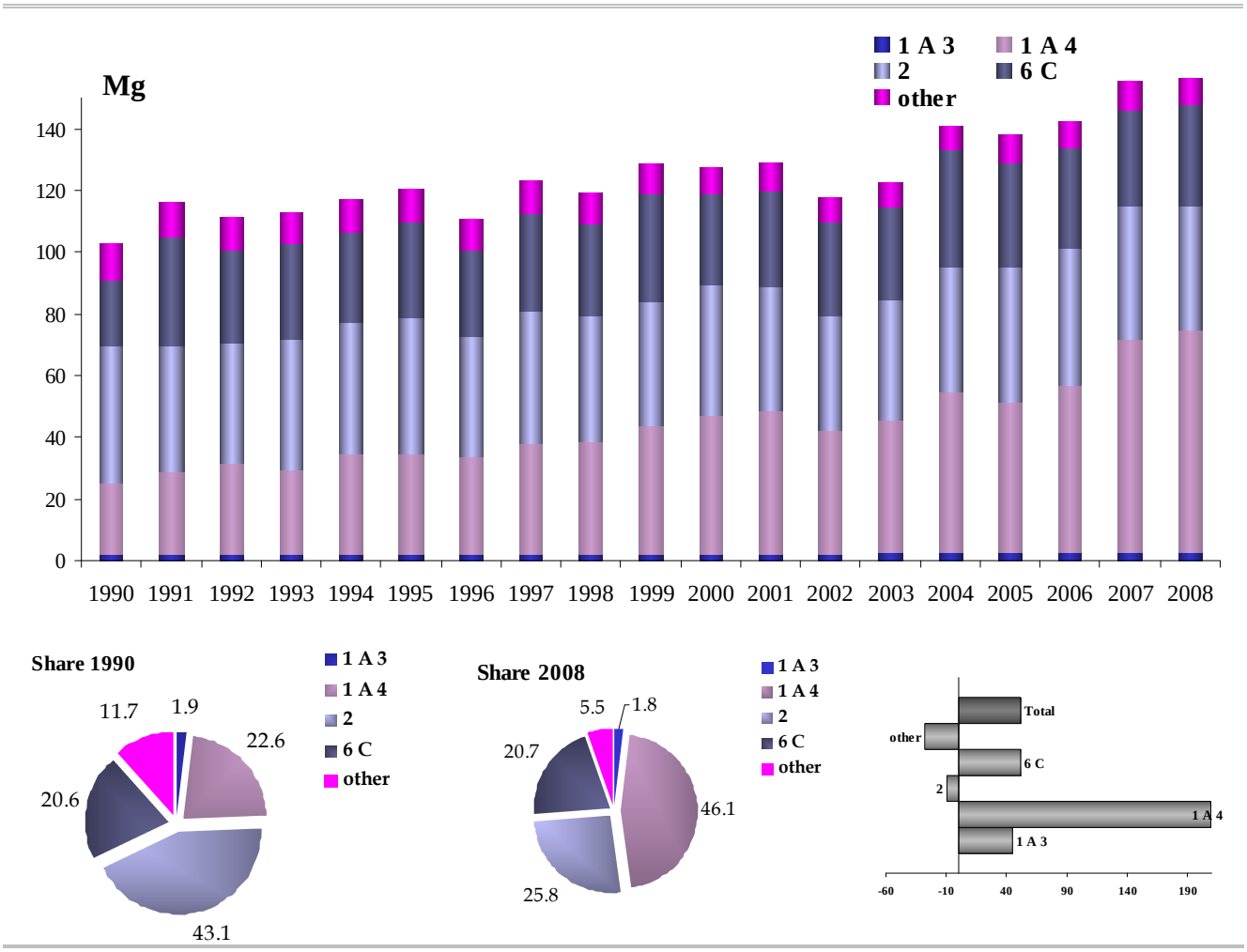

Figure 2.11 PAH emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2005	2006	2007	2008
			Mg				
Combustion in energy and transformation industries	9.09	7.68	6.54	6.41	6.56	6.52	6.19
Non-industrial combustion plants	23.11	32.72	44.56	48.68	53.78	68.75	71.93
Combustion - industry	2.91	2.93	2.16	2.27	2.23	2.45	2.39
Production processes	44.48	44.06	42.44	43.81	44.51	43.16	40.40
Road transport	1.85	1.88	2.04	2.58	2.71	2.79	2.72
Other mobile sources and machinery	0.37	0.37	0.36	0.37	0.36	0.34	0.34
Waste treatment and disposal	21.28	31.10	29.54	33.90	32.51	31.22	32.31
Total	***103.1***	***120.7***	***127.6***	***138.0***	***142.7***	***155.2***	***156.3***

Table 2.11 PAH emission trend from 1990 to 2008 (Mg)

Between 1990 and 2008, total emissions show a growth of about 52%. Among the most significant changes, emissions from *residential plants* account for 40% of the total and show a strong increase (about 177%) due to the increase in wood consumption for heating; emissions from *processes in iron* and *steel industries* and *collieries* account for 26% of the total and show a decrease of 9%; emissions from *open burning of agricultural wastes*, except stubble burning, accounting for 21% of the total, show an increase of 52%. Emissions from *plants in agriculture, forestry and aquaculture*, accounting for 5% in 2008, show a large growth from 2000 onwards, due to the use of biomass in plants. Emissions from combustion in iron and steel integrated plants account for 3.7% of the total and show a decrease by 29%. The share of other subsectors is less than 1.5%.

2.4.2 Dioxins

The national atmospheric emissions of dioxins show a decreasing trend between 1990 and 2008, with values varying from 473 g I Teq to 311 g I Teq. Figure 2.12 and Table 2.12 illustrate the emission trend from 1990 to 2008. Figure 2.12 also illustrates the share of dioxin emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

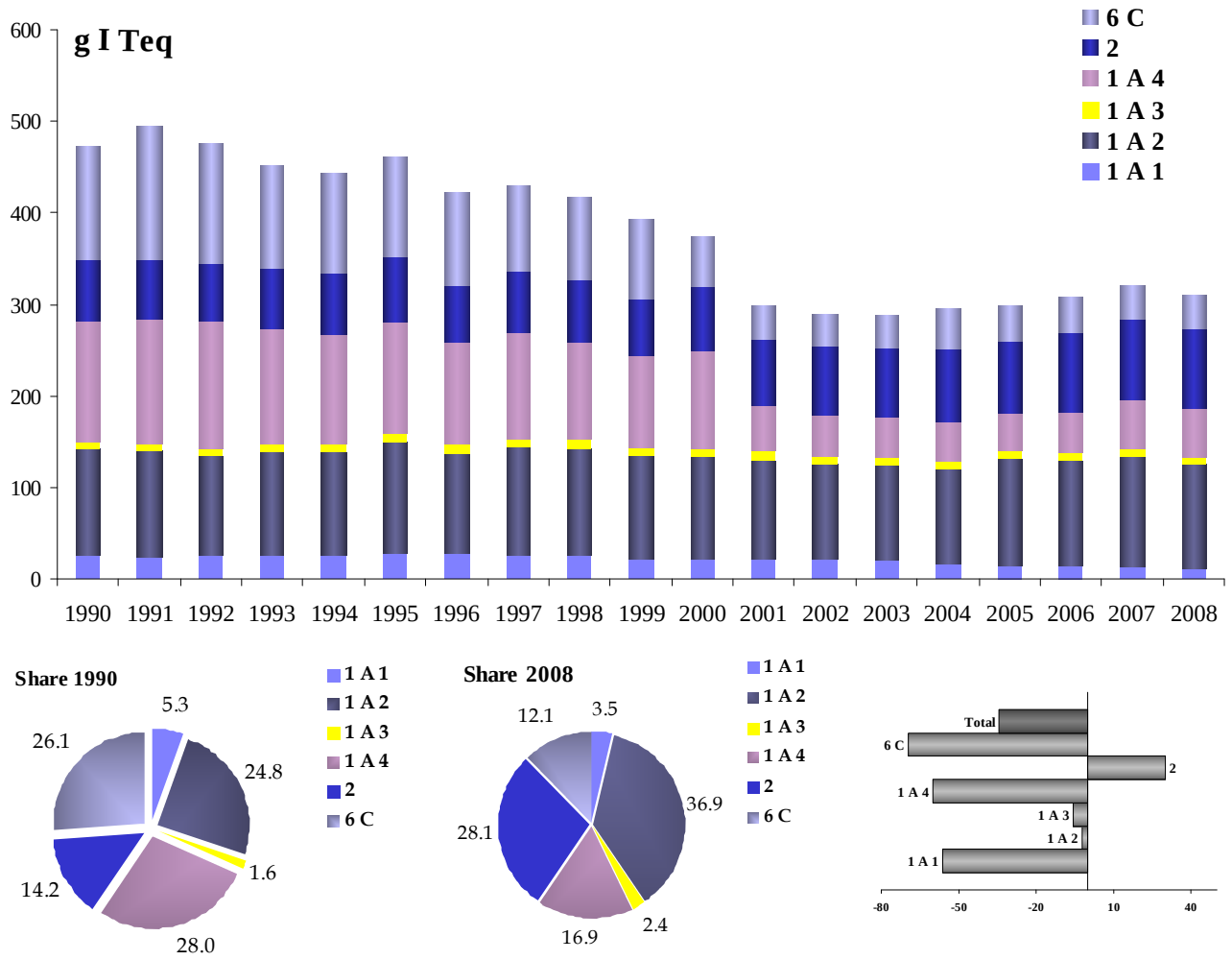

Figure 2.12 Dioxin emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2005	2006	2007	2008
			g I Teq				
Combustion in energy and transformation industries	25.0	28.3	21.9	14.7	14.3	12.0	10.9
Non-industrial combustion plants	132.2	120.5	106.5	41.8	43.7	53.8	52.6
Combustion - industry	117.3	121.1	110.7	116.3	115.7	121.7	114.8
Production processes	67.2	71.7	70.7	78.6	87.8	88.7	87.3
Road transport	7.8	10.1	10.1	8.6	8.1	7.8	7.3
Waste treatment and disposal	123.5	110.5	55.6	39.6	38.0	36.5	37.7
Total	**472.9**	**462.3**	**375.4**	**299.6**	**307.6**	**320.5**	**310.7**

Table 2.12 Dioxin emission trend from 1990 to 2008 (g I Teq)

The general trend shows a decrease from 1990 to 2008 equal to 34%, with a noticeable decline between 1995 and 2001. The most considerable reductions, between 1990 and 2008, are observed in *non-industrial combustion plants* and *waste treatment disposal* (-60% and -69%, respectively). Specifically, the reduction is principally due to the cut of emissions from the combustion of municipal waste both with energy recovery, reported under the non industrial sector, and without recovery, reported under the waste sector due to the introduction of regulations establishing more stringent limits of dioxin emissions from stacks.
In 2008, the subsector which has contributed most to total emissions is *combustion in industry*, accounting for 37% of the total and showing a decrease of 2% in the period 1990-2008. *Production processes* account for 28% of the total emissions in 2008 showing an increase of about 30% in the period 1990-2008.

