Italian Greenhouse Gas Inventory
1990-2004

National Inventory Report 2006

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Daniela Romano, Rocío Cóndor G., Mario Contaldi, Riccardo De Lauretis,
Eleonora Di Cristofaro, Domenico Gaudioso, Barbara Gonella, Marina Vitullo

APAT - Agency for the Protection of the Environment and for Technical Services

Annual Report for submission under the UN Framework Convention on Climate Change and the European Union's Greenhouse Gas Monitoring Mechanism

Authors

Rocío Cóndor G. (agriculture), Mario Contaldi (energy), Riccardo De Lauretis (energy, industrial processes), Eleonora Di Cristofaro (solvent and other product use), Domenico Gaudioso (industrial processes, waste), Barbara Gonella (industrial processes, waste), Daniela Romano (general coordination and editing, cross cutting issues), Marina Vitullo (land use, land use change and forestry)

Contact: Riccardo De Lauretis
telephone +39 0650072543
fax +39 0650072657
e-mail delauretis@apat.it

APAT- Agency for the Protection of the Environment and for Technical Services
Climate Change and Sustainable Development Division
Air Emission Inventory Unit
Via V. Brancati, 48
00144 Rome
ITALY

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Executive Summary

ES.1. Background information on greenhouse gas inventories and climate change

The United Nations Framework Convention on Climate Change (FCCC) was ratified by Italy in the year 1994 through law no.65 of 15/01/1994. As a Party to the Convention, Italy is committed to develop, publish and regularly update national emission inventories of greenhouse gases (GHGs) as well as formulate and implement programmes addressing anthropogenic GHG emissions.

The Kyoto Protocol, adopted in December 1997, has established emission reduction objectives for Annex B Parties (i.e. industrialised countries and countries with economy in transition): in particular, the European Union as a whole is committed to an 8% reduction within the period 2008-2012, in comparison with base year levels. For Italy, the EU burden sharing agreement, set out in Annex II to Decision 2002/358/EC and in accordance with Article 4 of the Kyoto Protocol, has established a reduction objective of 6.5% in the commitment period, in comparison with 1990 levels.

Subsequently, on 1st June 2002, Italy ratified the Kyoto Protocol with law no.120 of 01/06/2002. The ratification law prescribed also the preparation of a National Action Plan to reduce greenhouse gas emissions, which was adopted by the Interministerial Committee for Economic Planning (CIPE) on 19th December 2002 (deliberation n. 123 of 19/12/2002).

The Kyoto Protocol finally entered into force in February 2005.

In order to establish compliance with national and international commitments, the national GHG emission inventory is compiled and communicated annually by the Agency for the Protection of the Environment and for Technical Services (APAT), after endorsement by the Ministry for the Environment and Territory, to the competent institutions. The submission is carried out through compilation of the Common Reporting Format (CRF), according to the guidelines provided by the United Nations Framework Convention on Climate Change and the European Union's Greenhouse Gas Monitoring Mechanism. Totally, an annual GHG inventory submission shall consist of a national inventory report (NIR) and the common reporting format (CRF) tables as specified in the Guidelines on reporting and review of greenhouse gas inventories from Parties included in Annex 1 to the Convention, implementing decisions 3/CP.5 and 6/CP.5, doc.FCCC/SBSTA/2002/L.5/Add.1.

Detailed information on emission figures and estimation procedures, including all the basic data needed to carry out the final estimates, are to be 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 use of the best information available. Adjustments are applied retrospectively to earlier years, which accounts for any difference in previously published data.

This report is compiled according to the guidelines on reporting as specified in the document FCCC/SBSTA/2002/L.5. It provides an analysis of the Italian GHG emission inventory communicated to the Secretariat of the Climate Change Convention and to the European Commission in the framework of the Greenhouse Gas Monitoring Mechanism in the year 2006, including the update for the year 2004 and the revision of the entire time series 1990-2003.

Emission estimates comprise the six direct greenhouse gases under the Kyoto Protocol (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride) which contribute directly to climate change owing to their positive radiative forcing effect and four indirect greenhouse gases (nitrogen oxides, carbon monoxide, non-methane volatile organic compounds, sulphur dioxide).

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

ES.2. Summary of national emission and removal related trends

Total greenhouse gas emissions, in CO_2 equivalent, excluding emissions and removals of CO_2 from land use change, increased by 12.2% between 1990 and 2004 (from 520 to 583 million CO_2 equivalent tons), while the national Kyoto target is a reduction of 6.5% as compared the base year levels by the period 2008-2012.

The most important greenhouse gas, CO_2, which accounted for 83.9% of total emissions in CO_2 equivalent in 2004, showed an increase by 12.7% between 1990 and 2004. In the energy sector, specifically, emissions in 2004 were 13.6% greater than in 1990.

CH_4 and N_2O emissions were equal to 7.2% and 7.7%, respectively, of the total CO_2 equivalent greenhouse gas emissions in 2004. CH_4 emissions showed a small increase by 0.5% from 1990 to 2004, while N_2O increased by 9.8 %.

Other greenhouse gases, HFCs, PFCs and SF_6, ranged from 0.3% to 1% of total emissions; at present, variations in these gases are not relevant to reaching the objectives for emissions reduction.

Table ES.1 illustrates the national trend of greenhouse gases for 1990-2004, expressed in CO_2 equivalent terms, by substance and category.

	1990 base year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
GHG EMISSIONS	**CO_2 equivalent (Gg)**														
Net CO_2 emissions/removals	354,575	332,699	336,213	344,814	322,180	342,067	332,713	343,636	357,773	355,252	363,283	358,845	356,452	374,713	383,670
CO_2 emissions (without LUCF)	434,489	433,955	433,610	427,416	420,397	445,384	438,843	443,056	454,031	459,051	463,311	469,062	470,821	486,126	489,590
CH_4	41,665	42,864	42,251	42,637	43,229	44,103	44,224	44,713	44,819	44,912	45,099	44,368	42,870	42,575	41,858
N_2O	41,147	42,061	41,262	41,698	40,549	41,503	41,158	42,378	42,350	43,434	43,673	43,911	43,413	43,222	45,177
HFCs	351	355	359	355	482	671	450	755	1,181	1,452	2,005	2,761	3,568	4,590	5,699
PFCs	1,808	1,452	850	707	477	491	243	252	270	258	346	452	414	484	407
SF_6	333	356	358	370	416	601	683	729	605	405	493	795	738	486	602
Total (with net CO_2 emissions/removals)	439,879	419,788	421,292	430,582	407,332	429,436	419,470	432,464	446,998	445,711	454,899	451,133	447,455	466,070	477,413
Total (without CO_2 from LUCF)	519,793	521,044	518,690	513,184	505,550	532,753	525,600	531,884	543,257	549,511	554,927	561,350	561,825	577,482	583,333

	1990 base year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
GHG SOURCE AND SINK	**CO_2 equivalent (Gg)**														
1. Energy	422,600	422,491	421,557	418,047	411,635	435,280	431,177	435,368	446,497	451,986	455,539	460,373	462,401	477,127	479,955
2. Industrial Processes	36,544	36,165	35,572	32,736	31,399	34,590	31,556	32,032	32,489	32,817	34,979	37,206	37,460	38,955	41,982
3. Solvent and Other Product Use	2,394	2,338	2,338	2,295	2,217	2,182	2,284	2,284	2,371	2,354	2,297	2,221	2,230	2,179	2,124
4. Agriculture	41,177	41,963	41,420	41,712	41,193	40,888	40,662	41,767	41,069	41,488	40,457	39,972	38,775	38,636	38,362
5. Land-Use Change and Forestry	-79,722	-101,215	-97,331	-82,397	-98,050	-103,206	-106,104	-99,318	-96,004	-103,525	-99,711	-110,156	-114,335	-111,341	-105,107
6. Waste	16,884	18,047	17,736	18,189	18,938	19,703	19,896	20,331	20,577	20,591	21,338	21,517	20,924	20,514	20,096
7. Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table ES.1. Total greenhouse gas emissions and removals in CO_2 equivalent

ES.3. Overview of source and sink category emission estimates and trends

Table ES.2 provides an overview of the CO_2 equivalent emission trends by IPCC source category.

Source category	1990 base year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO_2 equivalent (Gg)														
1A. Energy: fuel combustion	412,158	412,156	411,246	407,688	401,631	425,605	421,756	425,791	436,952	443,318	446,797	452,076	454,540	468,764	472,447
CO_2: 1. Energy Industries	134,092	128,410	128,309	122,892	125,531	137,973	133,477	135,233	145,629	141,709	147,775	150,930	157,781	158,592	160,903
CO_2: 2. Manufacturing Industries and Construction	88,937	85,985	84,303	84,766	85,541	87,823	85,608	88,673	82,778	86,493	87,889	85,138	81,109	86,005	85,351
CO_2: 3. Transport	101,461	104,331	108,652	110,378	110,205	112,005	113,173	114,898	118,710	119,966	120,431	122,772	124,886	126,035	128,008
CO_2: 4. Other Sectors	76,548	82,112	78,674	78,329	69,168	75,928	77,774	75,099	78,055	82,620	78,471	81,252	78,464	85,018	84,109
CO_2: 5. Other	1,041	1,192	1,276	1,443	1,455	1,436	1,178	1,222	1,036	1,107	806	354	314	660	1,091
CH_4	1,548	1,619	1,683	1,684	1,732	1,820	1,822	1,856	1,722	1,789	1,683	1,582	1,560	1,621	1,794
N_2O	8,531	8,507	8,349	8,197	7,999	8,620	8,724	8,809	9,022	9,635	9,742	10,047	10,426	10,832	11,190
1B2. Energy: fugitives from oil & gas	10,443	10,335	10,311	10,359	10,004	9,675	9,421	9,576	9,545	8,668	8,742	8,298	7,861	8,363	7,508
CO_2	3,048	2,990	2,926	3,084	2,913	2,843	2,692	2,875	2,768	2,091	2,298	2,183	1,924	2,497	1,822
CH_4	7,395	7,345	7,385	7,275	7,091	6,832	6,728	6,702	6,776	6,577	6,444	6,115	5,937	5,866	5,687
2. Industrial processes	36,544	36,165	35,572	32,736	31,399	34,590	31,556	32,032	32,489	32,817	34,979	37,206	37,460	38,955	41,982
CO_2	27,268	26,827	27,360	24,488	23,607	25,474	23,092	23,165	23,219	23,336	24,153	24,906	24,782	25,780	26,770
CH_4	108	104	101	102	106	113	63	68	65	64	63	59	57	58	61
N_2O	6,676	7,071	6,544	6,712	6,311	7,239	7,025	7,063	7,148	7,303	7,918	8,232	7,902	7,557	8,443
HFCs	351	355	359	355	482	671	450	755	1,181	1,452	2,005	2,761	3,568	4,590	5,699
PFCs	1,808	1,452	850	707	477	491	243	252	270	258	346	452	414	484	407
SF_6	333	356	358	370	416	601	683	729	605	405	493	795	738	486	602
3. Solvent and other product use	2,394	2,338	2,338	2,295	2,217	2,182	2,284	2,284	2,371	2,354	2,297	2,221	2,230	2,179	2,124
CO_2	1,598	1,588	1,590	1,537	1,470	1,426	1,384	1,383	1,332	1,337	1,287	1,305	1,316	1,322	1,325
N_2O	796	750	748	758	747	756	901	901	1,039	1,017	1,011	915	913	857	799
4. Agriculture	41,177	41,963	41,420	41,712	41,193	40,888	40,662	41,767	41,069	41,488	40,457	39,972	38,775	38,636	38,362
CH_4: Enteric fermentation	12,178	12,448	12,070	11,943	12,050	12,266	12,322	12,376	12,291	12,428	12,165	11,666	11,029	11,055	10,831
CH_4: Manure management	3,462	3,468	3,335	3,327	3,252	3,327	3,333	3,316	3,346	3,381	3,303	3,380	3,320	3,318	3,235
CH_4: Rice Cultivation	1,562	1,493	1,551	1,627	1,664	1,657	1,652	1,676	1,622	1,616	1,375	1,382	1,420	1,462	1,527
CH_4: Field Burning of Agricultural Residues	13	14	14	13	13	13	13	12	14	13	12	11	13	11	14
N_2O: Manure management	4,518	4,495	4,299	4,255	4,215	4,277	4,318	4,375	4,442	4,498	4,361	4,560	4,302	4,272	4,125
N_2O: Agriculture soils	19,441	20,041	20,147	20,543	19,994	19,345	19,019	20,009	19,351	19,548	19,238	18,969	18,687	18,514	18,626
N_2O: Field Burning of Agricultural Residues	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5A. Land-use change and forestry	-79,722	-101,215	-97,331	-82,397	-98,050	-103,206	-106,104	-99,318	-96,004	-103,525	-99,711	-110,156	-114,335	-111,341	-105,107
CO_2	-79,914	-101,255	-97,397	-82,603	-98,217	-103,317	-106,130	-99,420	-96,259	-103,799	-100,028	-110,217	-114,369	-111,413	-105,920
CH_4	143	37	60	151	61	27	22	74	86	42	87	55	31	65	35
N_2O	49	4	6	55	106	83	3	28	169	232	230	6	3	7	779
6. Waste	16,884	18,047	17,736	18,189	18,938	19,703	19,896	20,331	20,577	20,591	21,338	21,517	20,924	20,514	20,096
CO_2	496	521	520	500	507	475	464	508	504	393	202	222	245	216	211
CH_4	15,256	16,336	16,051	16,515	17,260	18,048	18,268	18,633	18,897	19,001	19,968	20,118	19,503	19,118	18,675
N_2O	1,131	1,190	1,165	1,173	1,172	1,180	1,164	1,191	1,175	1,197	1,169	1,177	1,176	1,179	1,211
TOTAL EMISSIONS	519,793	521,044	518,690	513,184	505,550	532,753	525,600	531,884	543,257	549,511	554,927	561,350	561,825	577,482	583,333

Table ES.2. Summary of emission trends by source category and gas in CO_2 equivalent (Gg)

The energy sector is the largest contributor to national total GHG emissions with a share, in 2004, of 82% out of total GHG emissions from this sector increased by about 13.6% from 1990 to 2004. Substances with the highest increase rates are CO_2, whose levels increased by 14% from 1990 to 2004 and accounts for 96.1% of the total in the energy sector, and N_2O which shows an increase of 31% but its share out of the total is only 2.2%; CH_4, on the other hand, shows a decrease of 16% from 1990 to 2004 but it is not relevant on total emissions, accounting only for 1.6%. Specifically, in terms of total CO_2 equivalent, the most significant increase is observed in the transport and energy industries sectors, about 26.2% and 20% from 1990 to 2004, respectively; these sectors, altogether, account for 59% of total energy emissions.

For the industrial processes sector, emissions show a total increase of 15% from the base year to 2004. Specifically, by substance, CH_4 decreased by 44%, but it accounts only for 0.1%, while N_2O, whose levels share 20% of total industrial emissions, raised up to 26%. A considerable increase is observed in F-gas emissions (about 169%), which level on total emissions is 16%.

In contrast, emissions from the solvent and other use sector, which refer to CO_2 and N_2O emissions except for gases other than greenhouse, decreased by 11% from 1990 to 2004. The reduction is mainly to be attributed to a decrease by 17% in CO_2 emissions, which account for 62% of the sector. The most significant reduction affected both the paint application sector (-18%), which accounts for 52%, and other use of solvents in related activities (-24%), such as domestic solvent use other than painting, printing industries, vehicle dewaxing, which account for 42%. Emissions from metal decreasing and dry cleaning activities, also decreased (-57%) but account for only 6%.
The level of N_2O emissions, on the other hand, didn't show a significant variation from 1990 to 2004.

For agriculture, emissions refer to CH_4 and N_2O levels, which account, in 2004, for 41% and 59% of the sector, respectively. The decrease observed in the total emissions (-7%) is mostly due to the decrease of CH_4 emissions from enteric fermentation (-11%), which account for 28%, and to a minor decrease from manure management (-8%), which account for most of the sectoral emissions.

Finally, emissions from the waste sector increased by 19% from 1990 to 2004 due to the increase in the emissions from solid waste disposal (22%), which account for 80% of waste emissions.
The most important greenhouse gas in this sector is CH_4 which accounts for 93% of the sectoral emissions and shows an increase of 22% from 1990 to 2004. N_2O levels increased by 7%, whereas CO_2 decreased by 58%; these gases account for 6% and 1%, respectively.

ES.4. Other information

In Table ES.3 NO_X, CO, NMVOC and SO_2 emission trends from 1990 to 2004 are summarised.
All gases show a significant reduction in 2004 as compared to 1990 levels. The highest reduction is observed for SO_2 (-72%), while CO and NO_X emissions reduced by about 40% and NMVOC levels showed a decrease by 36%.

Indirect greenhouse gases and SO_2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Emissions in ktons															
NO_X	1,943	2,001	2,020	1,921	1,841	1,808	1,732	1,654	1,554	1,453	1,373	1,352	1,258	1,245	1,173
CO	7,183	7,477	7,677	7,623	7,402	7,166	6,867	6,607	6,197	5,897	5,164	5,086	4,468	4,381	4,207
NMVOC	1,986	2,048	2,129	2,097	2,033	2,004	1,952	1,884	1,779	1,688	1,506	1,432	1,335	1,299	1,263
SO_2	1,795	1,677	1,578	1,478	1,388	1,320	1,210	1,134	997	900	755	705	625	528	496

Table ES.3. Total emissions of indirect greenhouse gases and SO_2 (1990-2004)

Sommario (*Italian*)

Nel documento "Italian Greenhouse Gas Inventory 1990-2004. National Inventory Report 2006" si descrive la comunicazione annuale italiana dell'inventario delle emissioni dei gas serra in accordo a quanto previsto nell'ambito della Convenzione Quadro sui Cambiamenti Climatici delle Nazioni Unite (UNFCC) e del Meccanismo di Monitoraggio dei Gas Serra dell'Unione Europea.

Ogni Paese che partecipa alla Convenzione, infatti, oltre a fornire annualmente l'inventario nazionale delle emissioni dei gas serra secondo i formati richiesti, deve documentare in un *report*, il *National Inventory Report*, la serie storica delle emissioni. La documentazione prevede una spiegazione degli andamenti osservati, una descrizione dell'analisi delle sorgenti chiave, *key sources*, e dell'incertezza ad esse associata, un riferimento alle metodologie di stima e alle fonti dei dati di base e dei fattori di emissione utilizzati per le stime, un'illustrazione del sistema di *Quality Assurance/Quality Control* a cui è soggetto l'inventario e delle attività di verifica effettuate sui dati.

Il *National Inventory Report* facilita, inoltre, i processi internazionali di verifica a cui le stime di emissione dei gas serra sono sottoposte al fine di esaminarne la rispondenza alle proprietà di trasparenza, consistenza, comparabilità, completezza e accuratezza nella realizzazione, qualità richieste esplicitamente dalla Convenzione suddetta. Nel caso in cui, durante il processo di *review*, siano identificati eventuali errori nel formato di trasmissione o stime non supportate da adeguata documentazione e giustificazione nella metodologia scelta, il Paese viene invitato ad una revisione delle stime di emissione.

I dati di emissione dei gas-serra, così come i risultati dei processi di *review*, sono pubblicati sul sito web del Segretariato della Convenzione sui Cambiamenti Climatici www.unfccc.int.

I dati di emissione della serie storica italiana sono disponibili sul sito web http://www.sinanet.apat.it/it/sinanet/serie_storiche_emissioni.

Da una analisi di sintesi della serie storica dei dati di emissione dal 1990 al 2004, si evidenzia che le emissioni nazionali totali dei sei gas serra, espresse in CO_2 equivalente, sono aumentate del 12% nel 2004 rispetto all'anno base (corrispondente al 1990), a fronte di un impegno nazionale di riduzione del 6.5% entro il periodo 2008-2012.

In particolare, le emissioni complessive di CO_2 sono pari all'85% del totale e risultano nel 2004 superiori del 13% rispetto al 1990, mentre le emissioni relative al solo settore energetico sono aumentate del 14%. Le emissioni di metano e di protossido di azoto sono pari rispettivamente a circa il 7% e l'8% del totale e presentano andamenti in aumento sia per il metano (0.5%) che, più rilevante (+9.8%), per il protossido di azoto. Gli altri gas serra, HFC, PFC e SF_6, hanno un peso complessivo intorno all'1% sul totale delle emissioni; le emissioni di questi ultimi gas sono in forte crescita per quanto riguarda gli HFCs ed in diminuzione per i PFC e l'SF_6. Anche se al momento non rilevanti ai fini del raggiungimento degli obiettivi di riduzione delle emissioni, il significativo *trend* di crescita li renderà sempre più importanti nei prossimi anni.

Chapter 1: INTRODUCTION

1.1 Background information on greenhouse gas inventories and climate change

In 1988 the World Meteorological Organisation (WMO) and the United Nations Environment Program (UNEP) established a scientific Intergovernmental Panel on Climate Change (IPCC) in order to evaluate the available scientific information on climate variations, examine the social and economical influence on climate change and formulate suitable strategies for the prevention and the control of climate change.

The first IPCC report in 1990, although considering the high uncertainties in the evaluation of climate change, emphasised the risk of a global warming due to an unbalance in the climate system originated by the increase of anthropogenic emissions of greenhouse gases (GHGs) caused by industrial development and use of fossil fuels. Hence the need of reducing those emissions, particularly for the most industrialised countries.

The first initiative was taken by the European Union (EU) at the end of 1990, when the EU adopted the goal of a stabilisation of carbon dioxide emissions by the year 2000 at the level of 1990 and requested Member States to plan and implement initiatives for environmental protection and energy efficiency. The contents of EU statement were the base for the negotiation of the United Nations Framework Convention on Climate Change (UNFCC) which was approved in New York on 9th May 1992 and signed during the summit of the Earth in Rio the Janeiro in June 1992. Parties to the Convention are committed to develop, publish and regularly update national emission inventories of greenhouse gases (GHGs) as well as formulate and implement programmes addressing anthropogenic GHG emissions. Specifically, Italy ratified the convention through law no.65 of 15/1/1994.

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The Kyoto Protocol finally entered into force in February 2005.

In order to establish compliance with national and international commitments air emission inventories are compiled and communicated annually to the competent institutions.

Specifically, the national GHG emission inventory is communicated through compilation of the Common Reporting Format (CRF), according to the guidelines provided by the United Nations Framework Convention on Climate Change and the European Union's Greenhouse Gas Monitoring Mechanism (IPCC, 1997; IPCC, 2000; IPCC, 2003; EMEP/CORINAIR, 2005).

Detailed information on emission figures and estimation methodologies, including all basic data needed to carry out final estimates, are requested in order to improve transparency, consistency, comparability, accuracy and completeness of the inventory provided.

The national inventory is updated annually in order to reflect revisions and improvements in methodology and availability of new information. Recalculations are applied retrospectively to earlier years, which accounts for any difference in previously published data.

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

1.2 Description of the institutional arrangement for inventory preparation

Italy is currently developing a national emission inventory system, National System, which involves and attributes specific roles and responsibilities to the different institutions which should collect and communicate basic data necessarily and timely for the GHG inventory compilation. As required by article 5.1 of the Kyoto Protocol, Annex I Parties shall have in place a National System by the end of 2006 at the latest for estimating anthropogenic greenhouse gas emissions by sources and removals by sinks and for reporting and archiving inventory information according to the guidelines specified in the UNFCC Decision 20/COP.7. In addition, the Decision of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions (280/2004/EC) requires that Member States establish a national greenhouse gas inventory system by the end of 2005 at the latest and that the Commission adopts the EC's inventory system by 30 June 2006.
The Agency for the Protection of the Environment and for Technical Services (APAT) is the technical agency responsible for the development and compilation of the National Air Emission Inventory. In particular, as National Reference Centre of the European Environment Agency (EEA), APAT develops the national atmospheric emission inventory in order to ensure compliance with international commitments concerning the protection of the environment (Framework Convention on Climate Change, Convention on Long Range Transboundary Air Pollution, European Directives on emission ceilings). Therefore the Italian greenhouse gas inventory is compiled and updated annually by the Agency and officially communicated to the Secretariat of the Framework Convention on Climate Change and to the European Commission in the framework of the Greenhouse Gas Monitoring Mechanism, after endorsement by the Ministry for the Environment and Territory.
Specifically APAT 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 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, the compilation of the inventory following the QA/QC procedures, the assessment of uncertainty, the preparation of the National Inventory Report and the reporting through the Common Reporting Format, the response to the review process, the updating and data storage.
In addition, there are different institutions responsible for statistical basic data and data publication, which are primary to APAT for carrying out emission estimates. These institutions are already part of a National Statistical System (Sistan), which provides national official statistics, and therefore are asked periodically to update statistics; moreover, the National Statistical System assures 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 by the Italian Decree No 322/89. The system is coordinated by the Italian National Institute of Statistics (ISTAT) whereas other bodies belonging to the National Statistical System are the statistical offices of ministries, national agencies, regions and autonomous provinces, provinces, municipalities, research institutes, chambers of commerce, local governmental offices, some private agencies and private subjects who have specific characteristics determined by law.

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 MAP (Ministry of Production Activities);
- Transport Statistics Yearbooks, by MINT (Ministry of Transportation);
- Annual Statistics on Electrical Energy in Italy, by GRTN (National Independent System Operator);
- Annual Report on Waste, by APAT.

The national emission inventory itself is also a Sistan product.
APAT, on behalf of the Ministry for the Environment and Territory, is establishing a robust national system building upon the Sistan, with a sound legal basis.

1.3 Brief description of the process of inventory preparation

APAT 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.
APAT 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 GHG inventory are energy statistics published by the Ministry of Production Activities (MAP) 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 IPCC Good Practice Guidance and 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 (EPER) are taken into account as a verification of emission inventory estimates for some specific categories. According to the Italian Decree of 23 November 2001, data from the Italian EPER are validated and communicated by APAT to the Ministry of the Environment and the Territory and to the European Community within October of the current year for data referring to the previous year. These data are not always directly used for the compilation of the inventory because industries communicate figures only if exceeding specific thresholds; furthermore, basic data such as fuel consumption are not supplied and production data are not split by product but given as an overall value. Anyway, EPER is a good basis for data checks and a way to facilitate contacts with industries which, in many cases, 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.
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 UNFCC Secretariat filling in the CRF files. The process takes over annually; in the year t final emissions are calculated for the year t-2: in case of methodological changes or additional information, emissions are recalculated from 1990 onwards.
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 Agency.

1.4 Brief general description of methodologies and data sources used

A detailed description of methodologies and data sources used in the preparation of the emission inventory for each sector is outlined in the relevant chapters. In Table 1.1 a summary of the activity data and sources used in the inventory compilation is reported.
Methodologies are consistent with the Revised 1996 IPCC Guidelines, IPCC Good Practice Guidance and EMEP-CORINAIR Emission Inventory Guidebook (IPCC, 1997; IPCC, 2000; IPCC, 2003; EMEP/CORINAIR, 2005); 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.

SECTOR	ACTIVITY DATA	SOURCE
1 Energy 1A1 Energy Industries	Fuel use	Energy Balance - Ministry of Production Activities Major national electricity producers
1A2 Manufacturing Industries and Construction	Fuel use	Energy Balance - Ministry of Production Activities Major National Industry Corporation
1A3 Transport	Fuel use Number of vehicles Aircraft landing and take-off cycles and maritime activities	Energy Balance - Ministry of Production Activities Statistical Yearbooks - National Statistical System Statistical Yearbooks - Ministry of Transportation
1A4 Residential-public-commercial sector	Fuel use	Energy Balance - Ministry of Production Activities
1B Fugitive Emissions from Fuel	Amount of fuel treated, stored, distributed	Energy Balance - Ministry of Production Activities Statistical Yearbooks - Ministry of Transportation Major National Industry Corporation
2 Industrial processes	Production data	National Statistical Yearbooks- National Statistics Institute International Statistical Yearbooks-UN Sectoral Industrial Associations
3 Solvent 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 Statistics Institute Sectoral Agriculture Associations
5 Land use change and forestry	Forest and soil surfaces Amount of biomass Biomass burnt Biomass growth	Statistical Yearbooks - National Statistics Institute State Forestry Corps National and Regional Forestry Inventory Universities and Research Institutes
6 Waste	Amount of waste	National Waste Cadastre - Agency for the Protection of the Environment and for Technical Services National Waste Observatory

Table 1.1 Main activity data and sources for the Italian Emission Inventory

In Table 1.2 a summary of the methods and emission factors used in the compilation of the Italian inventory is reported. A more detailed table as communicated to the European Community in the framework of the monitoring mechanism of GHG emission inventory for the purpose of Article 4(1)(b) under the Implementing Provisions (EC, 2005) is included in Annex 8.

SUMMARY 3 SUMMARY REPORT FOR METHODS AND EMISSION FACTORS USED

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6	
	Method applied (1)	Emission factor (2)	Method applied (1)	Emission factor (2)	Method applied (1)	Emission factor (2)	Method applied (1)	Emission factor (2)	Method applied (1)	Emission factor (2)	Method applied (1)	Emission factor (2)
1. Energy												
A. Fuel Combustion												
1. Energy Industries	T3	CS	T3	D	T3	D						
2. Manufacturing Industries and Construction	T2	CS	T2	D	T2	D						
3. Transport	T1, T2a, C	CS	T1, T2a, C	C, CS	T1, T2a, C	C, CS						
4. Other Sectors	T2	CS	T2	C	T2	C						
5. Other	T2	CS	T2	C	T2	C						
B. Fugitive Emissions from Fuels												
1. Solid Fuels			T1	D, C,CS								
2. Oil and Natural Gas	T2	CS	T2, T3	CS								
2. Industrial Processes												
A. Mineral Products	D, T2	CS, PS										
B. Chemical Industry	D	C, PS	D	C, PS	D	D, PS						
C. Metal Production	D	C, CS	D	C, CS					T1, T2	PS	D	PS
D. Other Production												
E. Production of Halocarbons and SF_6							CS	PS	CS	PS	CS	PS
F. Consumption of Halocarbons and SF_6							T2a, CS	D, CS, PS	CS	PS	T3c, CS	CS, PS
G. Other												
3. Solvent and Other Product Use	**C**	**C, CS**			**CS**	**CS**						
4. Agriculture												
A. Enteric Fermentation			T1, T2	D, CS								
B. Manure Management			T1, T2	D, CS	D	D, CS						
C. Rice Cultivation			T2	CS								
D. Agricultural Soils					D	D, CS						
E. Prescribed Burning of Savannas												
F. Field Burning of Agricultural Residues			D	D	D	D						
G. Other												
5. Land-Use Change and Forestry												
A. Changes in Forest and Other Woody Biomass Stocks	T1, T2	D, CS										
B. Forest and Grassland Conversion												
C. Abandonment of Managed Lands												
D. CO_2 Emissions and Removals from Soil												
E. Other	T1, T2	D, CS	T1, T2	D, CS	T1, T2	D, CS						
6. Waste												
A. Solid Waste Disposal on Land			T2	D, CS								
B. Wastewater Handling			D	D	D	D, C						
C. Waste Incineration	D	CS	D	C	D	CS						
D. Other			CS	CS								
7. Other ***(please specify)***												

(1) Use the following notation keys to specify the method applied: D (IPCC default), RA (Reference Approach), T1 (IPCC Tier 1), T1a, T1b, T1c (IPCC Tier 1a, Tier 1b and Tier 1c, respectively), T2 (IPCC Tier 2), T3 (IPCC Tier 3), C (CORINAIR), CS (Country Specific). If using more than one method, enumerate the relevant methods. Explanations of any modifications to the default IPCC methods, as well as information on the proper use of methods per source category where more than one method is indicated, and explanations on the country specific methods, should be provided in the documentation box of the relevant Sectoral background data table.
(2) Use the following notation keys to specify the emission factor used: D (IPCC default), C (CORINAIR), CS (Country Specific), PS (Plant Specific). Where a mix of emission factors has been used, use different notations in one and the same cells with further explanation in the documentation box of the relevant Sectoral background data table.

Table 1.2 Methods and emission factors used in the inventory preparation

Activity data used in emission calculations and their sources are briefly described herebelow.
In general, for the energy sector, basic statistics for estimating emissions are fuel consumption published in the Energy Balance and provided by the Ministry of Production Activities. 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 associations.
For the other sectors, i.e. industrial processes, the annual production is provided by national and international statistical yearbooks; 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 land use change and forestry, forest and soil surfaces are provided by the National Institute of Statistics and the hectares burnt by the State Forestry Corps. For waste, the main activity data are provided by the Agency for the Protection of the Environment and for Technical Services 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 Agency for the Protection of the Environment and for Technical Services. 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 review process or the new year inventory compilation.
Technical reports and emission figures are publicly accessible by website http://www.sinanet.apat.it/it/sinanet/serie_storiche_emissioni.

1.5 Brief description of key categories

A key category analysis has been carried out according to the Tier 1 and Tier 2 methods described in the IPCC Good Practice Guidance with and without emissions and removals from the LULUCF sector (IPCC, 2000; IPCC, 2003). A key category is defined as an emission category that has a significant influence on a country's GHG inventory in terms of the absolute level and trend in emissions and removals, or both. 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 proposed in the Good Practice Guidance; other categories have been added to reflect specific national circumstances. Both level and trend analysis has been applied.
Applying the category analysis without considering emissions from the LULUCF sector, 29 key categories were totally individuated, both at level and trend. Results are reported in Table 1.3.

Key categories (excluding the LULUCF sector)	
CO2 stationary combustion liquid fuels	L, T
CO2 stationary combustion solid fuels	L, T2
CO2 stationary combustion gaseous fuels	L, T
CO2 Mobile combustion: Road Vehicles	L, T
CO2 Cement production	L, T2
CH4 Enteric Fermentation in Domestic Livestock	L, T
CH4 from Solid waste Disposal Sites	L, T
Direct N2O Agricultural Soils	L, T
N2O Adipic Acid	L, T
Indirect N2O from Nitrogen used in agriculture	L, T
N2O stationary combustion	L, T2
HFC, PFC substitutes for ODS	L, T
CO2 Mobile combustion: Waterborne Navigation	L1
CH4 Fugitive emissions from Oil and Gas Operations	L, T
N2O Manure Management	L, T
CH4 Manure Management	L, T2
N2O Mobile combustion: Road Vehicles	L, T
CO2 Mobile combustion: Aircraft	T1
CO2 Fugitive emissions from Oil and Gas Operations	L2, T
N2O from animal production	L2, T2
CH4 Emissions from Wastewater Handling	L2, T2
CO2 Emissions from solvent use	L2, T2
N2O Emissions from solvent use	T2
CH4 stationary combustion	L2
CO2 Iron and steel production	T1
CO2 Ammonia production	T1
PFC Aluminium production	T1
CO2 Lime production	L1
N2O Emissions from Wastewater Handling	T2

L1 = level key category by Tier 1
T1 = trend key category by Tier 1
L2 = level key category by Tier 2
T2 = trend key category by Tier 2
L = level key category by Tier 1 and Tier 2
T = trend key category by Tier 1 and Tier 2

Table 1.3 Key categories by the IPCC Tier 1 and Tier 2 approaches (L=Level, T=Trend)

If considering emissions from the LULUCF, 28 key categories were individuated. There are no additional categories as compared to the previous analysis expect for those referring to LULUCF.

Key categories (including the LULUCF sector)	
CO_2 Forest land	L, T
CO_2 Cropland	L, T
CO_2 Land converted to Forest Land	L, T
CO_2 Land converted to Settlements	T2
CO_2 Land converted to Cropland	L, T
CO_2 stationary combustion liquid fuels	L, T
CO_2 stationary combustion solid fuels	L, T
CO_2 stationary combustion gaseous fuels	L, T
CO_2 Mobile combustion: Road Vehicles	L, T
CO_2 Cement production	L, T
CH_4 Enteric Fermentation in Domestic Livestock	L, T
CH_4 from Solid waste Disposal Sites	L, T2
Direct N_2O Agricultural Soils	L, T
N_2O Adipic Acid	L1, T1
Indirect N_2O from Nitrogen used in agriculture	L, T
N_2O stationary combustion	L
HFC, PFC substitutes for ODS	L, T
CO_2 Mobile combustion: Waterborne Navigation	L1
CH_4 Fugitive emissions from Oil and Gas Operations	L, T
N_2O Manure Management	L, T
CH_4 Manure Management	L2, T2
N_2O Mobile combustion: Road Vehicles	L, T
CO_2 Fugitive emissions from Oil and Gas Operations	T1
N_2O from animal production	L2
CH_4 Emissions from Wastewater Handling	L2, T2
CO_2 Iron and steel production	T1
CO_2 Ammonia production	T1
PFC Aluminium production	T1

L1 = level key category by Tier 1
T1 = trend key category by Tier 1
L2 = level key category by Tier 2
T2 = trend key category by Tier 2
L = level key category by Tier 1 and Tier 2
T = trend key category by Tier 1 and Tier 2

Table 1.4 Key categories by the IPCC Tier 1 and Tier 2 approaches (L=Level, T=Trend)

It should be noted that higher tiers are mostly used for calculating emissions from these categories as requested by the Good Practice Guidance (IPCC, 2000).

1.6 Information on the QA/QC plan including verification and treatment of confidentiality issues where relevant

A specific QA/QC system is being developed in the framework of the establishment of the National System, but a QA/QC plan has been already drafted (APAT, 2005; APAT, 2006). Specific QA/QC techniques and different verification procedures are applied thoroughly the inventory compilation and as part of the estimation process.

The Italian Atmospheric Emission Inventory and the Italian Greenhouse Gas Inventory are compiled and maintained by the Agency for the Protection of the Environment and for Technical Services which is the technical Agency responsible for data submission. The whole inventory is compiled by the agency; scientific and technical institutions and consultants may help in improving information both on activity data and emission factors of some specific activities. All the measures to guarantee and improve the transparency, consistency, comparability, accuracy and completeness of the inventory are undertaken.

The quality of the inventory has improved over the years and further investigations are planned for all those sectors relevant in terms of contribution to total CO_2 equivalent emissions and with a high uncertainty.
Future planned improvements are also part of the QA/QC plan and are prepared, for each sector, by the relevant inventory compiler (APAT, 2006). Each expert individuates area for sectoral improvement based on his own knowledge and in response to inventory UNFCCC review and other kind of processes.
In addition to *routine* control activities related to completeness, consistency in the time series and correctness in the sum of sub-categories, specific quality control activities regard the check of figures and documentation for categories where methodological and data changes result in recalculations. Special attention is also paid to sources which show significant changes from a year to another or new sources.
All the information used for the inventory compilation is traceable back to its source. 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. Particular attention is paid to the archiving and storing of all inventory data, supporting information, inventory records as well as all the reference documents. To this end, a major improvement which increases the transparency of the inventory is the 'documentation catalogue'. This database consists of a number of excel files that references all documentation used in the inventory compilation, for each sector, the link to electronically available documents and the place where they are stored. After each reporting cycle, all database files, spreadsheets and electronic documents are archived as 'read-only' mode.
All information and documentation are stored at the Agency and can be consulted whenever needed.

Quality assurance procedures regard some verification activities of the inventory as a whole and at sectoral level. Drawbacks derive, in particular, from the communication of data to different institutions and/or at local level. 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 Yearbook published by the Agency; they are also published by the Ministry of Environment in the Report on the State of the Environment and communicated to the National Institute of Statistics to be published in their Environmental Statistics Yearbooks and used in the framework of the EUROSTAT NAMEA Project.
Comparisons of national activity data with data from international databases are usually carried out in order to find out the main differences and an explanation to them. Such a comparison has mainly regarded data for the agriculture and industrial processes sectors. The results are reported in the specific chapters. Additional comparisons of emission estimates from industrial sectors with 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.
In order to verify of the effectiveness of policies and measures undertaken by Italy to reduce greenhouse gas emissions to the levels established by the Kyoto Protocol, a study was carried out by Ecofys. In this framework an independent review and checks on emission levels were carried out as well as controls on the transparency and consistency of methodological approaches (Ecofys, 2001).
The quality of the inventory has also improved by the organization and participation in sector specific workshops. Follow-up processes are also set up in the framework of the WGI under the EC Monitoring Mechanism, which address to the improvement of different inventory sectors. Specifically last year, two workshops were held, one related to the management of uncertainty in national inventories and problems on the application of higher methodologies to calculate uncertainty figures, the other on how to use data from the EU emissions trading scheme in the national greenhouse gas inventories. Previous workshops addressed to improve methodologies to

estimate emissions from the waste sector as well as from international bunkers. Regarding this last point, national methodologies used to estimate emissions from aviation and marine bunkers were explained by various European countries in order to raise the most common problem which is the split of fuel into domestic and international; the International Energy Agency and EUROCONTROL also attended the workshop. For the waste sector, methodologies to estimate emissions and projections from different countries were discussed; the European Topic Center on Resource and Waste Management was also involved in the workshop and documentation is available on the website at the ETC/ACC web site: http://air-climate.eionet.eu.int/meetings/past_html.
International reviews also contribute to improve the inventory and identify areas where further studies are needed. Specifically, the Italian GHG inventory was subjected to an in-country review by the UNFCC Secretariat in September 2005, which results and recommendations are available at http://unfccc.int/resource/docs/2005/arr/ita.pdf (UNFCCC, 2005).
In response to the review process, as a general improvement, notation keys have been revised throughout the CRF tables, emission trends have been explained referring to the main drivers and including the LULUCF sector, key category analysis has been carried out also adding the LULUCF categories.
A specific procedure undertaken for improving the inventory regards the establishment of national expert panels (specifically, in road transport, land use change and forestry and energy production sectors) which involve, on a voluntary basis, different institutions, local agencies and industrial associations which cooperate for improving activity data and emission factors accuracy.
In addition to these expert panels, APAT participates in technical working groups within the National Statistical System (Sistan). These groups, namely *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.