2.4.3 Hexachlorobenzene (HCB)

The national atmospheric emissions of hexaclorobenzene show an increasing trend in the period 1990-2008, varying from 22 kg to 31 kg. Figure 2.13 and Table 2.13 illustrate the emission trend from 1990 to 2008. Figure 2.13 also illustrates the share of HCB emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

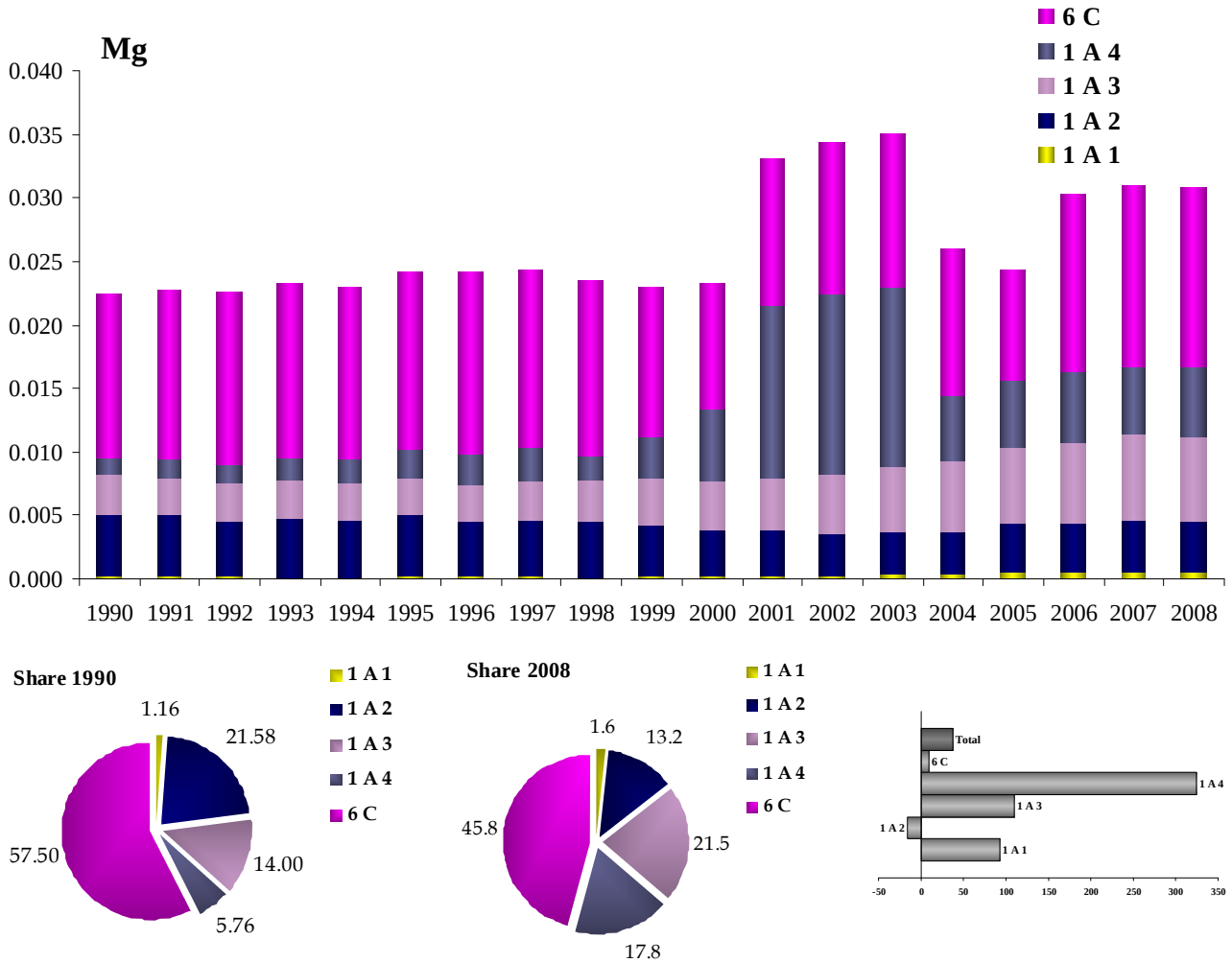

Figure 2.13 HCB emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2005	2006	2007	2008
			Mg				
Combustion in energy and transformation industries	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Non-industrial combustion plants	0.001	0.002	0.006	0.005	0.006	0.005	0.005
Combustion - industry	0.005	0.005	0.004	0.004	0.004	0.004	0.004
Road transport	0.003	0.003	0.004	0.006	0.006	0.007	0.007
Waste treatment and disposal	0.013	0.014	0.010	0.009	0.014	0.014	0.014
Total	***0.022***	***0.024***	***0.023***	***0.024***	***0.030***	***0.031***	***0.031***

Table 2.13 HCB emission trend from 1990 to 2008 (Mg)

The sector contributing most to the general trend is *waste treatment and disposal*, waste incineration, with exception of the years 2001-2003 where peaks are observed because of the relevant weight of the commercial sector due to the considerable increase of the amount of sludge incineration with energy recovery (which is accounted for in this sector) burnt in a specific incinerator. The other two relevant sectors are *road transport* and *non industrial combustion plants*, accounting for 21% and 18%, respectively; both sectors show a significant increase between 1990 and 2008.

2.4.4 Polychlorinated biphenyl (PCB)

The national atmospheric emissions of polychlorinated biphenyl show a slight decreasing trend in the period 1990-2008, about 1.8%, from 279 kg to 263 kg.

Figure 2.14 and Table 2.14 illustrate the emission trend from 1990 to 2008. Figure 2.14 also illustrates the share of PCB emissions by category in 1990 and 2008 as well as the total and sectoral variation from 1990 to 2008.

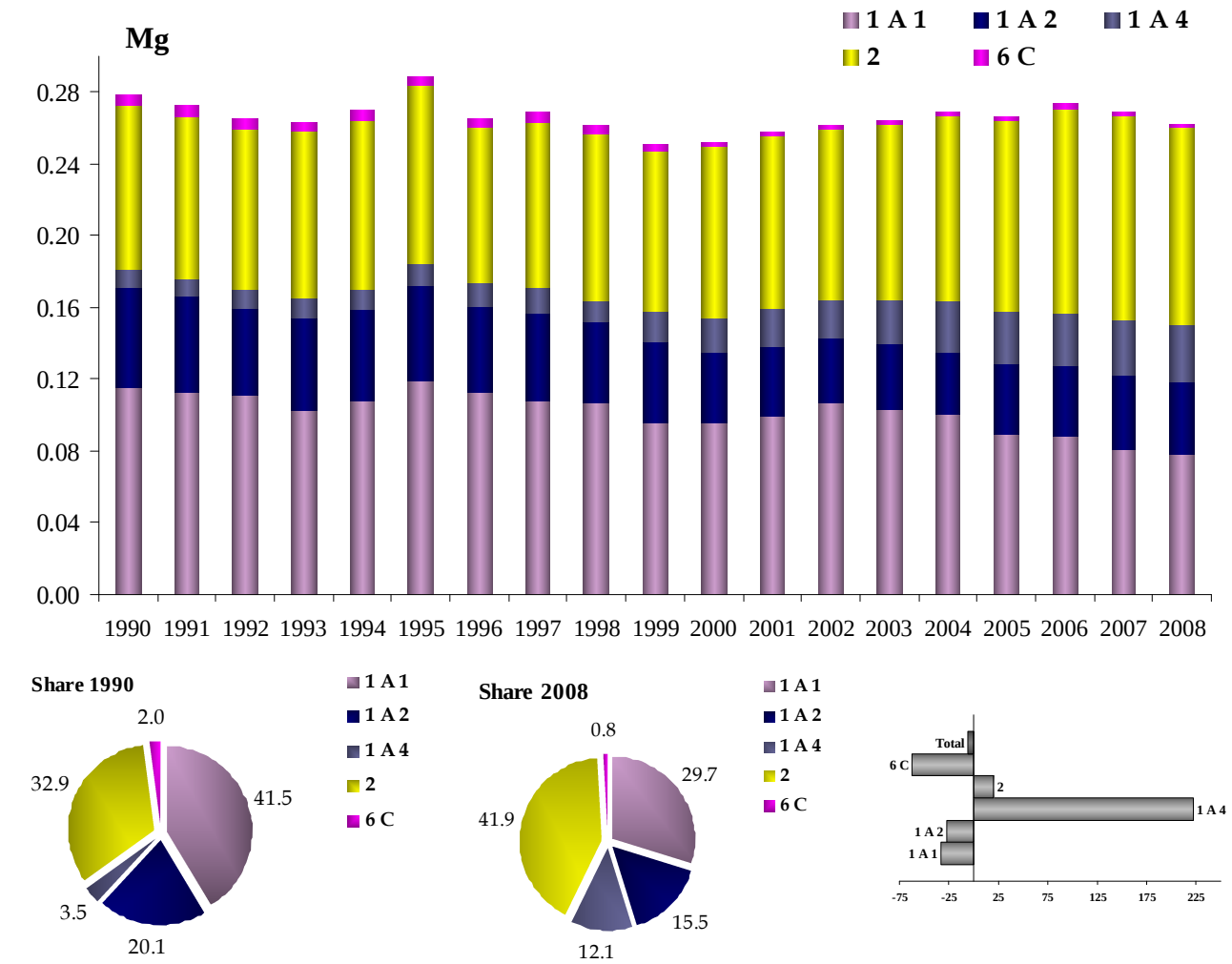

Figure 2.14 PCB emission trend, percentage share by sector and variation 1990-2008

	1990	1995	2000	2005	2006	2007	2008
			Mg				
Combustion in energy and transformation industries	0.115	0.119	0.096	0.089	0.089	0.081	0.078
Non-industrial combustion plants	0.010	0.012	0.019	0.029	0.030	0.031	0.032
Combustion - industry	0.056	0.053	0.039	0.040	0.039	0.041	0.041
Production processes	0.092	0.100	0.096	0.106	0.114	0.114	0.110
Waste treatment and disposal	0.006	0.005	0.002	0.002	0.002	0.002	0.002
Total	***0.279***	***0.289***	***0.252***	***0.266***	***0.273***	***0.269***	***0.263***

Table 2.14 PCB emission trend from 1990 to 2008 (Mg)

The subsectors contributing most to the general trend are the *production processes* sector and the *combustion in energy and transformation industries* sector, accounting for 42% and 30% of the total emissions, respectively, and showing a reduction by 20% and 32%. The other relevant subsectors are *non industrial combustion plants* accounting for 12% and relevantly increasing and *combustion in industry* which account for 15% and decrease between 1990 and 2008 of 27%.

3 ANALYSIS OF KEY TRENDS BY SECTOR

3.1 Energy (NFR SECTOR 1)

3.1.1 Methodological issues

Methodologies used for estimating emissions from this sector are based on and conform to the EMEP/CORINAIR guidebook (EMEP/CORINAIR, 2007), the IPCC Guidelines (IPCC, 1997; IPCC, 2006) and the Good Practice Guidance (IPCC, 2000).

Specifically, for road transport, the most recent version of COPERT 4 programme, version 7.1, as for February 2010, has been used to calculate emissions (EEA, 2010); the updated version of the model has been applied for the whole time series, resulting, in particular, in a decrease of NO_X and an increase in NMVOC emission levels. In the recalculation chapter, more detailed information is supplied on these figures.

A detailed description on the methods and national specific circumstances as well as reference material of the energy sector is documented in the national inventory report of the Italian greenhouse gas inventory (ISPRA, 2010[b]). At national level, trends of the CLRTAP pollutants are described in the environmental data yearbook published by ISPRA (ISPRA, 2010 [d]).

The National Energy Balance, published by the Ministry of Economic Development, is the main source of information to estimate emissions from the energy sector as it reports fuel consumption for different sectors at national levels. Additional information for electricity production is provided by the major national electricity producers and by the major national industry corporation. On the other hand, basic activity data for road transport, maritime and aviation, such as the number of vehicles, harbour statistics and aircraft landing and take-off cycles are provided in statistical yearbooks published both by the National Institute of Statistics and the Ministry of Transportation. Other data are communicated by different category associations.

Emission factors used are based as far as possible on national sources, or else on values specified in the EMEP/CORINAIR guidebook and/or IPCC guidelines which are appropriate for Italy.

The Institute, specifically the same unit responsible for the inventory compilation, also collects data in the framework of the European Emissions Trading Scheme, the National Pollutant Emission Register (EPER, now E-PRTR) and the Large Combustion Plants (LCP) Directives. All these data are managed and used to compile the inventory. Figures are cross checked to develop country-specific emission factors and input activity data levels; whenever data cannot be straight used for the inventory compilation, they are taken into account as verification. A unique database is under finalisation in order to improve the process for the analysis of this information and the efficiency in collecting data.

The analysis of data collected from point sources allowed to distribute emissions at local level, for 2005 and previous years, as submitted under the CLTRAP. To illustrate an example, NO_X emissions from point sources are reported in Figure 3.1, for the year 2005; point sources include public electricity and heat production plants, petroleum refineries, stationary combustion plants (*iron and steel, non-ferrous metals, chemicals, clinker*) and *pipeline compressors*.

The figure highlights that the most critical industrial areas are distributed in few regions.

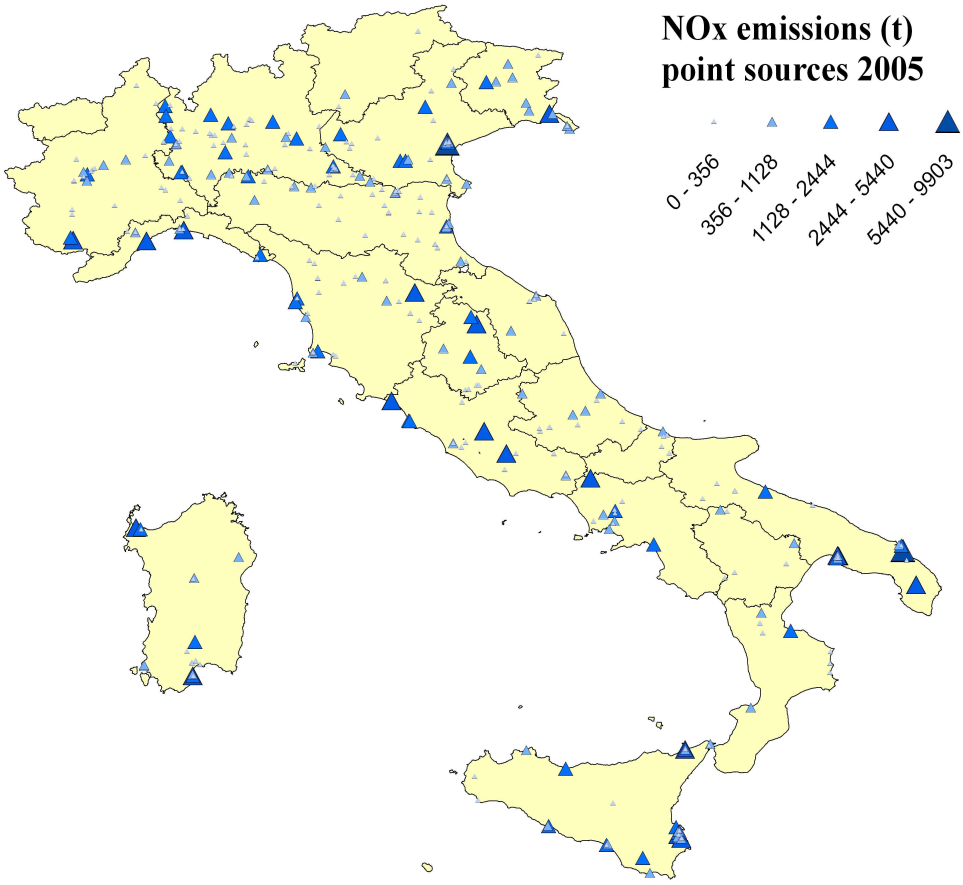

Figure 3.1 NO_X emissions from point sources in 2005 (t)

A complete description of methodological and activity data improvements are documented every year in a QA/QC plan (ISPRA, 2010[c]).

The following sections present an outline of the main key categories in the energy sector. Table 3.1 highlights the key categories identified in the sector.

The *energy* sector is the main source of emissions in Italy with a share of more than 80% in different pollutants under the UNECE convention; specifically, for the main pollutants, in 2008 the sector accounts for:

- 98% in national total NO_X emissions;
- 86% in national total CO emissions;
- 92% in national total SO_X emissions.

Moreover, the sector comprises 80% of total PM2.5 emissions and is also an important source for heavy metals; specifically in 2008 energy sector is responsible for 83% of total Cd emissions and accounts for a high share of other heavy metals, i.e As (99%), Cu (96%), Ni (95%), Se (92%).

There are no particular differences as compared the sectoral share in 1990, except for lead whose contribution in 1990, accounting for 98% of total emissions, was about 30% higher than 2008.

The most important source of emissions in the sector, in 2008, is represented by *road transport* at least for the main pollutants: NO_X (51.8%), CO (43.2%), NMVOC (26.5%), particulate matter (PM10 23.5%, PM2.5 26.0%) and HCB (21.5%). There has been a strong reduction of lead emissions from 1990 to 2008 in road transport due to replacement of lead gasoline.

	1A1a	1A1b	1A1c	1A2	1A2f ii	1A3a ii (i)	1A3a i (i)	1A3b i	1A3b ii	1A3b iii	1A3b iv	1A3b v	1A3b vi	1A3c	1A3d ii	1A3e	1A4a i	1A4b i	1A4b ii	1A4c	1A5b	1B1a	1B1b	1B2
SO_x	19.8	15.5	3.1	19.9	0.0	0.1	0.1	0.3	0.1	0.1	0.0			0.0	16.1	0.0	1.5	3.3	0.0	0.1	0.0			11.6
NO_x	5.5	2.2	0.8	11.9	2.3	0.2	0.2	19.5	7.2	24.1	0.9			0.3	8.4	0.2	3.7	3.4	0.0	7.1	0.8			0.3
NH_3	0.1			0.4	0.0			2.6	0.1	0.0	0.0			0.0	0.0			0.0	0.0	0.0	0.0			
NMVOC	0.3	0.1	0.1	0.7	0.4	0.0	0.1	6.1	0.8	1.4	16.2	1.9		0.0	8.2	0.0	1.5	4.4	0.1	2.0	0.1		0.2	6.3
CO	1.0	0.1	0.1	9.3	0.5	0.1	0.1	22.1	2.3	1.8	16.9			0.0	6.1	0.0	0.7	19.6	0.1	4.8	0.7			0.0
PM10	1.3	0.6	0.5	11.6	1.3	0.0	0.0	6.4	4.5	4.5	1.9		6.2	0.2	4.3	0.0	0.7	16.0	0.0	7.4	0.7	0.5	0.1	0.3
PM2.5	1.6	0.7	0.6	13.8	1.6	0.0	0.0	8.1	5.6	5.7	2.4		4.3	0.3	5.4	0.0	0.9	19.1	0.0	9.3	0.9	0.6	0.1	0.4
Pb	1.1	0.2	0.0	47.9		0.1	0.2						4.3		0.1		15.7	0.3		0.0	0.0		0.4	
Cd	1.4	0.3	0.0	36.8	0.0	0.0	0.0	2.4	0.7	0.9	0.2		0.7	0.0	0.2		25.6	9.9	0.0	1.1	0.0		2.6	
Hg	7.9	1.5	0.3	29.6													18.1	8.3		0.9			1.3	
PAH	0.2	0.0	3.7	1.5	0.0	0.0	0.0	1.1	0.3	0.3	0.0			0.0	0.0		0.8	40.2	0.0	5.2	0.0			
Dioxin	1.8	1.6	0.1	36.9				1.8	0.1	0.1	0.4						2.4	13.0		1.5				
HCB	1.6			13.2				14.3	4.5	2.6	0.1						16.2	1.4		0.2				
PCB	29.2	0.2	0.3	15.5													10.2	1.7		0.2				

Note: grey shaded are key categories

Table 3.1 Key categories in the energy sector in 2008

NO_X emissions from *road transport* have been disaggregated at NUTS3 level (ISPRA, 2009); disaggregation related to 2005 is reported in Figure 3.2.

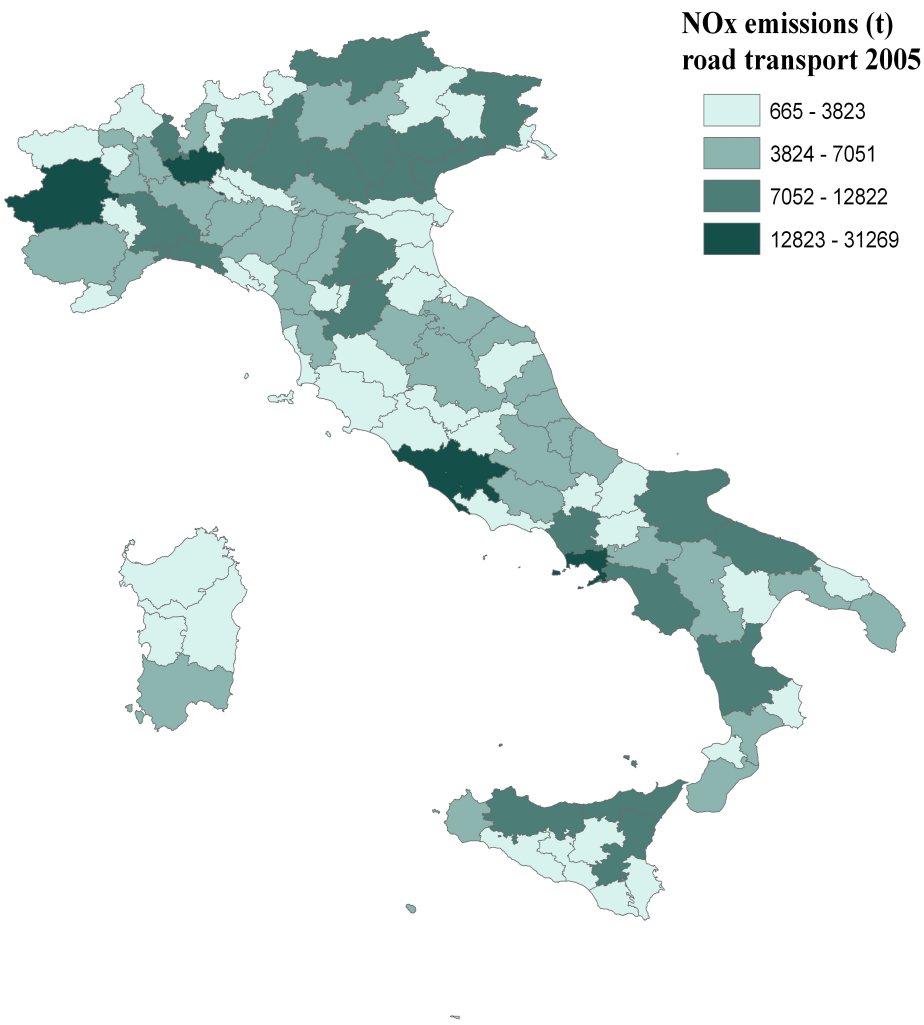

Figure 3.2 NO_X emissions from *road transport* in 2005 (t)

Manufacturing industries and *construction* is the main source for heavy metals, accounting for about 48% of lead total emissions, 37% for cadmium, 30% for mercury, and dioxin (37%). The source is also relevant for PM_{10} and $PM_{2.5}$, as well as SO_X and NO_X, about 12-20% of total emissions.

Public electricity and *heat production* is a main source of SO_X emissions in 2008 with a share of 19.8%, together to *manufacturing industries and construction*, 19.9%, national *navigation* (16.1%) and *petroleum refining* (15.5%); the source is also important for PCB emissions (29%).

A sector which seems of increasing importance is the *non-industrial combustion*, as for NO_X, CO, PM, emissions, accounting for 15-30%, and PAH (46%); these emissions are prevalently due to *biomass combustion* which occurs in the winter period becoming critical for air quality issues. This source is a key category for heavy metals, HCB and PCB due to the increase of combustion of waste with energy recovery reported under the sector.

3.2 Industrial Processes (NFR SECTOR 2)

3.2.1 Methodological issues

Methodologies used for estimating emissions from this sector are based on and conform to the *EMEP/CORINAIR guidebook* (EMEP/CORINAIR, 2007), the *IPCC Guidelines* (IPCC, 1997; IPCC, 2006) and the *Good Practice Guidance* (IPCC, 2000). Included in this sector are by-products or fugitive emissions, which originate from industrial processes.

There are different sources relevant to estimate emissions from this sector; activity data are provided by national statistics and industrial associations' but a lot of information is supplied directly from industry. In fact, as for the *energy* sector, references derive from data collected in the framework of the EPER/E-PRTR registry, *Large Combustion Plant* directives and *European Emissions Trading Scheme*. Other small plants communicate their emissions which are also considered individually. These processes have improved the efficiency in collecting data and exchange of information, and whenever data cannot be straight used for the inventory compilation, they are taken into account as verification practice. Environmental Reports published by industrial associations are also considered in the verification process.

A detailed description on the methods and national specific circumstances as well as reference material is documented in the national inventory report of the Italian greenhouse gas inventory (ISPRA, 2010[b]). At national level, trends of the CLRTAP pollutants are described in the environmental data yearbook published by ISPRA (ISPRA, 2010[d]). A complete description of methodological and activity data improvements are documented every year in a QA/QC plan (ISPRA, 2010[c]).

The main sources of emissions are iron and steel and cement productions (see Table 3.2).

The main processes involved in iron and steel production are those related to sinter and blast furnace plants, to basic oxygen and electric furnaces and to rolling mills. In 1990, there were four integrated iron and steel plants in Italy. In 2008, only three of the above mentioned plants still operate, one of which lacks sintering facilities. Oxygen steel production represents about 36% of the total production and the arc furnace steel the remaining 64% (FEDERACCIAI, several years).Currently, long products represent about 50% of steel production in Italy, flat products about 40% and pipes the remaining 10%. Almost the whole flat production derives from one only integrated iron and steel plant while, in steel plants equipped with electric ovens, almost all located in the northern regions, long products are produced (e.g carbon steel, stainless steels) and seamless pipes (only one plant) (FEDERACCIAI, 2008). Activity data supplied by official statistics published in the national statistics yearbook (ISTAT, several years) and by the sectoral industrial association (FEDERACCIAI, several years) are used to estimate emissions from iron and steel production.

During the last 15 years in Italy, changes in cement production sector have occurred which have led to a more stable structure. The oldest plants closed, wet processes were abandoned in favour of dry processes so as to improve the implementation of more modern and efficient technologies. There are 27 companies (90 plants of which: 60 full cycle and 30 grinding plants) currently operating in this sector: multinational companies and small and medium size enterprises (operating at national or only at local level) are present in the country. As for the localization of the operating plants: 47% is in northern Italy, 18% is in the central regions of the country and 35% is in the southern regions and in the islands. There are 80 active sintering rotary kilns which belong to the "dry" or of "semidry" types. To estimate emissions from cement production, activity data on clinker production are used as provided by ISTAT (ISTAT, several years).

The sector represent in 2008 42% of PCB emissions (33% in 1990), more than 30% of Hg emissions (43% in 1990), 28% of lead and dioxin emissions, about 26% of PAH emissions and 15% of Cd emissions. Also PM10 and PM2.5 emissions are estimated, accounting for 11.5% and 6.1% of national totals respectively, so as SO_X (8.4%), CO (4.5%), NMVOC (4.1%), NO_X and NH3 (less than 0.5% of national total emissions).
The distribution of PM10 emissions from the *industrial processes* sector at NUTS3 level (ISPRA, 2009) for 2005 is reported in Figure 3.3.