Specific activities relating to improvements of the inventory and QA/QC carried out in the last years were:

- *Energy – Industrial processes Sectors Review*. An overall revision has concerned the iron and steel emissions coming both from the combustion itself and the production process. A full carbon balance has been calculated and CO_2 emissions have been properly allocated between the relevant subsectors.
- *Waste Sector Emissions Review.* A revision of emissions from solid waste disposal on land, specifically of the methodology to estimate the methane generation potential, has been carried out to fully implement the GPG and overcoming the underestimation of CH_4 emissions.
- *Agriculture sector*. CH_4 and N_2O emissions have been revised taking into consideration the results from the MeditAIRaneo project.
- *Solvent and Other Product Use*. Emissions were revised on account of new information made available from the Italian manufacturers and the Italian Association of Aerosol Producers as well as other relevant associations.
- *Energy Balance Verification.* The task force of energy and inventory experts (Ministry of Production Activities, ENEA and APAT) established to examine differences in basic data between the CRF and the joint EUROSTAT/IEA/UNECE questionnaire submissions and to improve the details of the National Energy Balance finalised its study and reported the results in the document “Energy data harmonization for CO_2 emission calculations: the Italian case” (ENEA/MAP/APAT, 2004).

- *Road Transport Emissions Review.* The Italian Expert Panel on Transport, which includes experts from Research Institutes, Universities, Industrial Associations, Local Authorities, Ministries and Public Authorities, has continued its work on the improvement and assessment of emission estimations from road transport. There has been a considerable improvement on the details of basic data to be used within the COPERT model, both in terms of availability and timeliness. Studies of the expert panel group as well as presentations held in different meetings can be found on the website www.inventaria.sinanet.apat.it/ept.
- *MeditAIRaneo Project.* A three years project involving the Inventory Reference Centres of the European Mediterranean Countries (Italy, Spain, France, Greece, Portugal) started at the end of the year 2000. The aim was to examine in details emissions that are specific and/or typical of the Mediterranean Countries. Four different studies on air emissions from vegetation, agriculture, solvent use and urban road transport in Mediterranean areas were funded by APAT. Common objectives are analysis of methodologies and emission factors used by Mediterranean countries for estimating emissions, individuation of Mediterranean peculiarities, in comparison with other European countries, such as climate, technologies, industrial management, identification of methodological points which need in-depth examination and uncertainty assessment. An Italian case study has been developed for each of the four projects. By 2006, all the projects are concluded and the results have been used in the national inventory to improve country-specific emission factors.
- *Emissions Trading Scheme*. The analysis of sectoral industrial data from the Italian Emission Trading Scheme database has been used to develop country-specific emission factors and check activity data levels.
- Data from the Italian Pollutant Emission Register (EPER) from some industrial sectors were used as a check and comparison with the estimates carried out at national level. In particular, this regards the production of non-ferrous metals, chemical productions such as nitric and sulphuric acid, and the production of iron and steel.
- *Local inventories*. A study on the top-down approach to the preparation of local inventories was conducted and Italian emissions for different local areas were derived. The results were checked out by regional and local environmental agencies and authorities in order to find out the main weak points and contribute with information available to characterise the local environment, this contributing as well as a feedback to the improvement of the national inventory. Final estimates and the detailed methodologies followed for each SNAP sector to carry out emission figures are published in a technical report (Liburdi et al., 2004).

QC procedures are also undertaken on the calculation of uncertainties in order to confirm the correctness of the estimates and that there is sufficient documentation to duplicate the analysis. Figures used to draw up uncertainty analysis are checked with the relevant analyst experts and literature references and they are proved to be consistent with the IPCC Good Practice Guidance (IPCC, 2000).

Further improvements in 2006 will concern: the collection of statistical data and information to estimate uncertainty; for the agriculture sector, an update of the information on the basis of a specific survey ‘farm and structure’ by the National Institute of Statistics, which APAT has collaborated with, will improve emissions from manure management; for the waste sector, improvements will concern the results from a survey by a relevant operator on off site plant for wastewater handling, and a on waste composition in incineration plants; more accurate estimates of carbon stored in different pools are also expected for the LULUCF sector following the results of European projects. Finally for the energy sector, basic data reported in the European emissions trading scheme will improve the knowledge on the specific sectors involved.

1.7 General uncertainty evaluation, including data on the overall uncertainty for the inventory totals

The IPCC Good Practice Guidance (IPCC, 2000) defines the Tier 1 and Tier 2 approaches to estimating uncertainties in national greenhouse gas inventories. Quantitative estimates of the uncertainties for the Italian GHG inventory are calculated using a Tier 1 approach, which provides a calculation based on the error propagation equations. In addition, a Tier 2 approach, corresponding to the application of Monte Carlo analysis, has been applied to specific categories of the inventory but the results show that, with the information available at present, applying methods higher than the Tier 1 does not make a significant difference in figures. The results of the study, 'Evaluating uncertainty in the Italian GHG inventory', were presented at a EU workshop on Uncertainties in Greenhouse Gas Inventories, held in Finland in September 2005, and they are also available on website at the address
http://air-climate.eionet.europa.eu/docs/meetings/050905_EU_GHG_Uncert_WS/meeting050905.html.
A further research on uncertainty, specifically on the comparison of different methodologies to evaluate emissions uncertainty, was also carried out (Romano et al., 2004).
For the Italian inventory, the application of the Tier 1 approach is shown in Annex 1 considering national total with or without emissions and removals from the LULUCF sector. Emission sources are disaggregated into a detailed level and uncertainties are therefore estimated for these categories.
The Tier 1 approach suggests an uncertainty of 3.3% in the combined GWP total emissions, excluding emissions and removals from LULUCF, in 2004, whereas for the trend between 1990 and 2004 the analysis estimates an uncertainty of 2.6%.
Including the LULUCF sector into the national figures, the uncertainty according to the Tier 1 approach is equal to 8.3% for the year 2004, whereas the uncertainty for the trend is estimated to be 7.9%.

1.8 General assessment of the completeness

The inventory covers all major sources and sinks, as well as direct and indirect gases, included in the IPCC guidelines.
Table 1.5 summarizes the sectoral coverage of the GHG emissions in the Italian inventory.

TABLE 7 OVERVIEW TABLE[(1)] FOR NATIONAL GREENHOUSE GAS INVENTORIES - COMPLETENESS AND QUALITY OF ESTIMATES																				
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6		NO_x		CO		NMVOC		SO_2	
	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality
Total National Emissions and Removals																				
1 Energy																				
A. Fuel Combustion Activities																				
Reference Approach	ALL	H																		
Sectoral Approach																				
1. Energy Industries	ALL	H											ALL	H	ALL	M	ALL	M	ALL	H
2. Manufacturing Industries and Construction	ALL	H	ALL	M	ALL	M							ALL	M	ALL	M	ALL	M	ALL	H
3. Transport	ALL	H	ALL	M	ALL	M							ALL	H	ALL	M	ALL	H	ALL	H
4. Other Sectors	ALL	H	ALL	M	ALL	M							ALL	M	ALL	M	ALL	M	ALL	H
5. Other	ALL	H	ALL	M	ALL	M							ALL	M	ALL	M	ALL	M	ALL	H
B. Fugitive Emissions from Fuels																				
1. Solid Fuels	NA		ALL	M	NA															
2. Oil and Natural Gas	ALL	M	ALL	H	NA								ALL	M	ALL	M	ALL	H	ALL	M
2 Industrial Processes																				
A. Mineral Products	ALL	M	NA		NA								NA		NA		ALL	M	ALL	M
B. Chemical Industry	ALL	M	ALL	M	ALL	M	NO		NO				ALL	M	ALL	M	ALL	M	ALL	M
C. Metal Production	ALL	M	ALL	M	NA				ALL	M	ALL	M	ALL	M	ALL	M	ALL	M	ALL	M
D. Other Production	ALL	M											ALL	M	NA		ALL	M	ALL	M
E. Production of Halocarbons and SF_6							ALL	M	ALL	M	ALL	M								
F. Consumption of Halocarbons and SF_6																				
Potential [(2)]							ALL	M	NE		ALL	M								
Actual [(3)]							ALL	M	ALL	M	ALL	M								
G. Other	NO		NO		NO		NO		NO		NO		NO		NO		NO		NO	
3 Solvent and Other Product Use	**ALL**	**M**			**ALL**	**M**							NA		NA		ALL	M	NA	
4 Agriculture																				
A. Enteric Fermentation			ALL	H																
B. Manure Management			ALL	H	ALL	H											ALL	M		
C. Rice Cultivation			ALL	H													NA			
D. Agricultural Soils	NA		NA		ALL	H											NA			
E. Prescribed Burning of Savannas			NO		NO								NO		NO		NO		NO	
F. Field Burning of Agricultural Residues			ALL	M	ALL	M							ALL	M	ALL	M	ALL	M	NO	
G. Other			NO		NO								NO		NO		NO		NO	
5 Land-Use Change and Forestry																				
A. Changes in Forest and Other Woody Biomass Stocks	ALL	H																		
B. Forest and Grassland Conversion	NO		NO		NO								NO		NO		NO			
C. Abandonment of Managed Lands	ALL	M																		
D. CO_2 Emissions and Removals from Soil																				
E. Other	ALL	M	ALL	M	ALL	M							ALL	M	ALL	M	ALL	M	ALL	M
6 Waste																				
A. Solid Waste Disposal on Land	NA		ALL	M											NA		ALL	M		
B. Wastewater Handling			ALL	M	ALL	M							NA		NA		NA			
C. Waste Incineration	ALL	M	ALL	M	ALL	M							ALL	M	ALL	M	ALL	M	ALL	M
D. Other	NA		ALL	M	NA								NA		NA		ALL	M	NA	
7 Other *(please specify)*	**NO**		**NO**		**NO**		**NO**		**NO**		**NO**		**NO**		**NO**		**NO**		**NO**	
Memo Items:																				
International Bunkers																				
Aviation	ALL	H	ALL	M	ALL	M							ALL	M	ALL	M	ALL	M	ALL	H
Marine	ALL	H	ALL	M	ALL	M							ALL	M	ALL	M	ALL	M	ALL	H
Multilateral Operations	**NE**		**NE**		**NE**								**NE**		**NE**		**NE**		**NE**	
CO_2 Emissions from Biomass	**ALL**	**M**																		

(1) This table is intended to be used by Parties to summarize their own assessment of completeness (e.g. partial, full estimate, not estimated) and quality (high, medium, low) of major source/sink inventory estimates. The latter could be understood as a quality assessment of the uncertainty of the estimates. This table might change once the IPCC completes its work on managing uncertainties of GHG inventories. The title of the table was kept for consistency with the current table in the IPCC Guidelines.

Note: To fill in the table use the notation key as given in the IPCC Guidelines (Volume 1. Reporting Instructions, Tables. 37).

Table 1.5 Completeness of the Italian GHG inventory

Sectoral and background tables of CRF sheets are complete as far as the details of basic information are available. For instance, emissions from the military sector are not distinguished between stationary and mobile but only mobile emissions can be reported separately; stationary emissions are, on the other hand, included in commercial/institutional sector (1.A.4.a).
Potential emissions of PFCs are not estimated because no information on import-export is available at the moment. Multilateral operations emissions are not estimated because no activity data are available.
For fugitive emissions, CH_4 emissions from oil and natural gas exploration and venting are included in those from oil production because no detailed information is available. CH_4 emissions from gas exploration are also included in production while other leakage emissions are included in distribution emission estimates. Further investigation will be carried out closely with industry about these figures. CH_4 emissions from gas venting are included with natural gas under 1.B.2.b, production, as not separately supplied by the relevant industries. For industrial processes, emissions from soda ash use are included in glass and paper production emissions because the use of soda is part of that specific production process.

Chapter 2: TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Description and interpretation of emission trends for aggregate greenhouse gas emissions

Summary data of the Italian greenhouse gas emissions for the years 1990-2004 are reported in Tables A7.1- A7.5 of Annex 7.
The emission figures presented are those sent to the UNFCCC Secretariat and to the European Commission in the framework of the Greenhouse Gas Monitoring Mechanism.
Total greenhouse gas emissions, in CO_2 equivalent, excluding CO_2 emissions and removals from LULUCF, have increased by 12.2% between 1990 and 2004, varying from 520 to 583 CO_2 equivalent million tons (Mt), whereas the national Kyoto target is a reduction of 6.5%, as compared the base year levels, by the period 2008-2012.
The most important greenhouse gas, CO_2, which accounts for 83.9% of total emissions in CO_2 equivalent, shows an increase by 12.7% between 1990 and 2004. In the energy sector, in particular, emissions in 2004 are 13.9% greater than in 1990.
CH_4 and N_2O emissions are equal, respectively, to 7.2% and 7.7% of the total CO_2 equivalent greenhouse gas emissions. CH_4 emissions have increased by 0.5% from 1990 to 2004, while N_2O has by 9.8%.
Other greenhouse gases, HFCs, PFCs and SF_6, range from 0.3% to 1% of total emissions; at present, variations in these gases are not relevant to reaching the emission reduction objectives. Figure 2.1 illustrates the national trend of greenhouse gases for 1990-2004, expressed in CO_2 equivalent terms and by substance; CO_2 emissions do not include emissions and removals from land use, land use change and forestry.

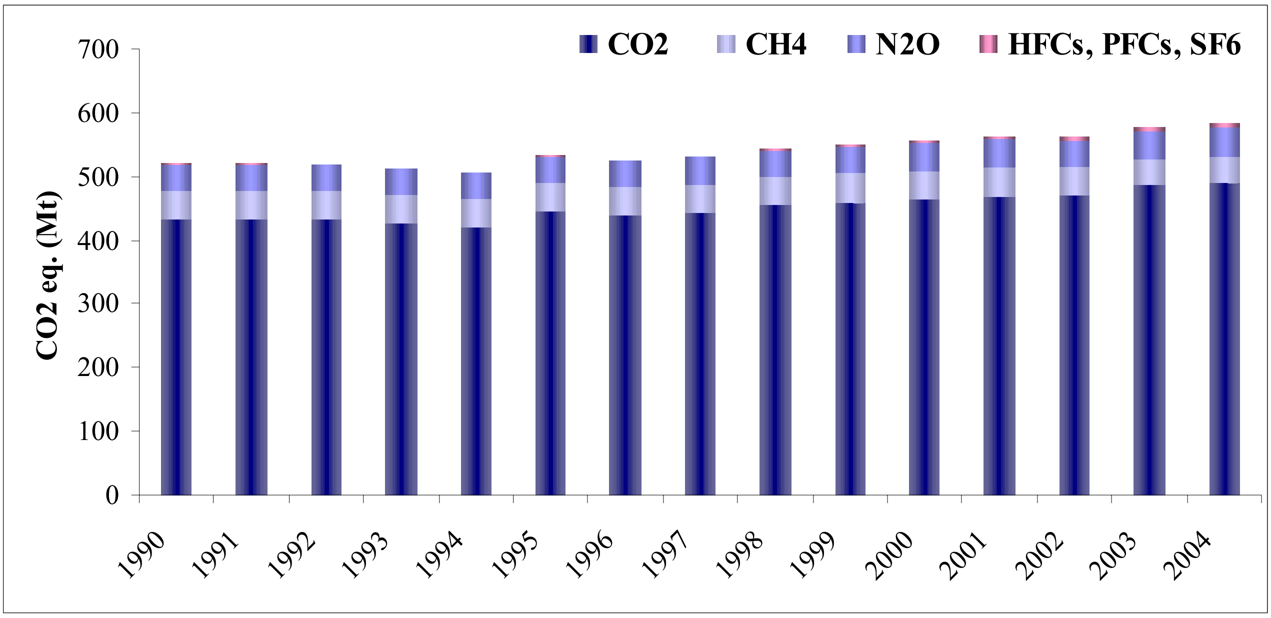

Figure 2.1 National greenhouse gas emissions from 1990 to 2004 (without CO_2 from LULUCF)

The share of the different sectors in terms of total emissions remains nearly unvaried over the period 1990-2004. Specifically for the year 2004, the greatest part of the total greenhouse gas emissions is to be attributed to the energy sector, with a percentage of 82%, followed by industrial processes, accounting for 7% of total emissions, agriculture, contributing with 6.6%, waste and use of solvents.
Considering total greenhouse gas emissions with emissions and removals from LULUCF, the energy sector accounts, in 2004, for 70% of total emissions and removals, as absolute weight, followed by the LULUCF sector which contributes with 15%.

Figure 2.2 shows total greenhouse gas emissions and removals subdivided by sector.

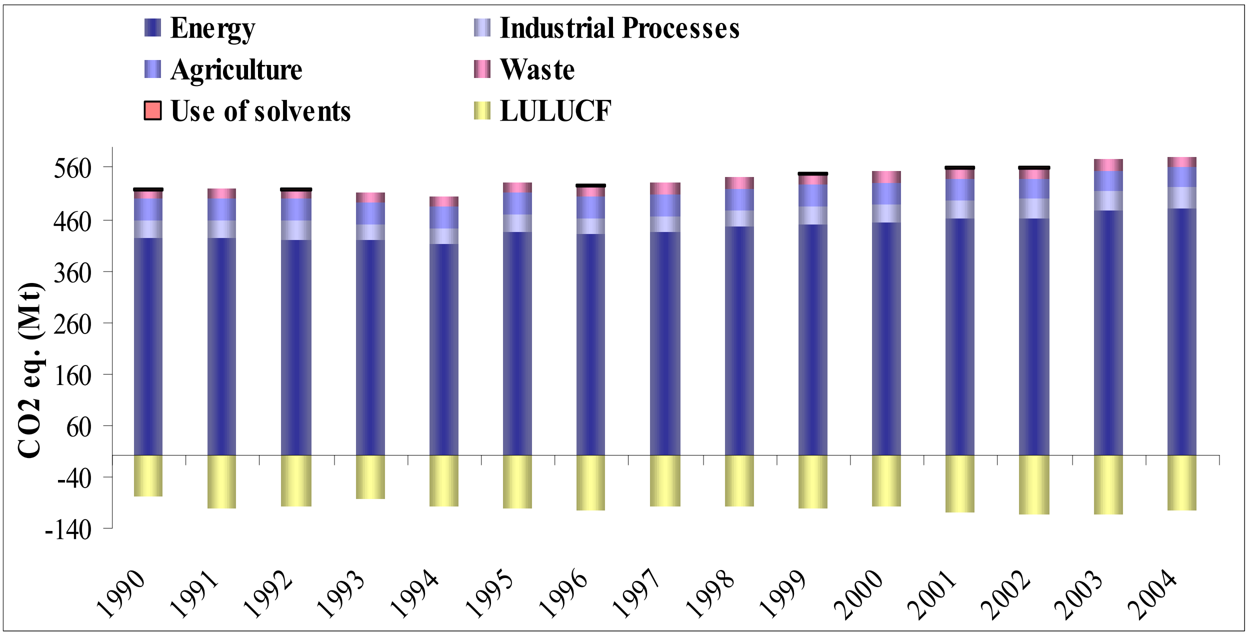

Figure 2.2 Greenhouse gas emissions and removals from 1990 to 2004 by sector

2.2 Description and interpretation of emission trends by gas

2.2.1 Carbon dioxide emissions

CO_2 emissions, excluding CO_2 emissions and removals from LULUCF, have increased by approximately 13% from 1990 to 2004, ranging from 434 to 490 million tons.
The most relevant emissions derive from the energy industries (33%) and transportation (26%). Manufacturing and construction industries and non-industrial combustion account for 17% each, while the remaining emissions derive from industrial processes (5%) and other sectors (1%).
The performance of CO_2 emissions by sector is shown in Figure 2.3.

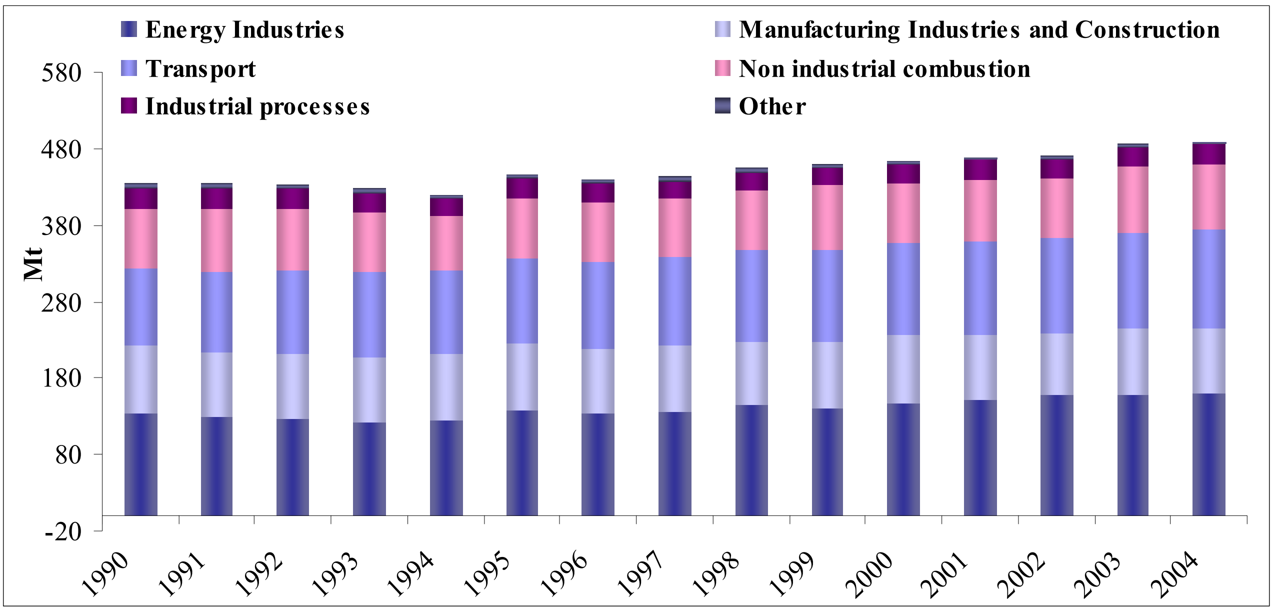

Figure 2.3 National CO_2 emissions by sector from 1990 to 2004

The main sectors responsible for the increase of CO_2 emissions are transport and energy industries; in particular, emissions from transport have increased by 26% from 1990 to 2004 while those from energy industries increased by 20%. Non industrial combustion emissions have raised by 10%, minor increases are also observed for the industrial processes and manufacturing industries and construction, whereas emissions in the 'Other' sector, mostly fugitive emissions from oil and natural gas and emissions from solvent and other product use, reduced by 35%.

Figure 2.4 illustrates the performance of the following economic and energy indicators:

- Gross Domestic Product (GDP) at market prices as of 1995 (base year 1990=100);
- Total Energy Consumption;
- CO_2 emissions, excluding emissions and removals from land-use change and forests;
- CO_2 *intensity*, which represents CO_2 emissions per unit of total energy consumption.

The figures of CO_2 emissions per total energy unit show that CO_2 emissions in the 1990s essentially mirrored energy consumption. A decoupling between the curves is observed only in recent years, mainly as a result of the substitution of fuels with high carbon contents by methane gas in the production of electric energy and in industry; nevertheless, this trend slowed in 2002, due to the increase of coal consumption in power plants.

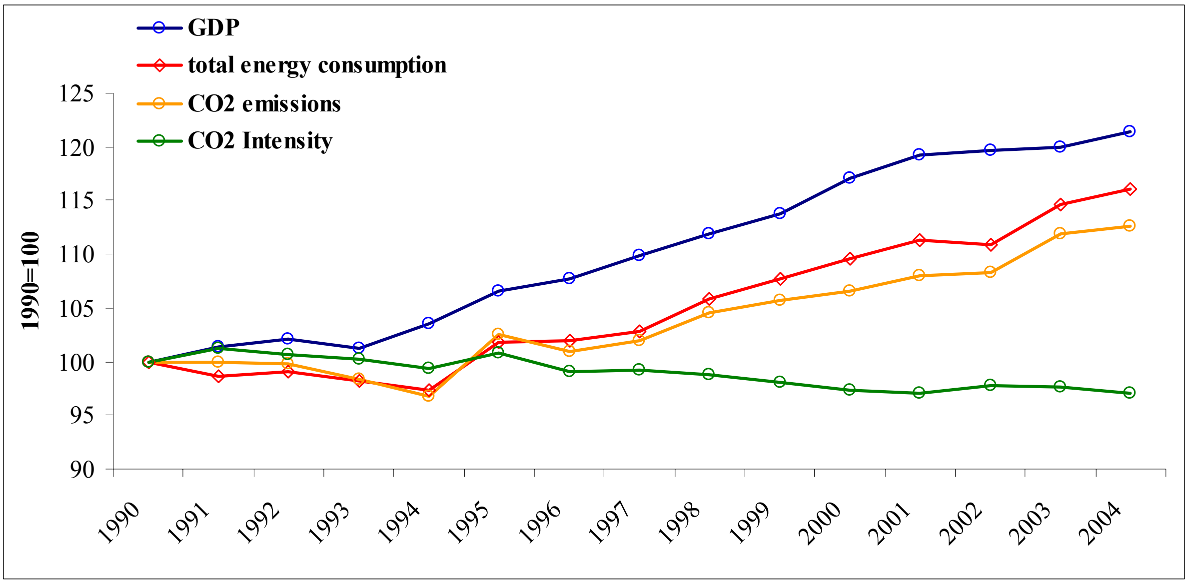

Figure 2.4 Energy-related and economic indicators and CO_2 emissions

2.2.2 Methane emissions

Methane emissions in 2004 represent 7.2% of total greenhouse gases, equal to 41.9 Mt in CO_2 equivalent, and show an increase of approximately 0.2 Mt as compared to 1990 levels.
CH_4 emissions, in 2004, are mainly originated from waste sector which accounts for 44.6% of total methane emissions, as well as to agricultural sector (37.3%) and to energy (17.9%).
Activities typically leading to emissions in the waste-management sector are the operation of dumping sites and the treatment of industrial waste-water. The waste sector shows an increase in emission levels, 22% compared to 1990, mainly due to solid waste disposal on land subcategory.
Emissions in the agricultural sector regard mainly the enteric fermentation and manure management categories. The agriculture sector shows a decrease of emissions equal to 9.3% as compared to 1990.
In terms of CH_4 emissions in the energy sector, the reduction (-16%) is the result of two contrasting factors; on the one hand there has been a considerable reduction in emissions caused by leakage from the extraction and distribution of fossil fuels, due to the gradual replacement of natural-gas

distribution networks; at the same time, combustion emissions in the road transport sector have increased on account of the overall rise in consumption and, in the civil sector, as the result of increased use of methane in heating systems.
Figure 2.5 shows the emission figures by sector.

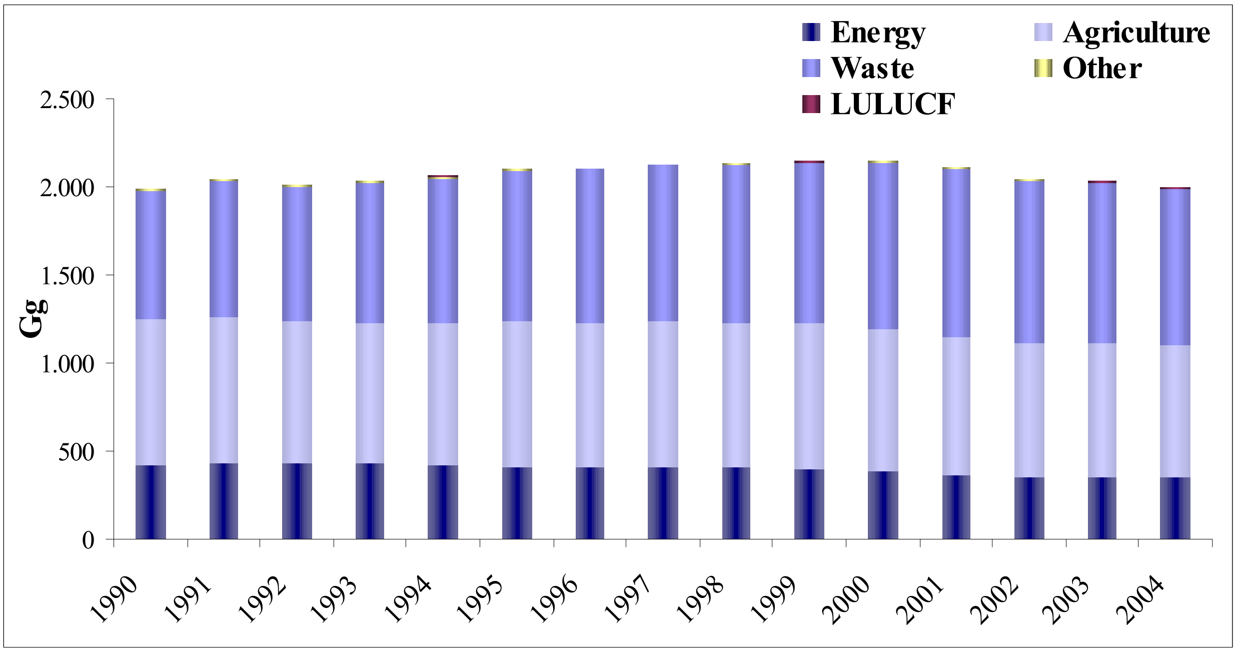

Figure 2.5: National CH_4 emissions by sector from 1990 to 2004

2.2.3 Nitrous oxide emissions

In 2004 nitrous oxide emissions represent 7.7% of total greenhouse gases, with a growth rate of 9.8% between 1990 and 2004, from 41.1 to 45.2 Mt CO_2 equivalent.
The major source of N_2O emissions is the agricultural sector (50.4%), in particular the use of both chemical and organic fertilisers in agriculture, as well as the management of waste from the raising of animals. These emissions show a decrease of 5% during the period 1990-2004.
Emissions in the energy-use sector (24.8% of the total) show an increase by approximately 31% from 1990 to 2004; this growth can be traced primarily to the road transport sector and is related to the introduction of catalytic converters. However, a high degree of uncertainty still exists with regard to the N_2O emission factors of catalysed automobiles.
The production of nitric acid, which has decreased in recent years, and of adipic acid, whose levels have grown, account totally for 18.7% of total emissions.
Other emissions in the waste sector primarily regard the processing of industrial and domestic waste-water.
Figure 2.6 shows national emission figures by sector.

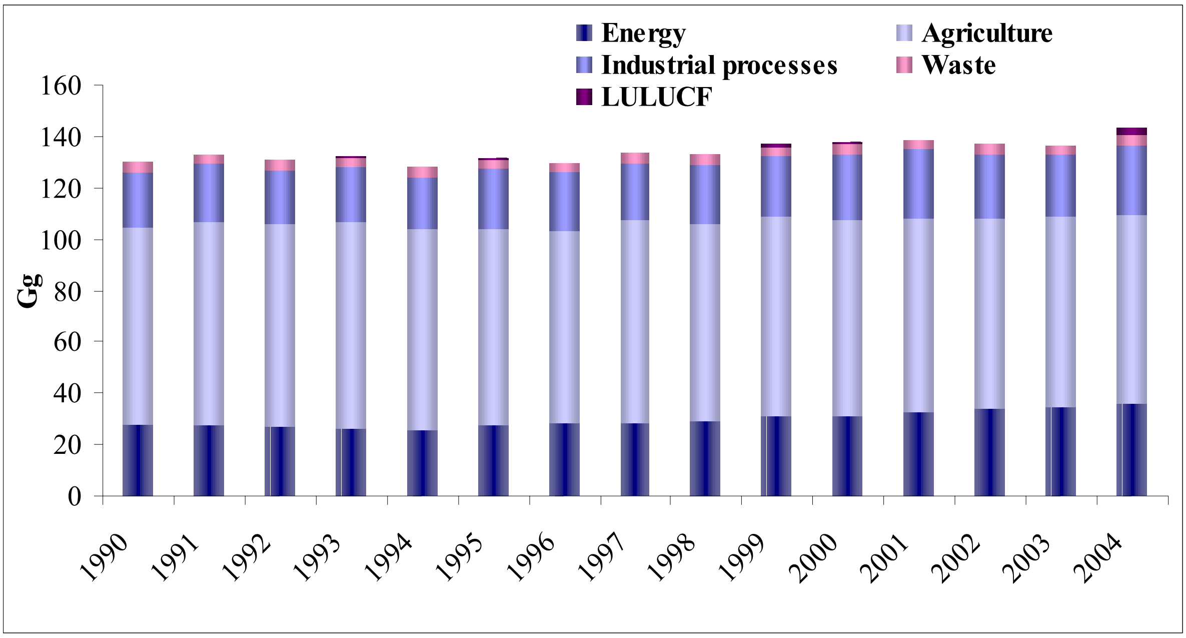

Figure 2.6 National N_2O emissions by sector from 1990 to 2004

2.2.4 Fluorinated gas emissions

Italy has set 1990 as the base year for reduction in the emissions of the fluorinated gases covered by the Kyoto Protocol, that's HFCs, PFCs and SF_6. The previous choice of selecting the year 1995 as the base year for hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride is no more to be considered valid. Taken altogether, the emissions of fluorinated gases represent 1.15% of total greenhouse gases in CO_2 equivalent in 2004, and they show an increase of 169% between 1990 and 2004. This increase is the result of different features for different gases.

HFCs, for instance, have increased considerably from 1990 to 2004, from 0.4 to 5.7 CO_2 equivalent Mt. The main sources of emissions are the consumption of HFC-134a, HFC-125, HFC-32 and HFC-143a in refrigeration and air-conditioning devices, together with the use of HFC-134a in pharmaceutical aerosols. Increases during this period are due both to the use of these substances as replacements for gases that destroy the ozone layer and to the greater use of air conditioners in automobiles.

Emissions of PFCs show a decrease of 78% from 1990 to 2004. The level of these emissions in 2004 is 0.4 Mt in CO_2 equivalent, and it can be traced in equal proportion to the use of the gases in the production of aluminium and in the production of semiconductors. Although the production of PFCs is equal to zero in Italy from the year 1999 onwards, the upward trend shown by the series is due to their consumption and to their use in metal production.

Emissions of SF_6 are equal to 0.6 Mt in CO_2 equivalent in 2004, with an increase of 81% as compared to 1990 levels. Out of the SF_6 emissions, 28% can be traced to the use of gas in magnesium foundries, 60% to the gas contained in electrical equipments. The rest of the emissions results from the gas use in the production of semiconductors. The gas use both in magnesium foundries has been on the rise in recent years, unlike the figures for the gas contained in electrical equipments, which have fallen.

The National Inventory of fluorinated gases has largely improved in terms of the sources and the gases identified and a strict cooperation with the relevant industry has been established. Higher methods are applied to estimate these emissions; nevertheless, uncertainty still regards some activity data which are considered of strategic economic importance and therefore kept confidential.

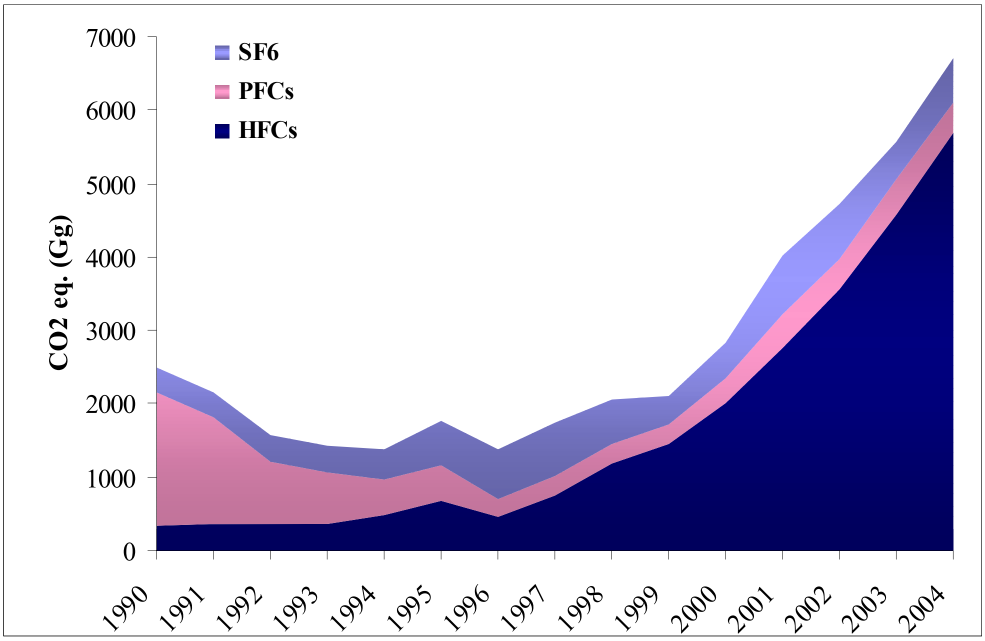

Figure 2.7 National emissions of fluorinated gases by sector from 1990 to 2004

2.3 Description and interpretation of emission trends by source

2.3.1 Energy

Emissions in CO_2 equivalent from the energy sector are reported in Table 2.1 and Figure 2.8.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
								Gg CO_2 eq							
Total emissions	**422.600**	**422.491**	**421.557**	**418.047**	**411.635**	**435.280**	**431.177**	**435.368**	**446.497**	**451.986**	**455.539**	**460.373**	**462.401**	**477.127**	**479.955**
Fuel Combustion (Sectoral Approach)	412.158	412.156	411.246	407.688	401.631	425.605	421.756	425.791	436.952	443.318	446.797	452.076	454.540	468.764	472.447
Energy Industries	*136.093*	*130.318*	*130.130*	*124.599*	*127.287*	*139.962*	*135.405*	*137.163*	*147.489*	*143.570*	*149.682*	*152.923*	*160.056*	*160.993*	*163.481*
Manufacturing Industries and Construction	*90.703*	*87.741*	*86.065*	*86.426*	*87.194*	*89.518*	*87.269*	*90.361*	*84.449*	*88.176*	*89.631*	*86.890*	*82.863*	*87.813*	*87.187*
Transport	*103.952*	*106.890*	*111.332*	*113.153*	*113.130*	*115.128*	*116.490*	*118.355*	*122.466*	*123.967*	*124.467*	*126.825*	*129.204*	*130.428*	*132.632*
Other Sectors	*80.295*	*85.937*	*82.364*	*81.977*	*72.482*	*79.489*	*81.354*	*78.620*	*81.456*	*86.450*	*82.167*	*85.072*	*82.094*	*88.828*	*87.967*
Other	*1.114*	*1.269*	*1.355*	*1.533*	*1.537*	*1.507*	*1.238*	*1.292*	*1.092*	*1.154*	*851*	*365*	*322*	*701*	*1.180*
Fugitive Emissions from Fuels	10.443	10.335	10.311	10.359	10.004	9.675	9.421	9.576	9.545	8.668	8.742	8.298	7.861	8.363	7.508
Solid Fuels	*122*	*112*	*112*	*82*	*71*	*65*	*60*	*60*	*55*	*53*	*73*	*81*	*78*	*95*	*64*
Oil and Natural Gas	*10.321*	*10.223*	*10.200*	*10.277*	*9.933*	*9.611*	*9.360*	*9.517*	*9.489*	*8.615*	*8.669*	*8.217*	*7.783*	*8.269*	*7.444*

Table 2.1 Total emissions in CO_2 equivalent from the energy sector by source (1990-2004)

An upward trend is noted from 1990 to 2004. Substances with the highest increase rate are CO_2, whose levels have increased by 13.8% from 1990 to 2004 and account for 96% of the total, and N_2O which shows an increase of 31% but its share out of the total is only 2%; CH_4, on the other hand, shows a decrease of 16.3% from 1990 to 2004 but this is not relevant on total emissions, accounting only for 1%.
Totally emissions from this sector increase by 13.6% from 1990 to 2004.
Details on these figures are described in the specific chapter.
It should be noted that the most significant increase, in terms of total CO_2 equivalent, is observed in the transport and energy industries sectors, about 27% and 20%, respectively, from 1990 to 2004; these sectors, altogether, account for more than 61% of total emissions.