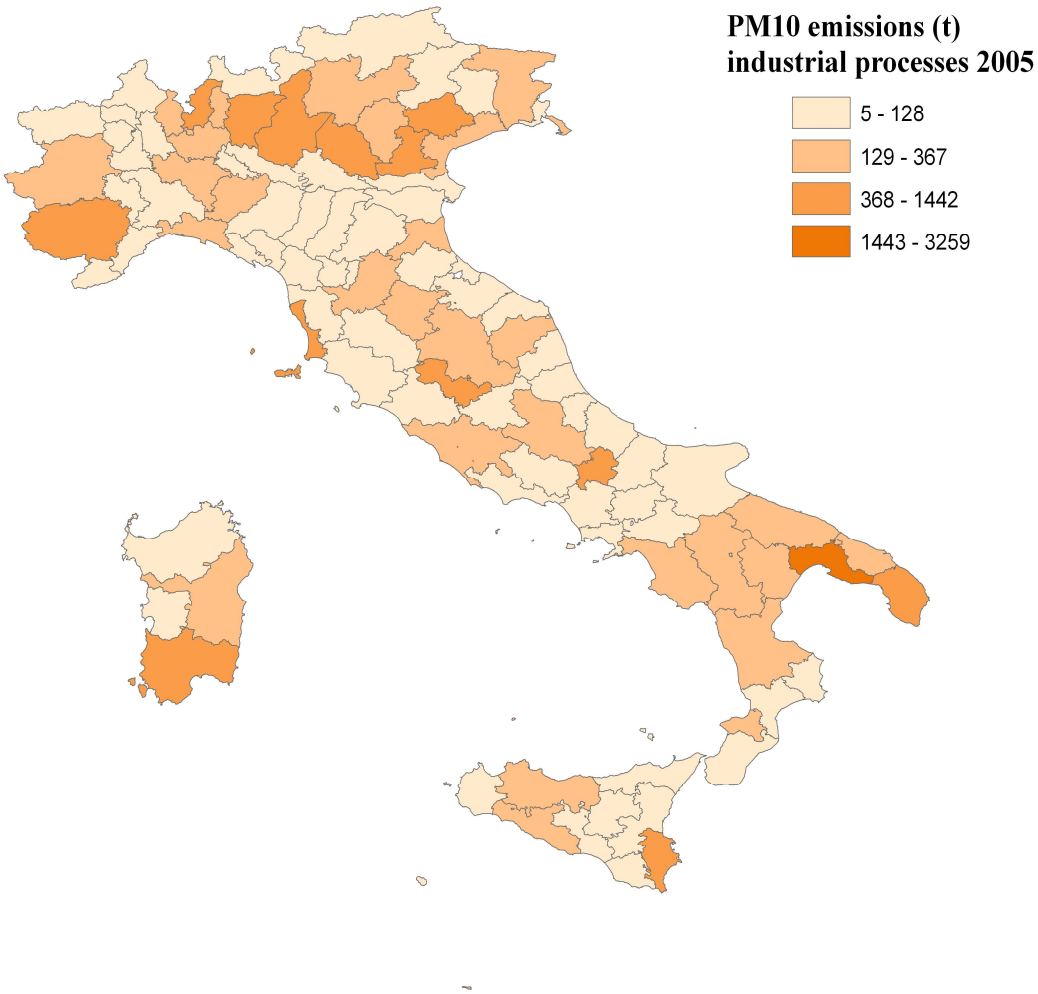

Figure 3.3 PM10 emissions from *industrial processes* in 2005 (t)

There is a general reduction of emissions in the period for most of the pollutants due to the implementation of different directives at European and national level. A strong decrease is observed especially in the *chemical industry* due to the introduction of relevant technological improvements; this sector is still a key source for Hg emissions from chlorine production.
Only PCB, Dioxin and lead emissions increased from 1990 to 2008 due to the strong increase of steel production in the same period.
The following sections present an outline of the main key categories in the *industrial processes* sector. Table 3.2 reports the key categories identified in the sector.

	2A1	2A2	2A4	2A5	2A6	2B1	2B2	2B3	2B5a	2C1	2C2	2C3	2D1	2D2	2G
								%							
SO_x	4.35					0.00			2.53	0.15	0.00	1.32	0.03		
NO_x						0.04	0.04	0.00	0.17	0.24	0.00	0.05	0.01		
NH_3			0.07			0.00	0.00		0.04						
NMVOC				0.00	0.76	0.01			0.30	0.32		0.01	0.15	2.53	
CO			0.69			0.00			0.36	2.61	0.01	0.83			
PM10	3.60	1.10		0.06	1.55				0.44	4.43	0.04	0.22		0.01	
PM2.5	0.68	0.21		0.01	0.29				0.25	4.44	0.03	0.17		0.00	
Pb										27.62					0.80
Cd									0.81	14.45		0.21			
Hg									2.11	28.43					
PAH										25.79			0.06		
Dioxin										28.11					
HCB															
PCB										41.95					

Note: grey shaded are key sources

Table 3.2 Key categories in the industrial processes sector in 2008

The most important source of emissions in the sector, in 2008, is represented by *metal production*, specifically iron and steel, at least for particulate matter, heavy metals and POPs.
For SO_X and particulate matter, significant emissions derive from *cement production*.

3.3 Solvent and other product use (NFR SECTOR 3)

3.3.1 Methodological issues

The sector is characterized by a multitude of activities which implies that the collection of activity data and emission factors is laborious. A lot of contacts have been established in different sectors with industrial associations and documentation has been collected even though improvements are still needed especially in some areas.

Emissions of NMVOC from solvent use have been estimated according to the methodology reported in the EMEP/CORINAIR guidebook, applying both national and international emission factors (Vetrella, 1994; EMEP/CORINAIR, 2007). Country specific emission factors provided by several accredited sources have been used extensively, together with data from the national EPER Registry; in particular, for paint application (Offredi, several years; FIAT, several years), solvent use in dry cleaning (ENEA/USLRMA, 1995), solvent use in textile finishing and in the tanning industries (Techne, 1998; Regione Toscana, 2001; Regione Campania, 2005; GIADA 2006). Basic information from industry on percentage reduction of solvent content in paints and other products has been applied to EMEP/CORINAIR emission factors in order to evaluate the reduction in emissions during the considered period.

Specific surveys based on local and regional inventories have been funded by ISPRA to check NMVOC emission factors and update emission estimates. In the framework of the MeditAIRaneo project, ISPRA commissioned to Techne Consulting S.r.l. a survey to collect national information on emission factors in the solvent sector. The results, published in the report "*Rassegna dei fattori di emissione nazionali ed internazionali relativamente al settore solventi*" (Techne, 2004), have been used to verify and validate the emission estimates. At the end of 2008, ISPRA commissioned to Techne Consulting S.r.l. a survey to compare emission factors with the last update published in the EMEP/CORINAIR guidebook. The results are reported in "*Fattori di emissione per l'utilizzo di solventi*" (Techne, 2008) and have been used to update emission factors for polyurethane and polystyrene foam processing activities.

Emissions from domestic solvent use have been calculated using a detailed methodology, based on VOC content per type of consumer product.

As regards household and car care products, information on VOC content and activity data has been supplied by the Sectoral Association of the Italian Federation of the Chemical Industry (Assocasa, several years) and by the Italian Association of Aerosol Producers (AIA, several years [a] and [b]). As regards cosmetics and toiletries, basic data have been supplied by the Italian Association of Aerosol Producers too (AIA, several years [a] and [b]) and by the national Institute of Statistics and industrial associations (ISTAT, several years; UNIPRO, several years); emission factors time series have been reconstructed on the basis of the information provided by the European Commission (EC, 2002).

A detailed description on the methods and national specific circumstances, as well as reference material, is documented in the national inventory report of the Italian greenhouse gas inventory (ISPRA, 2010[b]). At national level, trends of the CLRTAP pollutants are described in the environmental data yearbook published by ISPRA (ISPRA, 2010[d]).

3.3.2 Time series and key sources

The sector accounts, in 2008, for 43% of total national NMVOC emissions, whereas in 1990 the weight out of the total was equal to 30%. PM and PAH are also estimated in this sector but they account for less than 0.1%.

NMVOC emissions from the sector decreased from 1990 to 2008 of about 20%, from 604 Gg in

1990 to 483 Gg in 2008, mainly due to the reduction of emissions in industrial coating applications, in degreasing and dry cleaning and in other product use. The general reduction observed in the emission trend of the sector is due to the implementation of the European Directive 1999/13/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents, entered into force in Italy in January 2004, and the European Directive 2004/42/EC, entered in force in Italy in March 2006, which establishes a reduction of the solvent content in products.
Figure 3.4 shows emission trends from 1991 to 2008 with respect to 1990 by sub-sector.

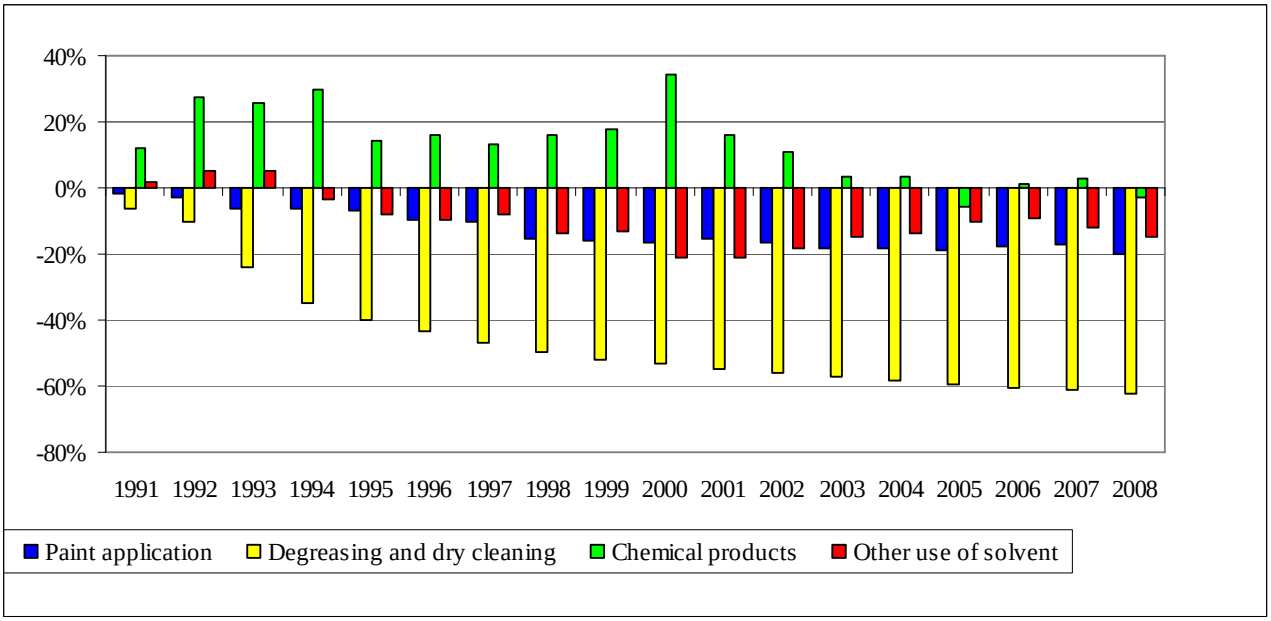

Figure 3.4 Trend of NMVOC emissions from 1991 to 2008 as compared to 1990

Table 3.3 represents the pollutants estimated in the sector and the key categories identified.

	3A1	3A2	3B1	3B2	3C	3D1	3D2	3D3
					%			
SO_x								
NO_x								
NH_3								
NMVOC	12.86	6.38	1.62	0.27	6.66	1.73	10.64	2.75
CO								
PM10					0.01			
PM2.5					0.01			
Pb								
Cd								
Hg								
PAH							0.01	
Dioxin								
HCB								
PCB								

Note: grey shaded are key sources

Table 3.3 Key categories in the solvent and other product use sector in 2008

The main source of emissions is *paint application* where NMVOC emissions derive mainly from construction and building and wood application. The second source of emissions is *domestic solvent use*, mostly for the consumption of cosmetics, followed by *chemical products and other product use*, especially for emissions from polyurethane processing, paints manufacturing and leather tanning.
The distribution of NMVOC emissions from the *solvent and other product use* sector at NUTS3 level (ISPRA, 2009) for 2005 is reported in Figure 3.5.

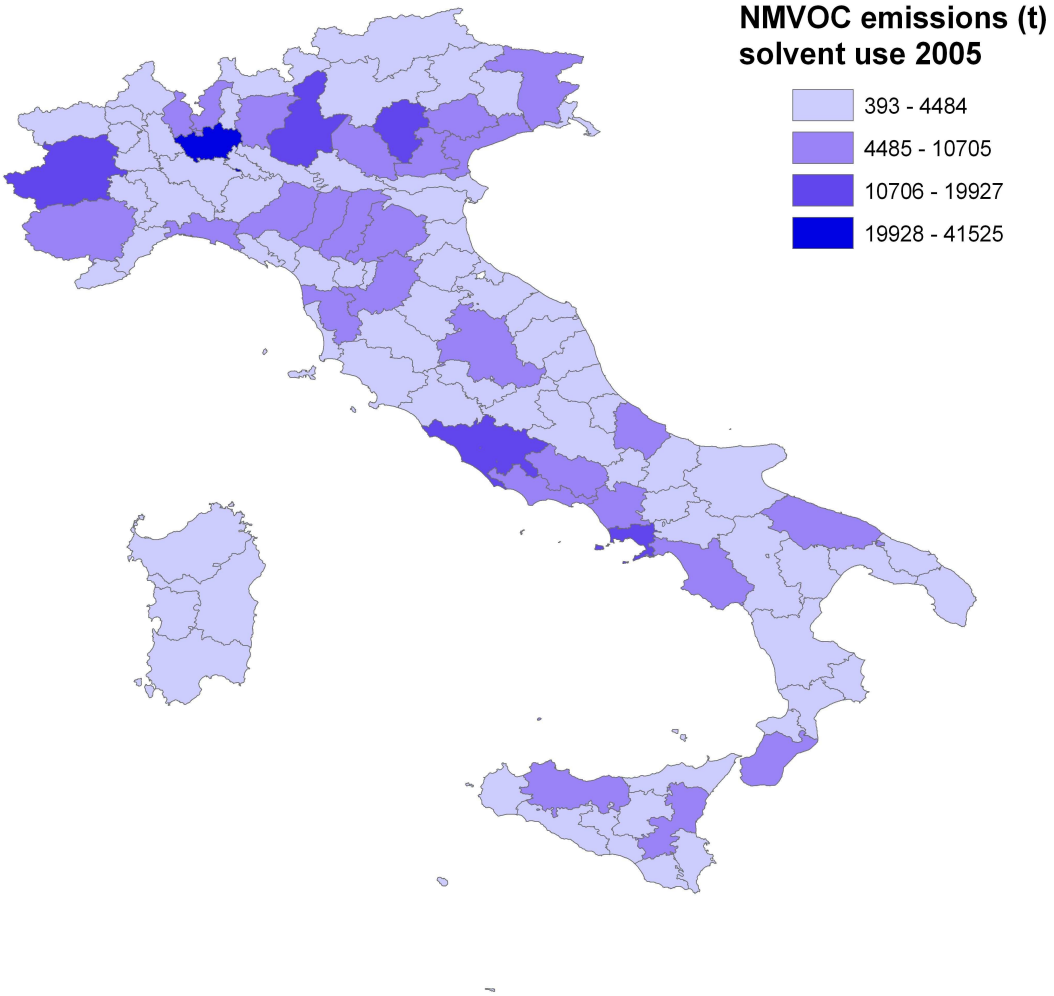

Figure 3.5 NMVOC emissions from *solvent and other product use* in 2005 (t)

3.4 Agriculture (NFR SECTOR 4)

The agriculture sector is responsible for the largest part of NH_3 emissions, and contributes also to PM10, PM2.5, NMVOC, CO emissions.
In 2008, NH_3 emissions from the *agriculture* sector were 386 Gg. Two main source categories are estimated: *manure management* (4B) and *agricultural soils* (4D), which represent 79% and 21% of total agricultural emissions. The trend of NH_3 from 1990 to 2008 shows a decrease of 16% due to reduction in the number of animals and cultivated surface/crop production. A representation of the distribution of agriculture NH_3 emissions is provided in Figure 3.6.

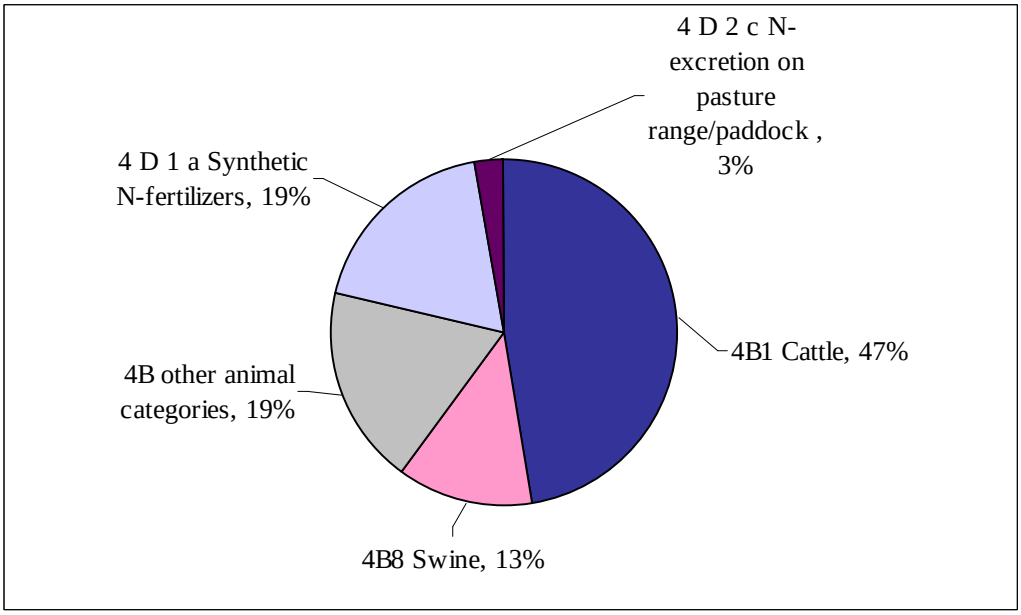

Figure 3.6 Distribution of NH_3 emissions from the agriculture sector

3.4.1 Source of information

Activity data (agricultural statistics) is mainly collected from the National Institute of Statistics, ISTAT[1]. Main agricultural data (number of animals, N-fertilizers, agricultural surface and production, milk production) is available on-line: http://agri.istat.it/jsp/Introduzione.jsp. For consistency reasons the same agricultural statistics are used for both GHG and CLRTAP emission inventory. ISPRA participates to the *Agriculture, Forestry and Fishing Quality Panel*, which has been established to monitor and improve national statistics. This is the opportunity to get in touch with experts from the Agriculture Service from ISTAT in charge for main agricultural surveys in Italy. In this way, data used for the inventory is continuously updated according to latest information available. ISTAT has a major role in the comprehensive collection of data through structural (such as the Farm Structure Survey, FSS), and conjunctural surveys, and the General Agricultural census.

3.4.2 Methodological issues

Methodologies used for estimating national emissions from this sector are based on and conform to the *EMEP/CORINAIR guidebook* (EMEP/CORINAIR, 2007), the *IPCC Guidelines* (IPCC, 1997; IPCC, 2006) and the *Good Practice Guidance* (IPCC, 2000). Therefore, consistency among methodologies for the preparation of the agriculture emission inventory under the CLRTAP and

[1] *Istituto Nazionale di Statistica, ISTAT*

UNFCCC is guaranteed and synergies among international conventions/European directives are implemented (Cóndor and De Lauretis, 2007).
A detailed and updated description of the methodologies for the estimation of NH_3 emissions, as well as of national specific circumstances and reference material, is described in sectoral reports (Cóndor *et al*., 2008, APAT, 2005), and in the National Inventory Report for greenhouse gases (ISPRA, 2010[b]).
The national NH_3 emission inventory has been prepared by ISPRA with the support of *Research Centre on Animal Production* (CRPA[2]), according to EMEP/CORINAIR guidebook.
For NH_3 estimations the following emission categories were considered: animal husbandry for all livestock species (4B), which includes housing, storage and manure application emissions; and agricultural soils (4D), which includes: synthetic N-fertilizers, N-excretion from pasture (animal grazing) and leguminous cultivation emissions.
The estimation procedure for 4B NH_3 emissions consists in successive subtractions from the quantification of nitrogen excreted annually for each livestock category. This quantity can be divided in two different fluxes, depending if animals are inside (housing, storage and manure application) or outside the stable (grazing). The animal grazing source is reported in 4D. The excretion rates (CRPA, 2006[a]; GU, 2006; Xiccato *et al*., 2005), slurry and solid manure production, and average weights (CRPA, 2006[a]; GU, 2006; Regione Emilia Romagna, 2004) were updated with country-specific information. Other improvements of country-specific emission factors (EFs) were obtained with research studies (CRPA, 2006[b]). In Table 3.4 key parameters for NH_3 estimations are reported.

Livestock category	Average weight (kg)	N excreted Housing (kg head^{-1} yr^{-1})	N excreted Grazing (kg head^{-1} yr^{-1})	TOTAL (kg head^{-1} yr^{-1})
Non-dairy cattle	379	48.52	1.24	**49.76**
Dairy cattle	603	110.20	5.80	**116.00**
Buffalo	506	88.414	2.69	**91.05**
Other swine (*)	84	12.79	0.00	**12.79**
Sow (*)	172	28.09	0.00	**28.09**
Sheep	47	1.62	14.58	**16.20**
Goats	47	1.62	14.58	**16.20**
Horses	500	20.00	30.00	**50.00**
Mules and asses	300	20.00	30.00	**50.00**
Poultry	1.8	0.53	0.00	**0.53**
Rabbit	1.6	1.02	0.00	**1.02**

(*) other swine and sow are sources that represent the 'swine' category

Table 3.4 Average weight and nitrogen excretion rates from livestock categories in 2008

For *agricultural soils* (4D), estimations of NH_3 account for the direct application of synthetic N-fertilizers, direct emission from animal grazing and emissions from nitrogen fixed by leguminous cultivation. Emissions from synthetic fertilizer are based on the detailed EMEP/CORINAIR methodology, which provides different EFs for the different type of fertilizers, taking into account climatic conditions. Ammonia emissions from synthetic N-fertilizers are obtained with the amount of

[2] *Centro Ricerche Produzioni Animali*

the nitrogen content by type of fertilizer multiplied by the specific EFs. Nitrogen input from N-fixing crops has considered data on surface and production for N-fixing crops and forage legumes.
The particulate (PM10 and PM2.5) and NMVOC emission estimations are based on the EMEP/CORINAIR Emission Inventory Guidebook. Two emission sources are estimated: *manure management (*4B) and *field burning of agricultural residues* (4F). Emissions factors are those recommended in the guidelines. For 4B, based on animal breeding characteristics in Italy and animal weight parameters, the PM10 and PM2.5 EFs were corrected (see Cóndor *et al*., 2008).

3.4.3 Time series and key sources

The following sections present an outline of the main key categories in the agriculture sector. Table 3.5 reports the key categories identified in the agriculture sector.

	4B1a	4B1b	4B2	4B3	4B4	4B6	4B7	4B8	4B9a	4B9b	4B9d	4B13	4D1a	4D2c	4F
								%							
SO_x															
NO_x															0.05
NH_3	21.87	23.09	3.08	1.36	0.16	0.49	0.05	12.06	2.45	4.00	3.39	2.72	17.86	2.52	
NMVOC	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.01							0.06
CO															0.44
PM10	0.71	0.87	0.08			0.05	0.01	2.36	0.67	5.74					1.50
PM2.5	0.57	0.72	0.06			0.04	0.00	0.49	0.10	0.94					1.88
Pb															
Cd															
Hg															
PAH															
Dioxin															
HCB															
PCB															

Note: grey shaded are key sources

Table 3.5 Key categories in the *agriculture* sector in 2008

The agriculture sector is the main source of NH_3 emissions in Italy with a share of more than 95%; for the main pollutants, in 2008 the sector accounts for:

- 95% in national total NH_3 emissions;
- 12% in national total PM10 emissions;
- 5% in national total PM2.5 emissions.

Moreover, the sector comprises 0.4% of total CO emissions, 0.1% of NMVOC and 0.05% of NO_x. There are no particular differences as compared to the sectoral share in 1990 when the agriculture sector accounted for 98% of NH_3 emissions, 8% of PM10 and 3% of PM2.5.
The time series of NH_3 emissions for the *agriculture* sector by sources is shown in Table 3.6.