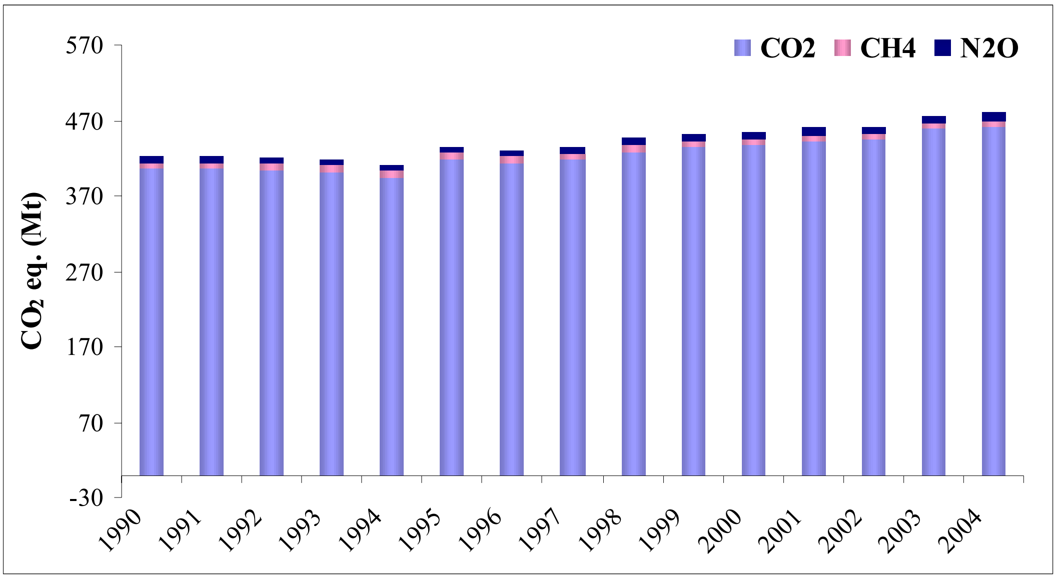

Figure 2.8 Trend of total emissions in CO_2 equivalent from the energy sector by gas (1990-2004)

2.3.2 Industrial processes

Emission trends from industrial processes are reported in Table 2.2 and Figure 2.9.

Total emission levels, in CO_2 equivalent, show an increase of 14.8%, from the base year to 2004. Taking into account emissions by substance, CO_2 level decreased by 1.8% while N_2O level increased by 26%, respectively; these two substances account altogether for about 84% of the total emissions from industrial processes. The increase in emissions is mostly due to an increase in the mineral products category (13%), for the increase in production figures especially for lime and glass, and also to an increase in the chemical industry (10%) due to adipic acid production. On the other hand, emissions from metal production decreased by 58% mostly for the different materials used in the pig iron and steel production processes.

A considerable increase is observed in F-gas emissions (169%) which share on total emissions is 16%.

Details for industrial processes emissions can be found in the specific chapter.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
								Gg CO_2 eq							
Total emissions	**36.544**	**36.165**	**35.572**	**32.736**	**31.399**	**34.590**	**31.556**	**32.032**	**32.489**	**32.817**	**34.979**	**37.206**	**37.460**	**38.955**	**41.982**
CO_2	27.268	26.827	27.360	24.488	23.607	25.474	23.092	23.165	23.219	23.336	24.153	24.906	24.782	25.780	26.770
CH_4	108	104	101	102	106	113	63	68	65	64	63	59	57	58	61
N_2O	6.676	7.071	6.544	6.712	6.311	7.239	7.025	7.063	7.148	7.303	7.918	8.232	7.902	7.557	8.443
HFCS	351	355	359	355	482	671	450	755	1.181	1.452	2.005	2.761	3.568	4.590	5.699
PFCS	1.808	1.452	850	707	477	491	243	252	270	258	346	452	414	484	407
SF_6	333	356	358	370	416	601	683	729	605	405	493	795	738	486	602

Table 2.2 Total emissions in CO_2 equivalent from the industrial processes sector by gas (1990-2004)

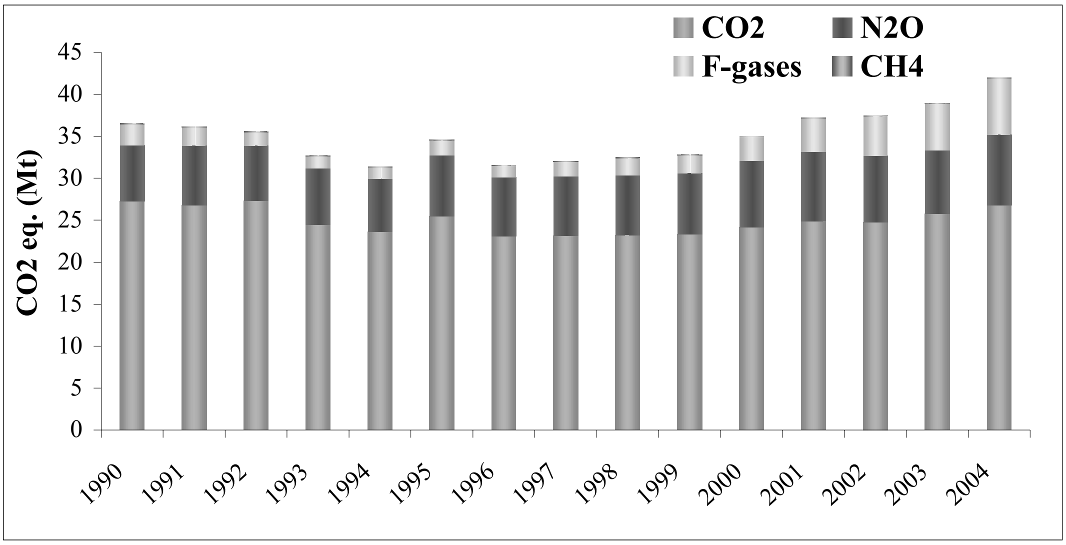

Figure 2.9 Trend of total emissions in CO_2 equivalent from industrial processes by gas (1990-2004)

2.3.3 Solvent and other product use

Emissions from the solvent and other product use sector refer to CO_2 and N_2O, except for gases other than greenhouse.

A considerable amount of emissions from this sector is, in fact, mostly to be attributed to NMVOC. The share of CO_2 emissions, in this sector, is 62% out of the total; a decrease by 17% is noted from this sector from 1990 to 2004, which is to be attributed to different sources. Emission levels from paint application sector, which accounts for 52% of total CO_2 emissions from this sector, decreased by 18%; emissions from other use of solvents in related activities, such as domestic solvent use other than painting, printing industries, vehicle dewaxing, which account for 42% of the total, show a decrease of 24%. Finally, emissions from metal decreasing and dry cleaning activities, decreased by 57% but they account for only 6% of the total.

In 2004, solvent use is responsible for 0.3% of the total CO_2 emissions (not considering CO_2 from LULUCF) and 38% of the total NMVOC emissions, and represents the main source of anthropogenic NMVOC national emissions.

The N_2O emissions, in 2004, represent about 2% of the total N_2O national emissions.

Emissions from paint application and other use of solvents for NMVOC and CO_2 are more than 80% and 90%, respectively, of the total sector.

From 1990 to 1995, a constant level of N_2O emissions is observed, afterwards from 1995 to 1998 emissions increased by 37%. From 1999, there appears to be a reduction in N_2O emissions, due to a decrease in the anaesthetic use of N_2O, that has been replaced by halogen gas.

Further details about this sector can be found in the specific chapter.

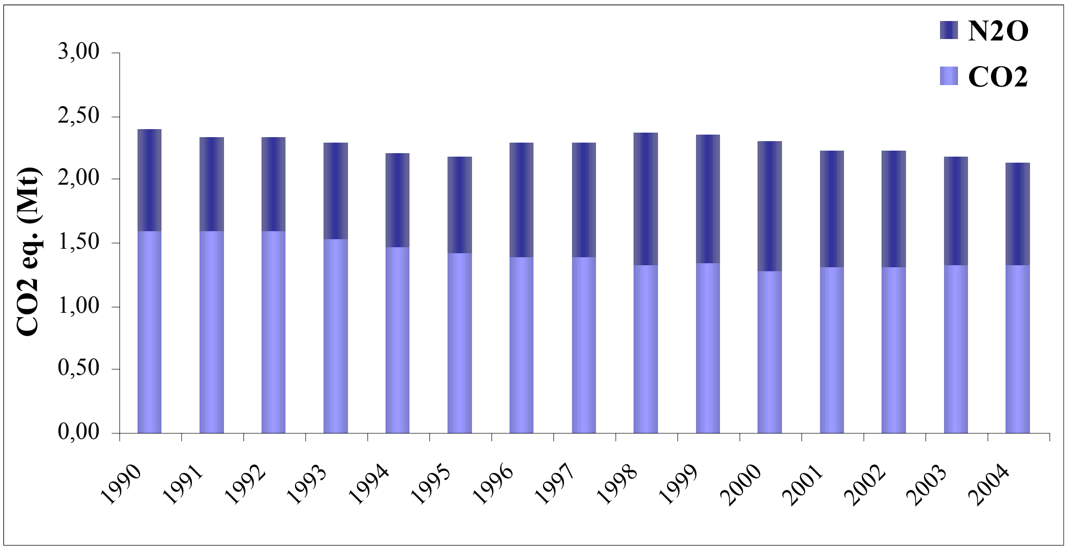

Figure 2.10 Trend of total emissions in CO_2 equivalent from the solvent and other product use sector (1990-2004)

2.3.4 Agriculture

Emissions from the agriculture sector are reported in Table 2.3 and Figure 2.11.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
								Gg CO_2 eq							
Total emissions	**41.177**	**41.963**	**41.420**	**41.712**	**41.193**	**40.888**	**40.662**	**41.767**	**41.069**	**41.488**	**40.457**	**39.972**	**38.775**	**38.636**	**38.362**
Enteric fermentation	12.178	12.448	12.070	11.943	12.050	12.266	12.322	12.376	12.291	12.428	12.165	11.666	11.029	11.055	10.831
Manure Management	7.980	7.962	7.634	7.582	7.467	7.603	7.651	7.691	7.787	7.879	7.664	7.940	7.622	7.590	7.360
Rice Cultivation	1.562	1.493	1.551	1.627	1.664	1.657	1.652	1.676	1.622	1.616	1.375	1.382	1.420	1.462	1.527
Agricultural Soils	19.441	20.041	20.147	20.543	19.994	19.345	19.019	20.009	19.351	19.548	19.238	18.969	18.687	18.514	18.626
Field Burning of Agricultural Residues	17	19	18	17	18	17	18	16	18	17	16	15	17	15	18

Table 2.3 Total emissions in CO_2 equivalent from the agricultural sector by source (1990-2004)

Emissions refer to CH_4 and N_2O levels, which account for 41% and 59% of the total emission of the sector, respectively. The decrease observed in the total emissions (-7%) is mostly due to the decrease of CH_4 emissions from enteric fermentation (-11%) which account for 28% of the total emissions. Detailed comments can be found in the specific chapter.

Figure 2.11 Trend of total emissions in CO_2 equivalent from agriculture (1990-2004)

2.3.5 LULUCF

Emissions from the agriculture sector are reported in Table 2.4 and Figure 2.12.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
								Gg CO_2 eq							
Total emissions - removals	**-79.722**	**-101.215**	**-97.331**	**-82.397**	**-98.050**	**-103.206**	**-106.105**	**-99.318**	**-96.004**	**-103.525**	**-99.711**	**-110.156**	**-114.335**	**-111.341**	**-105.107**
Forest Land	-58788	-80483	-76806	-62280	-78700	-84044	-86933	-79924	-77800	-85549	-81676	-88054	-94557	-84625	-92562
Cropland	-22214	-22249	-22007	-21397	-20631	-20443	-20151	-20674	-19484	-19256	-19315	-20941	-20799	-20552	-13826
Settlements	1280	2527	2531	1280	1280	1280	2572	1280	1280	1280	1280	2559	2560	2550	1280
Grassland	0	-1011	-1048	0	0	0	-1593	0	0	0	0	-3721	-1538	-8713	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.4 Total emissions in CO_2 equivalent from the LULUCF sector by source/sink (1990-2004)

Total removals, in CO_2 equivalent, show an increase of 31%, from the base year to 2004.
CO_2 accounts for more than 99% to total emissions and removals of the sector: in the period 1990–2004 CO_2 removals increased by 32%, mostly because of the increase of forest areas.
Further details for LULUCF emissions and removals can be found in the specific chapter.

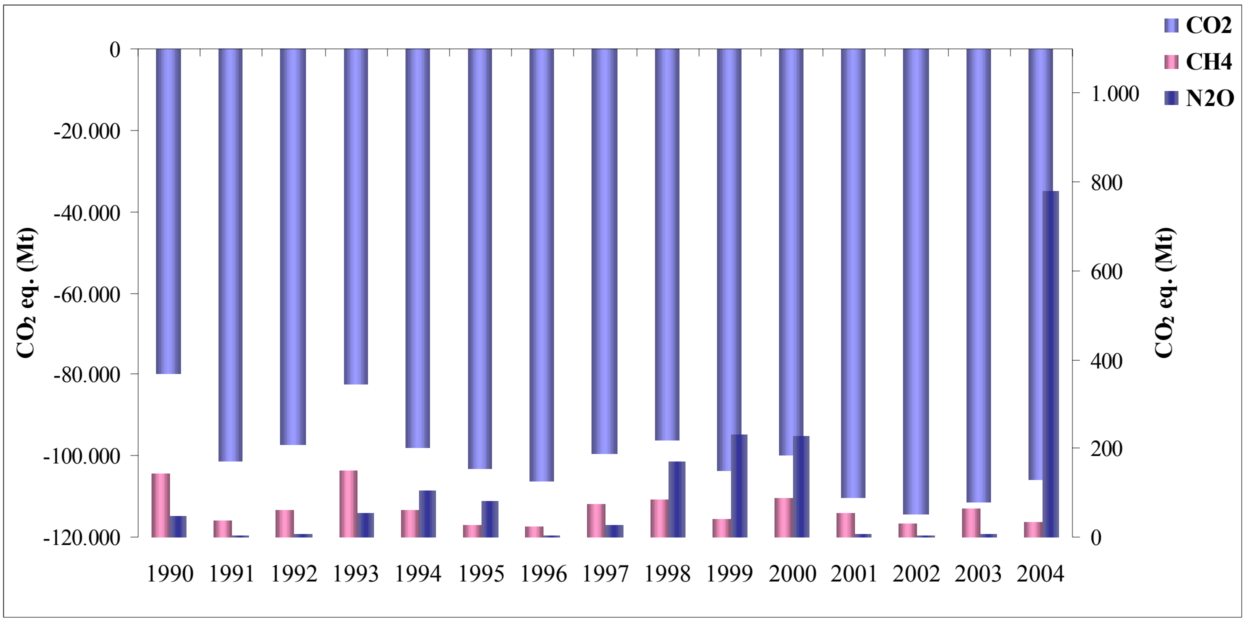

Figure 2.12 Trend of total emissions and removals in CO_2 equivalent from LULUCF (1990-2004)

2.3.6 Waste

Emissions from the waste sector are shown in Table 2.5 and Figure 2.13.
Total emissions in CO_2 equivalent increased by 19% from 1990 to 2004. The increase is mostly due to the increase in emissions from solid waste disposal (22%) due to the increase of waste production, which account for 80% of the total, as well as those from waste-water handling (12%) which account for 17%.
Considering emissions by gas, the most important greenhouse gas is CH_4 which accounts for 93% of the total and shows an increase of 22% from 1990 to 2004. N_2O levels have increased by 7% while CO_2 decreased by 58%; these gases account for 6% and 1%, respectively.
Further details can be found in the specific chapter.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
								Gg							
Total emissions CO_2 eq	**16.884**	**18.047**	**17.736**	**18.189**	**18.938**	**19.703**	**19.896**	**20.331**	**20.577**	**20.591**	**21.338**	**21.517**	**20.924**	**20.514**	**20.096**
Solid Waste Disposal on Land	13.127	13.977	13.696	14.070	14.816	15.583	15.824	16.107	16.392	16.435	17.434	17.539	16.922	16.545	16.020
Waste-water Handling	3.013	3.087	3.154	3.225	3.245	3.244	3.269	3.302	3.312	3.319	3.340	3.361	3.374	3.362	3.378
Waste Incineration	744	982	886	894	877	876	803	920	871	836	562	615	625	602	695
Other	0	0	0	0	0	0	0	1	1	2	2	3	3	4	4

Table 2.5 Total emissions in CO_2 equivalent from the waste sector by source (1990-2004)

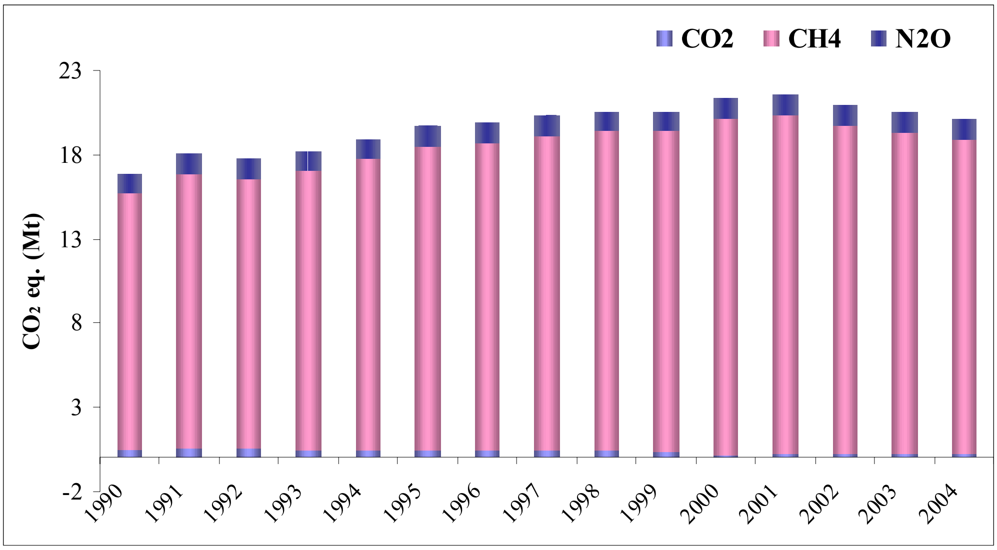

Figure 2.13 Trend of total emissions in CO_2 equivalent from waste (1990-2004)

2.4 Description and interpretation of emission trends for indirect greenhouse gases and SO_2

Emission trends of NO_X, CO, NMVOC and SO_2 from 1990 to 2004 are presented in Table 2.6 and Figure 2.14.

Indirect greenhouse gases and SO_2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
								kt							
NO_X	1,943	2,001	2,020	1,921	1,841	1,808	1,732	1,654	1,554	1,453	1,373	1,352	1,258	1,245	1,173
CO	7,183	7,477	7,677	7,623	7,402	7,166	6,867	6,607	6,197	5,897	5,164	5,086	4,468	4,381	4,207
NMVOC	1,986	2,048	2,129	2,097	2,033	2,004	1,952	1,884	1,779	1,688	1,506	1,432	1,335	1,299	1,263
SO_2	1,795	1,677	1,578	1,478	1,388	1,320	1,210	1,134	997	900	755	705	625	528	496

Table 2.6 Total emissions for indirect greenhouse gases and SO_2 (1990-2004)

All gases show a significant reduction in 2004 as compared to 1990 levels. The highest reduction is observed for SO_2 (-72%), CO levels have reduced by 41%, while NO_X and NMVOC show a decrease by 40% and 36%, respectively. A detailed description of the trend by gas and sector as well as the main reduction plans can be found in the Italian National Programme for the progressive reduction of the annual national emissions of SO_2, NO_X, NMVOC and NH_3, as requested by the 2001/81/EC Directive.

The most relevant reductions occurred as a consequence of the Directive 75/716/EC and following related to the transport sector and other European Directives which established maximum levels for sulphur content in liquid fuels and introduced emission standards for combustion installations. As a consequence, in the combustion processes, oil with high sulphur content and coal have been substituted with oil with low sulphur content and natural gas.

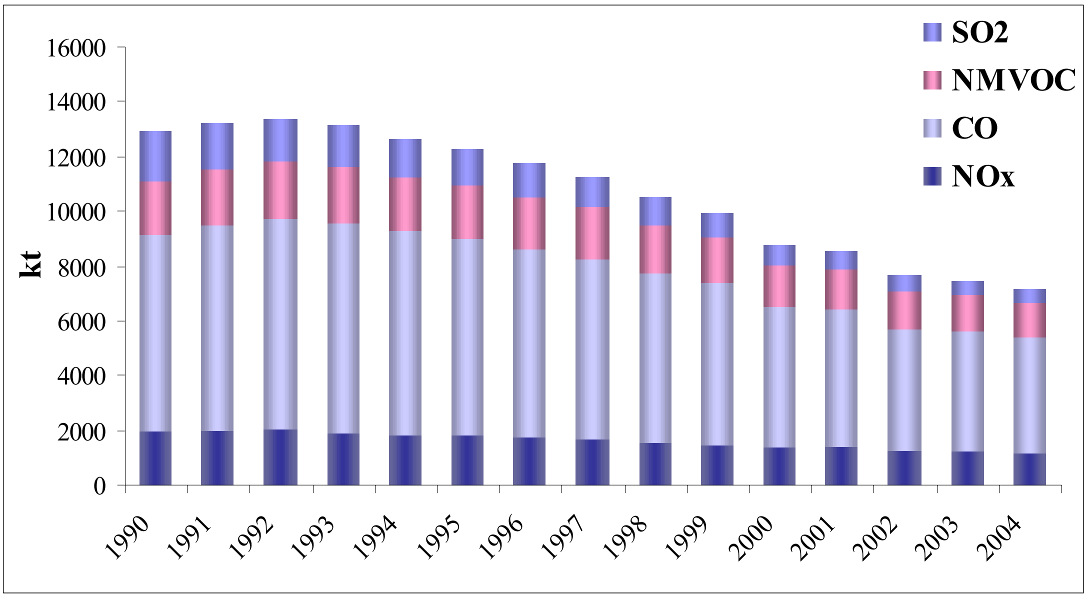

Figure 2.14 Trend of total emissions for indirect greenhouse gases and SO_2 (1990-2004)

Chapter 3: ENERGY [CRF sector 1]

3.1 Introduction

The aim of this section is to describe in detail the methodology used to estimate the emissions arising from fuel combustion for energy. These sources correspond to IPCC Tables 1A.
Emission inventory is prepared using the energy consumption information available from national statistics and an estimate of the actual use of the fuels. The latter information is available at sectoral level in a great number of publications and it is needed to evaluate emissions of methane and nitrous oxide. Those emissions are related to the actual physical conditions of the combustion process and to environmental conditions.
The continuous monitoring of GHG emissions in Italy is negligible hence information is rarely available on actual emissions over a specific period of time from an individual emission source. Therefore, the majority of emissions is estimated from other information such as fuel consumption, distance travelled or some other statistical data related to emissions. Estimates for a particular source sector are calculated by applying an emission factor to an appropriate statistic. That is:

Total Emission = Emission Factor x Activity Statistic

Emission factors are typically derived from measurements on a number of representative sources and the resulting factor applied to the whole country.
For certain sectors, emissions data are available for individual sites. Hence the emission for a particular sector can be calculated as the sum of the emissions from these point sources. That is:

Emission = Σ Point Source Emissions

However, it is necessary to carry out an estimate of the fuel consumption associated with these point sources, so that the emissions from non-point sources can be estimated from fuel consumption data without double counting. In general the point source approach is only applied to emissions of indirect greenhouse gases for well defined point sources (e.g. power stations, cement kilns, refineries). Direct greenhouse gas emissions and most non-industrial sources are estimated using emission factors.

3.2 Key sources

Key source analysis for the 2004 inventory has identified 11 categories at level or trend assessment with the Tier 1 and Tier 2 approach in the energy related emissions.
In the case of the energy sector in Italy, a sector by sector analysis instead of a source by source analysis will better illustrate the accuracy and reliability of the emission data, given the interconnection between the underlining data of most key source categories. In the following box the relevant key sources are listed making reference to the section of the text where they are quoted.
With reference to the box, half of the key sources (n. 1, 2, 3, 5, and 11) are linked to stationary combustion and to the same set of energy data: the energy sector CRF table 1.A.1, the industrial sector, table 1.A.2 and the civil sector 1.A.4a and .4b. Three out of 5 key sources refer to CO_2 emissions. All those sectors refer to the national energy balance (MAP, 2006 [a]) for the basic energy data and the distribution among various subsectors, even if more accurate data for the electricity production sector can be found in GRTN database (GRTN, 2006). Evolution of energy consumptions/emissions is linked to the activity data of each sector; refer to paragraph 3.4, 3.5 and 3.7 for the detailed analysis of those sectors. Electricity production is the most "dynamic" sector and most of the emissions increase from 1990 to 2004, for CO_2, N_2O and CH_4, is due to the increase of thermoelectric production, see Tables 3.2, 3.4 and 3.9 for more details.

Another consistent group of four key sources (n. 4, 6, 8 and 9) are referred to the transport sector, with basic total energy consumption reported in the national energy balance and then subdivided in the different subsectors with activity data taken from various statistical sources; refer to paragraph 3.6, transport, for an accurate analysis of those key sources. Also this sector shows a remarkable increase in emissions, in particular CO_2 from air transport and road transport, as can be seen in the following box and in the Table 3.18 and 3.19, respectively. The evolution of N_2O emissions is linked to technological changes occurred in the period.
Finally, the last group of two key sources refers to oil and gas operations. Also for this sector basic overall production data are reported in the national balance but emissions are calculated with more accurate data published or delivered to APAT by the relevant operators, see paragraph 3.11.

Key-source identification in the energy sector with the IPCC Tier1 and Tier2 approaches

	ENERGY RELATED KEY SOURCE CATEGORIES	TIER	Relevant paragraph	Notes
1	CO_2 stationary combustion liquid fuels	L,T	3.4, 3.5 and 3.7	Table 3.9
2	CO_2 stationary combustion solid fuels	L,T2	3.4, 3.5 and 3.7	Table 3.9
3	CO_2 stationary combustion gaseous fuels	L,T	3.4, 3.5 and 3.7	Table 3.9
4	CO_2 Mobile combustion: Road Vehicles	L,T	3.6 and 3.6.3	Tables 3.18, 3.19
5	N_2O stationary combustion	L,T2	3.4, 3.5 and 3.7	Table 3.9
6	CO_2 Mobile combustion: Waterborne Navigation	L1	3.6.4	Table 3.24
7	CH_4 Fugitive emissions from Oil and Gas Operations	L,T	3.11	Table 3.28
8	N_2O Mobile combustion: Road Vehicles	L,T	3.6 and 3.6.3	Tables 3.18, 3.19
9	CO_2 Mobile combustion: Aircraft	T1	3.6.1	Table 3.14
10	CO_2 Fugitive emissions from Oil and Gas Operations	L2,T	3.11	Table 3.28
11	CH_4 Stationary combustion	L2	3.4, 3.5 and 3.7	Table 3.9

3.3 Methodology for estimation of emissions from combustion

For the pollutants and sources discussed in this section, emissions result from the combustion of fuel. The activity statistics used to calculate emissions are fuel consumptions provided in the national energy balance ((MAP, 2006 [a])), GRTN (GRTN, 2006) for the power sector and some additional data sources to characterise the technologies used at sectoral level, quoted in the relevant sections.

Emissions are calculated using sector specific spreadsheets according to the equation:

$$E(p,s,f) = A(s,f) \times e(p,s,f)$$

where
$E(p,s,f)$ = Emission of pollutant p from source s from fuel f (kg)
$A(s,f)$ = Consumption of fuel f by source s (TJ-t)
$e(p,s,f)$ = Emission factor of pollutant p from source s from fuel f (kg/TJ-kg/t)

The pollutants estimated in this way are:
- carbon dioxide (CO_2);
- NO_x as nitrogen dioxide;
- nitrous oxide (N_2O);
- methane (CH_4);
- non methane volatile organic compounds (NMVOC);
- carbon monoxide (CO);
- sulphur dioxide (SO_2).

The sources covered by this methodology are:

Electricity (power plants and Industrial producers);
Refineries (Combustion);
Chemical and petrochemical industries (Combustion);
Construction industries (roof tiles, bricks);
Other industries (metal works factories, food, textiles, others);
Road Transport;
Coastal Shipping;
Railways;
Aircraft;
Domestic;
Commercial;
Public Service;
Fishing
Agriculture.

The fuels covered are listed in Table 3.2, though not all fuels occur in all sources. Sector specific tables specify the emission factors used.

Emission factors are expressed in terms of kg pollutant/ TJ based on the net calorific value of the fuel.
The carbon factors used are based on national sources and should be appropriate for Italy. Most of the emission factors have been cross checked with the results of specific studies that evaluate the carbon content of the imported/produced fossil fuels at national level. A comparison of the current national factors with the IPCC ones was carried out and the results suggest quite limited variations in liquid fuels and some differences in natural gas, explained by basic hydrocarbon composition, and in solid fuels. In case of differences between IPCC and national emission factors the latter have been usually preferred.

The emission factors should apply for all years provided there is no change in the carbon content of fuel over time. There are exceptions to this rule:

- transportation fuels have shown a significant variation around the year 2000 due to the reformulation of gasoline and diesel to comply with the EU directive, see section 3.10 for details;
- the most important imported fuels, natural gas, fuel oil and coal show variations of carbon content from year to year, due to changes in the origin of imported fuel supply; a methodology has been set up to evaluate annually the carbon content of the average fuel used in Italy, see section 3.10 for details.

The Ministry of Production Activities (Ministero delle Attività Produttive, MAP) publishes annually energy balances (MAP, 2006 [a]) of fuels used in Italy. These balances compare total supply based on production, exports, imports, stock changes and known losses with the total demand. The difference between total supply and demand is reported as 'statistical difference'. In Annex 5 a copy of the 2004 data is attached, the full time series is available on the website: https://dgerm.attivitaproduttive.gov.it/dgerm/.

Additionally to fossil fuel, the national energy balance (BEN) reports commercial wood and straw combustion estimates for energy use, biodiesel and biogas. The estimate of GHG emissions are based on these data and on other estimates (ENEA, 2006) for non commercial wood use. Carbon dioxide emissions from biomass combustion are not included in the national total as suggested in the IPCC Guidelines (IPCC, 1997) but emissions of other GHG gases and other pollutants are

included. CORINAIR methodology (EMEP/CORINAIR, 2005) includes emissions from the combustion of wood in the industrial and domestic sectors as well as the combustion of biomass in agriculture.
The inventory reports also emissions from the combustion of lubricants based on data collected from waste oil recyclers and quoted in the BEN; from 2002 onwards this estimate is included in the column "Refinery feedstocks" row "Productions", see Annex 5, Table A5.1- National energy balance, year 2004, Primary fuels. From 2004 onwards it has been necessary to use also those quantities (column "Refinery feedstocks" row "Productions", see Annex 5, Table A5.1- National energy balance) to calculate emissions in the reference approach, so to minimize differences with sectoral approach. From 2004 the energy balances prepared by MAP do include those quantities in the input while estimating final consumption; this procedure summarizes a complex stock change reporting by operators.

For most of the combustion source categories, emissions are estimated from fuel consumption data reported in the BEN and an emission factor appropriate to the type of combustion. However the industrial category covers a range of sources and types, so the inventory disaggregates this category into a number of sub-categories, namely:

- Other Industry;
- Other Industry Off-road: See paragraph 3.7;
- Iron & Steel (Combustion, Blast Furnaces, Sinter Plant): See Annex 4;
- Petrochemical industries (Combustion): See Annex 4;
- Other combustion with contact industries: glass and tiles: See Annex 4;
- Other industries (Metal works factories, food, textiles, others);
- Ammonia Feedstock (natural gas only): See Annex 4;
- Ammonia (Combustion) (natural gas only): See Annex 4;
- Cement (Combustion): See Annex 4;
- Lime Production (non-decarbonising): See Annex 4.

Thus the inventory estimate from fuel consumption emission factors refers to stationary combustion in boilers and heaters. The other categories are estimated by more complex methods discussed in the sections indicated. However, for these processes, where emissions arise from fuel combustion for energy production, these are reported under IPCC Table 1A. The fuel consumption of Other Industry is estimated so that the total fuel consumption of these sources is consistent with BEN.

According to the IPCC 1996 Revised Guidelines (IPCC, 1997), electricity generation by companies primarily for their own use is auto-generation, and the emissions produced should be reported under the industry concerned. However, most national energy statistics (including Italy) report emissions from electricity generation as a separate category. The Italian inventory makes an overall calculation and then attempts to report as far as possible according to the IPCC methodology:

- auto-generators are reported in the relevant industrial sectors of section "1.A.2 Manufacturing Industries and Construction", including sector "1.A.2.f. Other";
- iron and steel auto-generation is included in section 1.A.1c.

Those reports are based on GRTN (GRTN, 2006) estimates of fuel used for steam generation connected with electricity production.

Emissions from waste incineration facilities with energy recovery are reported under category 1A4a (Combustion activity, commercial/institutional sector), whereas emissions from other types of waste incineration facilities are reported under category 6C (Waste incineration). For 2004, 95% of the total amount of waste incinerated is treated in plants with energy recovery system.
There has been an overall revision of CO_2 from the iron and steel industry. CO_2 emissions due to the consumption of coke, coal or other reducing agents as fuel used in the iron and steel industry

have been accounted for and reported in the energy sector, including fuel consumption of derived gases. On the other hand, CO_2 emissions from iron and steel industry referring to the carbonates used in sinter plants and basic oxygen furnaces, as well as iron and steel scraps and graphite electrodes used in electric arc furnaces have been accounted for and reported in the industrial processes sector under 2C1.

Recalculations affected the whole time series 1990-2003 and every subsector. The following table shows the percentage differences between the 2006 and 2005 submissions for the total energy sector and by gas.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
								%						
Energy	***0.87***	***0.82***	***1.00***	***0.75***	***0.84***	***-0.17***	***0.20***	***0.25***	***0.49***	***0.10***	***-0.50***	***-0.28***	***0.19***	***0.05***
CO2	0.75	0.66	0.82	0.53	0.61	-0.43	-0.07	-0.01	0.25	-0.14	-0.74	-0.49	0.01	-0.10
CH4	7.73	9.56	10.59	12.45	13.75	14.48	15.44	15.01	14.97	14.39	13.44	12.36	12.62	10.10
N2O	-0.03	0.04	0.03	-0.03	0.00	-0.05	0.06	0.08	0.09	0.19	0.24	0.15	0.13	-0.01

Table 3.1 Emission recalculations in the energy sector 1990-2003 (%)

Recalculations for the year 1990 are mainly related to modifications in the methodology used to estimate CO_2 emissions in the iron and steel industry attributed both to the energy and industrial process sectors; the description of this recalculation has been already reported above in detail. Differences in the time series also regard CH_4, which emissions from venting and flaring in extraction of oil and gas were recalculated on the basis of new information supplied by operators (ENI, 2006) together with the methodology reported in the IPCC good practice guidance (IPCC, 2000). Other minor modifications occurred on account of the updating of basic activity data and a better sectoral allocation of fuel consumption and emissions.

3.4 Energy industries

3.4.1 Electricity production

The source of data on fuel consumption is the annual report “Statistical data on electricity production and power plants in Italy” (“Dati statistici sugli impianti e la produzione di energia elettrica in Italia”), edited from 1999 by the Italian Independent System Operator (GRTN), a public enterprise that runs the high voltage transmission grid. For the period 1990-1998 the same data were published by ENEL (ENEL, several years), the former electricity monopoly. The time series is available since 1963.

In these publications consumptions of all power plants are reported, either public or privately owned. The base data are collected at plant level, on monthly basis. They include electricity production and estimation of physical quantities of fuels and the related energy content; for the biggest installations the energy content is based on laboratory tests. Up to 1999, the fuel consumption was reported at a very detailed level, 17 different fuels, allowing a quite precise estimation of the carbon content. From 2000 onward the published data aggregate all fuels in 5 groups that do not allow for a precise evaluation of the carbon content. In Table 3.2 a copy of the time series 1990-2004 is reported.

For the purpose of calculating GHG emissions, the detailed list of fuels used was delivered to APAT by GRTN for the year 2003. The detailed list is confidential and only the output of the simulation model used to calculate emissions for the years 2003 and 2004 at the aggregated level of Table 3.2 can be reported (see Annex 2).

At national level other statistics on the fuel used for electricity production do exist, the most remarkable being the National Energy Balance (BEN), published annually. Moreover the UP (Unione Petrolifera, Oil companies association) and ENI, the former national oil company, regularly publish data on this issue. In the past, up to the year 1998, also the association of the industrial electricity producers (UNAPACE) published production data with the associated fuel consumption.

	1990	1995	1999	2000	2001	2002	2003	2004
national coal	58	-	96	Solids	Solids	Solids	Solids	Solids
imported coal	10,724	8,216	8,378					
lignite	1,501	380	62	9,633	11,445	13,088	14,252	17,031
Natural gas, m^3	9,731	11,277	19,766	22,334	21,930	22,362	25,534	28,768
BOF(steel converter) gas, m^3	509	633	536	Coal	Coal	Coal	Coal	Coal
Blast furnace gas, m^3	6,804	6,428	8,611	gases	gases	gases	gases	gases
Coke gas, m^3	693	540	660	8,690	9,785	10,034	10,479	10,640
Light distillate	5	6	12	oil	oil	oil	oil	oil
Diesel oil	303	184	560	products	products	products	products	products
Heavy fuel oil	21,798	25,355	17,511	19,352	17,186	17,694	14,993	10,522
Refinery gas	211	378	409					
Petroleum coke	186	189	216					
Orimulsion	-	-	1,688					
Gases from chemical processes	444	803	1,155	Others	Others	Others	Others	Others
Tar	2	-	-			m^3=769	m^3=857	m^3=955
Heat recovered from Pyrite	146	3	-			kt=10,686	kt=12,588	kt=15,031
Other fuels	344	697	1,819	5,153	9,175			

Source: GRTN, 2005

Table 3.2 Time series of power sector production by fuel, kt or 10^6 m^3

Both BEN and GRTN publications could be used for the inventory preparation, as they are part of the national statistical system and published regularly. The preference, up to date, for GRTN data arises from the following reasons:

- BEN data are prepared on the basis of GRTN reports to IEA, so both data sets come from the same source;
- Before being published in the BEN, GRTN data are revised to be adapted to the reporting methodology: balance is done on the energy content of fuels and the physical quantities of fuels are converted to energy using standard conversion factors; so the total energy content of the fuels is the "right" information extracted from the GRTN reports and the physical quantities are changed to avoid discrepancies; the resulting information cannot be cross checked with detailed plant data (collected for the point source evaluation) based on the physical quantities;
- up to the year 1999, the types of fuel used were much more detailed in GRTN database: in BEN the 17 fuels are added up (using energy content) and reported together in 12 categories: emission factors for certain fuels (coal gases or refinery by-products) are quite different and essential information is lost with this process;
- activity data for "BOF converter gas" are not reported in BEN up to 1999, from the year 2000 they are added up to the blast furnace gas;
- finally, the two data sets are never the same, even considering the total energy values of fuels or the produced electricity, there are always small differences, less than 1% -see Annex 2 for details- that increase the already sizable discrepancy between the reference approach and the detailed approach.

In Annex 2 there are summary tables where the differences between BEN and ENEL/GRTN data are detailed by primary fuel for the last two years: 2003 and 2004. For previous years see NIR 2005. The other two statistical publications quoted before, UP (UP, 2006) and ENI (ENI, 2005), have direct access to fuel consumption data from the associated companies, but both rely on GRTN data for the complete picture. Data from those two sources are used for cross checking and estimation of point source emissions.

To estimate CO_2 emissions, and also N_2O and CH_4 emissions, a rather complex calculation sheet is used, see APAT, (APAT, 2003 [a], in Italian) for description. The data sheet summarizes all plants existing in Italy divided by technology, about 60 typologies, and type of fuel used; the calculation sheet can be considered a model of the national power system. For each year, a run estimates the fuel consumed by each plant type, the pollutant emissions and GHG emissions.

The energy data used for the years 2003 and 2004 are reported in Annex 2. The emission factors used are listed in Table 3.7.

The model reports the consumption and GHG emission data according to primary source (oil, coal, natural gas) so that they can be inserted in the CRF. Moreover the model is also able to estimate the energy/emissions data related to the electricity produced and used on site by the main industrial producers. Those data are reported in the industrial sector section, tables 1.A.1.b/c and 1.A.2.

The following Table 3.3 shows an intermediate part of the process, with all energy and emissions summarized by fuel and split in the two main categories of producers: public services and industrial producers for the year 2004. From 1998 onwards the expansion of the industrial cogeneration of electricity and the split of the national monopoly has transformed many industrial producers into "independent producers", regularly supplying the national grid. So part of the energy/emissions of the industrial producers are added to table 1.A.1.a, according to the best information available.

	TJ	C, Kt	CO_2, Kt - Gg
For table 1.A.1, a. Public Electricity and Heat Production			
Liquid fuels	4.09539E+05	8,598.9	31,507.0
Solid fuels	4.42946E+05	11,287.3	41,357.8
Natural gas	9.38442E+05	14,230.1	52,140.3
Refinery gases	1.903E+04	582.0	2,132.3
Coal gases	1.1060E+04	141.8	519.4
Biomass	3.7046E+04	-	-
Other fuels (incl.waste)	3.3552E+04	456.1	1,671.1
Total	**1.8916E+06**	**35,296,1**	**129,327,9**
Industrial producers (Table 1.A.1, a-b-c) and auto-producers, to table "1.A.2 Manufacturing Industries "			
Liquid fuels	4.7027E+03	107.1	392.3
Solid fuels	4.0E+00	0.1	0.4
Natural gas	5.78238E+04	876.8	3,212.7
Refinery gases	3.7876E+03	115.8	424.4
Other refinery products	7.6687E+04	1,678.3	6,149.5
Coal gases	3.6480E+04	2,690.5	9,858.4
Biomass			
Other fuels (incl.waste)	2.977E+02	7.6	28.0
Total	**1.80E+05**	**5,476.3**	**20,065.7**
General total	**2.0714E+06**	**40,772**	**149,394**

Table 3.3 Power sector, Energy/CO_2 emissions in CRF format, year 2004

In Table 3.4 the time series of the total CO_2 emissions deriving from electricity generation activities is reported, including total electricity produced and specific CO_2 emissions for the total production

and for the thermoelectric production only. With reference to the previous year report, emissions from 2000 have been updated, mainly for a revision of emissions from municipal solid waste reported in the CRF under 1.A.4.
The time series clearly shows that although the specific carbon content of the KWh generated in Italy has constantly improved over the years, total emissions are growing due to the even bigger increase of electricity production. Specific thermoelectric emissions are nearly stable from the year 2000 to 2002 because efficiency increases have been balanced by a growing coal share. In 2003 a remarkable improvement is reported in emissions of thermoelectric production, due to the entry into service of more efficient plants, but the improvement was much less in total production due to the reduction of hydroelectric production.

	1990	1995	2000	2001	2002	2003	2004
Total electricity produced (gross)	216.9	241.5	276.6	279.0	284.4	293.9	303.3
Total CO_2 emitted, Mt	128.5	135.7	140.5	138.3	145.4	148.1	149.4
g CO_2 / kwh of gross thermo-electric production	720	693	645	641	641	624	618
g CO_2 / kwh of total gross production	592	562	508	496	511	504	504

Table 3.4 Time series of CO_2 emissions from electricity production

3.4.2 Refineries

The consumption data used come from BEN (MAP, 2006 [a]), the same data are also reported by UP (UP, 2006).
The available data in BEN specify the quantities of refinery gas, petroleum coke and other liquid fuels. They are reported in Annex 5, Table A5.6.
All the fuel used in boilers and processes, the refinery "losses" and the reported losses of crude oil and other fuels (that are mostly due to statistical discrepancies) are considered to calculate emissions. Fuel lost in the distribution network is accounted for here and not in the individual end use sector.
Parts of refinery losses, flares, are reported in CRF table 1.B.2.a and c, using IPCC emission factors, the other emissions are reported in CRF table 1.A.1.b. From 2002 particular attention has been paid to avoid double counting of the CO_2 emissions checking if the individual refineries report sheets already include losses in the energy balances. It is planned to further investigate this aspect as soon as the new comprehensive reporting requirements of the IPPC directive are routinely used. Additional investigation is also planned to find out the fuel used for steam production, part of which presently seems to be allocated to the general industry.
IPCC Tier 2 emission factors and national emission factors are used, refer to Table 3.7. In Table 3.5 a sample calculation for the year 2004 is reported, with energy and emission data. In Table 3.6 GHG emissions in the years 1990, 1995, 2000-2004 are reported.

	Consumption, TJ			CO_2 emissions, kt		
REFINERIES	Petroleum coke	Ref. gas	Liquid fuels	Petroleum coke	Ref. gas	Liquid fuels
			25135			1824
	33269	107294	90100	3319	6661	6836
TOTAL			255798			18639

Table 3.5 Refineries, CO_2 emission calculation, year 2004

	1990	1995	2000	2001	2002	2003	2004
CO_2 emissions, Mt	18.3	18.8	17.6	19.8	18.8	18.7	18.6
CH_4 emissions, kt	0.88	0.72	0.63	0.76	0.74	0.73	0.73
N_2O emissions, kt	0.99	1.03	0.73	0.84	0.78	0.73	0.77
Refinery, total, Mt CO_2 eq	18.7	19.2	17.9	20.1	19.1	18.9	18.9

Table 3.6 Refineries, GHG emission time series

3.4.3 Manufacture of Solid Fuels and Other Energy Industries

In Italy all the iron and steel plants are integrated, so there is no separated reporting for the different part of the process. A few coke and "manufactured gas" producing plants were operating in the early nineties and they have been reported here. Only one small manufactured gas producing plant is still in operation from 2002.

In this section emissions from power plants which use coal gases are also reported. In particular we refer to the electricity generated in the steel plant sites (using coal gases and other fuels).

3.5 Manufacturing industries and construction

Energy consumption for this sector is reported in the BEN, reference Annex 5, Tables A5.9 and A5.10. The data comprise specification of consumption for 13 sub-sectors and more than 25 fuels. Those very detailed data, combined with industrial production data, allow for a good estimation of all the fuel used by most industrial processes (see list in paragraph 3.3). A more sophisticated procedure is used to estimate coal use in steel production and coal gasses used for electricity generation, see paragraph 3.5.1 and Annex 3 for details. The balance of fuel (total consumption less industrial processes consumption) is assumed as used in boilers and heaters in small and medium size enterprises; the emissions are estimated with the emission factors listed in Table 3.7. These factors already contain the correction for the fraction of carbon oxidised (IPCC default values).

	$t\ CO_2$ / TJ	$t\ CO_2$ / t	$t\ CO_2$ / tep
Liquid fuels			
Crude oil	72.549	3.035	3.035
Jet kerosene	70.735	3.078	2.959
Petroleum Coke	99.755	3.464	4.174
Orimulsion	77.733	2.177	3.252
TAR	80.189	3.120	3.355
Gaseous fuels			
Natural gas (dry) 2004 average	55.559	1.96 (sm^3)	2.325
Solid fuels			
Steam coal, 2004 average	93.370	2.428	3.907
"sub-bituminous" coal	96.234	2.557	4.026
Lignite	99.106	1.037	4.147
Coke	105.929	3.102	4.432
Biomass			
Solid Biomass		(1.124)	(4.495)
National emission factors			
Derived Gases	$t\ CO_2$ / TJ		$t\ CO_2$ / tep
Refinery Gas	62.080	3.120	2.60
Coke Gas	41.900	0.380	1.753
Blast furnace – oxygen converter Gas	261.711	1.30	10.950
Fossil fuels, national data			
Fuel oil , 2004 average	76.715	3.163	3.210
Coking coal	95.702	2.963	4.004
Other fuels			
Municipal solid waste	47.877	0.718	2.003
Transport			
Petrol, 1990-99	68.631	3.015	2.872
Petrol, test data, 2000-04	71.145	3.109	2.977
Gas oil, 1990-99	73.274	3.127	3.066
Gas oil, engines, test data, 2000-04	73.153	3.138	3.061
Gas oil, heating, test data, 2000-04	73.693	1.410	3.083
LPG, 1990-99, IPCC	62.392	2.872	2.610
LPG, test data, 2000-04	64.936	2.994	2.717

Table 3.7 Emission Factors for Power, Industry and Civil sector

3.5.1 Estimation of carbon content of coals used in industry

The preliminary use of the CRF software underlined an unbalance of emissions in the solid fuel rows above 20%. A detailed verification pointed out to an already known fact: the combined use of standard IPCC emission factors for coals, national emission factors for coal gases and CORINAIR methodology emission factors for steel works processes can bring to double counting of emissions. The main reason for this is the extensive recovery of coal gases from blast furnaces and coke ovens for electricity generation, a specific national circumstance of Italy.

To avoid double counting, a methodology has been developed: it balances energy and carbon content of coking coals used by steelworks, industry, for non energy purposes and coal gasses used for electricity generation. The detailed procedure is described in Annex 3, here we underline that a balance is made between the input coals for coke production and the quantities of derived fuels used in various sectors. The iron and steel sector gets the resulting quantities of energy and carbon after subtraction of what is used for electricity generation, non energy purposes and other industrial sectors.

3.5.2 Time series

In the following Table 3.8, GHG emissions connected to the use of fossil fuels, process emissions excluded, in the years 1990, 1995 and 2000-2004 are reported. Industrial emissions do show oscillations, connected to economic cycles.

	1990	1995	2000	2001	2002	2003	2004
CO_2 emissions, kt	80,657	76,419	81,028	78,340	75,527	78,477	78,462
CH_4 emissions, t	14,936	14,730	14,343	14,217	13,710	13,954	14,495
N_2O emissions, t	3,325	2,678	3,264	3,204	3,148	3,324	3,307
Industry, total, kt CO_2 eq	82,001	77,559	82,341	79,632	76,791	79,800	79,792

Table 3.8 Manufacturing industry, GHG emission time series

In Table 3.9 the emissions of energy industries (paragraph 3.4), manufacturing industries (paragraph 3.5) and other sectors (paragraph 3.7) are summarized according to key sources categories. From 1990 to 2004 an increase in use of natural gas instead of fuel oil and gas oil in stationary combustion plants has been observed; it results in a decrease of CO_2 emissions from combustion of liquid fuels and an increase of emissions from gaseous fuels.

		1990	2004
CO_2 stationary combustion liquid fuels	kt	155,117	113,917
CO_2 stationary combustion solid fuels	kt	59,395	65,725
CO_2 stationary combustion gaseous fuels	kt	85,065	150,721
CH_4 stationary combustion	t	770	1,135
N_2O stationary combustion	t	6,744	7,137

Table 3.9 Stationary combustion, GHG emissions in 1990 and 2004

3.6 Transport

This sector shows the most pronounced increase in emissions over time, reflecting the huge increase in fuel consumption for road transportation. The mobility demand and particularly the road transportation share have always increased in the time period from 1990 to 2004.

The time series of CO_2, CH_4 and N_2O emissions is reported in Table 3.10. Emissions in the table comprise all the emissions reported in table 1.A.3 of the CRF.

Emission estimates are discussed below for each sub sector.

In general the increase in N_2O emissions is related to the expansion of the car fleet equipped with exhaust gases catalytic converters. On the contrary, methane emissions are quite stable, due to the combined effect of technological improvements that limit VOCs from tail pipe and evaporative emissions (for cars) and the expansion of two-wheelers fleet. It has to be underlined that in Italy there is a remarkable fleet of motorbikes and mopeds (about 9.2 millions vehicles in 2004) that use gasoline and is increasing every year since 1990. Only a small part of this fleet comply with tight VOC emissions controls.

		1990	1995	2000	2001	2002	2003	2004
CO_2	Mt	101.9	112.1	120.4	122.8	124.9	126.0	128.0
CH_4	Mt	0.77	0.95	0.84	0.72	0.65	0.62	0.66
N_2O	Mt	1.72	2.17	3.19	3.34	3.67	3.77	3.97
Total, Mt CO_2 eq.	Mt	104.4	115.2	124.5	126.8	129.2	130.4	132.6

Table 3.10 GHG emissions for the transport sector (Mt)

3.6.1 Aviation

The IPCC requires the estimation of emissions for 1A3ai International Aviation and 1A3aii Domestic Aviation, including figures both from the cruise phase of the flight and the landing and take-off cycles (LTO). According to the methodologies described in the IPCC Good Practice Guidance (IPCC, 1997) and in the EMEP/CORINAIR Guidebook (EMEP/CORINAIR, 2005), a method was devised based on the following assumptions and information:

(i) Total inland deliveries of aviation gasoline and aviation turbine fuel to air transport are provided in the national energy balance BEN (MAP, 2006 [a]), see Annex 5, Table A5.10. This figure is the best approximation of aviation fuel consumption available and it covers international and domestic but not the split between domestic and international;

(ii) Data on annual arrivals and departures of domestic and international landing and take-off cycles at Italian airports are reported by different sources: National Institute of Statistics in the statistics yearbooks (ISTAT, several years), Ministry of Transport in the national transport statistics yearbooks (MINT, 2005) and the Italian civil aviation in the national aviation statistics yearbooks (ENAC/MINT, 2005);

(iii) Total consumption for military aviation is given in the petrochemical bulletin (MAP, 2006 [b]) by fuel. Emissions from military aircraft are reported under 1A5 Other.

(iv) Emission factors and consumption factors for LTO cycles and cruise phases are derived by the EMEP/CORINAIR guidebook (EMEP/CORINAIR, 2005), considering national specificities. These specificities derive from the results of a national study which, taking into account detailed information on the Italian air fleet and the origin-destination flights for the year 1999, calculated default national values for both domestic and international flights (Romano et al., 1999; ANPA, 2001; Trozzi et al., 2002 [a]) on the basis of the emission and consumption factors reported in the EMEP/CORINAIR guidebook. National average emissions and consumption factors were therefore calculated for LTO cycles and cruise both for domestic and international flights.

To carry out national estimates for greenhouse gases and other pollutants in the Italian inventory, consumptions are calculated for the complete time series using the average consumption factors multiplied by the number of flights for LTO, both domestic and international, and for domestic cruise; on the other hand, consumptions for international cruise are derived by difference from the total fuel consumption reported in the national energy balance and the above estimated values.

The current methodology may overestimate emissions from aircraft for the last years. This is because default factors used pertain to older models and the distribution of the international flights between European and extra-European flights has changed from 1999 with an increase of the shortest distances. Currently the use of a more detailed model for estimating aircraft emissions is under consideration, provided the availability of more data on the flights by national and European civil aviation control authorities.

Data on domestic and international aircraft movements from 1990 to 2004 are shown in Table 3.11 where domestic flights are those entirely within Italy. Emission factors are reported in Table 3.12 and Table 3.13. Total fuel consumptions both domestic and international are reported by LTO and cruise in Table 3.14. GHG domestic emissions from the aviation sector are summarised in Table 3.15. Emissions from international aviation are reported for information only and are not included in national totals.

Military aviation emissions cannot be estimated in this way since LTO data are not available. Therefore emissions are calculated by multiplying military fuel consumption data for the EMEP/CORINAIR default emission factors shown in Table 3.13. These factors are appropriate for military aircrafts.

	1990	1995	2000	2001	2002	2003	2004
Domestic flights	186,446	199,585	319,963	303,354	315,010	325,179	313,171
International flights	139,733	184,233	303,747	315,736	293,365	325,755	343,052

Source: ISTAT, several years; ENAC/MINT, 2005

Table 3.11 Aircraft Movement Data (LTO cycles)

	CO_2[a]	SO_2
Aviation Turbine Fuel	859	1.0
Aviation Spirit	865	1.0

a Emission factor as kg carbon/t.

Table 3.12 CO_2 and SO_2 emission factors for Aviation (kg/t) 1990-2004

	Units	CH_4	N_2O	NO_x	CO	NMVOC	Fuel
Domestic LTO	kg/LTO	0.168	0.1	7.913	7.163	1.580	647.6
International LTO	kg/LTO	0.354	0.3	10.840	11.608	3.334	878.4
Domestic Cruise	kg/t fuel	0.048	0.048	14.653	1.617	0.448	-
International Cruise	kg/t fuel	0.058	0.011	15.040	1.241	0.546	-
Aircraft Military [a]	kg/t fuel	0.400	0.2	15.800	126.0	3.600	-

a EMEP/CORINAIR, 2005

Table 3.13 Non-CO_2 Emission Factors for Aviation

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
						kt					
Domestic LTO	132	135	151	163	177	205	218	208	216	226	217
International LTO	123	162	181	196	213	236	267	277	258	286	301
Domestic cruise	387	414	464	502	546	629	664	629	654	675	650
International cruise	1,215	1,662	1,773	1,797	1,952	2,140	2,279	2,015	2,003	2,330	2,320

Source: APAT elaborations

Table 3.14 Aviation fuel consumptions, domestic and international flights (kt)

		1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2 Mobile combustion: Aircraft	kt	1,597	1,691	1,894	2,047	2,228	2,570	2,716	2,580	2,677	2,772	2,668
CH_4 Mobile combustion: Aircraft	t	50	49	52	52	50	53	60	65	70	81	85
N_2O Mobile combustion: Aircraft	t	37	37	39	39	37	40	45	48	53	61	64

Source: APAT elaborations

Table 3.15 GHG emissions from domestic aviation

3.6.2 Railways

The electricity used by the railways for electric traction is supplied from the public distribution system, so the emissions arising from its generation are reported under 1A1a Public Electricity.
Emissions from diesel trains are reported under the IPCC category 1A3c Railways. These estimates are based on the gas oil consumption for railways reported in BEN (MAP, 2006 [a]).
Carbon dioxide, sulphur dioxide and N_2O emissions are calculated on fuel based emission factors using fuel consumption data from BEN. Emissions of CO, NMVOC, NO_x and methane are based on the EMEP/CORINAIR methodology (EMEP/CORINAIR, 2005). The emission factors shown in Table 3.16 are aggregate factors so that all factors are reported on the common basis of fuel consumption.

	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Diesel train	857	0.14	1.2	40.5	4.9	3.6	2.8

Source: EMEP/CORINAIR, 2005

Table 3.16 Railway Emission Factors (kt/Mt)

3.6.3 Road Transport

Emissions from road transport are calculated either from a combination of total fuel consumption data and fuel properties or from a combination of drive related emission factors and road traffic data.

3.6.3.1 Fuel-based emissions

Emissions of carbon dioxide and sulphur dioxide from road transport are calculated from the consumption of gasoline, diesel, LPG and natural gas and the carbon - sulphur content of the fuels consumed. Consumption data for the fuel consumed by road transport in Italy are taken from the BEN (MAP, 2006 [a]), refer to Annex 5, Tables A5.9 and A5.10, in physical units (rows "III - Road transportation" and "VI - Public Service", subtracting the quantities for military use in diesel oil and off-road uses in petrol).

Emissions of CO_2, expressed as kg carbon per tonne of fuel, are based on the H/C ratio of the fuel; emissions of SO_2 are based on the sulphur content of the fuel. Values of the fuel-based emission factors for CO_2 from consumption of petrol and diesel fuels are shown in Table 3.17. These factors already contain the correction for the fraction of carbon oxidised.

Values for SO_2 vary annually as the sulphur-content of fuels change and are shown in UP (UP, 2006).

National emission factors	t CO_2 / TJ	t CO_2 / t
Mtbe	73.121	-
Petrol, 1990-'99, IPCC OECD[a]	68.631	3.015
Petrol, test data, 2000-04[b]	71.145	3.109
Gas oil, 1990-'99, IPCC OECD[a]	73.274	3.127
Gas oil, engines, test data, 2000-04[b]	73.153	3.137
LPG, 1990-'99, IPCC[a]	62.392	2.872
LPG, test data, 2000-04[b]	64.936	2.994
Natural gas (dry) 2004	55.559	-
Fuel oil , 2004 average	76.715	-

a Revised 1996 IPCC Guidelines for National GHG Inventories, Reference Manual, ch1, tables 1-36 to 1-42

b Emission factor in kg carbon/tonne, based on APAT (APAT, 2003 [b])

Table 3.17 Fuel-Based Emission Factors for Road Transport

Emissions of CO_2 and SO_2 can be broken down by vehicle type based on estimated fuel consumption factors and traffic data in a manner similar to the traffic-based emissions described below for other pollutants. The 2004 inventory used fuel consumption factors expressed as g fuel per kilometre for each vehicle type and average speed calculated from the emission functions and speed-coefficients provided by COPERT III (EEA, 2000).

Fuel consumptions calculated from these functions are shown in Table 3.18 for each vehicle type, emission regulation and road type in Italy. A normalisation procedure was used to ensure that the breakdown of gasoline and diesel consumption by each vehicle type calculated on the basis of the fuel consumption factors added up to the BEN figures for total fuel consumption in Italy (adjusted for off-road consumption). Evaporative emissions are not shown in the table.

SNAP CODE	Sub sector	Type of fuel	Tons of fuel consumed	Mileage, KM_KVEH
070101	PC Hway	diesel	2,997,831	51,882,116
070101	PC Hway	gasoline	2,859,750	51,658,001
070101	PC Hway	lpg	338,776	5,631,884
070102	PC rur	diesel	4,187,719	87,682,304
070102	PC rur	gasoline	4,097,834	94,330,062
070102	PC rur	lpg	338,058	7,509,178
070103	PC urb	diesel	1,825,833	22,754,672
070103	PC urb	gasoline	5,717,266	63,458,293
070103	PC urb	lpg	429,171	5,631,884
070201	LDV Hway	diesel	1,128,779	10,728,042
070201	LDV Hway	gasoline	51,179	758,829
070202	LDV rur	diesel	1,805,974	29,502,116
070202	LDV rur	gasoline	140,871	2,086,779
070203	LDV urb	diesel	1,486,424	13,410,052
070203	LDV urb	gasoline	149,752	948,536
070301	HDV Hway	diesel	4,788,818	20,398,426
070301	HDV Hway	gasoline	991	6,007
070302	HDV rur	diesel	2,726,485	13,806,993
070302	HDV rur	gasoline	2,703	18,021
070303	HDV urb	diesel	1,518,706	4,788,396
070303	HDV urb	gasoline	1,352	6,007
070400	mopeds	gasoline	515,933	16,350,502
070501	Moto Hway	gasoline	46,135	1,315,414
070502	Moto rur	gasoline	249,234	9,207,900
070503	Moto urb	gasoline	471,528	15,784,971
Total				529,655,384

Source: APAT elaborations

Notes: PC, passenger cars ; LDV, light duty vehicles ; HDV, heavy duty vehicles; Moto, motorcycles; Hway, highway speed traffic; rur, rural speed traffic; urb, urban speed traffic; biodiesel included in diesel

Table 3.18 Average fuel consumption and mileage for main vehicle category and road type, year 2004

The following Table 3.19 summarizes the time series of GHG emissions in CO_2 equivalent from road transport, highlighting the evolution of this fast growing source.

		1990	1995	2000	2001	2002	2003	2004
CO_2	kt	93,616	95,930	100,347	102,417	102,535	104,153	104,545
CH_4	kt	743	789	852	874	897	915	930
N_2O	kt	1,605	1,620	1,679	1,758	1,888	2,062	2,236

Table 3.19 GHG emissions from road transport (kt CO_2 equivalent)

3.6.3.2 Traffic-based emissions

Emissions of NMVOC, NO_X, CO, CH_4 and N_2O are calculated from emission factors expressed in grams per kilometre and road traffic statistics estimated by APAT on data released from Ministry of Transport (MINT, 2005). The emission factors are based on experimental measurements of emissions from in-service vehicles of different types driven under test cycles with different average speeds calculated from the emission functions and speed-coefficients provided by COPERT III (EEA, 2000). This source provides emission functions and coefficients relating emission factors (in g/km) to average speed for each vehicle type and Euro emission standard derived by fitting experimental measurements to polynomial functions. These functions were then used to calculate emission factor values for each vehicle type and Euro emission standard at each of the average speeds of the road and area types.

The road traffic data used are vehicle kilometre estimates for the different vehicle types and different road classifications in the national road network. These data have to be further broken down by composition of each vehicle fleet in terms of the fraction of diesel- and petrol-fuelled vehicles on the road and in terms of the fraction of vehicles on the road made to the different emission regulations which applied when the vehicle was first registered. These are related to the age profile of the vehicle fleet.
Additional data are required for the estimation of consumption of buses, because the available traffic data seldom distinguish beyond “heavy vehicles”. Moreover traffic data on motorcycles are not exhaustive. In both cases the energy consumption is estimated on the basis of the oil companies' reports on sold fuels.
It is beyond the scope of this paper to illustrate in details the COPERT III methodology: in brief the emissions from motor vehicles fall into three different types calculated as hot exhaust emissions, cold-start emissions and, for NMVOC and methane, evaporative emissions.
Hot exhaust emissions are emissions from the vehicle exhaust when the engine has warmed up to its normal operating temperature. Emissions depend on the type of vehicle, type of fuel the engine runs on, the driving profile of the vehicle on a journey and the emission regulations applied when the vehicle was first registered as this defines the type of technology the vehicle is equipped with.
For a particular vehicle, the drive cycle over a journey is the key factor which determines the amount of pollutant emitted.
Key parameters affecting emissions are acceleration, deceleration, steady speed and idling characteristics of the journey, as well as other factors affecting load on the engine such as road gradient and vehicle weight. However, studies have shown that for modelling vehicle emissions over a road network at national scale, it is sufficient to calculate emissions from emission factors in g/km related to the average speed of the vehicle in the drive cycle (EEA, 2000). Emission factors for average speeds on the road network are then combined with the national road traffic data.

Emissions are calculated from vehicles of the following types:

- Gasoline cars;
- Diesel cars;
- Gasoline Light Goods Vehicles (Gross Vehicle Weight (GVW) <= 3.5 tonnes);
- Diesel Light Goods Vehicles (Gross Vehicle Weight (GVW) <= 3.5 tonnes);
- Rigid-axle Heavy Goods Vehicles (GVW > 3.5 tonnes);
- Articulated Heavy Goods Vehicles (GVW > 3.5 tonnes);
- Buses and coaches;
- Motorcycles.
-

Detailed data on the national fleet composition can be found in the yearly report from ACI (ACI, 2005).
In the following Tables 3.20, 3.21 and 3.22 detailed data on the relevant vehicles in the circulating fleet between 1990 and 2004 are reported, subdivided according to the main emission regulations that applied when the vehicle was sold.

	1990	1995	2000	2004
Older than 20 years, PRE ECE	0.005	0.007		
1972 -1977, ECE 15.00/.01	0.142	0.017	0.009	0.008
1978 -1986, ECE 15.02/.03	0.277	0.178	0.039	-
1987 -1989, ECE 15.04	0.159	0.103	0.061	0.028
1990 - 1992, ECE 15.04	0.417	0.388	0.264	0.160
91/441/EC, from 1/1/93, euro 1	0.000	0.308	0.218	0.183
94/12/ EC, from 1-1-97 , euro 2		0.000	0.410	0.292
98/69/EC, from 1/1/2001, euro 3 / 4				0.330
Totals	1.000	1.000	1.000	1.000

Source: APAT elaborations on ACI data

Table 3.20 Gasoline cars technological evolution: circulating fleet calculated as stock data multiplied by effective mileage (%)

	1990	1995	2000	2004
Older than 15 years, PRE ECE	0.006	0.009	-	-
1972 -1977, ECE 15.00/.01	0.008	0.000	0.009	-
1978 -1985, ECE 15.02/.03	0.248	0.103	-	0.005
1985-1989, ECE 15.04	0.359	0.285	0.053	0.014
1990 - 1992, ECE 15.04	0.378	0.390	0.109	0.033
91/441/EC, from 1/1/93, euro 1	0.000	0.213	0.127	0.050
94/12/ EC, from 1-1-97 , euro 2	-	-	0.702	0.242
98/69/EC, from 1/1/2001, euro 3/4	-	-	-	0.656
Totals	1.000	1.000	1.000	1.000

Source: APAT elaborations on ACI data

Table 3.21 Diesel cars technological evolution: circulating fleet calculated as stock data multiplied by effective mileage (%)

	1990	1995	2000	2004
pre -1985	0.60	0.32	0.18	0.05
1985-1989, Dir 88/77/EWG	0.29	0.26	0.17	0.08
1990 - 1992	0.11	0.21	0.14	0.08
1/gen/93 - 31/dic/95	-	0.10	0.07	0.06
from 1/1/96, Dir. 91/542 EEC, euro I	-	0.10	0.19	0.13
from 1/1/97, Dir. 91/542 EEC, euro II	-	-	0.25	0.30
from 1/1/2001, Dir. 99/96, euro III	-	-	-	0.30
Totals	1.00	1.00	1.00	1.00

Source: APAT elaborations on ACI data

Table 3.22 Trucks technological evolution: circulating fleet for light duty (%)

Average emission factors are calculated for average speeds on three specified types of roads and combined with the number of vehicle kilometres travelled by each type of vehicle on each of these road types:

- Urban
- Rural
- Motorway.

APAT estimates total annual vehicle kilometres for the road network in Italy by vehicle type, see Table 3.23, on the basis of data from various sources:

- Ministry of Transport (MINT, 2005) for rural roads and on other motorway; the latter estimates are based on traffic counts from the rotating census and core census surveys of ANAS;
- highway industrial association for fee-motorway;

- local authorities for built-up areas (urban).

	1990	1995	2000	2003	2004
All passenger vehicles, total mileage (10^9 veh-km/y)	339	394	426	454	459
Car fleet (10^6)	27.7	31.0	32.9	34.3	34.9
Goods transport, total mileage (10^9 veh-km/y)	65	66	79	82	90
Truck fleet (10^6), including LDV	3.0	3.3	3.7	4.4	4.5

Source: APAT elaborations

Table 3.23 Evolution of fleet consistency and mileage

When a vehicle engine is cold it emits at a higher rate than when it has warmed up to its designed operating temperature. This is particularly true for gasoline engines and the effect is even more severe for cars fitted with three-way catalysts, as the catalyst does not function properly until the catalyst is also warmed up. Emission factors have been derived for cars and LGVs from tests performed with the engine starting cold and warmed up. The difference between the two measurements can be regarded as an additional cold-start penalty paid on each trip a vehicle is started with the engine (and catalyst) cold.

Evaporative emissions of petrol fuel vapour from the tank and fuel delivery system in vehicles constitute a significant fraction of total NMVOC and methane emissions from road transport. The procedure for estimating evaporative emissions of NMVOCs and methane takes account of changes in ambient temperature and fuel volatility.

3.6.4 Navigation

This source category includes all emissions from fuels delivered to water-borne navigation.

Emissions of the Italian inventory from the navigation sector are carried out according to the CORINAIR methodology which provides estimates from Coastal Shipping, Fishing, Naval Shipping and International Marine. Coastal Shipping has been mapped onto 1A3dii National Navigation and Fishing onto 1A4ciii Fishing (EMEP/CORINAIR, 2005).

The emissions reported under Coastal Shipping, Naval Shipping and Fishing are estimated according to the base combustion datasheet using the emission factors given in Table 3.17.

The CORINAIR category International Marine is the same as the IPCC category 1A.3i International Marine. The methodology developed to estimate emissions is based on the following information and assumptions:

- Total deliveries of fuel oil, gas oil and marine diesel oil to marine transport are given in national energy balance (MAP, 2006 [a]) but the split between domestic and international is not provided;
- Naval fuel consumption for inland waterways, ferries connecting mainland to islands and leisure boats, is also reported in the national energy balance;
- Emission factors and consumption factors for national and international traffic derive from the results of a specific research which, taking into account detailed information on the Italian marine fleet and the origin-destination matrix for the year 1999, calculated default national values (ANPA, 2001; Trozzi et al., 2002 [b]) on the basis of emission factors reported in the EMEP/CORINAIR guidebook. National emissions were also divided into harbour activities and national cruise
- National consumption is estimated using the consumption factors provided by the study referring to the year 1999 whereas consumption for international cruise is derived by difference from the total fuel consumption reported in the national energy balance and the national consumption estimate.

In Table 3.24 the time series resulting from the above described methodology is shown. Data include the amounts of marine fuels reported by the national energy balance splitted in fuel consumption for domestic use, in the national harbours or for travel within two Italian destinations, and bunker fuels used for international travels. Carbon dioxide emissions relevant to the national total are also reported.

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Estimates of fuels used for domestic travels (kt)	778	706	802	843	888	859	875	871	851	867	866
Estimate of fuel in harbours (dom+int ships) (kt)	748	693	794	824	868	844	864	860	841	856	856
Estimate of fuel in international Bunkers (kt)	1,398	1,286	911	975	982	982	1,224	1,389	1,591	1,784	1,941
CO_2 Mobile combustion: Waterborne Navigation (kt)	5,401	5,095	5,726	5,936	6,219	6,072	6,201	6,194	6,064	6,162	6,132

Source: APAT elaborations

Table 3.24 Marine fuel consumptions in domestic and international travels (kt) and CO_2 emissions from domestic navigation (kt)

Emission estimates from 1A.3i International Marine are reported for information only and are not included in national totals.

3.7 Other sectors

The estimation procedure follows that of the base combustion data sheet, emissions are estimated from the energy consumption data and the emission factor illustrated in Table 3.7.
The category ‘Other sectors’ comprises emissions from agriculture, fisheries, residential, commercial and others. The national energy balance (refer to Annex 5, Tables A5.9 and A5.10, in physical units, row “DOMESTIC AND COMMERCIAL USES”, subtracting the quantities for military use in diesel oil and off-road uses in petrol) does separate energy consumption between civil and agriculture-fisheries, but it does not distinguish between Commercial – Institutional and Residential. The total consumption of each fuel is subdivided on the basis of the estimations reported by ENEA in its annual energy report (ENEA, 2006).
Emissions from 1A.4b Residential and 1A.4c Agriculture/Forestry/Fishing are disaggregated into those arising from stationary combustion and those from off-road vehicles and other machinery. The estimation of emissions from off-road sources is discussed in paragraph 3.7.2. Emissions from fishing vessels are estimated from fuel consumption data (MAP, 2006 [a]) and emission factors are shown in Table 3.7.

3.7.1 Other combustion

Emissions from military aircraft and naval vessels are reported under 1A.5b Mobile. The method of estimation is discussed in paragraph 3.6.1 and 3.6.4.
Emissions from off-road sources are estimated and they are reported under the relevant sectors, i.e. Other Industry, Residential, Agriculture and Other Transport. The methodology of these estimates is discussed in paragraph 3.7.2.

3.7.2 Other off-road sources

This category covers emissions from a range of portable or mobile equipment powered by reciprocating diesel or petrol driven engines. They include agricultural equipment such as tractors and combine harvesters; construction equipment such as bulldozers and excavators; domestic lawn mowers; aircraft support equipment; and industrial machines such as portable generators and compressors. In the CORINAIR inventory they are grouped into four main categories (EMEP/CORINAIR, 2005):

- domestic house & garden
- agricultural power units (includes forestry)
- industrial off-road (includes construction and quarrying)
- aircraft support.

Those categories are mapped to the appropriate IPCC classes: Aircraft support is mapped to Other Transport and the other categories map to the off-road vehicle subcategories of Residential, Agriculture and Manufacturing Industries and Construction.
Estimates are calculated using a modification of the methodology given in EMEP/CORINAIR (EMEP/CORINAIR, 2005). This involves the estimation of emissions from around seventy classes of off-road source using the following equation for each class:

$$Ej = Nj \cdot Hj \cdot Pj \cdot Lj \cdot Wj \cdot (1 + Yj \cdot aj /2) \cdot Ej$$

where

Ej = Emission of pollutant from class j	(kg/y)
Nj = Population of class j.	
Hj = Annual usage of class j	(hours/year)
Pj = Average power rating of class j	(kW)
Lj = Load factor of class j	(-)
Yj = Lifetime of class j	(years)
Wj = Engine design factor of class j	(-)
aj = Age factor of class j	(y-1)
ej = Emission factor of class j	(kg/kWh)

For petrol engined sources, evaporative NMVOC emissions are also estimated as:

$$Evj = Nj \cdot Hj \cdot evj$$

where

Evj = Evaporative emission from class j	kg
evj = Evaporative emission factor for class j	kg/h

Population data have been revised based on a survey of machinery sales (Frustaci, 1999). Machinery lifetime is estimated on the European averages, see EMEP/CORINAIR (EMEP/CORINAIR, 2005), the annual usage data were taken either from industry or published data (EEA, 2000). The emission factors used came mostly from EMEP/CORINAIR and from Samaras (EEA, 2000). The load factors were taken from Samaras (EEA, 2000).
It was possible to calculate fuel consumptions for each class based on fuel consumption factors given in EMEP/CORINAIR (EMEP/CORINAIR, 2005). Comparison with known fuel consumption for certain groups of classes (e.g. agriculture and construction) suggested that the population method overestimated fuel consumption by factors of 2-3, especially for industrial vehicles.

Estimates were derived for fuel consumptions for the years 1990-2004 for each of the main categories:

A. Agricultural power units: Data on gas oil consumption were taken from ENEA (ENEA, 2006). The consumption of gasoline was estimated using the population method for 1995 without correction. Time series is reconstructed in relation to the fuel used in agriculture.

B. Industrial off-road: The construction component of the gas oil consumption was calculated from the Ministry of Production Activities data (MAP, 2006 [a]) on building and construction. The industrial component of gas oil was estimated from the population approach for 1995. Time series is reconstructed in relation to the fuel use in industry.

C. Domestic house & garden: gasoline and diesel oil consumption were estimated from the EMEP/CORINAIR population approach for 1995. Time series is reconstructed in relation to the fuel use in agriculture.

Emissions from off-road sources are particularly uncertain. The revisions in the population data produced higher fuel consumption estimates. The gasoline consumption increased markedly but is still only a tiny proportion of total gasoline sales.

3.8 International Bunkers

The methodology used to estimate the quantity of fuels used from international bunkers in aviation and maritime navigation has been illustrated in the relevant transport paragraphs, 3.6.1 and 3.6.4. The methodology implements the IPCC guidelines according to the available statistical data.

3.9 Feedstock and non-energy use of fuels

In Table 3.25 and 3.26 detailed data on petrochemical and other non-energy use for the year 2003 are given.

Data are based on a rather detailed yearly report available by MAP. The report summarizes answers from a detailed questionnaire that all operators in Italy prepare monthly. The data are more detailed than those normally available by international statistics and refer to:

- input to plants (gross input);
- quantities of fuels returned to the marked (with possibility to estimate the net input);
- fuels used internally for combustion;
- quantities stored in products.

In the energy balances only the input and output quantities from the petrochemical plants are reported, so it may be that the output quantity is greater than the input quantity, due from internal transformation. Therefore it is possible to have negative values for some products mainly gasoline, refinery gas, fuel oil.

With these data it is possible to estimate the quantities of fuels stored in product in percentage on net and gross petrochemical input, see Table 3.26 for details by product and Table 3.25 for the overall figure. The data of Table 3.25 are reported also as a note in CRF table 1.A(d). As can be seen from the value reported for the year 2004 there is a sizeable difference of the estimated quantities of fuel stored in product if reference is made to “net” or “gross” input. Moreover the estimation of quantities stored in product are quite different from those reported in the Revised 1996 IPCC Guidelines for National GHG Inventories, Reference Manual, ch1, tables 1-5 (IPCC, 1997).

An attempt was made to estimate the quantities stored in products using IPCC percentage values as reported in table 1-5 and the fuels reported as “petrochemical input” in Table 3.26. The resulting estimate of about 6,897 kt of products for the year 2004, is more than 39% bigger than the quantities reported, 4,948 kt, see Table 3.25.

At national level this methodology seems the most precise according to the available data. The European Project “Non Energy use-CO_2 emissions” ENV4-CT98-0776 has analysed our methodology performing a mass balance between input fuels and output products in a sample year. The results of the project confirm the reliability of the reported data (Patel and Tosato, 1997).

With reference to the data of Table 3.27, those non energy products are mainly outputs of refineries. The estimate refers to quantities produced that are reported by manufacturers and summarized by BEN. The data should not be controversial. Minor differences in the overall energy content of those products do occur if the calculation is based on national data or IPCC default values.

BREAKDOWN OF TOTAL PETROCHEMICAL FLOW					
		Petroch. Input	Returns to refin./market	Internal consumption / losses	Quantity stored in products
ALL ENERGY CARRIERS, kt		10932	3442.3	2541.7	4948.1
	% of total input		31.5%	23.2%	45.3%
	% of net input			33.9%	66.1%

Table 3.25 Other non energy uses, year 2004

FUEL TYPE		**Petroch. Input kt**	**Returns to refinery/ market kt**	**Internal consumption / losses kt**	**Quantity stored in products kt**	**% on gross input**	**% on net input**	**Emission factor (IPCC) t C / t**
LPG		431	450.2	39.2	-58.4			0.8137
Refinery gas		233	113	816.6	-696.6			0.8549
Virgin naphtha		5,405	8.26	0	5,396.8			0.8703
Gasoline		1,065	1,921.1	0	-856.1			0.8467
Kerosene		867	599.4	9.9	257.7			0.8485
Gas oil		1,095	165.8	0	929.2			0.8569
Fuel oil		1,038	62.0	907.7	68.3			0.8678
Petroleum coke		0	0	0	0.0			0.955
Others (feedstock)		96	122.7	12.2	-38.9			0.8368
Losses				68.1	-68.1			0.8368
Natural gas		702	0	688	14.0			0.743
	total	10,932	3442.3	2541.7	4,948.1	45%	66%	

Table 3.26 Petrochemical, detailed data from MAP, year 2004 (MAP, detailed petrochemical breakdown)

NON ENERGY FROM REFINERIES	Quantity stored in products kt	Energy content IPCC '96	Emission factor t C / t	Total energy content, IPCC values TJ
Bitumen + tar	3,654	40.19	0.8841	146.9
lubricants	1,294	40.19	0.8038	52.0
recovered lubricant oils	0	40.19	0.8038	0.0
paraffin	54	40.19	0.8368	2.2
others (benzene, others)	901	40.19	0.8368	36.2
Totals	5,903			237.2

Table 3.27 Other non energy uses, year 2004, MAP 2006[a]

3.10 Country specific issues

3.10.1 National energy balance

Italian energy statistics are based mainly on BEN, National Energy Balance, which is annually edited by MAP. The report is quite reliable, by international standards, and it may be useful to summarize its main features:

- it is a balance, every year professional people carry out the exercise balancing final consumption data with import-export information;
- the balance is made on the energy value of energy carriers, taking into account transformations that may occur in the energy industries (refineries, coke plants, electricity production);
- data are collected regularly by the Ministry of Production Activities, on a monthly basis, from industrial subjects;
- oil products, natural gas and electricity used by industry, civil or transport sectors are taxed with excise duties linked to the physical quantities of the energy carriers; those excise duties are differentiated between products and between final consumption sectors (i.e. diesel oil for industrial use pays duties lower than for transportation use and higher than for electricity production; even bunker fuels have a specific registration paper that state that they are sold without excise duties;
- from the point of view of energy consumption information this system produces highly reliable data: BEN is always based on registered quantities of energy consumption, not on estimates; uncertainties may be present in the effective final destination of the product but total quantities are reliable;
- coal is an exception to this rule, it is not subject to excise duties; consumption information are estimates; anyway it is nearly all imported and it is used by a limited number of operators; all of them are monitored on a monthly basis by the Ministry of Production Activities.