Source categories for NFR SECTOR 4	1990	1995	2000	2005	2006	2007	2008
				Gg			
4 B 1 a Cattle Dairy	139	106	102	89	88	89	89
4 B 1 b Cattle Non-Dairy	120	118	110	95	90	96	94
4 B 2 Buffalo	4	6	8	9	10	12	12
4 B 3 Sheep	6	7	7	5	6	6	6
4 B 4 Goats	1	1	1	1	1	1	1
4 B 6 Horses	2	2	2	2	2	2	2
4 B 7 Mules and Asses	1	0	0	0	0	0	0
4 B 8 Swine	49	46	46	49	49	49	49
4 B 9 a Laying Hens	17	15	12	10	10	10	10
4 B 9 b Broilers	15	16	15	15	14	15	16
4 B 9 c Turkeys							
4 B 9 d Other Poultry	11	14	13	13	13	13	14
4 B 13 Other	9	10	10	12	11	12	11
4 D 1 a Synthetic N-fertilizers	73	80	79	77	81	80	72
4 D 2 c N-excretion on pasture range/paddock	12	13	13	10	10	10	10
Total emissions	**457**	**433**	**417**	**387**	**384**	**395**	**386**

Table 3.6 Time series of ammonia emissions in *agriculture* (Gg)

Concerning NH_3 emissions, the category *manure management (4B*) represents, in 2008, 75% of ammonia emissions (80% in 1990). In particular, NH_3 emissions from *cattle* (4B1) stand for 60% of the category emissions, while emissions from *swine* (4B8) and *poultry* (4B9) represent 16% and 13%, respectively. *Direct soil emissions (4D)*, especially for the use of chemical fertilizers, represent 20% in 2008 of ammonia emissions (18% in 1990).

Regarding PM10 emissions, the category *manure management (4B*) accounts for 10.5% in 2008 (6.8% in 1990). *Poultry* (4B9) and *swine* (4B8) represent the major contributors to the total PM10 emissions from category 4B (61% and 22%, respectively). The presence of large poultry and swine farms in the Po river basin assume a particular relevance, at regional level, for air quality issues especially for the specific meteorological conditions of that regional area.

Similar consideration may be done for PM2.5 emissions; the category *manure management* (4B) contributes for 2.9% in 2008 (1.9% in 1990). *Cattle* (4B1) accounts for 44%, while *poultry* (4B9) stands for 36% to the total PM2.5 emissions from category 4B.

Every 5 years the national agriculture UNFCCC/CLRTAP emission inventory is disaggregated at NUTS3 level as requested by CLRTAP (Cóndor *et al*., 2008). A database with the time series for all sectors and pollutants has been published (ISPRA, 2008[a]; ISPRA, 2008[b]; ISPRA, 2009; ISPRA, 2010[d]). Furthermore, a complete description of methods and activity data improvements are documented every year in a QA/QC plan (ISPRA, 2010[c]).

The disaggregation (NUTS3) of the NH_3 agricultural emissions is shown in Figure 3.7. In 2005, four regions from Italy contributed with 63% of agricultural NH_3 emissions: Lombardia (25%), Veneto (15%), Emilia Romagna (13%) and Piemonte (10%).

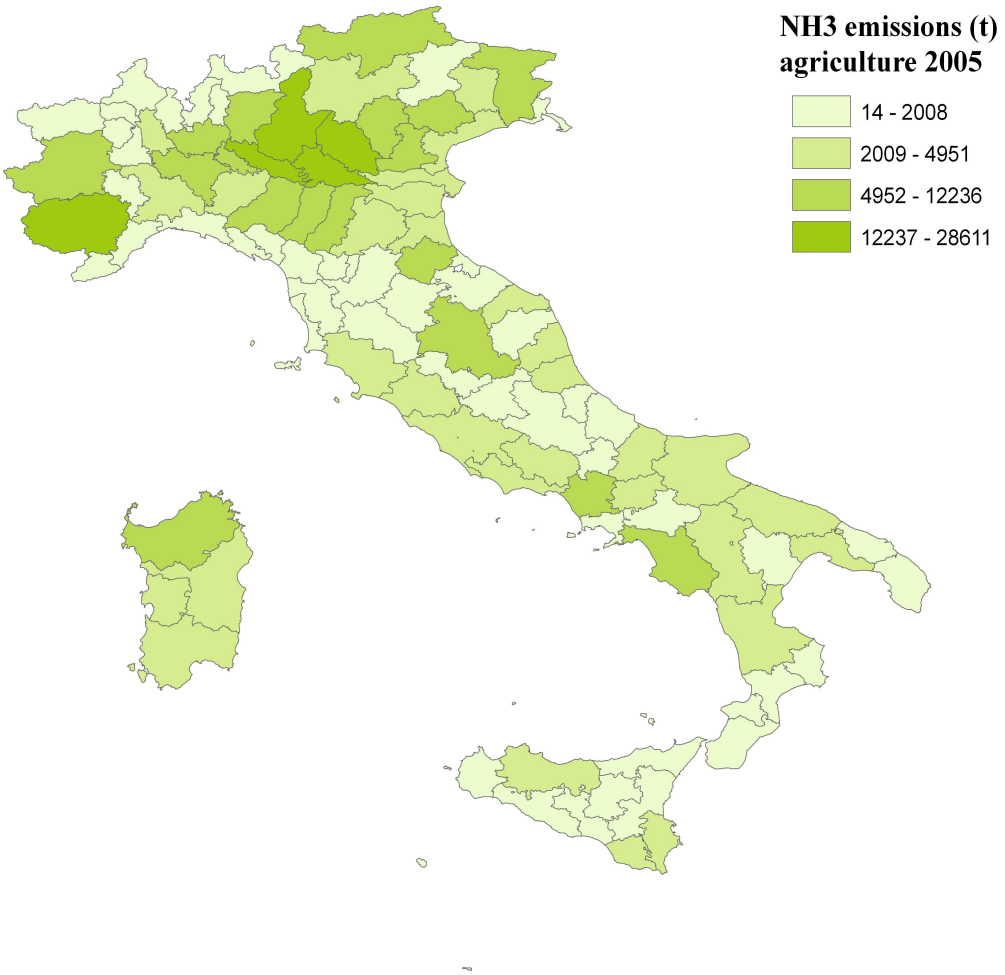

Figure 3.7 NH_3 emissions from *Agriculture* in 2005 (t)

3.4.4 Planned improvements

Since the 2006 submission, results from a specific project on Mediterranean area, the *MeditAIRaneo* project, have been included in the preparation of the CLRTAP/UNFCCC agriculture emission inventory (CRPA, 2006[a]). Moreover, outcomes from the convention signed between APAT and the Ministry for the Environment, Land and Sea on NH_3 emission scenarios have been incorporated (CRPA, 2006[b]; ENEA, 2006).

In the future the implementation of an *ad hoc* "Survey on Agricultural Production Methods" (SAPM) regulated by the European Commission will be crucial for improving the preparation of the national agriculture inventory. This survey will be carried out in Italy during the 2010 General Agricultural Census. Information such as animal grazing period, animal housing, storage systems characteristics, and the use of manure/slurry for land application will be collected. Some information at provincial level (NUTS3) has been already collected with the incorporation of specific queries in the Farm Structure Survey (FSS) from 2005 and 2007. Information on housing and storage systems, respectively, was analysed, and will be validated with information that will be obtained from the 2010 Agricultural Census (CRPA, 2010). Furthermore, a recent research study has evaluated the improvement of NH_3 emission estimations for the application of fertilizers to soils (organic and inorganic), and the identification of elements for monitoring agronomic practices (CRPA, 2009). Results of this study will be incorporated in future submissions.

3.5 Waste (NFR SECTOR 6)

The waste sector comprises the following categories:

6A Solid waste disposal on land
6B Wastewater handling
6Ca Clinical waste incineration
6Cb Industrial waste incineration
6Cc Municipal waste incineration
6Ce Small scale waste burning
6D Other waste

The following air pollutant emissions are estimated for each sector, as reported in Table 3.7.

Main pollutants	6A	6B	6Ca	6Cb	6Cc	6Ce	6D
NOx			X	X	X	X	
CO			X	X	X	X	
NMVOC	X		X	X	X	X	X
SOx			X	X	X		
NH_3	X						X
Particulate matter							
TSP							
PM10			X	X	X	X	
PM2.5			X	X	X	X	
Priority heavy metals							
Pb			X	X	X		
Cd			X	X	X		
Hg			X	X	X		
POPs Annex II							
PCB			X	X	X		
POPs Annex III							
Diox			X	X	X	X	
PAH			X	X	X	X	
HCB			X	X	X		
Other heavy metals							
As			X	X	X		
Cr			X	X	X		
Cu			X	X	X		
Ni			X	X	X		
Se			X	X	X		
Zn			X	X	X		

Table 3.7 Air pollutant emissions estimated for each sector

3.5.1 Methodological issues

Methodologies used for estimating emissions from this sector are based on and conform to the *EMEP/CORINAIR guidebook* (EMEP/CORINAIR, 2007), the *IPCC Guidelines* (IPCC, 1997) and the *Good Practice Guidance* (IPCC, 2000).

Solid waste disposal on land is a major source concerning greenhouse gas emissions but not concerning air pollutants. Notwithstanding, NMVOC and NH_3 emissions are estimated, as a percentage of methane emitted, calculated using the IPCC Tier 2 methodology, through the application of the First Order Decay Model (FOD). A detail description of the methodology is reported in the *National Inventory Report* on the Italian greenhouse gas inventory (ISPRA, 2010[b]).

Emission estimates are calculated on the assumption that ammonia is 1 volume per cent of methane,

whereas non-methane volatile organic compounds are 1.3 weight per cent of methane (Gaudioso et al., 1993).
Methane and consequently NMVOC and NH_3 air pollutants are emitted from the degradation of waste which occurs in municipal landfills. The main parameters that influence the estimation of emissions from landfills are, apart from the amount of waste disposed into managed landfill, the waste composition, the fraction of methane in the landfill gas and the amount of landfill gas collected and treated. These parameters are strictly dependent on the waste management policies throughout the waste streams which start from its generation, flow through collection and transportation, separation for resource recovery, treatment for volume reduction, stabilisation, recycling and energy recovery and terminate at landfill sites.
The disposal of municipal solid waste (MSW) in landfill sites is still the main disposal practice: the percentage of municipal solid waste disposed in landfills dropped from 91% in 1990 to 49% in 2008. This trend is strictly dependent from policies that have been taken in the last 20 years in waste management. In fact, at the same time, waste incineration has fairly increased, whereas composting and mechanical and biological treatment have shown a remarkable rise due to the enforcement of legislation (Figure 3.8).

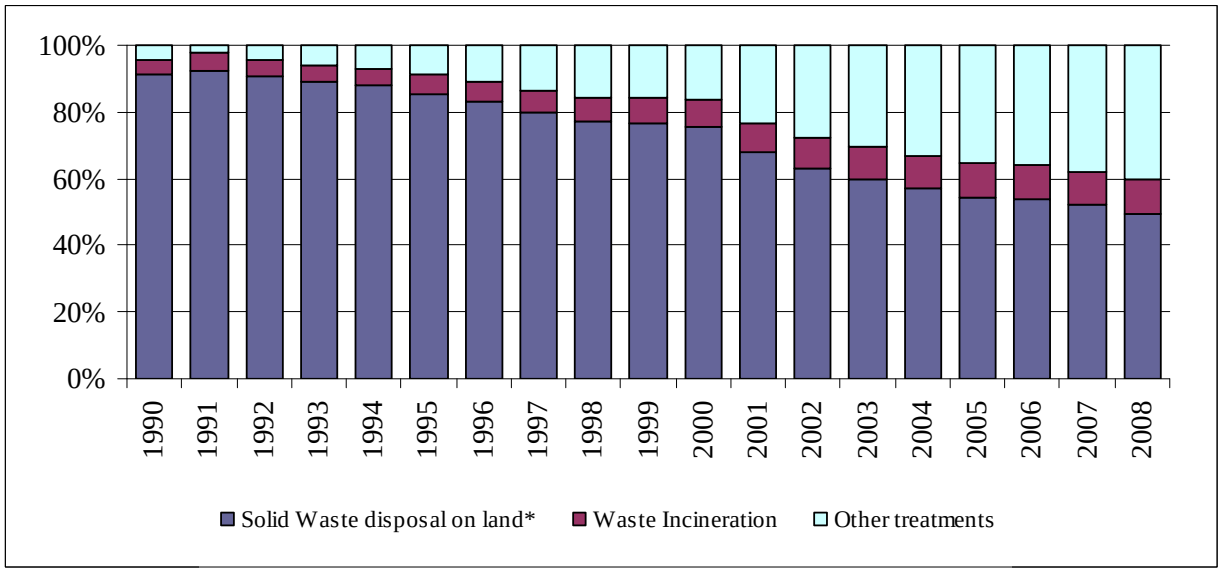

Figure 3.8 Percentage of municipal solid waste treatment and disposal, 1990 – 2008 (%)

Basic data on waste production and landfills system are those provided by the national Waste Cadastre. The Waste Cadastre is formed by a national branch, hosted by ISPRA, and by regional and provincial branches, and other national statistics.
Regarding waste incineration, in this sector only emissions from facilities without energy recovery are reported, whereas emissions from waste incineration facilities with energy recovery are reported in the Energy Sector 1A. For 2008, about 95% of the total amount of waste incinerated is treated in plants with energy recovery system.
Existing incinerators in Italy are used for the disposal of municipal waste, together with some industrial waste, sanitary waste and sewage sludge for which the incineration plant has been authorized from the competent authority. Other incineration plants are used exclusively for industrial and sanitary waste, both hazardous and not, and for the combustion of waste oils, whereas there are few plants that treat residual waste from waste treatments, as well as sewage sludge.
A complete database of the incineration plants is now available, updated with the information

reported in the yearly report on waste production and management published by ISPRA (APAT-ONR, several years; ISPRA, several years). For each plant a lot of information is reported, among which the year of the construction and possible upgrade, the typology of combustion chamber and gas treatment section, if it is provided of energy recovery (thermal or electric), and the type and amount of waste incinerated (municipal, industrial, etc.).
Here below (Table 3.8), emission factors for each pollutant and waste typology are reported. Emission factors have been estimated on the basis of a study conducted by ENEA (De Stefanis, 1999), based on emission data from a large sample of Italian incinerators (FEDERAMBIENTE, 1998; AMA-Comune di Roma, 1996), legal thresholds (Ministerial Decree 19 November 1997, n. 503 of the Ministry of Environment; Ministerial Decree 12 July 1990) and expert judgements.

Air Pollutant	u.m	Municipal	Industrial	Clinical	Sludge	Oil
NOx	*kg/t*	1.15	2	0.603624	3	2
CO	*kg/t*	0.07	0.56	0.07542	0.6	0.07542
NMVOC	*kg/t*	0.46046	7.4	7.4	0.25116	7.4
SO2	*kg/t*	0.39	1.28	0.02594	1.8	1.28
PM10	*g/t*	46	240	25.676	180	240
PM2.5	*g/t*	46	240	25.676	180	240
As	*g/t*	0.05	0.12	0.0042	0.5	0.12
Cu	*g/t*	1	1.2	0.564	10	1.2
Se	*g/t*	0.013	0.006	0.03736	-	0.006
Zn	*g/t*	0.017	12.6	-	10	12.6
Cd	*g/t*	0.25	0.8	0.001128	1.2	0.8
Cr	*g/t*	0.45	1.6	0.01168	3	1.6
Hg	*g/t*	0.15	0.8	0.03684	1.2	0.8
Ni	*g/t*	16.35	0.8	0.02504	3	0.8
Pb	*g/t*	1.35	24	0.0246	3	24
PAH	*g/t*	0.05	0.48	0.00014126	0.6	0.48
PCB	*g/t*	0.005	0.005	0.02	0.005	-
HCB	*g/t*	0.001	0.0001	0.019	0.500	-

Table 3.8 Emission factors for waste incineration

As regard dioxin emissions, clinical and industrial emission factors are also derived from data collected from a large sample of Italian incinerators and legal thresholds, as well as expert judgement; in particular for municipal solid waste, emission factors vary within the years and the facility on the basis of plant technology (i.e. typology of combustion chamber and gas treatment section) and the year of the upgrade. This site specific evaluation has been possible thanks to a study conducted in the past for a sample of municipal waste incinerators located in Regione Lombardia in order to produce an assessment of field-based values applicable to other facilities with the same

characteristics (Pastorelli et al., 2001). Moreover, for the incineration plants reported in the EPER register, verification on emissions has been carried out. In Table 3.9 dioxin emission factors are reported for 1990 and 2008.

Waste Typology	1990	2008
	µg/t	
Municipal	115 - 1.6	0.5
Clinical	200	0.8
Industrial	80 - 135	0.8
Sludge	77	0.6
Oil	200	0.8

Table 3.9 Dioxin emission factors

In Table 3.10 activity data are reported by type of waste.

Waste incinerated	1990	1995	2000	2005	2006	2007	2008
			(t)				
Total waste	**1,716,348**	**2,209,330**	**3,061,678**	**4,966,180**	**5,066,369**	**5,145,312**	**5,287,347**
with energy recovery	946,567	1,593,742	2,751,913	4,707,447	4,800,240	4,897,692	5,034,413
without energy recovery	769,781	615,588	309,765	258,733	266,129	247,620	252,934
Clinical waste (6Ca)	**138,151**	**154,542**	**110,318**	**126,204**	**145,343**	**131,916**	**134,974**
with energy recovery	25,270	41,105	76,684	89,770	95,068	76,313	79,370
without energy recovery	112,881	113,437	33,634	36,434	50,275	55,604	55,603
Industrial waste (6Cb)	**552,603**	**618,168**	**626,484**	**1,620,105**	**1,651,687**	**1,714,020**	**1,797,827**
with energy recovery	294,902	367,146	513,862	1,449,735	1,458,709	1,550,469	1,625,061
without energy recovery	257,701	251,022	112,622	170,370	192,979	163,551	172,766
Municipal waste (6Cc)	**1,025,594**	**1,436,620**	**2,324,876**	**3,219,871**	**3,269,338**	**3,299,375**	**3,354,546**
with energy recovery	626,395	1,185,491	2,161,367	3,167,942	3,246,463	3,270,911	3,329,981
without energy recovery	399,200	251,128	163,509	51,929	22,875	28,465	24,564

Table 3.10 Amount of waste incinerated by type

Under the waste sector the burning of removable agriculture residues that are collected and could be managed in different ways (disposed in landfills, used to produce compost or used to produce energy) is reported. Different percentages of the removable agriculture residue burnt for different residues are assumed, varying from 10% to 90%, according to national and international literature. Moreover, these removable wastes are assumed to be all burned in open air (e.g. on field) or in fireplaces without abatement technology control, taking in consideration the higher available CO, NOx, NMVOC, PM, PAH and dioxins emission factors.

3.5.2 Time series and key sources

The following Table 3.11 presents an outline of the main key categories in the waste sector.

	6A	6Ca	6Cb	6Cc	6Ce	6D
			%			
SO_x		0.0005	0.08	0.003		
NO_x		0.003	0.04	0.003	1.25	
NH_3	1.39		-			0.21
NMVOC	0.62	0.04	0.10	0.001	1.19	0.03
CO		0.0001	0.003	0.0001	9.25	
PM10		0.001	0.03	0.001	8.07	
PM2.5		0.001	0.03	0.001	8.68	
Pb		0.0005	1.29	0.01		
Cd		0.001	1.71	0.07		
Hg		0.02	1.42	0.04		
PAH		0.00001	0.06	0.001	20.62	
Dioxin		0.01	0.04	0.004	12.08	
HCB		3.43	42.34	0.08		
PCB		0.42	0.33	0.05		

Note: grey shaded are key sources

Table 3.11 Key categories in the waste sector in 2008

The waste sector, and in particular *Waste incineration* (6C), is a relevant source of different pollutants; for the main pollutants, in 2008, the sector accounts for:

- 46% in national total HCB emissions;
- 21% in national total PAH emissions.
- 12% in national total Dioxin emissions;

Moreover, the sector comprises 8.1% and 8.7% of total PM10 and PM2.5 emissions, respectively, 9.3% of CO, 1.3% of NO_X, and more than 1.5% of heavy metals (HM). Comparing the sectoral 1990 emissions, it's possible to note a severe reduction of the share of HCB (57.5% in 1990), and a decrease in the share of dioxin emissions (26.1% in 1990) as a consequence of the introduction of more stringent limits of these emissions for incineration plants.

Here below, the time series for the main pollutants of the waste sector (Table 3.12)

6C	1990	1995	2000	2005	2006	2007	2008
HCB (t)	0.0129	0.0140	0.0099	0.0086	0.0140	0.0141	0.0141
PAH (t)	21.3	31.1	29.5	33.9	32.5	31.2	32.3
Dioxin (g I-Teq)	123.5	110.5	55.6	39.6	38.0	36.5	37.7

Table 3.12 Time series of HCB, PAH and Dioxin emissions of the Waste sector (6C)

3.5.3 Planned improvements

Improvements are expected due to the entering into force of the landfill directive (EC, 1999). The application of the Directive would implement the availability of data regarding the main parameters influencing the estimation of emission from landfills: the waste composition, the fraction of methane in the landfill gas and the amount of landfill gas collected and treated. Moreover, whereas available, emissions data from specific incineration facilities with continuous measurement systems, could be collected in order to verify the updating of emission factors.

4 Recalculations and Improvements

4.1 Recalculations

To meet the requirements of transparency, consistency, comparability, completeness and accuracy of the inventory, the entire time series from 1990 onwards is checked and revised every year during the annual compilation of the inventory. Measures to guarantee and improve these qualifications are undertaken and recalculations should be considered as a contribution to the overall improvement of the inventory.

Recalculations are elaborated on account of changes in the methodologies used to carry out emission estimates, changes due to different allocation of emissions as compared to previous submissions, changes due to error corrections and in consideration of new available information.

The complete NFR files from 1980 to 2008 have been submitted.

The percentage difference between the time series reported in the 2009 submission and the series reported this year (2010 submission) are shown in Table 4.1 by pollutant.

Improvements in the calculation of emission estimates have led to a recalculation of the entire time series of the national inventory. Considering the total emissions, the emission levels for the year 2007 show a decrease for CO, PM10, PM2.5, NMVOC, SO_X, NO_X and NH_3, whereas an increase is observed for lead, heavy metals and dioxins.

Relevant changes in the whole time series regarded, in particular, a revision of the emission estimates from the road transport sector. Specifically, the new version of Copert model, Copert 4 (EEA, 2010), has been applied to calculate emissions of all pollutants for the whole period 1990-2007. The new version of the model upgraded the methodology, the software and fixed some bugs, with respect to the previous submission.

Methodological updates of the software regarded mileage degradation parameters, new hot emission factors for motorcycles, and the update of CO, NO_X, NMVOC, CH_4, PM and NH_3 emission factors especially for LPG fuelled passenger cars especially from EURO3 to EURO6.

Moreover, important bugs of the software have been corrected. The more relevant concerns the calculation of N_2O, NH_3 and CH_4 hot and cold emissions. Because of this bug there was a misallocation between the hot and cold emissions of these pollutants. Furthermore, the N_2O cold emissions were stored in place of NH_3 cold emissions and vice versa. These updates resulted in a further reduction of CH_4 emission levels and an increase of NMVOC emissions, with respect to previous submission.

The recalculation led to an increase in the emission levels of different pollutants: NO_X and NMVOC figures increased as compared the last year submission; also CO emissions were affected by a revision related to mopeds and motorcycles, which caused an increase in emissions at least for the first years of the time series whereas the estimates reduced for the last years. For heavy metals, including lead and cadmium, non exhaust emissions were added and for dioxins emissions from non EURO 0 vehicles (EURO 1-5) were included. On the other hand, there was a reduction in the whole time series in the levels of NH_3 and PAH. Other minor recalculations due to the application of Copert 4 concerned the decrease in PM emission levels.

A revision of integrated iron and steel plants information also occurred; specifically the update in emissions of the most important European integrated plant involved SO_X levels for the year 2007 which reduced and PCB and HCB which considerably increased for the whole time series. Dioxin levels also reduced for the update of information from another plant.

The update of activity data for incineration plants, which treat industrial wastes, in 2007, lead to a recalculation in mercury and cadmium levels, which increased, and a reduction in dioxins. Activity

data for sludge in wastewater handling were revised from 1999 which caused a reduction in NH_3 emission levels

Emissions from soda ash production were estimated for CO for the whole time series and for NH_3 which occurred from 2002.

Another sector involved in the recalculation is solvent and other product use, specifically NMVOC emissions from domestic solvent use were revised for the whole time series, leading to an increase from 1990 due to the update of EFs for dish cleaners and a reduction from 1998 due to the update of activity data for cosmetics.

NO_X emission factors for natural gas in residential plants were revised from 1995 resulting in a reduction in emission levels.

Finally, PM10 and PM2.5 emission levels decreased from 2005 for a revision of emission factors in the cement production processes.