3.10.2 National emission factors

Monitoring of the carbon content of the fuels used nationally is an ongoing activity at APAT. The principle is to analyse regularly the chemical composition of the used fuel or relevant activity statistics, to estimate the carbon content and the emission factor. National emission factors are reported in Tables 3.7 and 3.17.
The specific procedure followed for each primary fuel (natural gas, oil, coal) is reported in Annex 6.

3.11 Fugitive emissions from solid fuels, oil and natural gas

Fugitive emissions in this source category originate from the production and transformation of solid fuels, the production of oil and gas, the transmission and distribution of gas and from oil refining. Trends in fugitive emissions are summarised in Table 3.28.
Totally, fugitive emissions, in CO_2 equivalent, account for 1.5% out of the total emissions in the energy sector. Both CH_4 and CO_2 emissions show a reduction from 1990 to 2004 by 25% and 18%, respectively.
The decrease of CO_2 fugitive emissions is driven by the reduction in crude oil losses in refineries. The trend of CH_4 fugitive emissions from solid fuels is related to the extraction of coal and lignite that in Italy is quite low while the decrease of CH_4 fugitive emissions from oil and natural gas is due by the reduction of losses in pipelines for gas transportation and distribution, and to the gradual replacement of old pipelines.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2															
Solid fuels	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil and natural gas	3,048	2,990	2,926	3,084	2,913	2,843	2,692	2,875	2,768	2,091	2,298	2,183	1,924	2,497	1,822
CH4															
Solid fuels	122	112	112	82	71	65	60	60	55	53	73	81	78	95	64
Oil and natural gas	7.273	7.233	7.273	7.193	7.020	6.767	6.668	6.642	6.721	6.524	6.371	6.034	5.859	5.772	5.623

Table 3.28 Fugitive emissions from oil and gas 1990-2004 (Gg CO_2 eq.)

The results of key source analysis are shown in the following box.

Key-source identification in the fugitive sector with the IPCC Tier1 and Tier2 approaches

1B2	CH_4	Fugitive emissions from oil and gas operations	Key (L, T)
1B2	CO_2	Fugitive emissions from oil and gas operations	Key (T1)

Specifically, methane emissions from oil and gas operations are a key source according to the level and trend assessment both Tier 1 and Tier 2 approaches. CO_2 emissions from oil and gas operations are also a key source for trend assessment, Tier 1. The uncertainty in methane and CO_2 emissions from oil and gas operations is estimated to be 25% as a combination of 3% and 25% for activity data and emission factors, respectively.

Fugitive emissions from solid fuels, reported in 1.B.1, are not relevant. In fact, CH_4 emissions from coal mining refer to only two mines, one of which is underground and produces lignite and the other, on the surface, produces coal with very low production in the last ten years. CH_4 emissions from solid fuel transformation refer to the coke production in the iron and steel industry, which is also decreasing in the last years.
CH_4 emissions from coal mining have been estimated on the basis of activity data published on the National Energy Balance (MAP, 2006 [a]) and emission factors provided by the IPCC guidelines (IPCC, 1997). CH_4 emissions from coke production have been estimated on the basis of activity data published in the national statistical yearbooks (ISTAT, several years) and emission factors reported in the EMEP/CORINAIR Guidebook (EMEP/CORINAIR, 2005). CO_2 emissions from 1.B.1 are not occurring. The uncertainty in methane emissions from coal mining and handling is estimated to be 300% as combination of 3% and 300% for activity data and emission factors, respectively.

Fugitive CO_2 emissions reported in 1.B.2 refer to fugitive emissions in refineries during petroleum production processes, e.g. fluid catalytic cracking, and flaring. Emissions have been estimated on the basis of activity data published in the National Energy Balance (MAP, 2006 [a]) or supplied by industry (UP, 2006) and operators especially in the framework of the European emissions trading scheme. CO_2 emissions from other activities in 1.B.2 do not occur.
CH_4 emissions reported in 1.B.2 refer mainly to the production of oil and natural gas and to the transmission in pipelines and distribution of natural gas. CH_4 emissions from the production of oil and natural gas have been calculated on the basis of activity data published in the National Energy Balance (MAP, 2006 [a]) and by industry (UP, 2006), and emission factors published on the IPCC Good practice Guidance (IPCC, 2000). CH_4 emissions from the transmission in pipelines and distribution of natural gas have been estimated on the basis of activity data published by industry and competent national authority and information collected annually by the Italian gas operators. More in details, emission estimates take into account the information regarding the amount of natural gas distributed (ENI, 2006), length of pipelines distinct by low, medium and high pressure and by type, iron, grey iron, steel or polyethylene pipelines (AEEG, 2005), natural gas losses

reported in the national energy balance (MAP, 2006 [a]) methane emissions reported by operators in their environmental reports (ENI, 2006; EDISON, 2005); estimates include emissions emitted in the different phases of distribution and transmission of gas including losses in pumping stations and in reducing pressure stations. Emissions are verified considering emission factors reported in literature and detailed information supplied by the main operators (ENI, 2006; Riva, 1997). More detailed on the methodology used and on the basic information collected from operators are reported in a technical paper (Contaldi, 1999).

For the completeness of the CRF tables pertaining to these emissions, in particular 1.B.2, the rationale beyond the values reported and not reported is explained below.
CH_4 fugitive emissions from oil exploration are included in those from production because no detailed information is available. Emissions from transport and distribution of oil result as not occurring. CH_4 emissions from gas exploration are also included in those from production while other leakage emissions are included in distribution emission estimates. Further investigation will be carried out with industry about these figures.
CH_4 emissions from venting are included in production, respectively for oil under 1.B.2.a and natural gas under 1.B.2.b, as not separately supplied by the relevant industries.
CH_4 emissions from gas flaring are also included in production under 1.B.2.b.
A summary of the completeness of CH_4 fugitive emissions is shown in the following Table 3.29.

1.B. 2.a. Oil		
i. Exploration	CH_4	Included in 1.B.2.a production
1.B.2.b. Natural Gas		
i. Exploration	CH_4	Included in 1.B.2.b production
iii. Other leakage	CH_4	Included in 1.B.2.b distribution
1.B. 2.c. Venting and flaring		
i. Oil	CH_4	Included in 1.B.2.a production
ii. Gas	CH_4	Included in 1.B.2.b production

Table 3.29 Completeness of CH_4 fugitive emissions

Chapter 4: INDUSTRIAL PROCESSES [CRF sector 2]

4.1 Overview of sector

Included in this category are by-products or fugitive emissions which originate from industrial processes. Where emissions are released simultaneously from the production process and from combustion, as in the cement industry, these are estimated separately and included in category 1A2. All greenhouse gases as well as CO, NO_x, NMVOC and SO_2 emissions are estimated.
In 2004 industrial processes account for 5.5% of CO_2 emissions, 0.1% of CH_4, 18.7% of N_2O, 100% of PFCs, HFCs and SF_6. In term of CO_2 equivalent, industrial processes share 7.2% of total national greenhouse gas emissions.
The trends of greenhouse gas emissions from the industrial processes sector are summarised in Table 4.1. Emissions are reported in Gg for CO_2, CH_4 and N_2O and in Gg of CO_2 equivalent for F-gases. An increase in HFC emissions is observed from 1990 to 2004, while CO_2 emissions from chemical and metal industry reduced sharply.
It should be noted that the base year for fluorinated gases has been changed from 1995 to 1990.

Gas/ subsource	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2 (Gg)															
2A. Mineral Products	21,100	21,052	21,863	19,407	18,914	20,768	19,076	19,320	19,576	20,384	21,266	22,096	22,089	22,986	23,832
2B. Chemical Industry	2,186	2,089	2,051	1,461	1,197	1,223	962	1,035	1,041	958	1,062	1,034	1,082	1,243	1,328
2C. Metal Production	3,983	3,686	3,446	3,620	3,497	3,483	3,054	2,810	2,602	1,994	1,826	1,776	1,612	1,551	1,611
CH_4 (Gg)															
2B. Chemical Industry	2.45	2.43	2.40	2.28	2.49	2.65	0.60	0.62	0.59	0.59	0.40	0.33	0.33	0.31	0.33
2C.Metal Production	2.71	2.51	2.43	2.59	2.58	2.71	2.39	2.61	2.52	2.46	2.61	2.50	2.38	2.45	2.57
N_2O (Gg)															
2B. Chemical Industry	21.54	22.81	21.11	21.65	20.36	23.35	22.66	22.78	23.06	23.56	25.54	26.55	25.49	24.38	27.24
HFCs	351	355	359	355	482	671	450	755	1,181	1,452	2,005	2,761	3,568	4,590	5,699
PFCs	1,808	1,452	850	707	477	491	243	252	270	258	346	452	414	484	407
SF_6	333	356	358	370	416	601	683	729	605	405	493	795	738	486	602

Table 4.1 Trend in greenhouse gas emissions from the industrial process sector, 1990-2004

Seven key sources have been identified for this sector, for level and trend assessment, using both the Tier 1 and Tier 2 approaches. The results are reported in the following box.

Key-source identification in the industrial processes sector with the IPCC Tier1 and Tier2 approaches

2A	CO_2	Emissions from cement production	Key (L, T2)
2F	HFC, PFC	Emissions from substitutes for ODS	Key (L, T)
2B	N_2O	Emissions from adipic acid	Key (L, T)
2C	CO_2	Emissions from iron and steel production	Key (T1)
2B	CO_2	Emissions from ammonia production	Key (T1)
2A	CO_2	Emissions from lime production	Key (L1)
2C	PFC	Emissions from aluminium production	Key (T1)

CO_2 emissions from cement production and lime production are included in category 2A; N_2O emissions from adipic acid and CO_2 emissions from ammonia refer both to 2B; PFCs from aluminium production are included in 2C as CO_2 emissions from iron and steel production; HFC and PFC consumption as substitutes for Ozone Depleting Substances are included in 2F. Methane emissions from the sector are not a key source.

4.2 Mineral products (2A)

4.2.1. Source category description

In this sector the main source of emissions is CO_2 from cement production (2A1) which is, as already mentioned, a key source and accounts for 3.1% of the total national emissions.
CO_2 emissions also occur from processes where lime is produced and account for 0.46% of the total national emissions while CO_2 emissions due to the limestone and dolomite use accounts for 0.43% of the total national emissions. CO_2 emissions from lime production are a key source at level assessment with the Tier1 approach.
CO_2 emissions from decarbonising in glass production have been estimated and reported in other.
CO_2 emissions from soda ash production are also included in this category.
Asphalt roofing and road paving with asphalt activities contribute only with NMVOC emissions.

4.2.2. Methodological issues

IPCC Guidelines and Good Practice Guidance are used to estimate emissions (IPCC, 1997; IPCC, 2000).
Activity data are supplied in the national statistical yearbooks (ISTAT, several years) and by industries. Emission factors are those provided by the IPCC Guidelines (IPCC, 1997; IPCC, 2000), by the EMEP/CORINAIR guidebook (EMEP/CORINAIR, 2005) or by other international Guidebooks (USEPA, 1997).
CO_2 emissions from cement production are estimated by the IPCC Tier 2 approach. Activity data comprise data on clinker production provided by ISTAT (ISTAT, several years). Emission factors are estimated on the basis of information provided by the plants and by the Italian Cement Association (AITEC, 2003; AITEC, 2004; AITEC, 2005) in the framework of the European emission registry (EPER) and the European emission trading scheme. In this latter context, all cement production plants reported fuel consumption and emissions, split between combustion process and decarbonising process. The resulting emission factor for cement production is equal to 540 kg CO_2/ton clinker, based on the average CaO content in the clinker and taking in account the contribute of carbonates and additives.
The emission factor has been suggested to the operators by AITEC (AITEC, 2004) on the basis of a tool provided by the World Business Council for Sustainable Development and available on the website http://www.ghgprotocol.org/standard/tools.htm.
CO_2 emissions from lime have been estimated on the basis of production activity data supplied by ISTAT (ISTAT, several years) adding the amount of lime used in the sugar and iron and steel production sectors; emission factors have been estimated on the basis of detailed information supplied by plants in the framework of the European emission trading scheme. Specifically, in 2004 the implied emission factor is equal to 800 kg CO_2/ton lime production.
CO_2 emissions from limestone and dolomite use are related to the use of limestone and dolomite in bricks, tiles and ceramic production. In the CRF the total amount of limestone and dolomite used in these processes is reported as activity data and it has been estimated on the basis of the average content of $CaCO_3$ in the different products. Detailed production activity data and emission factors are derived by bricks and ceramic industry (ANDIL, 2000; ANDIL, 2004; ASSOPIASTRELLE, 2004; ASSOPIASTRELLE, 2005) and they have been supplied in the framework of the European emission trading scheme.
CO_2 emissions from soda ash production have been estimated on account of information available on the Solvay process (Solvay, 2003), whereas those from soda ash use are included both in glass and paper production.
CO_2 emissions from glass production have been estimated by production activity data (ISTAT, several years) and emission factors estimated on the basis of information supplied by plants in the framework of the European emission trading scheme.

NMVOC emissions from asphalt roofing and road paving have been estimated by production activity data (ISTAT, several years) and default emission factors (EMEP/CORINAIR, 2005).

4.2.3. Uncertainty and time-series consistency

The uncertainty in CO_2 emissions from cement, lime, limestone and dolomite use and glass production is estimated to be equal to 10.4% from each activity, as a combination of 3% and 10% for activity data and emission factor, respectively.
Emission trends are related to the production which are in particular increasing for lime and glass and decreasing for fine ceramics.

4.2.4. Source-specific QA/QC and verification

CO_2 emissions have been checked with the relevant industrial associations.
Both activity data and average emission factors are compared every year with data reported in the national EPER registry and in the European emissions trading scheme.

4.2.5. Source-specific recalculations

On account of new information available by the relevant industrial association and by the plants, especially in the framework of the European emission trading scheme, the time series of lime production have been recalculated. Specifically, the recalculation occurred for the whole time series because official data on lime production supplied by ISTAT do not include the lime produced by smaller production plants and the autoproduction and they represent only 80% of the total production (CAGEMA, 2005). The time series of activity data and emission recalculations are shown in Table 4.2.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
2005 submission														
Lime production (kt)	2,176	2,163	2,155	2,279	2,262	2,407	2,176	2,253	2,151	2,146	2,280	2,444	2,430	2,624
CO_2 emissions (Gg)	1,711	1,698	1,699	1,797	1,783	1,899	1,717	1,775	1,694	1,691	1,798	1,941	1,941	2,092
2006 submission														
Lime production (kt)	2,583	2,563	2,569	2,718	2,697	2,873	2,597	2,683	2,561	2,557	2,760	2,958	2,951	3,174
CO_2 emissions (Gg)	2,042	2,025	2,036	2,155	2,138	2,279	2,060	2,126	2,029	2,026	2,185	2,358	2,365	2,540
Δ emissions (%)	*16,2*	*16,1*	*16,6*	*16,6*	*16,6*	*16,7*	*16,7*	*16,5*	*16,5*	*16,5*	*17,7*	*17,7*	*17,9*	*17,6*

Table 4.2 Production activity data (kt) and recalculations of CO_2 (Gg) in the lime production sector 1990-2003

Emissions from limestone and dolomite use have also been recalculated; emissions from limestone and dolomite used in the iron and steel production sector have been removed from this activity and accounted for only in the 2C sector to avoid double counting.

For the 2A sector, recalculations result in a decrease of emissions for the whole time series from 3.7% in 1990 to 2.2% in 2003. The time series of recalculated emissions are shown in Table 4.3.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
2005 submission														
CO_2 emissions (Gg)	21,875	21,737	22,500	20,094	19,602	21,479	19,697	20,032	20,249	21,045	21,923	22,664	22,575	23,483
2006 submission														
CO_2 emissions (Gg)	21,100	21,052	21,863	19,407	18,914	20,768	19,076	19,320	19,576	20,384	21,266	22,096	22,089	22,986
Δ emissions (%)	*-3.7*	*-3.3*	*-2.9*	*-3.5*	*-3.6*	*-3.4*	*-3.3*	*-3.7*	*-3.4*	*-3.2*	*-3.1*	*-2.6*	*-2.2*	*-2.2*

Table 4.3 Recalculations of CO_2 emissions (Gg) in the mineral products sector 1990-2003

4.2.6. Source-specific planned improvements

No further improvements are planned.

4.3 Chemical industry (2B)

4.3.1. Source category description

CO_2, CH_4 and N_2O emissions from chemical productions are estimated and included in this sector. Emissions from adipic acid production are supplied and referenced by the Italian producer (Radici Chimica, 1993; Radici Chimica, 2006). Specifically, for N_2O, adipic acid is a key source at level and trend assessment, both with the Tier 1 and Tier 2 approach. These emissions account for 14.7% of total N_2O emissions in 2004. CO_2 emissions from this source are also estimated and reported in the CRF under other chemical industry.
CO_2 emissions from ammonia production are also a key source, at trend assessment with the Tier 1 approach. In fact, these emissions show a relevant decrease in the last years as a consequence of the reduction in production.
N_2O emissions from nitric acid production are not a key source although they also show a relevant decrease in emissions from 1990 due to a reduction in production.
CO_2 emissions from carbon black and dioxide titanium production have been estimated on the basis of information supplied directly by the Italian production plants.
In the 2006 submission, N_2O emissions from caprolactame production have been estimated for the whole time series; emissions from this activity refer to the only one plant which closed in 2003.
Carbide production is not occurring in Italy while CH_4 emissions have been estimated for ethylene, propylene and carbon black production but total emission are not relevant.
The time series of production data related to ammonia, nitric and adipic acids are reported in the following Table 4.4.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Ammonia (kt)	1,455	1,392	1,358	885	612	592	397	446	409	367	414	430	474	578	648
Nitric acid (kt)	1,037	988	937	725	532	588	545	560	480	432	556	527	542	539	616
Adipic acid (kt)	49	54	50	55	55	64	62	62	65	68	71	75	74	69	78

Table 4.4 Production of ammonia, nitric acid and adipic acid (kt) from 1990 to 2004

4.3.2. Methodological issues

Italian production figures and emission estimates for adipic acid have been provided by the process operator (Radici Chimica, 2006) for the whole time series. N_2O emissions from adipic acid production (2B3) have been estimated using the default IPCC emission factor equal to 0.30 kg N_2O/kg adipic acid produced because abatement technology is not yet working on the production plants. Actually, in 2004, the abatement technology has been tested so that the value of emission factor has been reduced taking into account the efficiency and the time, one month, which the technology operated. In 2005 the N_2O abatement technology should be fully operating.
Ammonia production data are published in the international industrial statistical yearbooks (UN, several years) and they have been checked with information reported in the national EPER registry. For the years 1990-2001 CO_2 emission factors, equal to 1.175 t CO_2/t ammonia production, have been calculated on the basis of information reported by the production plants for 2002 and 2003 in the framework of the national EPER registry. This value has been used for the whole time series in consideration that no modifications to the production plants have occurred over the period. For the years 2002-2004 the average emission factors result from data reported by the plants in EPER. Natural gas is used as feedstock in the ammonia production plants and the amount of fuel used is included in the energy balance under the no energy final consumption sector (see Annex 5), therefore double counting does not occur.
With regard to nitric acid production (2B2), N_2O emissions have been recalculated for the whole time series on the basis of a detailed analysis of information reported in the framework of the national EPER registry and information collected directly from the plants. Production figures at

national level are published in the national statistical yearbooks (ISTAT, several years), while at plant level have been collected from industry (Norsk Hydro, 2006). The N_2O average emission factors have been recalculated from 1990 on the basis of EFs supplied by the existing production plants in the EPER registry, applied for the whole time series, and default IPCC emission factors for low and medium pressure plants attributed to the plants, now closed, where it was not possible to collect detailed information. The implied emission factor varies year by year depending on the production levels of the different plants and it is equal to 6.5 and 9.5 kg N_2O/Mg nitric acid production, in 1990 and in 2004 respectively.
N_2O emissions from caprolactame have been estimated on the basis of basic information supplied by the only plant present in Italy, production activity data published by ISTAT (ISTAT, several years), and data reported in the EPER registry. The average emission factor is equal to 0.3 kg N_2O/Mg caprolactame production. The plant closed in 2003.
CO_2 emissions from carbon black production process have been estimated, and reported in the CRF under other chemical industry, on the basis of information supplied by the Italian production plants in the framework of the EPER registry and the European emissions trading scheme. The average implied emission factor is equal to 2.33 t CO_2/t carbon black production.

4.3.3. Uncertainty and time-series consistency

The uncertainty in N_2O emissions from adipic and nitric acid and caprolactame production and in CO_2 emissions from ammonia and for other chemical production is estimated 10.4%, for each activity, as combination of uncertainties equal to 3% and 10% for activity data and emission factors, respectively.
Adipic acid emission trends are directly related to the production while nitric acid emissions are related to a reduction in production, and to the closure of the old technology plants. Adipic acid production is increasing whereas nitric acid production and emissions show a decrease in the last years.
Total CO_2 emissions from ammonia have decreased as a result of a relevant reduction in production while CO_2 emissions from other chemical production have increased.

4.3.4. Source-specific QA/QC and verification

Emissions from adipic, nitric acid, ammonia and other chemical industry production have been checked with the relevant process operators and with data reported to the national EPER registry.

4.3.5. Source-specific recalculations

On account of detailed information collected by industry, N_2O emissions from nitric acid production have been recalculated for the whole time series. In the 2006 submission, N_2O emissions from caprolactame, previously not estimated, have been reported. The recalculation in N_2O emissions accounts for a decrease of 1.1% and an increase of 6.6% for 1990 and 2003, respectively.
Total recalculation in CO_2 equivalent emissions for the chemical industry category (2B) results in a decrease of 0.8% and an increase of 5.6% for 1990 and 2003, respectively.
The time series of CO_2 equivalent emission recalculations for the 2B sector is reported in Table 4.5.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
2005 submission														
CO_2 eq. (Gg)	8,986	9,268	8,697	8,141	7,477	8,428	7,876	7,998	8,111	8,235	8,874	8,841	8,556	8,311
2006 submission														
CO_2 eq. (Gg)	8,914	9,211	8,645	8,221	7,561	8,518	8,000	8,111	8,202	8,274	8,988	9,273	8,990	8,807
Δ emissions (%)	*-0,8*	*-0,6*	*-0,6*	*1,0*	*1,1*	*1,1*	*1,6*	*1,4*	*1,1*	*0,5*	*1,3*	*4,7*	*4,8*	*5,6*

Table 4.5 Recalculations of CO_2 equivalent (Gg) emissions in the chemical production sector 1990-2003

4.3.6. Source-specific planned improvements

No further improvements are planned

4.4 Metal production (2C)

4.4.1. Source category description

The sub-sector metal production comprises four sources: iron and steel production, ferroalloys production, aluminium production and magnesium foundries; CO_2 emissions from iron and steel production and PFC emissions from aluminium production are key sources at Tier 1 trend analysis.
CO_2 emissions from steel production refer to carbonates used in basic oxygen furnaces and crude iron and electrodes in electric arc furnaces. CO_2 emissions from pig iron production refer to carbonates used in sinter and pig iron production. CO_2 emissions from iron and steel production due to the fuel consumption in combustion processes are estimated and reported in the energy sector (1A2a) to avoid double counting.
CH_4 emissions from steel production are estimated on the basis of emission factors derived from the IPPC "Bref Report" (IPPC, 2001) and the EMEP/CORINAIR "Guidebook" (EMEP/CORINAIR, 2005) and refer to Basic Oxygen furnace, Electric furnaces and Rolling mills. Therefore values are entered in "Other". CH_4 emissions from coke production are fugitive emissions during solid fuel transformation and have been reported in Table 1B1b of the CRF.
The share of CO_2 emissions from metal production accounts, in the year 2004, for 0.3% of the national total CO_2 emissions, and 6.0% of the total CO_2 from industrial processes.
The share of CH_4 emissions is, in the year 2004, equal to 0.1% of the national total CH_4 emissions while N_2O emissions do not occur.
The share of F-gas emissions from metal production out of the national total F-gas levels was 67.2% in the base-year and has decreased to 2.3% (0.02% of the national total greenhouse gas emissions) in the year 2004.

4.4.2. Methodological issues

CO_2 and CH_4 emissions from the sector have been estimated on the basis of activity data published in the national statistical yearbooks (ISTAT, several years), reported in the framework of the European emission registry (EPER) and the European emission trading scheme, and supplied by industry (FEDERACCIAI, 2004) and emission factors reported in the EMEP/CORINAIR Guidebook (EMEP/CORINAIR, 2005), in sectoral studies (APAT, 2003; CTN/ACE, 2000) or supplied directly by industry (FEDERACCIAI, 2004).
More in detail CO_2 emissions from iron and steel production refer to the carbonates used in the sinter plant and in basic oxygen furnaces to remove impurities and to the steel and pig iron scraps and graphite electrodes consumed in electric arc furnaces. The amount of carbonates used in sinter plants have been collected directly by industry, especially in the framework of the European emissions trading scheme; the average emission factor in 1990 was equal to 0.15 t CO_2/t pig iron production, while in 2004 it reduced to 0.053 t CO_2/t pig iron production. The reduction is driven by the increase in the use of lime instead of carbonates in sinter and blast furnaces in the Italian plants. Emissions are reported under pig iron because they are emitted as CO_2 in the blast furnaces producing pig iron. Carbonates used in basic oxygen furnaces have been estimated on the basis of information collected by industry (FEDERACCIAI, 2004) and data reported in the European emission trading scheme; CO_2 average emission factor in electric arc furnaces, equal to 0.035 t CO_2/t steel production, has been supplied by industry (FEDERACCIAI, 2004; APAT, 2003) and it has been calculated on the basis of equation 3.6B of the IPCC Good Practice Guidance (IPCC, 2000) taking into account the pig iron and steel scraps and graphite electrodes used in the furnace. Implied emission factors for steel reduced from 0.053 to 0.022 t CO_2/t steel production, from 1990 to 2004, due to the use of lime instead of limestone and dolomite in the basic oxygen furnaces. CO_2 emissions due to the consumption of coke, coal or other reducing agents used in the iron and steel industry have been accounted for as fuel consumption and reported in the energy sector, including fuel consumption of derived gases; as request by the expert review team the energy and carbon

balance in the iron and steel sector has been carried out. Detailed explanations are reported in Annex 3.
CH_4 emissions from steel production, reported in "Other", have been estimated on the basis of emission factors derived from the IPPC specific BREF Report (available at http://eippcb.jrc.es) and the EMEP/CORINAIR Guidebook (EMEP/CORINAIR, 2005) and refer to basic oxygen furnace, electric furnaces and rolling mills.
CO_2 emissions from ferroalloys have been estimated on the basis of activity data published in the national statistical yearbooks (ISTAT, several years) and average default emission factor, equal to 2.407 t CO_2/t ferroalloys production, reported in the IPCC Guidelines (IPCC, 1997).
PFC emissions from aluminium production, key source at trend assessment calculated with Tier 1, have been estimated using both IPCC Tier 1 and Tier 2 methodologies. These emissions, specifically CF_4 and C_2F_6, have been calculated on the basis of information provided by the national primary aluminium producer, with reference to the document drawn up by the International Aluminium Institute (IAI, 2003) and the IPCC Good Practice Guidance (IPCC, 2000).
The Tier 1 has been used to calculate PFC emissions relating to the entire period 1990-1999. As from the year 2000, the more accurate Tier 2 method has been followed, based on default technology specific slope and overvoltage coefficients.
Regarding the Tier 1 methodology, the emission factors for CF_4 and C_2F_6 were provided, whereas for the Tier 2 site specific values and, where they were not available, default coefficients were provided (ALCOA, 2004). In the following tables (Tables 4.6, 4.7, 4.8, 4.9) the EFs and the default parameters used are reported; site specific values are confidential but they have been supplied to the inventory team.

	Technology specific emissions (kg CF_4 / t Al)		
	1990 - 1993	**1994 - 1997**	**1998 - 2000**
Center Work Prebake	0.4	0.3	0.2
Point Fed Prebake	0.3	0.1	0.08
Side Work Prebake	1.4	1.4	1.4
Vertical Stud Søderberg	0.6	0.5	0.4
Horizontal Stud Søderberg	0.7	0.6	0.6

Table 4.6 Historical default Tetrafluoromethane (CF_4) emission values by reduction technology type

	Technology multiplier factor
Center Work Prebake	0.17
Point Fed Prebake	0.17
Side Work Prebake	0.24
Vertical Stud Søderberg	0.06
Horizontal Stud Søderberg	0.09

Table 4.7 Multiplier factor for calculation of Hexafluoroethane (C_2F_6) by technology type

	Baked Anode Properties (weight percent)		
	Sulphur	**Ash**	**Impurities**
Portovesme	ssv*	ssv	DV** = 0.4
Fusina	DV = 1.6	ssv	DV = 0.4

* site specific value
** default value

Table 4.8 Coefficients used for estimation with the Tier 2 methodology by plant

	Pitch content in green anodes (weight%)	**Hydrogen content in pitch** (weight%)	**Recovered tar** (kg/t BAP)	**Packing coke consumption** (t Pcc/ t BAP)	**Sulphur content of packing coke** (weight%)	**Ash content of packing coke** (weight%)
Portovesme	ssv	ssv	DV = 0	DV = 0.05	DV = 3	DV = 5
Fusina	ssv	DV = 4.45	DV = 0	DV = 0.05	DV = 3	DV = 5

Table 4.9 Coefficients used for estimation with the Tier 2 methodology by plant

At present in Italy there are two primary aluminium production plants, which use a prebake technology with point feeding (CWPB), characterised by low emissions. These plants have been progressively upgraded from a Side Work Prebake technology to Point Fed Prebake technology; three old plants with Side Work Prebake technology and Vertical Stud Søderberg technology stopped operation in 1991 and 1992. CO_2 emissions from aluminium production have been also estimated on the basis of activity data published in the national statistical yearbooks (ISTAT, several years) and default emission factor reported by industry (ALCOA, 2004) and by the IPCC Guidelines (IPCC, 1997) which refer to the prebaked anode process; emission factor has been assumed equal to 1.55 t CO_2/t primary aluminium production for the whole time series.
For SF_6 used in magnesium foundries, according to the IPCC Guidelines (IPCC, 1997), emissions are estimated from consumption data made available by the company which operates the only magnesium foundry located in Italy (Magnesium products of Italy, 2005). The plant started its activity in September 1995.

4.4.3. Uncertainty and time-series consistency

The combined uncertainty in PFC emissions from primary aluminium production is estimated to be about 11% in annual emissions, 5% and 10% concerning respectively activity data and emission factors; the uncertainty for SF_6 emissions from magnesium foundries is estimated to be about 7%, 5% for both activity data and emission factors. The uncertainty in CO_2 emissions from the sector is estimated to be 10.4%, for each activity, while for CH_4 emissions about 50%.
In Table 4.10 emission trends of CO_2 from iron and steel, aluminium and ferroalloys production are reported. The decreasing of CO_2 emissions from iron and steel sector is driven by the use of lime instead of limestone and dolomite to remove impurities in pig iron and steel while emissions from aluminium and ferroalloys are driven by the production levels.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Iron and steel (Gg)	3,124	2,963	2,854	3,071	2,972	2,898	2,324	2,147	1,951	1,480	1,225	1,239	1,187	1,125	1,179
Aluminium (Gg)	359	338	249	241	272	276	286	291	290	290	294	291	295	297	303
Ferroalloys (Gg)	499	384	342	307	252	310	444	372	362	224	307	247	129	129	129
Total (Gg)	*3,983*	*3,686*	*3,446*	*3,620*	*3,497*	*3,483*	*3,054*	*2,810*	*2,602*	*1,994*	*1,826*	*1,776*	*1,612*	*1,551*	*1,611*

Table 4.10 Trends in CO_2 emissions from metal production in Gg, 1990 – 2004

In Table 4.11 the emission trend of F-gases per compound from metal production is given.

COMPOUND	**1990**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
	Gg CO_2 equivalent										
CF_4 (PFC-14)	1,289.2	235.8	119.9	122.0	122.8	122.0	168.1	198.1	168.1	226.4	133.1
C_2F_6 (PFC-16)	384.1	61.7	28.8	29.4	29.5	29.3	30.6	36.0	30.6	41.2	24.2
Total PFC emissions from aluminium production	*1,673.4*	*297.5*	*148.7*	*151.4*	*152.3*	*151.3*	*198.7*	*234.1*	*198.6*	*267.6*	*157.3*
Total SF_6 emissions from magnesium foundries	0.0	0.0	12.0	15.5	23.9	35.9	172.1	449.9	400.1	135.2	94.3
Total F-gas emissions from metal production	**1,673.4**	**297.5**	**160.6**	**166.9**	**176.2**	**187.2**	**370.8**	**684.0**	**598.7**	**402.8**	**251.5**

Table 4.10 Actual F-gas emissions per compound from metal production in Gg CO_2 equivalent, 1990 – 2004

The consistency of the time series of PFC emissions from aluminium production has been verified, as two different methodologies have been used on the basis of the information provided by the industry (ALCOA, 2004). The results have been also presented during the in-country review of the 2005 GHG Italian inventory submission. In Table 4.12 two time-series are reported, one calculated with only the Tier 1 methodology and the other calculated with both the Tier 1 and Tier 2 methodologies as mentioned above. The trend of PFC emissions calculated with the Tier 1 methodology shows lower values compared to that calculated with the Tier 2 methodology (except for C_2F_6 value for the year 2004).

COMPOUND	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Tier 1											
CF_4 (t)	198.3	36.3	18.4	18.8	18.9	18.8	19.0	18.8	19.1	19.2	19.6
C_2F_6 (t)	41.8	6.7	3.1	3.2	3.2	3.2	3.2	3.2	3.2	3.3	3.3
Tier 1 and Tier 2											
CF_4 (t)	198.3	36.3	18.4	18.8	18.9	18.8	25.9	30.5	25.9	34.8	20.5
C_2F_6 (t)	41.8	6.7	3.1	3.2	3.2	3.2	3.3	3.9	3.3	4.5	2.6

Table 4.12 Comparison between PFC emissions from aluminium production in tonnes, calculated with only theTier 1 methodology and with both theTier 1 and Tier 2 methodologies

The decreasing of SF_6 consumption in the magnesium foundry from 2003 is due to the abandonment of recycling plant and the optimisation of mixing parameters (see Table 4.11).

4.4.4. Source-specific QA/QC and verification

Emissions from the iron and steel sector and from aluminium production are checked with the relevant process operators.

4.4.5. Source-specific recalculations

As suggested during the in-country review in 2005, on the basis of information collected by industry especially in the framework of the European emission trading scheme a complete revision of emissions from the iron and steel sector has been done, both in the energy and in the industrial processes sectors.
CO_2 emissions due to the limestone and dolomite use in sinter plants, previously accounted for and reported under 2A3, limestone and dolomite use sector, have been calculated and reported in 2C1, iron and steel sector; CO_2 emissions from carbonates used in basic oxygen furnaces have been revised from 1995 on the basis of information collected by the plants, especially in the framework of the European emissions trading scheme; repartition of steel production between basic oxygen furnaces and electric arc furnaces has been slightly modified from 2000 on the basis of data collected from the European emissions trading scheme.
Moreover a full carbon cycle from the sector has been realised such as the balance of carbon and energy for the whole time series, and CO_2 emissions due to the use of coal and coke as both fuel and reducing agent have been estimated and reported in the energy sector, under 1A2a.
The time series of CO_2 emission recalculations for the 2C1 sector is reported in Table 4.13.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
2005 submission														
CO_2 emissions (Gg)	1,346	1,338	1,290	1,393	1,409	1,501	1,313	1,393	1,380	1,345	1,412	1,374	1,348	1,384
2006 submission														
CO_2 emissions (Gg)	3,124	2,963	2,854	3,071	2,972	2,898	2,324	2,147	1,951	1,480	1,225	1,239	1,187	1,125
Δ emissions (%)	56,9	54,8	54,8	54,6	52,6	48,2	43,5	35,1	29,3	9,1	-15,3	-10,9	-13,5	-22,9

Table 4.13 Recalculations of CO_2 emissions (Gg) in the iron and steel sector (2C1) 1990-2003

The Aluminium Industry participated in the in-country review of the 2005 GHG Italian inventory submission to explain in details the primary aluminium process and the related PFC emissions. Some points were clarified and on account of the explanation figures have been corrected: for the Fusina plant, the conversion from Side Work Prebake to Center Work Prebake was completed in 1996 instead of 1995 (ALCOA, 2005).
For the years 1994 and 1995, primary aluminium production has been updated (Sotacarbo, 2004).
Moreover, updated data for PFC emissions have been communicated for the year 2003 (ALCOA, 2006).
For the year 2003, magnesium industry has communicated the updated SF_6 emission value.
In Table 4.14 the comparison between total estimation recalculated and previous estimation of the sector is given in percentages from 1990 to 2003.

COMPOUND	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total PFC emissions from aluminium production	0.00%	103.99%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-3.29%
Total SF_6 emissions from magnesium foundries	-	-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.23%

Table 4.14 Differences in percentages between F-gas emissions from aluminium production and magnesium foundries reported in the 2006 time series and the 2005 submission

4.4.6. Source-specific planned improvements
No further improvements are planned.

4.5 Other production (2D)

4.5.1. Source category description
Only indirect gas and SO_2 emissions occur from these sources.
In this sector, non-energy emissions from pulp and paper as well as food and drink production, especially wine and bread, are reported. CO_2 from food and drink production (e.g. gasification of water) can be of biogenic or non-biogenic origin but only information on CO_2 emissions of non-biogenic origin should be reported in the CRF.
According to the information provided by industrial associations, CO_2 emissions do not occur, but only NMVOC emissions originate from these activities. CO_2 emissions from food and beverage included in previous submissions have been removed since they originated from sources of carbon that are part of a closed cycle.
As regards the pulp and paper production, NO_X and NMVOC emissions as well as SO_2 are estimated.

4.6 Production of halocarbons and SF_6 (2E)

4.6.1. Source category description
The sub-sector production of halocarbons and SF_6 consists of two sources, "HFC-23 emissions from HCFC-22 manufacture" and "Fugitive emissions", identified as non-key sources.
The share of emissions of F-gases from the production of halocarbons and SF_6 in the national total of F-gases was 24.3% in the base-year 1990 and 0.3% in 2004; the share in the national total greenhouse gas emissions was 0.12% in the base-year and 0.003% in 2004.

4.6.2. Methodological issues

For source category ”HFC-23 emissions from HCFC-22 manufacture”, the IPCC Tier 2 method is used, based on plant-level data communicated by the national producer (Solvay-Solexis, 2006); since 1996, data are adjusted for HCFC-22 destruction.
Also for source category “Fugitive emissions”, emission estimates are based on plant-level data communicated by the national producer (Solvay-Solexis, 2006).

4.6.3. Uncertainty and time-series consistency

The uncertainty in F-gas emissions from production of halocarbons and SF_6 is estimated to be about 11% in annual emissions.
In Table 4.15 an overview of the emissions from production of halocarbons and SF_6 is given for the 1990-2004 period, per compound.
HFC-23 emissions from HCFC-22 had already been drastically reduced in 1988 due to the installation of a thermal afterburner in the plant located in Spinetta Marengo. Productions and emissions from 1990 to 1995 are constant as supplied by industry; from 1996, untreated leaks have been collected and sent to the thermal afterburner, thus allowing reduction of emissions to zero.
PFC and SF_6 emissions are constant from 1990 to 1995 and from 1996 to 1998, reducing to zero from 1999 due to the installation of the thermal afterburner mentioned above. PFCs are by-product emissions, whereas SF_6 production stopped from the 1st of January 2005.
Regarding fugitive emissions, emissions of HFC-134a have been cut in 1999 thanks to a rationalisation in the new production facility located in Porto Marghera, whereas HFC-125 and HFC-143 released as by-products from the production of HFC-134a have been recovered and commercialised.

COMPOUND	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	Gg CO_2 equivalent										
HFC 23	351.0	351.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total HFC 23 emissions from HCFC 22 manufacture	*351.0*	*351.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
HFC 125	0.0	28.0	22.4	98.0	56.0	5.6	2.8	5.6	5.6	11.2	2.8
HFC 134a	0.0	39.0	41.6	52.0	65.0	15.6	15.6	15.6	15.6	7.8	11.7
HFC 143a	0.0	22.8	22.8	30.4	38.0	3.8	3.8	3.8	0.0	3.8	3.8
HFC 227ea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CF_4	97.5	97.5	32.5	32.5	32.5	0.0	0.0	0.0	0.0	0.0	0.0
PFC C2÷C3	36.8	36.8	9.2	9.2	9.2	0.0	0.0	0.0	0.0	0.0	0.0
SF_6	119.5	119.5	47.8	47.8	47.8	0.0	0.0	0.0	0.0	0.0	0.0
Total F gas fugitive emissions	*253.8*	*343.6*	*176.3*	*269.9*	*248.5*	*25.0*	*22.2*	*25.0*	*21.2*	*22.8*	*18.3*
Total F-gas emissions from production of halocarbons and SF_6	**604.8**	**694.6**	**176.3**	**269.9**	**248.5**	**25.0**	**22.2**	**25.0**	**21.2**	**22.8**	**18.3**

Table 4.15 Actual emissions of F-gases per compound from production of halocarbons and SF_6 in Gg CO_2 equivalent, 1990 – 2004

4.7 Consumption of halocarbons and SF_6 (2F)

4.7.1. Source category description

The sub-sector consumption of halocarbons and SF_6 consists of three sources, “HFC, PFC emissions from ODS substitutes”, key source at level and trend assessment, both Tier 1 and 2 approaches, “PFC, HFC, SF_6 emissions from semiconductor manufacturing”, “SF_6 emissions from electrical equipment”, that are non-key sources. The share of emissions of F-gases from the consumption of halocarbons and SF_6 in the national total of F-gases was 8.6% in the base-year 1990 and 96% in 2004; the share in the national total greenhouse gas emissions was 0.04% in the base-year and 1.1% in 2004.

4.7.2. Methodological issues

The methods used to calculate emissions of F-gases from the consumption of halocarbons and SF_6 are presented in the following box:

Sub-sources of F-gas emissions and calculation methods

Source category	Sub-source	Calculation method
HFC, PFC emissions from ODS substitutes	Refrigeration and air conditioning equipment (2F1)	IPCC Tier 2a
	Foam blowing (2F2)	IPCC Tier 2a
	Fire extinguishers (2F3)	IPCC Tier 2a
	Aerosols/metered dose inhalers (2F4)	IPCC Tier 2a
PFC, HFC, SF_6 emissions from semiconductor manufacturing (2F6)		IPCC Tier 2a
SF_6 emissions from electrical equipment (2F7)		IPCC Tier 3b

Basic data have been supplied by industry: specifically, for the air conditioning equipment the national motor company and the agent's union of foreign motor-cars vehicles has provided the yearly consumptions (FIAT, 2006; IVECO, 2006; UNRAE, 2006; CNH, 2006); pharmaceutical industry has provided aerosols/metered dose inhaler data (Sanofi Aventis, 2006; Boehringer Ingelheim Istituto De Angeli, 2006; Chiesi Farmaceutici, 2006; GSK, 2006; Lusofarmaco 2006; Menarini, 2006); the semiconductor manufacturing industry has supplied consumption data for four national plants (ST Microelectronics, 2006; MICRON, 2006); finally, for the sub-source fire extinguishers, the European Association for Responsible Use of HFCs in Fire Fighting has been contacted (ASSURE, 2005).
SF_6 emissions from electrical equipment have been estimated according to the IPCC Tier 2a approach from 1990 to 1994, and IPCC Tier 3b from 1995. SF_6 leaks from installed equipment have been estimated on the basis of the total amount of sulphur hexafluoride accumulated and average leakage rates; leakage data published in environmental reports have also been used for major electricity producers (ANIE, 2006). Additional data on SF_6 used in high voltage gas-insulated transmission lines have been supplied by the main energy distribution companies.
The IPCC Tier 1a method has been used to calculate potential emissions, using production, import, export and destruction data provided by the national producer (Solvay Solexis, 2006).

4.7.3. Uncertainty and time-series consistency

The combined uncertainty in F-gas emissions from HFC, PFC emissions from ODS substitutes and PFC, HFC, SF_6 emissions from semiconductor manufacturing is estimated to be about 58% in annual emissions, 30% and 50% concerning respectively activity data and emission factors; the uncertainty in SF_6 emissions from electrical equipment is estimated to be 11.1% in annual emissions, 5% and 10% concerning respectively activity data and emission factors.
In Table 4.16 an overview of the emissions from consumption of halocarbons and SF_6 is given for the 1990-2004 period, per compound. In Table 4.17 an overview of the potential emissions is given for the 1990-2004 period, per compound. For PCF potential emissions, there is no information on import/export, whereas the production is zero (Solvay-Solexis, 2006).

COMPOUND	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
					Gg CO_2 equivalent						
HFC 23	0.00	1.58	2.30	3.03	3.77	4.51	5.27	6.03	6.80	7.58	8.37
HFC 32	0.00	0.00	0.19	0.51	12.10	21.33	50.33	93.13	146.71	229.91	337.24
HFC 125	0.00	1.85	10.81	24.34	96.19	178.34	381.68	671.68	1,029.60	1,527.51	2,143.65
HFC 134a	0.00	224.33	333.00	508.06	785.79	945.18	1,136.80	1,365.13	1,586.77	1,741.20	1,853.56
HFC 143a	0.00	2.74	15.51	34.39	63.67	125.29	234.94	381.18	556.46	757.56	985.04
Total HFC emissions from refrigeration and air conditioning equipment	*0.00*	*230.49*	*361.81*	*570.33*	*961.52*	*1,274.66*	*1,809.02*	*2,517.16*	*3,326.35*	*4,263.77*	*5,327.86*
HFC 134a emissions from foam blowing	0.00	0.00	0.00	0.00	31.27	36.29	41.09	45.68	51.62	57.70	63.92
HFC 227ea emissions from fire extinguishers	0.00	0.00	1.56	4.60	11.54	15.33	19.64	28.52	38.95	50.85	64.15
HFC 134a emissions from aerosols/metered dose inhalers	0.00	0.00	0.00	0.00	0.00	80.63	108.37	137.62	123.71	186.21	215.21
Total HFC emissions from ODS substitutes	*0.00*	*0.00*	*1.56*	*4.60*	*42.81*	*132.25*	*169.10*	*211.82*	*214.29*	*294.76*	*343.28*
HFC 23	0.00	0.00	0.00	0.00	17.61	19.86	5.12	7.42	6.19	8.57	9.85
HFC 134a	0.00	0.00	0.00	0.00	0.03	0.05	0.05	0.01	0.00	0.00	0.00
CF_4	0.00	24.43	21.94	24.43	27.20	40.94	64.81	107.81	106.17	117.11	134.68
C_2F_6	0.00	34.57	31.06	34.57	49.17	65.59	81.98	99.12	108.01	97.68	112.33
C_4F_8	0.00	0.00	0.00	0.00	0.04	0.15	0.37	11.30	0.77	2.04	2.34
SF_6	0.00	0.00	0.00	0.00	55.57	62.14	20.91	49.40	53.30	60.46	69.53
Total PFC, HFC, SF_6 emissions from semiconductor manufacturing	*0.00*	*59.00*	*53.00*	*59.00*	*149.62*	*188.74*	*173.25*	*275.06*	*274.44*	*285.86*	*328.74*
SF_6 emissions from electrical equipment	*213.42*	*481.95*	*622.81*	*665.30*	*477.54*	*306.52*	*300.44*	*296.05*	*284.96*	*289.97*	*438.59*
Total F-gas emissions from consumption of halocarbons and SF_6	**213.42**	**771.45**	**1,039.17**	**1,299.23**	**1,631.49**	**1,902.16**	**2,451.81**	**3,300.08**	**4,100.03**	**5,134.35**	**6,438.47**

Table 4.16 Actual F-gas emissions per compound from the consumption of halocarbons and SF_6 in Gg CO_2 equivalent, 1990-2004

COMPOUND	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
					Gg CO_2 equivalent						
HFC 32	0.00	0.00	0.00	0.00	0.00	0.00	10.40	3.25	-5.20	29.25	70.20
HFC 125	0.00	148.40	-36.40	47.60	-109.20	260.40	268.80	1,671.60	803.60	-123.20	2,200.80
HFC 134a	0.00	1,739.40	2,059.20	1,886.30	4,101.50	3,367.00	2,107.30	4,371.90	2,960.10	4,551.30	4,308.20
HFC 143a	0.00	11.40	45.60	-11.40	60.80	266.00	68.40	258.40	79.80	547.20	972.80
HFC 227ea	0.00	0.00	0.00	0.00	2.90	40.60	72.50	133.40	89.90	0.00	0.00
SF_6	3,752.30	3,675.82	3,451.16	4,612.70	11,495.90	3,465.50	3,919.60	5,903.30	3,689.20	3,211.20	2,943.24
Total F-gases	**3,752.30**	**5,575.02**	**5,519.56**	**6,535.20**	**15,551.90**	**7,399.50**	**6,447.00**	**12,341.85**	**7,617.40**	**8,215.75**	**10,495.24**

Table 4.17 Potential F-gas emissions per compound from the consumption of halocarbons and SF_6, in Gg CO_2 equivalent, 1990 – 2004

4.7.4. Source-specific recalculations

In Table 4.18 the comparison between total estimation recalculated and previous estimation of the sector is given in percentages from 1990 to 2003, for every gas. Only percentages different from zero have been reported.

COMPOUND	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003
HFC 23	-	-	-	-	-	-	-	-	-	-
HFC 32	-	-	-	-	-	-	-	-	-	-
HFC 125	-	-	-	-	-	-	-	-	-	-
HFC 134a	-	-	-	-	-	-	-	-	0.03%	0.06%
HFC 143a	-	-	-	-	-	-	-	-	-	-
Total HFC emissions from refrigeration and air conditioning equipment										
HFC 134a emissions from foam blowing	-	-	-	-	-	-	-	-	-	-
HFC 227ea emissions from fire extinguishers	-	-	-	-	-	-	-	10.08%	22.24%	35.53%
HFC 134a emissions from aerosols/metered dose inhalers	-	-	-	-	-	-	-	-	-	-
Total HFC emissions from ODS substitutes										
HFC 23	-	-	-	-	-	-	-	-	-	-
HFC 134a	-	-	-	-	-	-	-	-	-	-
CF_4	-	-	-	-	-	-	-	-	-	-
C_2F_6	-	-	-	-	-	-	-	-	-	-
C_4F_8	-	-	-	-	-	-	-	-	-	-
SF_6	-	-	-	-	-	-	-	-	-	-
Total PFC, HFC, SF6 emissions from semiconductor manufacturing										
SF_6 emissions from electrical equipment	-	-	-	-	-	-	-	-	-	-
Total F-gas emissions from consumption of halocarbons and SF_6										

Table 4.18 Comparison between recalculated and previous F-gas emissions from the consumption of halocarbons and SF_6 per gas in percentage, 1990-2003

For HFC-134a, an off-road vehicles company has supplied consumption data for the last years and the time series has been consequently updated.
Other minor modifications have regarded HFC-227ea

Chapter 5: SOLVENT AND OTHER PRODUCT USE [CRF sector 3]

5.1 Overview of sector

In this sector all non-combustion emissions from other industrial sectors than the manufacturing and energy industry are reported. The indirect CO_2 emissions, related to Non-Methane Volatile Organic Compound (NMVOC) emissions from solvent use in paint application, degreasing and dry cleaning, chemical products manufacturing or processing and other use, have been estimated.
N_2O emissions from this sector have also been estimated. These emissions arise from the use of N_2O in medical applications, such as anaesthesia, and in food industry, where N_2O is used as a propelling agent in aerosol cans, specifically those for whipped cream.
In 2004, solvent use is responsible for 0.23% of the total CO_2 emissions and 37.8% of total NMVOC emissions, and represents the second source of anthropogenic NMVOC national emissions.
N_2O emissions, in 2004, represent 1.77% of the total N_2O national emissions.
The trends of NMVOC, CO_2 and N_2O emissions are summarised in Table 5.1. Paint application and other use of solvents are the main sources in terms of NMVOC and CO_2 emissions in the total of the sector.
From 1999, the reduction in N_2O emissions is due to a decrease in the anaesthetic use of N_2O that has been replaced by halogen gas.

GAS/SUBSOURCE	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
NMVOC (Gg)											
3A. Paint application	270.8	252.6	243.9	243.0	228.6	228.0	226.1	229.6	226.4	221.6	221.3
3B. Degreasing and dry cleaning	56.7	34.1	31.9	30.2	28.6	27.1	26.4	25.7	25.0	24.4	23.7
3C. Chemical products	59.5	59.0	60.4	58.1	58.4	58.0	61.1	58.6	58.0	54.1	52.5
3D. Other	185.2	170.8	168.0	170.5	170.1	173.8	160.3	163.5	171.0	178.1	180.2
CO_2 (Gg)											
3A. Paint application	844.1	787.3	760.3	757.5	712.5	710.6	704.7	715.7	705.6	690.9	689.8
3B. Degreasing and dry cleaning	176.6	106.3	99.5	94.2	89.1	84.5	82.3	80.1	78.0	75.9	73.9
3D. Other	577.4	532.4	523.7	531.3	530.1	541.8	499.8	509.5	532.9	555.1	561.6
N_2O (Gg)											
3D. Other (use of N2O for anaesthesia and aerosol cans)	2.57	2.44	2.91	2.91	3.35	3.28	3.26	2.95	2.95	2.76	2.58

Table 5.1 Trend in NMVOC, CO_2 and N_2O emissions from the solvent use sector, 1990 – 2004 (Gg)

CO_2 emissions from the sector is a key source both for level and trend assessment calculated with the Tier 2 approach, especially because of the high level of uncertainty in the estimates and a strong reduction of emissions in the years. On the other hand, N_2O emissions from the use of the gas in anaesthesia and aerosol cans are a key source for trend assessment calculated with Tier 2 approach too. The results are reported in the following box.

Key-source identification in the solvent and other product use sector with the IPCC Tier1 and Tier2 approaches

3	CO_2	Solvent and other product use	Key (L2, T2)
3D	N_2O	Use of N_2O in anaesthesia and aerosol cans	Key (T2)

5.2 Source category description

In accordance with the indications of the IPCC Guidelines (IPCC, 1997), the carbon contained in oil-based solvents, or released from these products, has been considered both as NMVOC and CO_2 emissions as final oxidation of NMVOC. Emissions from the following sub-sectors are estimated:

solvent use in paint application (3A), degreasing and dry cleaning (3B), manufacture and processing of chemical products (3C), other solvent use, such as printing industry, glues application, use of domestic products (3D).
CO_2 emissions have been estimated and included in this sector as they are not already accounted for in the energy and industrial processes sectors.
N_2O emissions from the use of N_2O for anaesthesia and from aerosol cans (3D) have been estimated. Emissions of N_2O from fire extinguishers do not occur.
Emissions of N_2O from other use of N_2O (3D) have not been estimated because no information on activity data and emission factors is available at present.

5.3 Methodological issues

Emissions of NMVOC from solvent use have been estimated according to the CORINAIR methodology with a bottom-up approach, applying both national and international emission factors (Vetrella, 1994; EMEP/CORINAIR, 2005). All the activities in the Selected Nomenclature for Air Pollutant classification (SNAP97) have been estimated.
Country specific emission factors provided by several accredited sources have been used extensively, together with data provided by the national EPER Registry, in particular for paint application (Professione Verniciatore del Legno, several years; FIAT, 2004), solvent use in dry cleaning (ENEA/USLRMA, 1995), solvent use in textile finishing and in the tanning industries (TECHNE, 1998). 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.
Emissions from domestic solvent use have been revised. Instead of the simpler method, that uses a single emission factor expressed on a per person basis, a detailed methodology, based on VOC content per type of consumer product, has been applied.
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, 2006) 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 national statistics (ISTAT, several years [a], [b] and [c]); emission factors time series have been reconstructed on the basis of the information provided by the European Commission (EC, 2002). The conversion of NMVOC emissions into CO_2 emissions has been carried out considering specific factors calculated on the basis of molecular weights and suggested by the European Environmental Agency for the CORINAIR project (EEA, 1997), except for emissions from the 3C sub-sector to avoid double-counting.
Emissions of N_2O have been estimated taking into account information made available by industrial associations. Specifically, the manufacturers and distributors association of N_2O products has supplied data on the use of N_2O for anaesthesia from 1994 to 2004 (Assogastecnici, 2006). For previous years, data have been estimated by the number of surgical beds published by national statistics (ISTAT, several years [a]).
Moreover, the Italian Association of Aerosol Producers (AIA, several years [a] and [b]) has provided data on the annual production of aerosol cans. It is assumed that all N_2O used will eventually be released to the atmosphere, therefore the emission factor for anaesthesia is 1 Mg N_2O/Mg product use, while the emission factor used for aerosol cans is 0.025 Mg N_2O/Mg product use, because the N_2O content in aerosol cans is assumed to be 2.5% on average (Co.Da.P., 2005).
N_2O emissions have been calculated multiplying activity data, total quantity of N_2O used for anaesthesia and total aerosol cans, by the related emission factors.

5.4 Uncertainty and time-series consistency

The combined uncertainty in CO_2 emissions from solvent use is estimated equal to 58% due to an uncertainty by 30% and 50% in activity data and emission factors, respectively. For N_2O emissions, the uncertainty is estimated equal to 51% due to an uncertainty in activity data of N_2O use of 50% and 10% in the emission factors.

The decrease in NMVOC emission levels from 1990 to 2004 is about 17%, mainly due to the reduction of emissions in degreasing and dry cleaning. The European Directive (EC, 1999) regarding NMVOC emission reduction in this sector entered into force in Italy in January 2004, establishing a reduction of the solvent content in products. Figure 5.1 shows emission trends from 1991 to 2004 with respect to 1990 by sub-sectors.

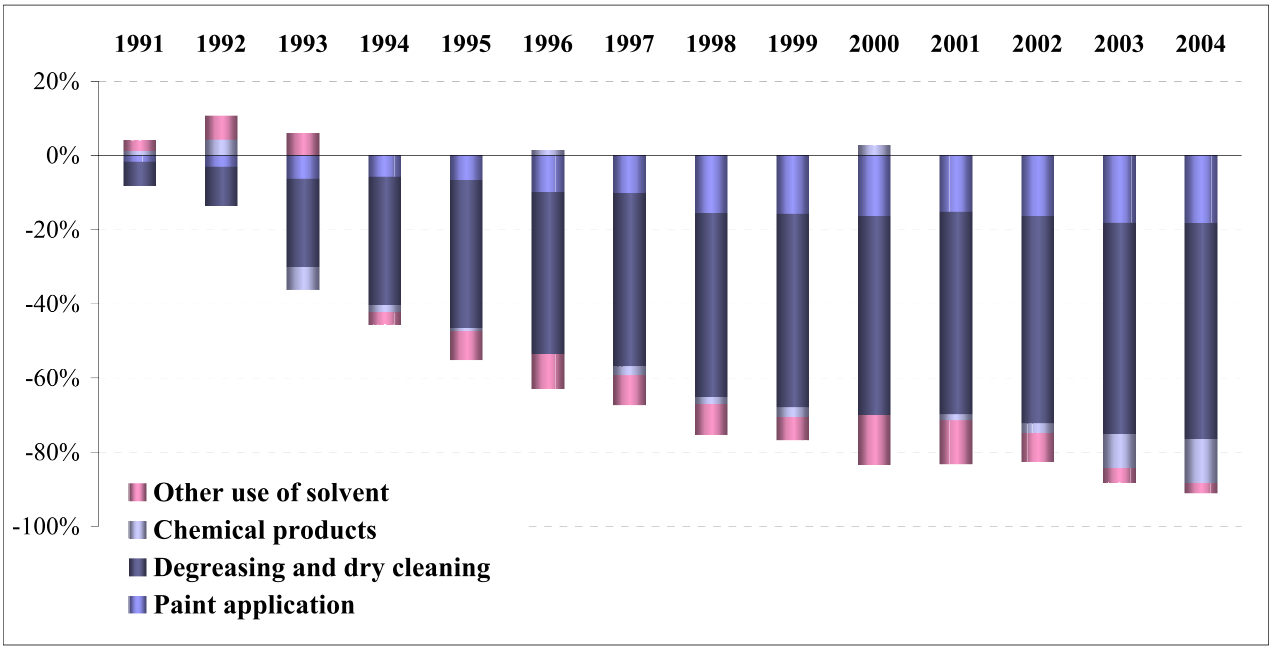

Figure 5.1 Trend of NMVOC emissions from 1991 to 2004 as compared to 1990 (%)

5.5 Source-specific QA/QC and verification

Data production and consumption time series for some activities (paint application in constructions and buildings, polyester processing, polyurethane processing, pharmaceutical products, paints manufacturing, glues manufacturing, textile finishing, leather tanning, fat edible and non edible oil extraction, application of glues and adhesives) are checked with data acquired by the National Statistics Institute (ISTAT, several years [a], [b] and [c]), the Sectoral Association of the Italian Federation of the Chemical Industry (AVISA, 2006) and the Food and Agriculture Organization of the United Nations (FAO, several years).

In the framework of the MeditAIRaneo project, APAT commissioned to the Techne Consulting 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.

5.6 Source-specific recalculations

In Table 5.2 the comparison between total estimation recalculated and previous estimation of the sector is given in percentages from 1990 to 2003, for every gas. Only the percentages different from zero have been reported.

GAS/SUBSOURCE	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003
NMVOC										
3A. Paint application	0.26%	-0.79%	-0.72%	-0.81%	-0.59%	-0.57%	-0.58%	-0.46%	-0.45%	-0.29%
3B. Degreasing and dry cleaning	-	-	-	-	-	-	-	-	-	-
3C. Chemical products	5.01%	-1.63%	-2.29%	-6.99%	-6.84%	-7.47%	-9.72%	-10.13%	-9.47%	-14.57%
3D. Other	-20.76%	-10.70%	-11.48%	-11.97%	-12.60%	-12.32%	-16.68%	-9.32%	-3.18%	0.05%
N_2O										
3D. Other (use of N2O for anaesthesia and aerosol cans)	-	-	-	-	-	-	-	-	-	-

Table 5.2 Differences in percentages between NMVOC and N_2O emissions from the sector reported in the updated time series and the 2005 submission

Concerning paint application, differences had occurred in the manufacture of automobiles and boat building.
As regards manufacture of automobiles, activity data have been revised on the basis of a new time series supplied by the national automobile club (ACI, 2006). Moreover, a revision of emission factor has been done for the year 2003 on the basis of information available by the national EPER Registry, and from 1990 on the basis of the trend supplied by the major vehicle company (FIAT, 2004).
For boat building paint application, activity data for the year 2003 have been updated.
Concerning chemical products, activity data and emission factors for the entire time series have been updated on the basis of new available information (AVISA, 2006; GIADA, 2006; Regione Toscana, 2001; Regione Campania, 2005; UNIC, 2004).
As regards other use of solvent, the entire time series have been recalculated due to the change of methodology for the estimation of emissions, as already explained in the methodological issues paragraph.

Chapter 6: AGRICULTURE [CRF sector 4]

6.1 Overview of sector

The agriculture sector in the Italian inventory includes five source categories: enteric fermentation (4A), manure management (4B), rice cultivation (4C), agriculture soils (4D) and field burning of agriculture residues (4F); the estimation of methane (CH_4) and nitrous oxide (N_2O) has been provided. Savannas areas (4E) are not present in Italy. Emissions from other sources (4G) have not been estimated. CO_2 and F-gas emissions do not occur.

In 2004 the agriculture sector contributed 6.6% of Italy's national GHG emissions without CO_2 emissions and removals from LULUCF, in CO_2 equivalent, the third source of emissions after the energy and industrial processes sectors. The agriculture sector has been the dominant national source for methane and nitrous oxide emissions, accounting for 37.3% (743.2 Gg CH_4) and 50.4% (73.4 Gg N_2O) of total national emissions, respectively. Emission trends for the agriculture sector, for methane and nitrous oxide gases, expressed in Gg, are summarised in Table 6.1. Methane emissions from enteric fermentation and nitrous oxide emissions from direct agriculture soils are the most relevant source categories in this sector; their individual share, in national total greenhouse gas emissions without CO_2 from LULUCF, in CO_2 equivalent, is 1.9% and 3.2%, respectively.

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
<u>CH_4</u>								*Gg*							
4A. Enteric Fermentation	579.89	592.76	574.76	568.70	573.83	584.11	586.77	589.35	585.29	591.80	579.26	555.54	525.21	526.44	515.77
4B. Manure management	164.86	165.13	158.79	158.42	154.85	158.42	158.73	157.91	159.31	161.02	157.27	160.93	158.10	158.01	154.03
4C. Rice cultivation	74.39	71.09	73.86	77.48	79.23	78.90	78.65	79.79	77.22	76.95	65.46	65.80	67.63	69.60	72.71
4F. Field burning of agricultural residues	0.62	0.68	0.66	0.64	0.64	0.62	0.64	0.57	0.64	0.62	0.58	0.53	0.60	0.55	0.67
TOTAL	819.75	829.66	808.08	805.23	808.54	822.05	824.79	827.63	822.46	830.39	802.57	782.81	751.54	754.60	743.18
<u>N_2O</u>								*Gg*							
4B. Manure management	14.57	14.50	13.87	13.73	13.60	13.80	13.93	14.11	14.33	14.51	14.07	14.71	13.88	13.78	13.31
4D. Agriculture soils	62.71	64.65	64.99	66.27	64.50	62.40	61.35	64.54	62.42	63.06	62.06	61.19	60.28	59.72	60.08
4F. Field burning of agricultural residues	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
TOTAL	77.30	79.16	78.87	80.01	78.11	76.21	75.29	78.67	76.76	77.58	76.14	75.91	74.17	73.52	73.40

Table 6.1 Trend in greenhouse gas emissions from the agriculture sector

In Figure 6.1 and 6.2, contributions of each sub-category to methane and nitrous oxide emissions in the agriculture sector are presented.

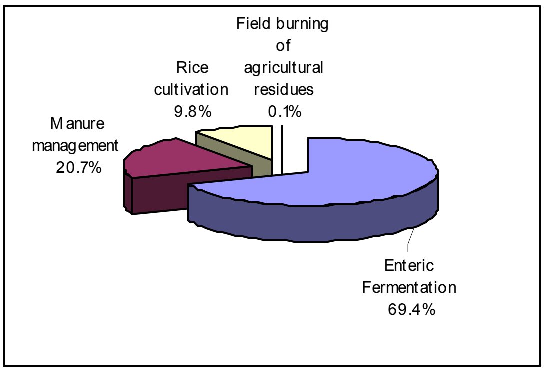

Figure 6.1 CH_4 emissions from the agriculture sector (2004)

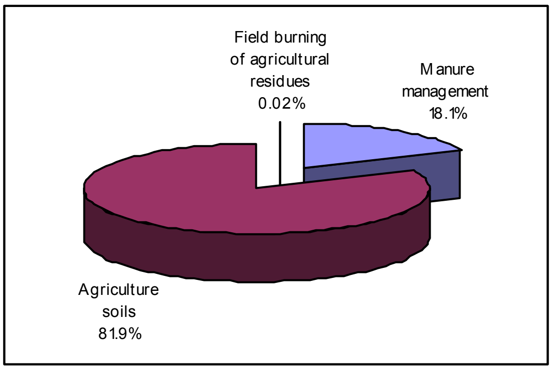

Figure 6.2 N_2O emissions from the agriculture sector (2004)

In 2004, methane emissions from manure management and nitrous oxide from agricultural soils, both direct and indirect emissions, are ranked among the top-10 level key sources with the Tier 2 analysis, including the uncertainty (L2). Methane emissions from enteric fermentation, direct and indirect nitrous oxide emissions are also ranked among the top-10 trend key sources with the Tier 2 analysis, including the uncertainty (T2).
In the following box, according to a level and/or trend assessment (*IPCC Tier 1 and Tier 2 approaches*), key and non-key sources from the agriculture sector are shown. Methane emissions from enteric fermentation and manure management, nitrous oxide emissions from manure management, agricultural soils (direct and indirect) and animal productions have been identified as key sources.

Key-source identification in the agriculture sector with the IPCC Tier1 and Tier2 approaches

4A	CH_4	Emissions from enteric fermentation	Key (L, T)
4B	CH_4	Emissions from manure management	Key (L, T2)
4B	N_2O	Emissions from manure management	Key (L, T)
4D1	N_2O	Direct soil emissions	Key (L, T)
4D2	N_2O	Emissions from animal production	Key (L2, T2)
4D3	N_2O	Indirect soil emissions	Key (L, T)
4C	CH_4	Rice cultivation	Non-key
4F	CH_4	Emissions from field burning of agriculture residues	Non-key
4F	N_2O	Emissions from field burning of agriculture residues	Non-key

As emission factors and activity data are the main parameters for the estimation of emissions, general improvements are worth to be mentioned. Emission factors used for the estimation of emissions reflect specific national characteristics. In some cases national research projects outputs have been included, such as the new excretion rates from the Inter-regional project on nitrogen balance, approved by legislative decree n. 152 published on 12/05/2006 (Gazzetta Ufficiale della Repubblica Italiana, 2006), which provide criteria and technical standards for regional agronomic utilization of farming effluents and sewage water. Regarding activity data, detailed information from national agriculture statistics has been obtained. All improvements mentioned in the Quality Assurance/Quality Control plan for the Italian Inventory for the agriculture sector have been incorporated (APAT, 2005[a]), and detailed description is provided for each source category. Recommendations, as mentioned in the Italian Individual Review (UNFCCC, 2005), specifically regarding transparency, have been incorporated in this submission; by adding some tables, more information for the review process is provided.

For the preparation of the agriculture air emission inventory, APAT is directly involved in the collection, elaboration and reporting of both inventories reported under the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Long-Range Transboundary Air Pollution (CLRTAP), for greenhouse gases and acidifying pollutants, respectively. In these years, APAT and the Research Centre on Animal Production (CRPA[1]), under the framework of the MeditAIRaneo project for agriculture, established a direct collaboration, in order to incorporate new findings and improvements to the emission inventory.
Another important activity to be mentioned is the collaboration with the National Institute of Statistics (ISTAT[2]), main source of activity data for the emission inventory. Activities such as the participation of APAT in the Agriculture, Forestry and Fishing Quality Panel for the monitoring of national statistics, as well as the participation of ISTAT in the Italian Individual Review of the national air emission inventory under UNFCCC, have been fruitful for both institutions. Furthermore, in the frame of a project for evaluating the potential of ammonia reduction established under a convention between APAT and the Ministry for the Environment and Territory, APAT is

[1] CRPA, Centro Ricerche Produzioni Animali, Reggio Emilia
[2] ISTAT, Istituto Nazionale di Statistica

working in order to establish a procedure to constitute a permanent network for collection and updating of activity data from ISTAT.

For some specific improvements, experts from different research institutions have been contacted in order to update activity data or emission factors. It has been the case for the rice cultivation and enteric fermentation (buffalo) categories, where the C.R.A.[3] – Experimental Institute of Cereal Research – Rice Research Section of Vercelli and the University of Napoli "Federico II"[4] have been contacted, respectively.

6.2. Enteric fermentation (4A)

6.2.1. Source category description

As mentioned previously, methane emissions from enteric fermentation are a major key source, both in terms of level and trend for Tier 1 and Tier 2 approaches.

In 2004, methane emissions from enteric fermentation were 515.77 Gg, which represents 69.4% of methane emissions for the agriculture sector (70.7% in 1990) and 25.9% for total methane emissions (29.2% in 1990). Methane emissions from this source mainly consist of cattle emissions, with 204.92 Gg from dairy cattle and 206.57 Gg from non-dairy cattle, representing 39.7% (42.3% in 1990) and 40.1% (40.2% in 1990) of enteric fermentation category, respectively. For this source, all livestock categories have been estimated except camels and llamas, which are not present in Italy; methane emissions from poultry do not occur and emissions from rabbits are estimated and included in "Other" as suggested by the IPCC guidelines.

6.2.2. Methodological issues

Methane emissions from enteric fermentation are estimated by defining an emission factor for each livestock category multiplied by the population of the same category. Data for each livestock category are collected from the National Institute of Statistics (ISTAT, several years [a], [b], [c], [f]; ISTAT, 2006[a]), and are based on specific national surveys, such as the 'milk production'[5] (ISTAT, 2006[b]) and the 'farm structure and production'[6] (ISTAT, 2005[a]), and from a general agriculture census carried out every 10 years (ISTAT, 2003).

All livestock categories provided by ISTAT are classified according to the type of production, slaughter or breeding, and the age of animals. Only for rabbits, activity data for 1990 have been collected from ISTAT agriculture census, and for the years 1991-2003, activity data from brood-rabbits and other rabbits have been reconstructed on the basis of meat production.

Methane emissions from enteric fermentation for dairy cattle are estimated using the Tier 2 approach, as suggested in the Good Practice Guidance (IPCC, 2000). Parameters used for the calculation of the emission factors are presented in the following box:

[3] Consiglio per la Ricerca e sperimentazione in Agricoltura, Istituto sperimentale per la Cerealicoltura, Sezione specializzata per la Risicoltura,

[4] Dipartimento di Scienze zootecniche e Ispezione degli alimenti , Università degli Studi di Napoli "Federico II

[5] Indagine annuale sul settore lattiero-caseraio, survey done every year to industries that treat and transforms milk (dairy factories, milk centres and centres for the collection of milk).

[6] Indagine sulla struttura e produzione delle aziende agricole (SPA), survey carried out every two years in agricultural farms.

Parameters for the calculation of dairy cattle emission factors from enteric fermentation

Parameters	Value	Reference
Average weight (kg)	602.7	CRPA, 2000
Coefficient NEm (dairy cattle)	0.335	NRC, 2001; IPCC, 2000
Pasture (%)	5	CRPA,2006; ISTAT, 2003
Weight gain (kg day^{-1})	0.051	CRPA, 2004[b]
Milk fat content (%)	3.59-3.71	ISTAT, several years [a], [b], [d], [e]; ISTAT, 2006[a]
Hours of work per day	0	CRPA, 2000
Portion of cows giving birth	0.90-0.97	AIA, 2005
Milk production (kg $head^{-1}$ day^{-1})	11.5-16.8	CRPA,2006; ISTAT, 2006[a]; OSSLATTE/ISMEA, 2003; ISTAT, several years [a], [b], [c] [d], [e], [f];OSSLATTE, 2001
Digestibility of feed (%)	65	CRPA, 2005
Methane conversion rate (%)	6	CRPA, 2000
MJ/kg methane	55.65	IPCC, 2000

Dairy cattle emission factor variation has been attributed to the updating of specific national parameters, such as fat content in milk, portion of cows giving birth, milk production, methane conversion factor, percentage of animal grazing and average weight; feeding characteristics are described in national publications (CRPA, 2004[a]) and have been discussed in a specific working group, in the framework of the MeditAIRaneo project (CRPA, 2006; CRPA, 2005).

Analysis of the different sources of the milk production activity data so as some problems found for the collection of national statistics have been described in a national publication (Cóndor et al., 2005). Two sources contribute to milk production: milk used for dairy production and milk used for calf feeding; these activity data have been reconstructed with national and ISTAT publications as well as personal communication with ISTAT (ISTAT, 2005[b]). For calculating the final milk production parameter (kg $head^{-1}$ d^{-1}), milk production has been divided by the number of animals and by 365 days, as suggested by the IPCC guidelines (IPCC, 2000). Both lactating and non-lactating periods are included in methane dairy cattle EF estimations when milk production is divided by 365 days (CRPA, 2006). In Table 6.2, data for fat content in milk, portion of cows giving birth, milk production and the dairy cattle population are presented.

Year	Fat content in milk (%)	Portion of cows giving birth	Milk production yield (kg $head^{-1}$ d^{-1})	Dairy cattle (head)
1990	3.59	0.97	11.5	2,641,755
1991	3.59	0.97	13.0	2,339,520
1992	3.59	0.96	13.9	2,146,398
1993	3.63	0.96	13.8	2,118,981
1994	3.64	0.96	14.5	2,011,919
1995	3.64	0.95	14.8	2,079,783
1996	3.65	0.95	15.2	2,080,369
1997	3.66	0.95	15.5	2,078,388
1998	3.71	0.93	15.3	2,116,176
1999	3.69	0.92	15.3	2,125,571
2000	3.65	0.93	15.1	2,065,000
2001	3.65	0.91	14.4	2,154,000
2002	3.67	0.91	16.2	1,910,948
2003	3.67	0.91	16.2	1,913,424
2004	3.71	0.90	16.8	1,838,330

Table 6.2 Parameters used for the estimation of CH_4 dairy cattle emission factors

In Table 6.5, resulting dairy cattle emission factors (EF) for the whole time series are presented. In 2004, methane dairy cattle EF was equal to 111.5 kg CH_4 head^{-1} year^{-1} with an average milk production of 6,138 kg head^{-1} year^{-1} equal to 16.82 kg head^{-1} day^{-1}, as reported in the CRF additional information. IPCC default EF is equal to 100 kg CH_4 head^{-1} year^{-1} but it refers to a milk production of 4,200 kg head^{-1} year^{-1} (IPCC, 1997).

For non-dairy cattle, methane emissions from enteric fermentation are estimated with the Tier 2 approach (IPCC, 2000), calculating emission factors with country-specific data. Emission factors, estimated for disaggregated livestock categories as shown in Table 6.3, are based on dry matter intake (kg head^{-1} day^{-1}) calculated as percentage of live weight (CRPA, 2000; INRA, 1988; NRC, 1984; NRC, 1988; Borgioli, 1981; Holter and Young, 1992; Sauvant, 1995). Dry matter intake is converted to gross energy (MJ head^{-1} day^{-1}) using 18.45 MJ/kg dry matter (IPCC, 2000). Emission factors for each category have been calculated with equation 4.14 of the Good Practice Guidance (IPCC, 2000). Parameters used for the estimation of non-dairy cattle emission factor are shown in table 6.4. In the 2006 submission non-dairy cattle average weights have been updated according to the Inter-regional project on nitrogen balance (CRPA, 2006; Regione Emilia Romagna, 2004).

Year	<1 year		1-2 years Males		1-2 years Females		>2 years Males	>2 years Females			TOTAL
	for slaughter	others	breeding	for slaughter	breeding	for slaughter	all	breeding	for slaughter	others	
1990	300,000	2,127,959	72,461	708,329	749,111	186,060	128,958	467,216	57,654	312,649	5,110,397
1991	300,000	2,060,091	71,191	732,421	1,077,802	197,078	82,957	498,136	59,281	503,041	5,581,998
1992	300,000	2,036,527	65,656	654,622	1,019,928	197,507	102,182	464,814	49,749	534,632	5,425,617
1993	300,000	2,002,856	63,214	639,922	995,481	175,146	95,929	449,996	47,921	551,683	5,322,148
1994	300,000	1,794,806	63,926	651,708	1,040,424	145,475	107,640	451,864	31,569	569,429	5,156,841
1995	458,936	1,796,034	27,871	783,300	684,881	154,548	155,116	430,564	40,198	657,856	5,189,304
1996	405,986	1,802,849	29,877	721,711	700,560	166,137	119,478	416,038	34,167	696,760	5,093,563
1997	354,006	1,910,283	62,983	600,315	699,133	160,238	162,187	413,383	63,765	668,553	5,094,846
1998	392,432	1,865,075	25,454	611,973	677,915	166,266	115,269	413,456	60,962	684,530	5,013,332
1999	385,251	1,807,169	28,133	655,749	708,152	179,488	101,922	410,062	46,392	713,872	5,036,190
2000	408,000	1,783,000	27,521	641,479	736,000	160,000	93,000	500,000	51,000	588,000	4,988,000
2001	386,000	1,694,000	26,986	629,014	721,000	164,000	83,000	480,000	39,000	625,000	4,848,000
2002	409,970	1,617,127	26,194	610,550	647,656	176,481	65,948	541,233	59,582	444,408	4,599,149
2003	412,682	1,594,994	27,598	643,277	673,246	158,094	78,890	520,237	48,873	433,388	4,591,279
2004	445,231	1,509,387	28,458	663,316	648,308	149,053	71,762	460,765	38,385	451,606	4,466,271

Table 6.3 Non-dairy cattle population classified by type of production and age

	<1 year	1-2 years Males		1-2 years Females		>2 years Males	>2 years Females		
Parameters	Others(*)	breeding	for slaughter	breeding	for slaughter	all	breeding	for slaughter	Others
Average weight (kg)	236	557	557	405	444	700	540	540	557
Percentage weight ingested	2.0	1.9	2.1	2.1	2.1	2.4	2.1	2.1	1.9
Dry matter intake (kg head^{-1}day^{-1})	4.8	10.7	11.6	8.5	9.3	17.1	11.5	11.5	10.6
Gross Energy (MJ head^{-1}day^{-1})	89.4	197.31	214.78	156.92	171.21	315.50	212.18	212.18	195.26
CH_4 conversion (%)	4	4.5	4	6	4	6	6	6	6

(*) It has been considered that calves for slaughter of <1 year do not emit methane emissions, as they are milk fed. Therefore, the average weight for the category “others” of <1 year takes into account fattening male cattle, fattening heifer and heifer for replacement.

Table 6.4 Main parameters used for non-dairy cattle CH_4 emission factor estimations

National characteristics of Italian breeding are reflected in emission factors and are related to the classification age of the animals and dry matter intake. Implied non-dairy cattle emission factors are presented in Table 6.5. In 2004, average non dairy-cattle EF was equal to 46.3 kg CH_4 head^{-1} year^{-1} while IPCC default EF is equal to 48 kg CH_4 head^{-1} year^{-1} (IPCC, 1997).