	SO_X	NO_X	NH_3	NMVOC	CO	PM10	PM2.5	Pb	Hg	Cd	DIOX	PAH
						%						
1980	-0.0	1.4	-0.0	3.3	3.4							
1981	-0.0	1.4	-0.0	3.3	3.4							
1982	-0.0	1.5	-0.0	3.2	3.4							
1983	-0.0	1.5	-0.0	3.2	3.4							
1984	-0.0	1.5	-0.0	3.2	3.4							
1985	-0.0	1.4	-0.0	3.1	3.5							
1986	-0.0	1.4	-0.0	3.2	3.4							
1987	-0.0	1.4	-0.0	3.1	3.5							
1988	-0.0	1.5	-0.0	3.1	3.4							
1989	-0.0	1.5	-0.0	3.1	3.4							
1990	-0.0	1.6	-0.0	3.3	3.5	-0.1	-0.2	0.9	-	0.3	0.1	0.0
1991	-0.1	2.2	-0.0	3.2	3.4	-0.1	-0.2	0.8	-	0.5	0.1	-0.0
1992	-0.2	2.6	-0.0	3.3	2.8	-0.5	-0.6	0.9	-	0.5	0.1	-0.0
1993	-0.3	2.8	-0.1	3.4	3.4	-0.6	-0.7	1.0	-	0.5	0.2	-0.0
1994	0.0	2.2	-0.1	3.3	3.4	-0.5	-0.6	0.8	-	0.6	0.4	0.0
1995	0.0	2.5	-0.3	3.6	4.0	-0.6	-0.8	1.2	-	0.6	0.6	-0.0
1996	-0.0	1.8	-0.3	2.8	2.9	-0.1	-0.1	1.2	-	0.6	0.8	-0.0
1997	-0.0	1.9	-0.5	2.9	2.7	-0.1	-0.2	1.5	-	3.6	0.9	-0.0
1998	0.0	1.3	-0.7	2.0	2.4	0.2	0.2	1.7	-	0.7	1.1	-0.0
1999	0.0	1.3	-1.0	1.9	1.7	0.1	0.0	2.0	-	0.7	1.4	-0.0
2000	0.0	1.4	-1.2	1.8	2.1	-0.3	-0.3	0.7	-	0.6	1.6	-0.0
2001	0.0	0.2	-0.9	0.7	0.5	-0.3	-0.4	1.1	-	0.6	2.1	-0.0
2002	-0.0	0.2	-0.9	0.8	1.1	-0.7	-0.8	5.1	-0.0	0.8	2.2	-0.0
2003	0.0	-0.9	-0.5	0.1	-0.2	-0.5	-0.6	5.0	0.0	0.8	2.1	-0.1
2004	0.0	-0.6	-0.4	0.2	0.1	-0.2	-0.2	4.7	-0.0	0.7	2.1	-0.1
2005	0.0	-0.2	-0.3	-0.1	-0.8	-1.0	-1.1	4.5	-0.0	0.7	2.0	-0.1
2006	0.1	-1.3	-0.5	-0.5	-1.9	-1.7	-2.0	4.5	-	0.7	1.8	-0.1
2007	-0.9	-0.9	-0.4	-1.1	-5.5	-2.5	-3.0	5.2	0.6	1.6	0.8	-0.0

Table 4.1 Recalculation between 2009 and 2010 submissions

4.2 Planned improvements

Specific improvements are specified in the 2010 QA/QC plan (ISPRA, 2010[c]); they can be summarized as follows.

For the *energy* and *industrial processes* sectors, a major progress will regard the finalisation of the database where information collected in the framework of different directives, Large Combustion Plant, E-PRTR and Emissions Trading, are gathered together thus highlighting the main discrepancies in information and detecting potential errors. For the *agriculture* and *waste* sectors, improvements will be related to the availability of new information on emission factors, activity data as well as parameters necessary to carry out the estimates; specifically, a study on the best available technologies used in agriculture practises and availability of information on waste

composition and other parameters following the entering into force of the European landfill directive.
A general revision will concern PAH, dioxin and heavy metals estimates in order to improve the accuracy and reduce the uncertainty.
The new chapters of the EMEP/CORINAIR Guidebook 2009/2010 will be considered and latest methodologies and update emission factors will be applied in the next year submission of the inventory.
The comparison between local inventories and national inventory and the meetings and exchange of information with local environmental agencies will continue.
Further analyses will concern the collection of statistical data and information to estimate uncertainty in specific sectors.

5 Projections

The national projections reported within the UNECE Convention are calculated by the model GAINS Italy, the Italian version of the GAINS Europe model (Amman et al., 1999; IIASA, 2008). The estimations of SO_2, NO_X, NMVOC and NH_3 are based on an assessment of economic activities and a control strategy, explained by economic sector, set of abatement technologies planned in terms of rates of application for the current and future years (Pignatelli et al., 2007). Emission factors are those used for the national emission inventory estimations as well as national references and personal communication with sectoral experts.

In order to assess future economic activities levels two scenarios are developed:

- an energy scenario to estimate emissions from energy sources. The Markal (MARket Allocation) model (Goldstein et al., 1999) is used to implement the scenario at 2010 and 2020. Actually, this model has been modified at the beginning of the 1990s to take into consideration the Italian circumstances and evaluate potential and costs of emissions reduction of CO_2, NO_x e SO_x. Markal Italy (Gracceva and Contaldi, 2004) is also used to develop the energy mitigation scenario also for the Fifth National Comunication under the UN Convention on Climate Change (MATTM, 2009) and the EU GHG Monitoring Mechanism requirements.
- a scenario on production activities to estimate emissions from non energy sources. National statistics and projections of non energy economic activities are used to this end.

In addition to these scenarios, the national control strategy, that's the whole set of abatement technological measures to be implemented in the time interval considered, need to be defined.

Other documentation on emission scenarios in Italy can be found in Vialetto et al. (2005), Zanini et al. (2005).

Emission projections at 2010 for the pollutants regulated by the National Emission Ceilings (NEC) Directive (2001/81/EC) are reported in Table 5.1.

Moreover in Table 5.2, the national emission ceilings for Italy established by the D.Lgs. 171/2004 according to Annex I of the NEC directive are reported.

NFR codes	NO_X	SO_X	NH_3	NMVOC
		kt		
1A1a: Public electricity and heat	82.85	43.24	1.50	21.62
1A1b,c: Other energy industries	25.50	47.13	0.09	0.80
1A2: Manufacturing industries & construction	117.51	42.88	0.40	32.06
1A3a: Civil aviation (LTO)	6.27	0.70		0.88
1A3b: Road transportation	447.60	0.70	11.00	191.84
1A3c: Railways	4.94			0.75
1A3d: Navigation	97.42	41.89	0.04	8.76
1A4a,b,c i: Commercial/Residential/Agriculture stationary	87.70	12.46	1.7	74.94
1A4b ii: Household and gardening (mobile)	0.01			1.91
1A4c ii: Off-road vehicles and other machinery	62.39	0.05	0.03	16.24
1A5b: Other, mobile (including military)	18.05	0.01	0.03	7.90
1B1b: Solid fuel transformation		2.03		
1B2a: Oil	8.86	29.89		39.65
1B2b: Natural gas				29.40
1B2c: Flaring in oil and gas extraction	0.32	8.88		
2B: Chemical industry	0.55	1.45	0.15	3.24
2C: Metal industry		7.74		20.41
2D: Other production		0.27		27.82
3A: Paint application				178.45
3B: Degreasing and dry cleaning				12.16
3C: Chemical products, manufacturing and processing				53.88
3D: Other				178.50
4B1: Cattle			192.07	
4B3-7 & 13: Other			26.86	
4B8: Swine			48.11	
4B9: Poultry			41.66	
4D1: Direct soil emissions			77.90	
4F: Field burning of agricultural waste	1.68	0.74		4.18
6A: Solid waste disposal on land				11.12
6C: Waste incineration	0.59	0.26		
7: Other	7.60	28.79	1.17	
Total	**969.84**	**269.11**	**408.65**	**916.51**

Table 5.1 Emission projections for the year 2010

NO_X	SO_X	NH_3	NMVOC
	kt		
990	475	419	1159

Table 5.2 National emission ceilings for Italy

The latest projections show that the 2010 emissions ceilings will be reached for all the pollutants. An accurate comparative analysis of the possible further measure, in terms of cost/efficacy, has been carried out sector by sector. In particular, studies showed that a significant margin of reduction can

be obtained in the following sectors:

- *industrial sector*. Adoption of best available technologies in the old large plants according to authorisation (environmental permit), as required in 2007 by Annex I of Directive 96/61/EC concerning integrated pollution prevention and control (IPCC).
- *transport sector*. Implementation of technical measures according to Directives on additional measures on light and heavy duty vehicles and non-technical measures, such as rationalization and promotion of public transport for the general population and goods.
- *tertiary industrial and residential sector*. Measures to increase the usage of more efficient household heating plants and appliances and the energy efficiency of buildings; adoption of innovative technologies, usage of low pollution fuels and energy renewable sources.

Results of the studies are reported on the website of the Ministry for the Environment, Land and Sea http://www.minambiente.it/.

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Annex: NFR codes

1 A 1 a	Public Electricity and Heat Production
1 A 1 b	Petroleum refining
1 A 1 c	Manufacture of Solid Fuels and Other Energy Industries
1 A 2 a	Manufacturing industries and construction (stationary combustion): Iron and Steel
1 A 2 b	Manufacturing industries and construction (stationary combustion): Non-ferrous Metals
1 A 2 c	Manufacturing industries and construction (stationary combustion): Chemicals
1 A 2 d	Manufacturing industries and construction (stationary combustion): Pulp, Paper and Print
1 A 2 e	Manufacturing industries and construction (stationary combustion): Food Processing, Beverages and Tobacco
1 A 2 f i	Manufacturing industries and construction (stationary combustion): Other industries
1 A 2 f ii	Mobile Combustion in Manufacturing Industries and Construction
1 A 3 a ii (i)	Civil Aviation (Domestic, LTO)
1 A 3 a i (i)	Civil Aviation (International, LTO)
1 A 3 b i	Road Transport, Passenger cars
1 A 3 b ii	Road Transport, Light duty vehicles
1 A 3 b iii	Road Transport, Heavy duty vehicles
1 A 3 b iv	Road Transport, Mopeds & Motorcycles
1 A 3 b v	Road Transport, Gasoline evaporation
1 A 3 b vi	Road Transport, Automobile tyre and brake wear
1 A 3 b vii	Road Transport, Automobile road abrasion
1 A 3 c	Railways
1 A 3 d i (ii)	International inland waterways
1 A 3 d ii	National Navigation
1 A 3 e	Pipeline compressors
1 A 4 a i	Commercial / Institutional: Stationary
1 A 4 a ii	Commercial / Institutional: Mobile
1 A 4 b i	Residential: Stationary plants
1 A 4 b ii	Residential: Household and gardening (mobile)
1 A 4 c i	Agriculture/ Forestry / Fishing: Stationary
1 A 4 c ii	Agriculture/ Forestry / Fishing: Off-road Vehicles and Other Machinery
1A 4 c iii	Agriculture/ Forestry / Fishing: National Fishing
1 A 5 a	Other, Stationary (including Military)
1 A 5 b	Other, Mobile (Including military)
1 B 1 a	Fugitive emission from Solid Fuels: Coal Mining and Handling
1 B 1 b	Fugitive emission from Solid Fuels: Solid fuel transformation
1 B 1 c	Other fugitive emission from Solid Fuels
1 B 2 a i	Exploration Production, Transport
1 B 2 a iv	Refining / Storage
1 B 2 a v	Distribution of oil products
1 B 2 a vi	Geothermal energy extraction
1 B 2 b	Natural gas
1 B 2 c	Venting and flaring
2 A 1	Cement Production
2 A 2	Lime Production
2 A 3	Limestone and Dolomite Use
2 A 4	Soda Ash Production and use
2 A 5	Asphalt Roofing
2 A 6	Road Paving with Asphalt
2 A 7 a	Quarrying and mining of minerals other than coal

2 A 7 b	Construction and demolition
2 A 7 c	Storage, handling and transport of mineral products
2 A 7 d	Other Mineral products
2 B 1	Ammonia Production
2 B 2	Nitric Acid Production
2 B 3	Adipic Acid Production
2 B 4	Carbide Production
2 B 5	Other chemical industry
2 C 1	Iron and steel Production
2 C 2	Ferroalloys Production
2 C 3	Aluminium Production
2 C 5 a	Copper Production
2 C 5 b	Lead Production
2 C 5 c	Nickel Production
2 C 5 d	Zinc Production
2 C 5 e	Other metal production
2 C 5 f	Storage, handling and transport of metal products
2 D 1	Pulp and Paper
2 D 2	Food and Drink
2 D 3	Wood processing
2 E	Production of POPs
2 F	Consumption of POPs and Heavy Metals (e.g. electrical and scientific equipment)
2 G	Other production, consumption, storage, transportation or handling of bulk products
3 A 1	Decorative coating application
3 A 2	Industrial coating application
3 A 3	Other coating application
3 B 1	Degreasing
3 B 2	Dry cleaning
3 C	Chemical products
3 D 1	Printing
3 D 2	Domestic solvent use including fungicides
3 D 3	Other product use
4 B 1 a	Cattle Dairy
4 B 1 b	Cattle Non-Dairy
4 B 2	Buffalo
4 B 3	Sheep
4 B 4	Goats
4 B 6	Horses
4 B 7	Mules and Asses
4 B 8	Swine
4 B 9 a	Laying Hens
4 B 9 b	Broilers
4 B 9 c	Turkeys
4 B 9 d	Other Poultry
4 B 13	Other (rabbits and animal furs)
4 D 1	Synthetic N-fertilizers
4 D 2 a	Farm-level agricultural operations including storage, handling and transport of agricultural products
4 D 2 b	Off-farm storage, handling and transport of bulk agricultural products
4 D 2 c	N-excretion on pasture range and paddock
4 F	Field burning of agricultural wastes
4 G	Agriculture Other
6 A	Solid waste disposal on land
6 B	Waste-water handling

6 C a	Clinical Waste Incineration
6 C b	Industrial Waste Incineration
6 C c	Municipal Waste Incineration
6 C d	Cremation
6 C e	Small Scale Waste Burning
6 D	Other waste