For estimating the methane buffalo emission factor, the IPCC Tier 2 approach has been followed, as suggested in the Good Practice Guidance (IPCC, 2000). Two different country specific methane emission factors, for cow buffalo and other buffaloes have been developed. Detailed description of the methodology, parameters and assumptions are reported in a paper (Cóndor et al., 2006). In 2004, cow buffalo methane emission factor is equal to 72.9 kg CH_4 head^{-1} year^{-1} and for other buffaloes is equal to 56.0 kg CH_4 head^{-1} year^{-1}; the implied emission factor reported in the CRF is an average EF for the buffalo livestock category (68.4 kg CH_4 head^{-1} year^{-1}). In the following boxes, parameters used for the Tier 2 approach applied for the cow buffalo and other buffalo categories are presented:

Parameters for the calculation of methane cow buffalo emission factors from enteric fermentation

Parameters	Value	Reference
Average body weight (kg)	630	Infascelli, 2003; Consorzio per la tutela del formaggio mozarella di bufala campana, 2002
Coefficient NEm, cattle/buffalo (lactating)	0.335	IPCC, 2000
Pasture (%)	2.90	ISTAT, 2003; Zicarelli, 2001
Weight gain (kg day^{-1})	0.27	Our estimation
Milk fat content (%)	7.7-8.1	ISTAT, several years [a], [b], [d], [e]; ISTAT, 2006[a]
Hours of work per day	0	Our estimation
Proportion of calving cows	0.85-0.89	De Rosa and Trabalzi, 2004; Barile, 2005
Milk production (kg head^{-1} day^{-1})	3.4-4.0	ISTAT, 2006[a]; OSSLATTE/ISMEA, 2003; ISTAT, several years [a], [b], [c] [d], [e], [f];OSSLATTE, 2001
Digestibility of feed (%)	65	Masucci et al., 1997, 1999; Infascelli, 2003
Methane conversion rate (%)	6	IPCC, 2000
MJ/kg methane	55.65	IPCC, 2000

Parameters for the calculation of other buffalo emission factors from enteric fermentation

Parameter	Calves (3 months-1 year)	Sub-adult buffaloes (1-3 years)
Average body weight (kg)	130	405
Dry matter intake (% of body weight head^{-1} day^{-1})	3.0	2.5
Dry matter intake (kg head^{-1} day^{-1})	3.9	10.1
Gross Energy (MJ head^{-1} day^{-1})	71.68	186.58
CH_4 conversion (%)	6	6
CH_4 emission factor (kg head^{-1} year^{-1})	21.16 (*)	73.42

(*) original methane emission factor is equal to 28.208 kg CH4 head-1 year-1 a correction factor of 9/12 has been applied in order to consider the time between 3 months and 1 year, therefore the final emission factor is equal to 21.16 kg CH_4 head^{-1} year^{-1}.

According to Italian specific characteristics, methane emissions from rabbits have been estimated using a country-specific emission factor suggested by the Research Centre on Animal Production. Daily dry matter intake for brood-rabbits and rabbits are 0.13 kg day^{-1} and 0.11 kg day^{-1}, respectively, and it has been assumed 0.6% as methane conversion rate (CRPA, 2004[c]).

A Tier 1 approach, with IPCC default emission factors, has been used to estimate methane emissions from swine, sheep, goats, horses, mules and asses (IPCC, 1997). In Table 6.5, emission factors from 1990 to 2004 for all livestock categories (dairy cattle, non-dairy cattle, buffalo, swine, sheep, goats, horses, mules and asses, and rabbit) are presented.

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sheep	Goat	Horses	Mules and asses	Sow	Other swine	Rabbit
1990	92.8	45.6	61.7	8	5	18	10	1.5	1.5	0.08
1991	97.7	47.5	62.9	8	5	18	10	1.5	1.5	0.08
1992	100.9	47.5	62.4	8	5	18	10	1.5	1.5	0.08
1993	100.6	47.4	65.5	8	5	18	10	1.5	1.5	0.08
1994	103.4	48.7	65.6	8	5	18	10	1.5	1.5	0.08
1995	104.3	47.4	63.2	8	5	18	10	1.5	1.5	0.08
1996	105.8	47.5	62.4	8	5	18	10	1.5	1.5	0.08
1997	106.7	47.8	62.9	8	5	18	10	1.5	1.5	0.08
1998	106.4	46.9	62.0	8	5	18	10	1.5	1.5	0.08
1999	106.3	47.3	64.9	8	5	18	10	1.5	1.5	0.08
2000	105.3	47.0	65.7	8	5	18	10	1.5	1.5	0.08
2001	102.7	47.4	68.7	8	5	18	10	1.5	1.5	0.08
2002	109.1	46.5	66.4	8	5	18	10	1.5	1.5	0.08
2003	109.0	46.6	66.2	8	5	18	10	1.5	1.5	0.08
2004	111.5	46.3	68.4	8	5	18	10	1.5	1.5	0.08

Table 6.5 Average methane emission factors for enteric fermentation (kg CH_4 head^{-1} year^{-1})

6.2.3. Uncertainty and time-series consistency

Uncertainty related to methane emissions from enteric fermentation has been estimated equal to 28% for annual emissions, resulting from the combination of 20% of uncertainty for both activity data and emission factors.

In 2004, livestock methane emissions from enteric fermentation have been 11.1% (515.8 Gg) lower than in 1990 (579.9 Gg), while from 1990 to 2004 cattle livestock have decreased by 18.7% (from 7,700,000 to 6,300,000 heads), with a decrease of 30.4% for dairy cattle (from 2,600,000 to 1,800,000) and 12.6% for non-dairy cattle (from 5,100,000 to 4,400,000). The decrease in cattle number is tending to drive down livestock emissions, particularly as emissions per head from cattle are 10 times greater than emissions per head of sheep or goat. In 2004 cattle contributes with 79.8% to the total methane emissions for enteric fermentation, sheep with 12.6% and the rest of livestock categories with 7.6%. In Table 6.6, enteric fermentation emission trends are presented.

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sheep	Goats	Horse	Other equines	Sows	Other swine	Rabbit	TOTAL
1990	245.11	232.95	5.83	69.91	6.29	5.18	0.84	0.98	11.63	1.16	**579.89**
1991	228.61	265.06	5.24	67.18	6.30	5.65	0.66	1.07	11.76	1.23	**592.76**
1992	216.49	257.48	6.44	67.68	6.78	5.69	0.57	1.04	11.33	1.27	**574.76**
1993	213.23	252.34	6.61	69.36	7.04	5.82	0.49	1.05	11.47	1.28	**568.70**
1994	207.94	251.18	7.10	79.71	8.29	5.83	0.43	1.02	11.02	1.31	**573.83**
1995	216.88	246.18	9.38	85.34	6.86	5.67	0.38	1.03	11.06	1.33	**584.11**
1996	220.10	241.75	10.71	87.55	7.10	5.62	0.34	1.09	11.17	1.35	**586.77**
1997	221.80	243.74	10.15	87.15	6.76	5.63	0.30	1.04	11.40	1.37	**589.35**
1998	225.18	235.34	11.54	87.15	6.66	5.22	0.34	1.06	11.42	1.38	**585.29**
1999	225.85	238.29	13.00	88.13	6.99	5.18	0.33	1.04	11.58	1.40	**591.80**
2000	217.40	234.45	12.61	88.71	6.88	5.04	0.33	1.06	11.40	1.39	**579.26**
2001	221.27	229.91	13.19	66.49	5.13	5.13	0.33	1.08	11.60	1.42	**555.54**
2002	208.45	213.92	12.32	65.11	4.94	5.00	0.29	1.13	12.62	1.44	**525.21**
2003	208.65	214.13	14.72	63.61	4.80	5.09	0.29	1.10	12.63	1.42	**526.44**
2004	204.92	206.57	14.38	64.85	4.89	5.00	0.29	1.09	12.37	1.42	**515.77**

Table 6.6 Trend in methane emissions from enteric fermentation (Gg)

6.2.4. Source-specific QA/QC and verification

Specific activities from the MeditAIRanean project have been mainly focused on the assessment of critical points of the enteric fermentation category (CRPA, 2006; Valli et al., 2004). In Table 6.7, a list of parameters from the QA/QC plan, analysed and discussed in the framework of the MeditAIRanean project, and resulting in improvements for 2006 submission, are reported:

Sub category	Parameter	Year of submission 2005	2006	Activities
Dairy cattle	Weight gain	√		Modification of parameter for 2005 submission (CRPA, 2006)
Dairy cattle	Digestibility		√	Discussion of the digestibility parameter according to the national average value for milk production (CRPA, 2006)
Dairy cattle	Fat content		√	Update of parameters according to update data obtained from ISTAT (ISTAT, 2006a)
Dairy cattle	Portion cow giving birth		√	Update of parameters according to update data obtained from AIA (2005)
Dairy cattle	Milk production		√	Reconstruction of parameter according to different sources (ISTAT, several years [a], [b], [c] [d], [e], [f]; ISTAT, 2006a; OSSLATTE, 2001; OSSLATTE/ISMEA, 2003)
Dairy cattle and non dairy-cattle	Average weight		√	Update the average weight with Inter-project on nitrogen balance results (CPRA, 2006; Regione Emilia Romagna, 2004)
Dairy cattle	% grazing		√	Update with statistics obtained from the Agriculture Census (CRPA, 2006)

Table 6.7 Improvements for enteric fermentation category according to the QA/QC plan

6.2.5. Source-specific recalculations

Recalculations in the dairy cattle category are due to the update of parameters used to estimate emission factors. These parameters are: fat content in milk, portion of cows giving birth, milk production, methane conversion factor, percentage of animal grazing and average weight (see Table 6.2). Livestock activity data for the last years (2002-2003) have been updated with new data available from ISTAT. In Table 6.8, new and old dairy cattle emission factors, from 2005 and 2006 submissions, are presented. In the 2006 submission, emission factors for dairy cattle increase during the years. As compared the base year, the latest EF submission is lower of 1.4% with respect the 2005 submission.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
EF 2005 submission	94.1	98.7	102.0	101.6	102.5	103.0	102.7	103.3	103.3	101.0	101.1	98.5	97.4	99.9	
EF 2006 submission	92.8	97.7	100.9	100.6	103.4	104.3	105.8	106.7	106.4	106.3	105.3	102.7	109.1	109.0	111.5

Table 6.8 Dairy cattle average methane emission factors for enteric fermentation (kg head $^{-1}$year^{-1})

6.2.6. Source-specific planned improvements

In the framework of collaboration between APAT and ISTAT, update of some activity data and parameters only for the last years are expected.

6.3. Manure management (4B)

6.3.1 Source category description

As mentioned above, methane and nitrous oxide emissions from manure management are key sources. Nitrous oxide emissions are key source at level and trend assessment, both Tier 1 and Tier 2, while methane emissions are key sources at level, both with Tier 1 and Tier 2, and Tier 2 trend assessment.

In 2004, methane emissions from manure management were 154.03 Gg, which represent 20.7% of methane emissions for the agriculture sector (20.1% in 1990) and 7.7% for total methane emissions (8.3% in 1990). Methane emissions come mainly from swine category, followed by cattle; emissions are equal to 70.07 Gg and 62.20 Gg, respectively, representing 45.5% (41.4% in 1990) and 40.4% (47.3% in 1990) of manure management methane emissions, respectively.
In 2004, nitrous oxide emissions from manure management were 13.31 Gg, which represents 18.1% of total nitrous oxide emissions for the agriculture sector (18.9% in 1990) and 9.1% for total nitrous oxide emissions (11.0% in 1990). In 2004, nitrous oxide emissions from this source mainly consist of the solid storage source with 11.98 Gg, accounting for 90.1% of the nitrous oxide manure management source.
For this sector, main parameters related to the estimation of both methane and nitrous oxide emissions have been updated. According to the results from the Inter-regional project on nitrogen balance and other national studies, parameters such as the average weight, production of slurry and solid manure and the nitrogen excretion rates have been updated.

6.3.2. Methodological issues

Methane emission factors for manure management have been calculated for cattle, buffalo and swine with the IPCC Tier 2 approach. For estimating slurry and solid manure management emission factors and specific conversion factors, detailed methodologies (*Method 1*) for cattle and buffalo categories have been applied at a regional basis. Then, a simplified methodology, for estimating emission factors time series, has been applied (*Method 2*). As mentioned before (section 6.2.2), livestock population activity data has been collected from ISTAT. For the specific case of rabbit, activity data have been reconstructed on the basis of a livestock production index.

Methane emissions (cattle and buffalo)

Method 1: Regional basis

Estimations of methane emissions from manure management, drawn up on a regional basis, depend on the specific manure management practices and environmental conditions (Safley et al., 1992; Steed and Hashimoto, 1995; Husted, 1994), particularly for the following factors: average regional monthly temperatures (UCEA, 2006), amount of slurry and solid manure produced per livestock category (CRPA, 1993) and management techniques for the application of slurry and solid manure for agricultural purposes in Italy.
For cattle and buffalo, the estimation of the emission factor starts with the calculation of the *methane emission rate* (g CH_4 m^{-3} day^{-1}), obtained from an equation presented by Husted, which is different for slurry (Husted, 1994) and solid manure (Husted, 1993). The *methane emission rate* has been then transformed to g m^{-3} $month^{-1}$. Equations used are presented below and are reported by CRPA (CRPA, 2006; CRPA, 1997[a]):
For slurry:

$$CH_4\ (g\ m^{-3}\ day^{-1}) = e^{(0.68+0.12*\text{average regional monthly temperature})} \qquad \textit{Eq. 6.1}$$

For solid manure:

$$CH_4\ (g\ m^{-3}\ day^{-1}) = e^{(-2,3+0,1*\text{ monthly storage temperature})} \qquad \textit{Eq. 6.2}$$

The monthly storage temperature from the solid manure is estimated according to the following equation (Husted, 1994):

$$T\text{ solid manure storage} = 6,7086e^{\,0,1014t\ (°C)\ (\text{average regional monthly temperature})}$$

For temperatures below 10°C emissions are considered negligible.

The volume of slurry and solid manure produced per livestock category has been obtained (m^3 $head^{-1}$) with the average production of slurry and solid manure per livestock category per day (m^3 $head^{-1}$ day^{-1}) and the days of storage of slurry and solid manure; these days are related to the temporal application dynamics of slurry and solid manure under Italian conditions (CRPA, 1997[a]). Emission factors for slurry and solid manure (g CH_4 $head^{-1}$ $month^{-1}$) are obtained with the following parameters: *methane emission rates* (Eq. 6.1 and 6.2) and the volume of slurry and solid manure produced. Emission factors obtained at this level are calculated for each month; therefore, the annual emission factor for each livestock category will be the sum of slurry and solid manure emission factors from all months, and will be expressed in kg CH_4 $head^{-1}$ $year^{-1}$.
After estimating emission factors, a *specific conversion factor* has been estimated in order to correlate methane emission production and volatile solid production, which have been finally used for the simplified methodology (*Method 2*). The *specific conversion factor* values are equal to 15.32 g CH_4/kg VS and 4.80 g CH_4/kg VS, for slurry and solid manure, respectively.

Method 2: National basis
A simplified methodology (*Method 2*) for estimating methane emission factors from manure management has been used for the complete time series. The slurry and solid manure emission factors (kg CH_4 $head^{-1}$ $year^{-1}$) have been calculated with Equations 6.3 and 6.4, respectively. These equations include the *specific conversion factor* previously estimated on a regional basis. The production of volatile solids (kg $head^{-1}day^{-1}$) has been estimated with the slurry and solid manure production, and factors proposed by Husted, which are 47g VS/kg and 142 g VS/kg, respectively. The daily VS amount excreted, estimated for both slurry and solid manure, are then summed and used for estimating the methane producing potential (Bo). In Table 6.9, estimations for 2004 manure management EFs are presented.

EF slurry = 15.32 gCH_4/Kg VS • VS production slurry (kg VS $head^{-1}$ day-^{1}) • 365 days *Eq. 6.3*

EF manure = 4.8 gCH_4/Kg VS • VS production slurry (kg VS $head^{-1}$ day-^{1}) • 365 days *Eq. 6.4*

Livestock category	Slurry (kg CH_4 $head^{-1}$ yr^{-1})	Solid manure (kg CH_4 $head^{-1}$ yr^{-1})	CH_4 manure management for cattle (kg CH_4 $head^{-1}$ yr^{-1})
Calf (*vitelli*)	6.22	0	6.22
Cattle (*bovini*)	4.94	3.40	8.34
Female cattle (*bovine*)	2.80	4.17	6.98
Other dairy cattle (*altre vacche*)	4.01	6.65	10.66
Dairy cattle (*vacche da latte*)	5.64	9.41	15.04
Cow buffalo (*bufale*)	4.88	10.38	15.25
Other buffaloes (*bufalini*)	3.11	3.19	6.30

Table 6.9 Methane manure management emission factors for cattle and buffalo in 2004

For both, *Method 1* and *Method 2*, the average production of slurry and solid manure per livestock category per day (m^3 $head^{-1}$ day^{-1}) has been updated according to results from the Inter-regional project on nitrogen balance. Currently, there is a time series of slurry and solid manure production, based on the type and distribution of housing systems for the different animal categories, and the average weight of animals. As a consequence of that, while in the 2005 submission, emission factors used for slurry and solid manure were fixed for all time series, in the current submission they are different for the whole time series. New estimations are based on a complete time series of slurry and solid manure production per livestock category per day, and on the volatile solid content. In Table 6.10 times series of average manure management emission factors are presented.

In 2004, implied emission factors, as reported in the CRF, for dairy cattle and non-dairy cattle are equal to 15.04 kg CH_4 head^{-1}year^{-1} and 7.73 kg CH_4 head^{-1}year^{-1}, respectively. IPCC default emissions factors for cool temperature are 14 kg CH_4 head^{-1}year^{-1} and 6 kg CH_4 head^{-1}year^{-1}, respectively. The implied emission factors for non-dairy cattle and buffalo represent an average of different sub-categories, weighted with the livestock population. The non-dairy cattle implied emission factor includes the following categories: calf, cattle, female cattle and other dairy cattle. The buffalo category includes the cow buffalo and other buffaloes subcategories.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Calf (*vitelli*)	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22
Cattle (*bovini*)	8.11	8.06	8.01	7.99	8.20	8.56	8.29	8.33	8.16	8.22	8.27	8.27	8.23	8.38	8.34
Female cattle (*bovine*)	6.71	6.91	6.86	6.83	6.93	6.71	6.76	6.62	6.65	6.71	6.80	6.82	6.99	6.94	6.98
Other dairy cattle (*altre vacche*)	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66
Dairy cattle (*vacche da latte*)	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04
Cow buffalo (*bufale*)	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25
Other buffaloes (*bufalini*)	6.34	6.34	6.34	6.33	6.33	6.33	6.32	6.32	6.32	6.31	6.31	6.31	6.30	6.30	6.30

Table 6.10 Methane manure management emission factors for cattle and buffalo (kg CH_4 head^{-1} yr^{-1})

For reporting purposes, the estimation of the methane producing potential (Bo) has been estimated with Equation 4.17 from the IPCC Good Practice Guidance. The average methane conversion factors (MCF) related to each manure management system by climate have been estimated on the basis of the animal population from the Agriculture Census from 1990 and 2000. In CRF 4(b)a tables, MCF and allocation (%) parameters used for estimating the average MCF are reported. Average MCFs have not been used for estimating manure management emission factors, but they have been helpful to verify EF estimations accuracy. In the following box, estimated country-specific VS and Bo parameters, compared with IPCC default values, are presented for both cattle and swine livestock categories.

Country specific and IPCC VS and Bo parameters

Livestock category	VS country-specific (kg dm head^{-1} yr^{-1})	VS IPCC default (kg DM head^{-1} yr^{-1})	Bo country-specific (CH_4 m^3/kg VS)	Bo IPCC default (CH_4 m^3/kg VS)
Dairy cattle	6.37	4.13	0.17	0.24
Non-dairy cattle	2.87	2.68	0.15	0.17
Buffalo	5.39	2.68	0.15	0.10
Swine	0.36	0.50	0.41	0.45

Methane emissions (swine)

For the estimation of swine methane emissions a country-specific *methane emission rate* has been experimentally determined at the Research Centre on Animal Production (CRPA, 1996). The estimation of the emission factor considers the structure of the storage for slurry (tank and lagoons), type of breeding and seasonal production of biogas. Different parameters have been considered, such as livestock population, average weight for fattening swine and sows, and *methane emission rate*. Methane emission rates used are 41 normal litre CH_4/100 kg live weight/day for fattening swine and 47 normal litre CH_4/100 kg live weight/day for sows including piglets (CRPA, 1997[a]). A reduction of emissions of 8% for covered storage structures has been applied to the *methane emission rate*. In Table 6.11 characteristics from swine breeding as well as emission factors are presented.

For the 2006 submission, different parameters have been updated, such as the average weight of sows, the production of slurry (t $year^{-1}$ per t live weight) and the volatile solids content in the slurry (g SV/kg slurry w.b.). The slurry production for the swine category has been estimated taking into account the different animal categories, which are classified by weight and housing characteristics. Volatile solids content has been determined experimentally from 598 measurements done at CRPA laboratory (CRPA, 2006).

In 2004, the emission factor of sow, including piglets, is equal to 22.22 kg CH_4 $head^{-1}year^{-1}$ while is 8.21 kg CH_4 $head^{-1}$ $year^{-1}$ for other swine. Implied emission factor (IEF), as reported in the CRF, is equal to 7.81 kg CH_4 $head^{-1}$ $year^{-1}$, which refers to the total number of swine including piglets.

Livestock category		Average weight (kg)	Breed live weight (t)	Methane emission rate with 8% emission reduction (nl CH_4/100 kg live weight)	Emission factor (kg CH_4 $head^{-1}$ yr^{-1})
Other swine		**83**	**543,336**	**13,768**	**8.21**
	20-50 kg	35	63,655	13,768	3.48
	50-80 kg	65	100,740	13,768	6.46
	80-110 kg	95	131,467	13,768	9.44
	110 kg and more	135	243,675	13,768	13.41
	Boar	200	3,799	13,768	19.86
Sow		**172**	**141,458**	**15,783**	**22.22**
	Piglets	10	16,705	15,783	1.14
	Sow	172.1	124,754	15,783	19.60
				TOTAL	**7.81**

Table 6.11 Methane manure management parameters and emission factors for swine in 2004

The fundamental characteristics of Italian swine production is the high live weight of the animals slaughtered as related to age; the optimum weight for slaughtering to obtain meat suitable for producing the typical cured meats is between 155 and 170 kg of live weight. Such a high live weight must be reached in no less than nine months of age. Additionally, other two specific characteristics have to be considered: feeding, in order to obtain high quality meat and the concentration of Italian pig production, which is limited to a small area (Lombardia, Emilia-Romagna, Piemonte and Veneto), representing 75% of national swine resources. All this peculiarities of Italian swine production influenced methane emission factors for manure management as well as nitrogen excretion factors used for estimating nitrous oxide emissions (Mordenti et al., 1997). For reporting purposes, the VS daily excretion and Bo have been estimated; their estimates, in particular, represent a procedure to verify EF estimations, since they have not been used for calculations. The VS daily excretion parameter has been estimated for each sub-category, with the following parameters: animal number, production of slurry (t/a/t live weight) and the volatile solids content in the slurry (gSV/kg slurry w.b.). Methane producing potential (Bo) has been estimated with Equation 4.17 from the IPCC Good Practise Practice Guidance.

Methane emission factors used for calculating other livestock categories from manure management are those proposed by IPCC; according to the yearly average temperature in Italy (13 °C), chosen emission factors are characteristic of "cold" climatic region (IPCC, 1997). In Table 6.12, the average methane EF from cattle, buffalo, swine, rabbit and poultry categories are presented.
For sheep, goat, horses and mule and asses, the following EFs have been used: 0.22 kg CH_4 $head^{-1}$ $year^{-1}$, 0.145 kg CH_4 $head^{-1}$ $year^{-1}$, 1.48 kg CH_4 $head^{-1}$ $year^{-1}$and 0.84 kg CH_4 $head^{-1}$ $year^{-1}$, respectively.

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sow	Other swine	Rabbit	Hen	Broiler	Other poultry
1990	15.0	7.5	12.2	22.14	8.54	0.080	0.082	0.079	0.079
1991	15.0	7.6	11.9	22.03	8.42	0.080	0.082	0.079	0.079
1992	15.0	7.6	12.0	22.01	8.41	0.080	0.082	0.079	0.079
1993	15.0	7.6	11.9	22.05	8.43	0.080	0.082	0.079	0.079
1994	15.0	7.7	11.9	21.96	8.42	0.080	0.082	0.079	0.079
1995	15.0	7.8	12.0	21.96	8.52	0.080	0.082	0.079	0.079
1996	15.0	7.8	11.9	21.95	8.54	0.080	0.082	0.079	0.079
1997	15.0	7.7	11.9	22.05	8.34	0.080	0.082	0.079	0.079
1998	15.0	7.7	12.1	22.04	8.36	0.080	0.082	0.079	0.079
1999	15.0	7.7	12.1	22.12	8.44	0.080	0.082	0.079	0.079
2000	15.0	7.7	11.7	21.97	8.43	0.080	0.082	0.079	0.079
2001	15.0	7.7	11.9	22.00	8.44	0.080	0.082	0.079	0.079
2002	15.0	7.7	14.1	22.27	8.21	0.080	0.082	0.079	0.079
2003	15.0	7.7	13.0	22.19	8.20	0.080	0.082	0.079	0.079
2004	15.0	7.7	12.9	22.22	8.21	0.080	0.082	0.079	0.079

Table 6.12 Average methane EF for manure management (kg CH_4 head^{-1} year^{-1})

Nitrous oxide emissions

Nitrous oxide emissions have been estimated with equation 4.18 from IPCC, as suggested in the Good Practice Guidance (IPCC, 2000). For estimations, different parameters have been used, such as the number of livestock species, country-specific nitrogen excretion rates per livestock category (CRPA, 2006; Gazzetta Ufficiale della Repubblica Italiana, 2006; Xiccato et al., 2005), the fraction of total annual excretion per livestock category related to a manure management system (CRPA, 2006), and emission factors for manure management systems (IPCC, 1997).

Liquid system, solid storage and other management systems (chicken-dung drying process system) have been considered according to their significance and major application in Italy; therefore, emission factors 0.001 kg N_2O-N/kg N excreted, 0.02 kg N_2O-N/kg N excreted and 0.02 kg N_2O-N/kg N excreted, respectively (IPCC, 1997; IPCC, 2000), have been used. When estimating emissions from manure management, the amount related to manure excreted while grazing is subtracted and reported in “Agricultural soils” under soil emissions - animal production (see Table 6.13).

Livestock category	**Average weight (kg)**	**N excreted Housing** *(Ricoveri)* **(kg head^{-1} yr^{-1})**	**N excreted Grazing** (*Pascolo*) **(kg head^{-1} yr^{-1})**	**TOTAL Nitrogen excreted (kg head^{-1} yr^{-1})**
Non-dairy cattle	384	48.8	1.3	50.0
Dairy cattle	603	110.2	5.8	116.0
Buffalo	545	96.1	2.9	99.0
Other swine	83	12.6	0.0	12.6
Sow (include piglets)	172	28.2	0.0	28.2
Sheep	48	1.6	14.6	16.2
Goat	47	1.6	14.6	16.2
Horses, mules and asses	526	20.0	30.0	50.0
Poultry	1.8	0.5	0.0	0.5
Rabbit	1.6	1.0	0.0	1.0

Table 6.13 Average weight and nitrogen excretions from the different livestock categories in 2004

For the 2006 submission, different parameters have been updated: nitrogen excretion rates, slurry and solid manure production and the average weight for the different livestock categories. In Table 6.13, nitrogen excretion rates used for nitrous oxide emission estimations are presented.
In previous submissions the annual nitrogen excretion rates have been estimated by livestock categories and were defined by the livestock population characteristics in Italy on the basis of European literature (CRPA, 2000; CRPA, 1997[b]; APAT, 2005[c]). In the 2006 submission, country-specific annual nitrogen excretion rates have been incorporated, according to the Inter-regional nitrogen balance project results (CRPA, 2006; Gazzetta Ufficiale della Repubblica Italiana, 2006; Regione Emilia Romagna, 2004). The nitrogen balance project has involved Emilia Romagna, Lombardy, Piemonte and Veneto regions, where animal breeding is concentrated. Methodology of nitrogen balance has been followed, as suggested by IPCC; as a result estimation of nitrogen excretion rates[7] and net nitrogen arriving to the field[8] has been obtained. The project has taken into consideration the territorial and dimensional representation of Italian breeding as well as the type of breeding, in order to get reliable information on feed consumption and characteristics, and composition of the feed ration. The final values of the annual nitrogen excretion rates used for the UNFCCC and CLRTAP inventories have been elaborated and reported by CRPA (2006).
In Table 6.14 time series of all livestock categories nitrogen excretion rates are presented. Nitrogen excretion rates from categories such as non-dairy cattle, buffalo, other swine, and sow varies because they are average nitrogen excretion rates, weighted with the livestock population.

Year	Dairy cattle	Non-dairy cattle	Buffalo	Other swine	Sow	Horses	Mules and asses	Goat	Sheep	Hen	Broilers	Other poultry	Rabbit	Fur animals
1990	116.0	50.0	93.9	13.1	28.1	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
1991	116.0	51.4	92.3	12.9	27.9	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
1992	116.0	51.0	92.9	12.9	27.9	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
1993	116.0	50.8	92.2	13.0	28.0	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
1994	116.0	51.8	92.0	13.0	27.8	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
1995	116.0	49.9	92.4	13.1	27.9	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
1996	116.0	49.8	92.2	13.1	27.8	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
1997	116.0	49.8	92.0	12.8	28.0	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
1998	116.0	49.2	93.2	12.9	28.0	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
1999	116.0	49.6	93.7	13.0	28.1	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
2000	116.0	50.1	90.8	13.0	27.9	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
2001	116.0	50.3	92.1	13.0	27.9	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
2002	116.0	50.4	107.6	12.6	28.3	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
2003	116.0	50.5	99.8	12.6	28.2	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1
2004	116.0	50.0	99.0	12.6	28.2	50.0	50.0	16.2	16.2	0.660	0.360	0.825	1.0	4.1

Table 6.14 Nitrogen excretion rates for all livestock categories (kg head^{-1} yr^{-1})

New data available for the average weight of different livestock categories have also been updated. Average weight used for both CLRTAP and UNFCCC inventories has been elaborated and reported by CRPA (CRPA, 2006), and are based on data reported in the Inter-regional project on nitrogen balance (Regione Emilia Romagna, 2004). In order to verify national average weight from the different livestock categories, a time series of data reported by ISTAT in the yearbooks (animal weight before slaughter) has been collected. For the specific case of sheep and goat, a detailed

[7] Nitrogen excretion = N consumed – N retained
[8] Net nitrogen to field= (N consumed – N retained) – N volatilized

analysis has been carried out with information from ASSONAPA[9], the National Association for Sheep Farming (ASSONAPA, 2006). To estimate the average weight for sheep and goat breed distribution in Italy as well as consistency for each breed have been considered (CRPA, 2006; PROINCARNE, 2005).
For slurry and solid manure production parameters, specifically for the cattle and buffalo category, updated data have been incorporated, according to new country specific data available. Slurry and solid manure production (m^3 $head^{-1}$ day^{-1}) includes estimations which take into account characteristics from Italian breeding, both for slurry and solid manure effluents, housing and its distribution for the different animal categories (CRPA, 2006; Bonazzi et al., 2005; APAT, 2004[a]; APAT, 2004[b]).

6.3.3. Uncertainty and time-series consistency

Uncertainty of methane and nitrous oxide emissions from manure management has been estimated equal to 102% for annual emissions, as a combination of 20% and 100% for activity data and emissions factor, respectively.
In 2004, livestock methane emissions from manure management were 6.6% (154.03 Gg CH_4) lower than in 1990 (164.86 Gg CH_4). From 1990 to 2004, dairy and non-dairy cattle livestock population has decreased of 30.4% and 12.6%, respectively, whereas swine has increased of 6.7%. Consequently, manure management emissions have been driven down mainly because of the reduction in the number of cattle, taking into account that cattle methane emissions contribute with 40.4% to the manure management methane emission category and swine with 45.5%, while in 1990, cattle contributes with 47.3% and swine with 41.4%. In Table 6.15, methane emissions from manure management are presented.

Year	Dairy cattle	Non-dairy cattle	Buffalo	Sheep	Goat	Horse	Other equines	Poultry	Swine	Rabbit	TOTAL
1990	39.744	38.184	1.150	1.901	0.183	0.426	0.071	13.82	68.19	1.187	164.9
1991	35.197	42.494	0.994	1.826	0.183	0.465	0.056	13.80	68.85	1.266	165.1
1992	32.291	41.190	1.241	1.840	0.197	0.467	0.048	13.77	66.44	1.307	158.8
1993	31.879	40.386	1.204	1.886	0.204	0.478	0.042	13.82	67.20	1.318	158.4
1994	30.268	39.848	1.289	2.167	0.240	0.479	0.036	14.24	64.93	1.348	154.8
1995	31.289	40.585	1.774	2.320	0.199	0.466	0.032	14.67	65.72	1.364	158.4
1996	31.298	39.661	2.044	2.380	0.206	0.462	0.029	14.57	66.69	1.390	158.7
1997	31.268	39.236	1.921	2.370	0.196	0.463	0.025	14.87	66.16	1.404	157.9
1998	31.837	38.385	2.246	2.370	0.193	0.429	0.028	15.85	66.56	1.411	159.3
1999	31.978	38.900	2.431	2.396	0.203	0.426	0.028	15.67	67.55	1.436	161.0
2000	31.067	38.244	2.249	2.412	0.199	0.414	0.028	14.09	67.14	1.425	157.3
2001	32.406	37.425	2.285	1.808	0.149	0.421	0.028	16.68	68.27	1.462	160.9
2002	28.749	35.245	2.610	1.770	0.143	0.411	0.024	16.39	71.28	1.475	158.1
2003	28.786	35.289	2.886	1.729	0.139	0.418	0.024	15.68	71.60	1.453	158.0
2004	27.657	34.539	2.705	1.763	0.142	0.411	0.024	15.27	70.07	1.453	154.0

Table 6.15 Trend in CH_4 emissions from manure management (Gg)

In 2004, nitrous oxide emissions from manure management were 8.7% (13.31Gg N_2O) lower than in 1990 (14.57 Gg N_2O). Major contribution to total nitrous oxide emissions is mainly given by the solid storage system category with 90.1%. It has been assumed that chicken-dung drying process system ("other" emissions) has been widely used from 1995 (CRPA, 1997[b]; CRPA, 2000). In Table 6.16 nitrous oxide emissions from manure management for the different manure management systems are presented.

[9] ASSONAPA, Associazione Nazionale della Pastorizia Ufficio Centrale dei Libri Genealogici e dei Registri Anagrafici.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Liquid system	0.52	0.52	0.50	0.49	0.48	0.49	0.48	0.47	0.47	0.47	0.46	0.46	0.45	0.45	0.44
Solid storage	14.05	13.98	13.37	13.23	13.12	13.22	13.29	13.39	13.44	13.51	13.05	13.48	12.59	12.45	11.98
Other	0.00	0.00	0.00	0.00	0.00	0.09	0.17	0.25	0.42	0.53	0.56	0.78	0.84	0.89	0.89
TOTAL	**14.57**	**14.50**	**13.87**	**13.73**	**13.60**	**13.80**	**13.93**	**14.11**	**14.33**	**14.51**	**14.07**	**14.71**	**13.88**	**13.78**	**13.31**

Table 6.16 Trend in N_2O emissions due to manure management, (Gg)

6.3.4. Source-specific QA/QC and verification

Specific activities from the MeditAIRanean project for the agriculture sector were focused on verification and updating of data for the manure management category. In Table 6.17 main improvements, in agreement with the QA/QC plan, are presented.

Category/sub category	Parameter	Year of submission 2006	2007	Activities
Dairy cattle	Slurry correction factor	√		According to update studies the correction factor, which was normally used for estimating slurry EF, has been cancelled (CRPA, 2006; Bonazzi et al., 2005; APAT, 2004[a]; APAT, 2004[b])
Dairy cattle	Volatile solids	√		The volatile solid parameters have been updated, according to new data available (CRPA, 2006)
Buffalo	Emission factor	√		New emission factor has been estimated for both cow buffalo and other buffaloes, according to new information (Cóndor et al., 2006)
Livestock categories	Type of housing		√	A query on the type of housing of different livestock categories has been introduced in the ISTAT survey “farm and structure”. Results are expected for 2006 and 2007.
Livestock categories	N excretion rates	√		New nitrogen excretion rates have been used for the 2006 submission (CRPA, 2006; Gazzetta Ufficiale della Repubblica Italiana, 2006; Xiccato et a., 2005)
Livestock categories	Slurry and solid manure production	√	√	Update data according to new studies (CRPA, 2006; Bonazzi et al., 2005; APAT, 2004[a]; APAT, 2004[b]). Probably, information collected from “farm and structure” survey from ISTAT will be useful for updating information.
Livestock categories	Average weight	√		Update with Inter-project on nitrogen balance (CRPA, 2006; PROINCARNE, 2005; Regione Emilia Romagna, 2004)
Management system	Emission factors	√		Verification of emission factors used for the liquid system, solid storage and other management systems has been done.

Table 6.17 Improvements for manure management category according to the QA/QC plan

6.3.5. Source-specific recalculations

In Table 6.18, parameters used for the 2005 and 2006 submissions are presented. Table 6.18 provides information on parameters that have been updated and used in the preparation of both UNFCCC and CLRTAP air emission inventories. In previous submissions such parameters have been estimated mainly based on expert judgement and European studies. In the 2006 submission, country-specific parameters, which have been collected from a recent Inter-regional nitrogen balance project and other national studies, have been used. Livestock activity data for the last years (2002-2003) have been updated.

6.3.6. Source-specific planned improvements

A recent publication describes how future agricultural surveys with specific queries related to livestock housing and manure storage systems will improve the emission inventory (Cóndor et al., 2005). At the end of 2006, results from the “farm and structure” survey (SPA[10] 2005) carried out by ISTAT are expected; information on the type of housing for different livestock categories for 2005 will be obtained. A new query on the manure storage system will be incorporated in the next “farm and structure” survey (SPA 2007). Moreover, information on the type of housing for swine and poultry are expected from a convention between APAT and the Ministry for the Environment and the Territory.

[10] Indagine sulla struttura e produzione delle aziende agricole (SPA)

Livestock category		Average weight (kg) Submission 2005	Average weight (kg) Submission 2006	N exretion (kgN head^{-1} yr^{-1}) Submission 2005	N exretion (kgN head^{-1} yr^{-1}) Submission 2006
NON- DAIRY CATTLE					
Less than 1 year (*)		190	Variable (218-228)	23.1	Variable (26-28)
From 1 year - less than 2 years					
Male	for reproduction	550	557	62.7	66.8
	for slaughter	450	557	51.7	66.8
Female	for breeding	450	405	51.7	67.6
	for slaughter	450	444	51.7	53.3
From 2 years and more					
Male	for reproduction	900	700	101.2	84.0
	for slaughter and work	900	700	101.2	84.0
Female	Breeding heifer (*manze da allevamento*)	550	540	62.7	90.2
	Slaughter heifer (*manze da macello*)	550	540	62.7	64.8
	Other dairy cattle (*altre vacche)*	750	557	84.7	54.1
Bufalini	Cow buffalo (*bufale*)	650	630	94.9	116
	Other buffaloes (*altri bufalini*)	300	313	35.2	52.2
DAIRY CATTLE (*vacche da latte*)		650	603	94.9	116
Other swine (swine-sow-piglets)	Weight less than 20 kg	10	10		
	From 20 kg weight and under 50 kg	35	35	6.2	5.3
	From 50 kg and more				
	Boar (*verri*)	200	200	16.8	30.5
	For slaughter (*macello*)				
	from 50 to 80 kg	65	65	11.5	9.9
	from 80 to 110 kg	95	95	16.8	14.5
	from 110 kg and more	135	135	16.8	20.6
SOW (*scrofe*)		160	172.1	Variable (24.1-25.9)	Variable (27.9-28.3)
SHEEP	Sheep (*pecore*)	51	51	16.2	16.2
	Other sheep (*altri ovini*)	5	21	16.2	16.2
GOAT	Goat (*capre*)	50	54	16.2	16.2
	Other goat (*altri caprini*)	5	15	16.2	16.2
EQUINE	Horses (*cavalli*)	550	550	50.0	50.0
	Mules and asses (*altri equine*)	300	300	50.0	50.0
POULTRY	Broilers (*polli da carne*)	1	1.2	0.45	0.36
	Hen (*galline da uova*)	2	1.8	0.7	0.66
	Other poultry (*atri avicoli*)	4	3.3	0.8	0.83
RABBIT	Female rabbits (f*attrici*)	4	4	1.6	2.5
	Other rabbit (*altri conigli*)	1.3	1.3	0.5	0.8

(*) Categories included in less than 1 year are: calf (*vitelli carne bianca*), fattening male cattle (*bovini maschi ingrasso*), fattening heifer (*manze ingrasso*) and heifer for replacement (*manze rimonta*).

Table 6.18 Comparison of parameters used in the 2005 and 2006 submissions for all livestock categories

6.4. Rice cultivation (4C)

6.4.1. Source category description

Concerning rice cultivation, only methane emissions are estimated; other greenhouse gases do not occur, and nitrous oxide from fertilisation during cultivation has been estimated and reported in "Agricultural soils" under direct soil emissions - synthetic fertilizers.
In 2004, methane emissions from rice cultivation were 72.71 Gg, which represents 9.8% of methane emissions for the agriculture sector (9.1% in 1990) and 3.6% for total methane emissions (3.7% in 1990).
According to specific characteristics of rice cultivation in Italy, methane emissions from rice cultivation are estimated only for an irrigated regime, other categories suggested by IPCC (rainfed, deep water and "other") are not present. Methane emissions reported in the CRF, represent two water regime sources, the single aeration and multiple aeration methane, which emissions are equal to 8.8 Gg and 63.9 Gg, respectively.
In response to the review process from 2004 (UNFCCC, 2004), new activity data and parameters have been used for the estimation of methane emissions. For updating activity data from the rice cultivation source category, APAT has involved C.R.A. – Experimental Institute of Cereal Research – Rice Research Section of Vercelli and different national experts from the rice cultivation sector.[11]

6.4.2. Methodological issues

Methane emissions from rice cultivation have been calculated following the IPCC Good Practice Guidance approach, taking into account country-specific circumstances, using the following parameters: adjusted integrated emission factor (kg CH_4 $m^{-2}day^{-1}$), cultivation period of rice (days) and annual harvested area (ha) cultivated under specific conditions. In the following box, information related to the collection of different data is reported.

Parameters used for the calculation of methane emissions from rice cultivation

Parameters	Reference
Cultivated surface with "dry-seeded" technique (%)	Centro Ricerche sul Riso (2006)
Cultivated surface – national (ha)	ISTAT, several years [a],[b]; ISTAT, 2006d
Cultivated surface by rice varieties (ha)	ENR, 2005
Cultivation period of rice varieties (days)	ENR, 2005
Methane emission factor (kg CH_4 m^{-2} d^{-1})	Schutz, 1989[a], [b]; Leip et al., 2002
Production (t yr^{-1})	ISTAT, several years [a],[b]; ISTAT, 2006[d]
Yield (t ha^{-1})	Estimations based on cultivated surface and production data
Straw incorporation (%)	Expert judgement (Tinarelli, 2005; Lupotto et al., 2005)
Agronomic practices (%)	Tinarelli, 2005; Lupotto et al., 2005; Zavattaro et. al, 2004; Tinarelli, 1973; Tinarelli, 1986; Baldoni and Giardini, 1989.
Scaling factors (SFw, SFp, SFo)	Yan et. al, 2005

In Italy, rice is sown from mid-April to the end of May and harvested from mid-September to the end of October; the only practised system is the controlled flooding system, with variations in water regimes (Tossato and Regis, 2002; Mannini, 2004; Confalonieri and Bocchi, 2005; Regione Emilia Romagna, 2005). In Table 6.19 water regimes description, during rice cultivation, are presented. Normally, the aeration periods are very variable in number and time, depending on different circumstances, as, for example, the type of herbicide which is used (Baldoni and Giardini, 1989).

[11] Stefano Bocchi, Crop Science Department (University of Milan); Aldo Ferrero, Department of Agronomy, Forestry and Land Management (University of Turin); Antonino Spanu, Department of agronomic science and agriculture genetics (University of Sassari).

Type of seeding	April	May	June	July	August	September-October	Description
Wet-seeded "classic"	15-30 April Flooding and wet-seeded (*)	10 may	Herbicide treatment.	Fertilizer application (1/3), soil is saturated but not flooded. Panicle formation	Final aeration	September-October Harvest	2 aeration periods during rice cultivation, as minimum, not including the final aeration IPCC classification : Intermittently flooded – multiple aeration
		1ºaeration - AR	2º aeration-AA		3º final aeration		
Wet-seeded "red rice control"	15 April Flooding and wet-seeded (*)	First application of herbicides, the soil is dry. Approximately, on 15 may flooding and after some days seeding	At the end of June, fertilization treatment	Fertilizer application (1/3), soil is saturated but not flooded. Panicle formation	Final aeration	September-October Harvest	2 aeration periods during rice cultivation, as minimum, not including the final aeration. In some cases, between April and May, even 3 aeration periods are practised. IPCC classification : Intermittently flooded – multiple aeration
		1° aeration – AC Approx. after 10 days 2° aeration - AR	3ºaeration -AA		Final aeration		
Dry-seeded with delay flooding	15 April Dry-seeded	Approximately, on 15 may flooding	Herbicide treatment	Fertilizer application (1/3), soil is saturated but not flooded. Panicle formation		September-October Harvest	1 aeration period during rice cultivation, as minimum, not including the final aeration. IPCC classification : Intermittently flooded – single aeration
			1º aeration-AA		2º final aeration		

(*) the first fertilization (2/3) during the initial part of the rice cultivation, generally on July there is a second period for the fertilization (1/3), normally there is no aeration during the second fertilization period. Aeration periods mostly last between 5-15 days and are classified as follows: AC= aeration to control red rice (*lotta al crodo*); AR = drained, aeration in order promote rice rooting, (*asciutta di radicamento*); AA= drained, tillering aeration (*asciutta di accestimento*).

Table 6.19 Water regimes in Italy and classification according to IPCC guidelines

In general, rice seeds are mechanically broadcasted in flooded fields. However, for the last 15 years, in Italy, seeds are also drilled to dry soil in rows. The rice that was planted in dry soil is generally managed as a dry crop until it reaches the 3-4 leaf stage. After this period, the rice is flooded and grows in continuous submersion, as in the conventional system (Ferrero and Nguyen, 2004; Russo, 1994).

During the cultivation period, water is commonly kept at a depth of 4-8 cm, and drained away 2-3 times during the season to improve crop rooting, to reduce algae growth and to allow application of herbicides. Rice fields are drained at the end of August to allow harvesting, once in a year (Ferrero and Nguyen, 2004; Tinarelli, 1973; Tinarelli, 1986; Baldoni and Giardini, 1989).

Nitrogen is generally the most limiting plant nutrient in rice production and is subject to losses because of the reduction processes (denitrification) and leaching. Sufficient nitrogen should be applied pre-plant or pre-flood to assure that rice plant needs no additional nitrogen until panicle initiation or panicle differentiation stage. When additional nitrogen is required, it should be top-dressed at either of these plant stages or whenever nitrogen deficiency symptoms appear. The above-mentioned applications are usually used in two or three periods, the first period is always before sowing, that is on dry soil, while the others occur during the growing season (Russo, 2001; Russo, 1993; Russo et al., 1990; Baldoni and Giardini, 1989).

Another type of fertilization, such as the incorporation of straw, is also an agronomic practise in Italy. The incorporation period can vary according to weather conditions, but probably straw is mainly incorporated approximately one month before flooding (Russo, 1988; Russo 1976). Rice straw is often burned in the field, otherwise incorporated into the soil or buried. For other agronomic practice, a recent national publication has been considered for understanding fertilizer and crop residues management (Zavattaro et al., 2004).

On the basis of the information reported above, in Italy methane emissions estimates consider rice cultivation with an irrigated regime, which includes intermittently flooded with single aeration and multiple aeration regimes.
Another water regime system, present in southern Italy, is the sprinkler irrigation, which exist only on experimental plots and could contribute to the diffusion of rice cultivation in areas where water availability is a limiting factor (Spanu et al., 2004; Spanu and Pruneddu, 1996).
An analysis on recent and past literature, for the methane daily emission factor (kg CH_4 m^{-2} d^{-1}), has been done. Different scientific articles related to the methane daily emission factor, in Italian rice fields, have been revised (Marik et al., 2002; Leip et al., 2002; Dan et al., 2001; Butterbach-Bahl et al., 1997; Schutz et al., 1989[a],[b]; Holzapfel-Pschorn and Seiler, 1986), there are other publications which are indirectly related with methane production (Kruger et al., 2005; Weber et al., 2001; Dannenberg and Conrad, 1999; Roy et al., 1997). Butterbach-Bahl et al. have presented interesting results related to the difference in emission factors of two cultivation periods (1990 and 1991). In these consecutive years, fields planted with rice cultivar Lido showed methane emissions by 24-31% lower than fields planted with cultivar Roma. Marik et al. have published detailed information on agronomic practices (fertilized fields) related to measurements of methane emission factor for years 1998 and 1999; values are similar to those presented in previous publications (Schutz et al., 1989[a], [b]; Holzapfel-Pschorn and Seiler, 1986). Leip et al., have also published specific methane emission factors for a particular agronomic practice, which is also presented in Table 6.19, the so called dry-seeded with delay flooding (*semina interrata a file*). The dry –seeded technique could bring interesting benefits in emission reduction, since experimentally it has been determined lower emission rates compared with a normal practice.
Following IPCC guidelines, methane emission factor has been adjusted with the following parameters: daily integrated emission factor for continuously flooded fields without organic fertilisers, scaling factor to account for the differences in water regime in the rice growing season (*SFw*), scaling factor to account for the differences in water regime in the preseason status (*SFp*) and scaling factor which varies for both types and amount of amendment applied (*SFo*). The scaling factor parameters have been taken from a recent publication, which provide a statistical analysis of the major variables controlling methane emission from rice field (Yan et al., 2005), and assumptions are presented in Table 6.19. In Table 6.20, parameters used for the estimation of methane emission from rice paddies are presented.

Rice cultivation water regimes: Intermittently flooded	**Single aeration**	**Multiple aeration**	**Multiple aeration**
Type of seeding	Dry-seeded	Wet-seeded (classic)	Wet-seeded (*red rice control*)
Surface (ha)	35,837	100,174	93,711
Daily EF (g CH_4 m^{-2} d^{-1})	0.20	0.28	0.28
SFw	0.6	0.52	0.52
SFp	0.68	0.68	0.68
SFo	2.2	2.2	2.2
Adjusted daily EF (g CH_4 m^{-2} d^{-1})	0.18	0.21	0.21
Days of cultivation (days)	138	155	155
Seasonal EF (g CH_4 m^{-2} yr^{-1})	24.54	32.96	32.96
Methane emissions (Gg)	8.79	33.02	30.89

Table 6.20 Parameters used for estimating methane emissions from rice cultivation in 2004

6.4.3. Uncertainty and time-series consistency

Uncertainty of emissions from rice cultivation has been estimated equal to 20% as a combination of 3% and 20% for activity data and emissions factor, respectively.

In 2004, methane emissions from rice cultivation were 2.3% (72.71 Gg CH_4) lower than in 1990 (74.39 Gg CH_4). In Italy, the driving force of methane emissions from rice cultivation is the harvest area and the percentage of single aerated surface. Methane emissions have decreased by 2.3% and the harvest area has increased by 6.6%, from 215,442 ha $year^{-1}$ in 1990 to 229,722 ha $year^{-1}$ in 2004. The percentage of single aerated surfaces have increased from 1% (1990) to 15.6% (2004), therefore, emissions have verified a slow decrease. Water regime trends have been calculated together with expert judgement expertise (Tinarelli, 2005; Lupotto et al., 2005) and available statistics (Centro Ricerche sul Riso, 2006). In Table 6.22, methane emissions from rice cultivation and harvested area are presented.

6.4.4. Source-specific QA/QC and verification

Specific activities have focused in updating estimations and activity data needed. As presented in Table 6.21, and according to the QA/QC plan, improvements in parameters, which have been taken into consideration, are the following:

Category/sub category	Parameter	Year of submission		Activities
		2006	2007	
Emission factor	Daily CH_4 EF	√		For the 2006 submission a seasonal methane emission factor has been estimated based on the daily methane emission factor and the period of cultivation of rice (Schutz et al., 1989[a], [b]). A new emission factor has been incorporated for the estimation of emissions from fields with the dry-seeded practise (Leip et al., 2002).
Emission factor	Post-harvest emissions	√		According to the review process from 2004 (UNFCCC, 2004), post-harvest emissions have been eliminated, because they do not correspond to water regimes applied in Italy (Wassmann, 2005).
Emission factor	Scaling factors	√		Scaling factors used for estimations have been updated with a recent publication (Yan et al., 2005)
Activity data	Days of cultivation and cultivars	√		In order to obtain the average national days of rice cultivation, characteristics from the different cultivars present in Italy for the whole time series were used (ENR, 2005)
Activity data	Agronomic practises	√		Agronomic practises in Italy have been revised (Tinarelli, 2005; Lupotto et al., 2005; Zavattaro et. al, 2004; ISTAT, 2006[d]; Tinarelli, 1973; Tinarelli 986; Baldoni and Giardini, 1989)

Table 6.21 Improvements for the rice cultivation category according to the QA/QC plan

6.4.5. Source-specific recalculations

Recalculations have been done for the rice cultivation category, since update activity data and parameters have been incorporated. In Table 6.22 methane emissions from the 2005 and 2006 submissions are presented. In the 2005 submission, a seasonal methane emission factor has been used for estimations for the whole time series; in the 2006 submission a daily methane emission factor and cultivation days, depending on cultivars present in Italy, has been used. Scaling factors have changed according to new data available.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Harvested area ($10^9 m^2 yr^{-1}$)	2.15	2.06	2.16	2.32	2.36	2.39	2.38	2.33	2.23	2.21	2.20	2.18	2.19	2.20	2.30
Emissions 2005 submission	73.3	70.2	73.6	78.8	80.2	81.4	80.8	79.8	77.2	77.0	65.5	65.8	67.6	69.6	
Emissions 2006 submission	74.4	71.1	73.9	77.5	79.2	78.9	78.7	79.8	77.2	77.0	65.5	65.8	67.6	69.6	72.7

Table 6.22 Harvest area and methane emissions from rice cultivation

6.4.6. Source-specific planned improvements

Lack of experimental data and of knowledge about the occurrence and duration of drainage periods in Italy is the major cause of uncertainty. Moreover, it is not easy to quantify the surface where the traditional or different number of aerations is practiced, depending on the degree and the type of infestation and on the results, positive or not, of the herbicide treatment application. In Table 6.19, a general classification has been done for the most common agronomic practices. For the 2005 submission, the assumption of the same water regime surfaces for the time series introduced an important uncertainty in the results. For the 2006 submission, a trend in water regime has been calculated together with expert judgement expertise (Tinarelli, 2005; Lupotto et al., 2005) and available statistics (Centro Ricerche sul Riso, 2006). Provincial estimations on the basis of the relation between emissions and temperature would result in further possible improvements, even if enhancement would be limited since the largest Italian rice production is in the Po valley, where monthly temperatures of the rice paddies are similar. In 1990, Piemonte and Lombardy regions represented 95% of the national surface area of rice cultivation, while in 2004 they represented 92% (ENR, 2005).

6.5. Agriculture soils (4D)

6.5.1. Source category description

Direct and indirect nitrous oxide emissions from agricultural soils are key sources at level and trend assessment, both with the Tier 1 and Tier 2 approaches, while animal production is key source at level and trend assessment with the Tier 2 approach, taking into account the uncertainty.
In 2004, nitrous oxide emissions from agricultural soils were 60.08 Gg, which represents 81.9% of emissions for the agriculture sector (81.1% in 1990) and 41.2% for total nitrous oxide emissions (47.2% in 1990). Nitrous oxide emissions from this source mainly consist of direct soil emissions, 30.03 Gg, and indirect soil emissions, 25.07 Gg, which represent together the 91.7% of total nitrous oxide emissions for the agriculture sector (91.1% in 1990).
In Italy, agricultural soil emissions are estimated for direct and indirect soils and animal production. For direct soil emissions all sources have been estimated: synthetic fertilizers, animal waste applied to soil, N-fixing crops and cultivation of histosols. For indirect soil emissions, atmospheric deposition and nitrogen leaching and run-off have been estimated. Nitrous oxide emissions from animal production are calculated together with the manure management category on the basis of nitrogen excretion, and reported in agricultural soils under “animal production”.

In response to the review process (UNFCCC, 2005), it is important to underline, that APAT is in charge of collecting, elaborating and reporting national air emission inventories for both UNFCCC and CLRTAP (APAT, 2005[b]). The CLRTAP inventory has been updated with country specific nitrogen excretion rates and emission factors (housing, storage and land application), which include best available technologies (BAT) to reduce ammonia emissions. Therefore, there is a consistent application of parameters and methodologies for both inventories; the nitrogen balance coming from the CLRTAP inventory feeds the GHG inventory, specifically for the calculation of $FRAC_{GASM}$ and $FRAC_{GASF}$, used for the estimation of F_{AM} and F_{SN}. As requested in the review process, a review of the $FRAC_{LEACH}$ parameter has been done. Italy has verified that the IPCC default value used for estimations is similar to the country specific reference value reported from the main regional basin authority - Po Valley (ADBPO, 1998; ADBPO, 2001).

6.5.2. Methodological issues

Methodologies used for estimating nitrous oxide emissions from “Agricultural soils” follow the IPCC approach. Emission factors suggested by the IPCC (IPCC, 1997) and by the Research Centre on Animal Production (CRPA, 1997[b]; CRPA, 2000) have been used; activity data have been collected from different sources, as presented in the following box:

Data used for estimating agricultural soil emissions

Data	Reference
Fertilizer distributed (t/yr)	ISTAT, several years [a],[b]; ISTAT, 2006[c]
Nitrogen content (%)	ISTAT, several years [a],[b]; ISTAT, 2006[c]
N excretion rates (kg $head^{-1}$ yr^{-1})	CRPA, 2006; Gazzetta Ufficiale della repubblica Italaina, 2006; Xiccato et al., 2005
Cultivated surface (ha yr^{-1})	ISTAT, several years [a],[b]; ISTAT, 2006[d]
Annual crop production (t yr^{-1})	ISTAT, several years [a],[b]; ISTAT, 2006[d]
N fixed by type of species (kg N ha^{-1})	Erdamn,1959 in Giardini, 1983
Residue/crop product ratio by crop type	CESTAAT, 1988
Crop residue production (t dry matter $ha^{-1}yr^{-1}$)	CRPA/CNR, 1992
Dry matter content by crop type	CRPA/CNR, 1992
Protein content in dry matter by crop type	CESTAAT, 1988
Livestock data	ISTAT, several years [a],[b]; ISTAT, 2006[a]

For estimating nitrous oxide direct soil emissions, the IPCC approach has been followed, and some modifications have been included because of country-specific peculiarities (IPCC, 1997; IPCC, 2000). N_2O-N emissions have been estimated from the amount of F_{SN}, $F_{AM,}$ F_{CR}, F_{BN} and F_{OS} applying defaults IPCC emission factors (IPCC, 2000); afterwards N_2O-N emissions have been converted to N_2O emissions, multiplying by the 44/28 coefficient. Animal production emissions have been estimated according to the methodology described in section 6.3.2, for manure management. Indirect emissions have been estimated using methodologies suggested by IPCC (IPCC, 1997).
For direct N_2O emissions from agricultural soils, the following parameters have been estimated: synthetic fertilizers (F_{SN}), animal waste applied to soil (F_{AM}), N-fixing crops (F_{BN}), crop residues (F_{CR}), and cultivation of histosols (F_{os}).

Synthetic fertilizers (F_{SN})
The total use of synthetic fertilizer (expressed in t N $year^{-1}$) has been estimated for all years and for each type of fertilizer. Calculation of synthetic fertilizer use (F_{SN}) has been obtained multiplying the total use of fertilizer by (1- $FRAC_{GASF}$). $FRAC_{GASF}$ parameter has been estimated for the whole time series, following the IPCC definition where the total N-NH_3 and N-NOx emissions from fertilizers are divided by the total nitrogen content of fertilizers referring to the Italian soils. Nitrous oxide emissions for synthetic fertilizers have been finally obtained multiplying F_{SN} by emission factor 0.0125 kg N-N_2O/kg N (IPCC, 1997). In Table 6.23, fertilizers distribution, nitrogen content (%) and total use of fertilizer are presented. In 2004 the total use of synthetic fertilizers has been equal to 841,363 t N, while F_{SN} equal to 768,519t N; the time series is reported in Table 6.26.

Type of fertilizers	Fertilizers distributed (t/yr)	Nitrogen content (%)	Total use of synthetic fertilizers ($t\ N\ yr^{-1}$)
Ammonium sulphate	145,116	20.8%	30,211
Calcium cianamide	12,307	19.8%	2,437
Ammonium nitrate < 27%	323,648	28.2%	91,207
Ammonium nitrate > 27%	237,167	28.2%	66,836
Calcium nitrate	72,794	15.3%	11,153
Urea + others	919,836	43.1%	396,819
Phosphate nitrogen	445,071	17.5%	77,949
Potassium nitrogen	79,788	15.3%	12,201
NPK nitrogen	947,970	12.3%	116,361
Organic mineral	368,503	9.8%	36,191
TOTAL	**3,552,201**		**841,363**

Table 6.23 Total use of synthetic fertilizer in 2004 ($t\ N\ yr^{-1}$)

Animal waste applied to soil (F_{AM})

The manure nitrogen corrected for NH_3 and NO_x emissions, excluding manure produced during grazing ($kg\ N\ yr^{-1}$), has been calculated with the IPCC methodology (IPCC, 1997), using a country-specific nitrogen excretion rates (CRPA, 2006; Gazzetta Ufficiale della Repubblica Italiana, 2006; Xiccato et al., 2005). A country-specific $FRAC_{GASM}$ parameter has been estimated and used for the calculation of the animal waste applied to soil (see Table 6.24); the estimation has followed the IPCC definition, therefore, the NH_3 and NOx emissions from animal manure has been divided by the total nitrogen excreted. The final F_{AM} ($t\ yr^{-1}$) value has been estimated by summing F_{AM} for each livestock category; emissions have been calculated with emission factor 0.0125 kg $N\text{-}N_2O$/kgN (IPCC, 1997). In 2004 the parameter F_{AM} has been equal to 438,785 t N, and the complete time series of $FRAC_{GASM}$ is reported in Table 6.24.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
$FRAC_{GASF}$	0.083	0.083	0.082	0.086	0.087	0.085	0.081	0.082	0.085	0.088	0.087	0.087	0.089	0.089	0.090
$FRAC_{GASM}$	0.32	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.30	0.30	0.30	0.29

Table 6.24 $FRAC_{GASF}$ and $FRAC_{GASM}$ time series

N-fixing crops (F_{BN})

Nitrogen input from N-fixing crops (F_{BN}, kg N yr-1) has been calculated with a country-specific methodology according to peculiarities present in Italy, which considers not only N-fixing crops but also legumes forage. F_{BN} has been calculated with two parameters: cultivated surface and nitrogen fixed per hectare (Erdamn 1959 in Giardini, 1983). Emissions are calculated with emission factor 0.0125 kg N_N2O/kgN (IPCC, 1997). In Table 6.25, cultivated surface from N-fixing species ($ha\ yr^{-1}$) and nitrogen fixed by each species ($kg\ N\ ha^{-1}\ yr^{-1}$) are presented. In 2004, F_{BN} has been equal to 172,530 t N.

	Nitrogen fixed (kg N $ha^{-1}yr^{-1}$)	1990	1995	2000	2004
		(ha)			
Bean, fresh seed (*fagiolo*)	40	29,096	23,943	23,448	23,562
Bean, dry seed (*fagiolo*)	40	23,002	14,462	11,046	9,246
Broad bean, fresh seed (*fava*)	40	16,564	14,180	11,998	9,683
Broad bean, dry seed (*fava*)	40	104,045	63,257	47,841	44,117
Pea, fresh seed (*pisello*)	50	28,192	21,582	11,403	11,575
Pea, dry seed (*pisello*)	72	10,127	6,625	4,498	10,315
Chickpea (*cece*)	40	4,624	3,023	3,996	5,443
Lentil (*lenticchia*)	40	1,048	1,038	1,016	1,719
Tare (*veccia*)	80	5,768	6,532	6,500	6,500
Lupin (*lupino*)	40	3,303	3,070	3,000	3,000
soya bean (*soia)*	58	521,169	195,191	252,647	150,368
Alfalfa (*erba medica)*	194	987,000	823,834	810,866	761,199
Clover grass (*trifoglio)*	103	224,087	125,009	114,844	101,201

Table 6.25 Cultivated surface and nitrogen fixed by each variety

Crop residues (F_{CR})
For the estimation of nitrogen input from crop residues (F_{CR}), a country-specific methodology has been used. The total amount of crop residues has been estimated (t dry matter yr^{-1}) for all crops, using the following parameters: annual crop production (t yr^{-1}), residue/crop product ratio, and dry matter content by type of crop (%), while, when cultivated surface (ha) has been used as activity data, only the crop residue production (t dry matter ha^{-1} yr^{-1}) parameter has been used to assess total amount of crop residues.
The nitrogen content from cereals, legumes, tubers and roots and legumes forages crop residues (t N yr^{-1}) has been estimated multiplying the total amount of crop residue as dry matter by the reincorporated fraction (1- $FRAC_{BURN,}$ where $FRAC_{BURN}$ is the fraction of crop residue that is burned rather than left on field equal to 0.1 kg N/kg crop-N), and the nitrogen content for each crop type. The nitrogen content has been obtained converting protein content in dry matter, dividing by factor 6.25. F_{CR} is obtained adding the nitrogen content from all cultivars crop residues. In 2004 F_{CR} has been equal to 143,022 t N. Emissions are calculated with emission factor 0.0125 kg N-N_2O/kg N (IPCC, 1997). The complete time series is presented in Table 6.26.

Cultivation of histosols (F_{os})
In Italy, the area of organic soils cultivated annually (histosols) is estimated to be 9,000 hectares (CRPA, 1997[b]); this value has been multiplied by 8 kg N-N_2O ha^{-1} yr^{-1}, as suggested by the Good Practice Guidance (IPCC, 2000). The data for surface area, reproduced in the national soil map of the year 1961, have been supplied by the Experimental Institute for the study and protection of soil from Florence (ISSDS). These values have been verified with related data for Emilia Romagna region, where this type of soil is the most prevalent.

Year	F_{SN} (t N)	F_{AM} (t N)	F_{BN} (t N)	F_{CR} (t N)	F_{os} (ha)
1990	694,753	475,239	254,654	147,541	9,000
1991	768,261	474,670	240,032	149,041	9,000
1992	811,773	455,717	228,560	152,456	9,000
1993	864,171	452,474	211,235	141,823	9,000
1994	798,981	446,109	201,884	141,799	9,000
1995	729,533	454,210	191,018	142,216	9,000
1996	694,915	455,088	190,601	145,826	9,000
1997	786,400	457,506	194,257	147,351	9,000
1998	708,633	464,404	202,718	150,090	9,000
1999	722,421	470,146	191,722	150,228	9,000
2000	717,276	457,967	189,313	144,237	9,000
2001	738,924	473,407	182,928	137,769	9,000
2002	748,413	453,180	177,529	142,457	9,000
2003	753,251	452,635	175,154	119,184	9,000
2004	768,519	438,785	172,530	143,022	9,000

Table 6.26 Parameters used for the estimation of direct and indirect N_2O emissions

Animal production

As mentioned in section 6.3.2, when estimating nitrous oxide emissions from manure management, the amount related to manure excreted while grazing is subtracted and reported in "Agricultural soils" under animal production**.** In Table 6.13, nitrogen excreted - housing and grazing (kg head^{-1}yr^{-1}) used for estimations are presented. Final nitrous oxide emissions are estimated with total nitrogen excreted from grazing (include all livestock categories), number of animals, and emission factor 0.02 kg N_2O-N/kg N excreted (IPCC, 1997).

For indirect emissions from agricultural soils the following parameters have been estimated:

- Atmospheric deposition
- Nitrogen leaching and run-off

The estimation of nitrous oxide emissions due to atmospheric deposition of NH_3 and NO_x has followed IPCC approach (IPCC, 1997). Parameters used are: total use of synthetic fertilizer, t N yr^{-1} (see Table 6.28), $FRAC_{GASF}$ emission factor, total N excreted by livestock (kg head^{-1}yr^{-1}), $FRAC_{GASM}$ emission factor and emission factor 0.01 kg N_2O-N per kg NH_3-N + NO_x-N emitted (IPCC, 1997; IPCC, 2000).
The estimation of nitrous oxide emissions due nitrogen leaching and run-off has also followed the IPCC approach (IPCC, 1997). Parameters used are: total use of synthetic fertilizer, t N yr^{-1} (see Table 6.15), total N excreted by livestock (kg head^{-1} yr^{-1}), $FRAC_{LEACH}$ emission factor 0.3 N/kg nitrogen of fertiliser or manure and the emission factor 0.025 Kg N_2O-N per kg nitrogen leaching/run-off (IPCC, 1997; IPCC, 2000). As abovementioned, $FRAC_{LEACH}$ IPCC default value has been compared with the country specific $FRAC_{LEACH}$, found in the main basin in Italy where agriculture activities are concentrated (ADBPO, 1998; ADBPO, 2001), resulting in a nearly similarity.

6.5.3. Uncertainty and time-series consistency

Uncertainty for nitrous oxide emissions from agricultural soils (direct soil emissions, indirect soil emissions and animal production) has been estimated to be 102%, as combination of 20% and 100%

for activity data and emission factor, respectively. In the Table 6.27 time series of emission estimates are reported.

Year	Direct Soil Emissions	Animal Production	Indirect Soil emissions	TOTAL
1990	31.00	5.60	26.12	62.71
1991	32.17	5.45	27.03	64.65
1992	32.49	5.47	27.02	64.99
1993	32.91	5.59	27.77	66.27
1994	31.32	6.27	26.90	64.50
1995	29.91	6.44	26.06	62.40
1996	29.31	6.58	25.46	61.35
1997	31.26	6.52	26.76	64.54
1998	30.09	6.50	25.83	62.42
1999	30.26	6.59	26.21	63.06
2000	29.75	6.60	25.70	62.06
2001	30.23	5.19	25.78	61.19
2002	30.00	5.03	25.25	60.28
2003	29.58	4.93	25.21	59.72
2004	30.03	4.98	25.07	60.08

Table 6.27 Nitrous oxide emission trends from Agricultural soils (Gg)

In 2004, nitrous oxide emissions from agricultural soils were 4.2% (60.08 Gg N_2O) lower than in 1990 (62.71 Gg N_2O). Major contributions come from direct soil emissions (30.03 Gg) and indirect soil emissions (25.07 Gg), representing 50.0% and 41.7%, respectively, from this source. In a detailed analysis, in 2004, indirect N_2O emissions from nitrogen leaching and run-off sub-category has the highest contribution with respect to total agricultural soil nitrous oxide emissions, with 19.88 Gg N_2O, representing 33.1% of N_2O emissions from agricultural soils. Nitrous oxide emissions from leaching and run-off are related to the nitrogen content in fertilizers and animal wastes; therefore, emissions are mainly related to the use of fertilizers in the country as well as the variation in livestock number. In 2004, the second main source respect to total N_2O emissions are direct emission of synthetic fertilizers with 15.09 Gg (25.1%), followed by animal wastes applied to soils, with 8.62 Gg (14.3).

6.5.4. Source-specific QA/QC and verification

Synthetic fertilisers and their nitrogen content have been compared with the international FAO agriculture database statistics (FAO, 2006). In Table 6.28, national and FAO time series of total nitrogen applied are reported. Differences between national data and FAO database are related to the difference in data elaboration (ISTAT, 2004). Differences could be attributed to different factors. First, national data are more disaggregated by substance than FAO data and the national N content is considered for each substance, while FAO utilises default values. Besides, differences could also derive from different products classification.

Year	National data (t N)	FAO database Nitrous fertilizer consumption (Mt)
1990	757,509	878,960
1991	837,402	906,720
1992	884,121	910,000
1993	945,290	917,900
1994	875,536	879,200
1995	797,500	875,000
1996	756,057	876,000
1997	856,945	855,000
1998	774,707	845,000
1999	791,982	868,000
2000	785,594	828,000
2001	808,963	773,161
2002	819,352	785,314
2003	824,649	Not available
2004	841,363	Not available

Table 6.28 Total annual N in fertiliser applied from 1990 to 2004

In response to the review process, different parameters have been revised and updated, as abovementioned. In Table 6.29 the QA/QC plan for this category is presented:

Category/sub category	Parameter	Year of submission		Activities
		2006	2007	
All livestock categories	N excretion rates	√		Update with Inter-project on nitrogen balance (CRPA, 2006; Gazzetta Ufficiale della Repubblica Italiana, 2006; Xiccato et al., 2005)
Direct emissions	$FRAC_{GASM}$	√		Last submission, $FRAC_{GASM}$ was not calculated correctly. Now $FRAC_{GASM}$ is calculated for the whole time series and based on the manure nitrogen used as fertiliser, corrected for NH_3 and NOx emissions (inputs from CLRTAP inventory).
Direct emissions	$FRAC_{GASF}$	√		In the last submission there was a fixed parameter, now the inventory contains a times series of $FRAC_{GASF}$, (inputs from the CLRTAP inventory). Estimations are based on N-NH_3 and N-NO emissions from soils with fertilisers and the content of N in fertilisers.
Direct emissions	Sewage sludge		√	Appropriate activity data needs to be refined, till now emissions are estimated in the waste sector (Wastewater Handling - N_2O from human sewage).
Indirect emissions	$FRAC_{LEACH}$	√		The IPCC default parameter has been verified with national sources (ADBPO, 1998; ADBPO, 2001)

Table 6.29 Improvements for the agricultural soils category in the QA/QC plan

6.5.5. Source-specific recalculations

Different parameters for the estimation of nitrous oxide emissions, direct and indirect, have been revised and updated. Recalculations have been done for the following parameters: $FRAC_{GASM}$ and $FRAC_{GASF}$. Additionally, new parameters such as the nitrogen excretion rates for the different livestock categories have been used. Livestock activity data for the last years have been updated.

6.5.6. Source-specific planned improvements

In this section, emission from sewage sludge applied for the agriculture has not been estimated. As described in the Report of the individual review, Italy is aware that sewage sludge is applied to soils. Currently, the total amount of nitrogen present in the sewage sludge and its emissions are estimate in the Waste sector (section 8.3, CRF 6B).

6.6. Field burning of agriculture residues (4F)

6.6.1. Source category description

Methane and nitrous oxide emissions from field burning agriculture residues have not been assessed as key source. In 2004, methane emissions from this source were 0.67 Gg, which represents only 0.09% of emissions for the agriculture sector (0.08% in 1990); nitrous oxide emissions were 0.01 Gg, which represents 0.02% of emissions for the agriculture sector.

6.6.2. Methodological issues

A country-specific methodology has been used for estimating emissions from field burning of agriculture residues. IPCC parameters have been considered, such as amount of residues produce, amount of dry residues, total biomass burned, and total carbon and nitrogen released. Activity data used for estimating burning of agriculture residues have been summarised in the following box.

Data used for estimating field burning of agriculture residues emission

Data	Reference
Annual crop production	ISTAT, several years [a],[b]; ISTAT, 2006[d]
Removable residues/product ratio	CESTAAT, 1988
Fixed residues/removable residues ratio	ENEA, 1994
Fraction of dry matter in residues	CESTAAT, 1988; Borgioli, 1981; CRPA/CNR, 1992; IPCC, 1997
Fraction of the field where “fixed” residues are burned	CESTAAT, 1988; IPCC,1997; ANPA-ONR, 2001
Fraction of residues oxidized during burning	IPCC, 1997
Fraction of carbon from the dry matter of residues	IPCC, 1997
Raw protein content from residues (dry matter fraction)	CESTAAT, 1988; Borgioli, 1981
IPCC Default Emission rates (CH_4, N_20)	IPCC, 1997

The same methodology has been used to estimate emissions from burning of agriculture residues, both fixed and removable, but they are reported in two different sectors. Emissions from fixed residues, stubble (*stoppie*), burnt on open fields, are reported in this category (4F) while emissions from removable residues (*asportabili*), burnt off-site, are reported under the waste sector (waste incineration- 6C category).

The methodology for estimating emissions refers to fixed residues burnt; the same steps have been followed to calculate emissions from removable residues burnt reported in 6C. Parameters taken into consideration are the following:

a) Amount of “fixed” burnable residues[12] (t), estimated with annual crop production, removable residues/product ratio, and “fixed” residue/removable residues ratio.
b) Amount of dry residues in “fixed” residue[13] (t dry matter), calculated with amount of burnable residues and fraction of dry matter.
c) Amount of “fixed” dry residues oxidized[14] (t dry matter), assessed with amount of dry residues in the “fixed” residues, fraction of the field where “fixed” residues are burned, and fraction of residues oxidized during burning.
d) Amount of carbon from stubble burning release in air[15] (t C), calculated with the amount of “fixed” dry residue oxidized and the fraction of carbon from the dry matter of residues.
e) C-CH_4 from stubble burning[16] (t C-CH_4), calculated with the amount of carbon from stubble burning release in air and default emissions rate for C-CH_4, equal to 0.005 (IPCC, 1997).

[12] Quantità di residuo "fisso" bruciabile (produzione totale) (ton)
[13] Quantità di residuo secco nel residuo "fisso" (tonnellate di sostanza secca)
[14] Quantità residuo secco "fisso" ossidato (ton di sost. secca)
[15] Quantità di carbonio rilasciato in aria dalla combustione delle stoppie (tonnellate di carbonio)
[16] Emissione di C-CH4 dalla combustione delle stoppie (tonnellate di C-CH4)

In 2004 final methane emissions from on field burning of agriculture residues (0.67 Gg CH_4) have been estimated multiplying the C-CH_4 value (0.502 Gg C-CH_4) by the coefficient 16/12. In Table 6.30 parameters used for the estimation of methane emissions from on field burning of agriculture residues are presented.

For estimating nitrous oxide emissions, the same amount of "fixed" dry residue oxidized described above has been used; further parameters are:

a) Amount of nitrogen from stubble burning release in air[17] (t N), calculated with the amount of "fixed" dry residue oxidized and the fraction of nitrogen from the dry matter of residues. The fraction of nitrogen has been calculated considering raw protein content from residues (dry matter fraction) divided by 6.25.
b) N-N_2O from stubble burning[18] (t N-N_2O), calculated with the amount of nitrogen from stubble burning release in air and the default emissions rate for N- N_2O, equal to 0.007 (IPCC, 1997).

In 2004, final nitrous oxide emissions from on field burning of agriculture residues (0.014 Gg N_2O) are estimated by multiplying the N-N_2O value (0.009 Gg N) with the coefficient 44/28. In Table 6.31 parameters used for the estimation of methane emissions from field burning of agriculture residues are presented.

6.6.3. Uncertainty and time-series consistency

Uncertainty for methane and nitrous oxide emissions from field burning of agriculture residues is estimated to be 54% as a result of 50% and 20% for activity data and emission factor, respectively. In 2004 methane emissions from field burning of agriculture residues were 7.3% (0.67 Gg CH_4) lower than in 1990 (0.62 Gg CH_4). In 2004 nitrous oxide emissions were 0.014 Gg N_2O, as mentioned before (see Table 6.32). Variation in emissions trend is related to cereal production.

Crop	Harvested annual production (t 1000)	Amount of "fixed" burnable residues (t 1000)	Amount of dry residue in the "fixed" residues (t 1000 dry matter)	Amount of "fixed" dry residues oxidized (t 1000 dry matter)	Amount of carbon from stubble burning (t 1000 C)	C-CH_4 from stubble burning (t C-CH_4)
Wheat (*frumento*)	8,639	1,490	1,271	111	54	270
Rye (*segale*)	8	1	1	0.11	0.04	0.19
Barley (*orzo*)	1,169	234	200	18	7	33
Oats (*avena*)	336	59	51	5	2	9
Rice (*riso*)	1,523	255	191	86	36	178
Maize (*granoturco)*	11,367	1,137	474	0	0	0
Sorghum (*sorgo da granella*)	215	75	62	6	2	10
TOTAL	23,256	3,251	2,251	226	100	502

Table 6.30 Parameters used for the estimation of methane emissions from agriculture residues in 2004

[17] Quantità di azoto rilasciato in aria dalla combustione delle stoppie (ton di azoto)
[18] Emissione di N-N2O dalla combustione delle stoppie (tonnellate di N-N2O)

Crop	Amount of "fixed" dry residue oxidized (t 1000 dry matter)	Raw protein content from residues (dry matter fraction)	Fraction of nitrogen from the dry matter of residues	Amount of nitrogen from stubble burning (t 1000 N)	$N-N_2O$ from stubble burning (t $N-N_2O$)
Wheat (*frumento*)	111	0.030	0.005	0.534	3.7
Rye (*segale*)	0	0.036	0.006	0.001	0.0
Barley (*orzo*)	18	0.037	0.006	0.107	0.7
Oats (*avena*)	5	0.040	0.006	0.029	0.2
Rice (*riso*)	86	0.041	0.007	0.565	4.0
Maize (*granoturco)*	0		0.007	0.000	0.0
Sorghum (*sorgo da granella*)	6	0.037	0.006	0.033	0.2
TOTAL	226			1.269	8.9

Table 6.31 Parameters used for the estimation of nitrous oxide from agriculture residues in 2004

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Methane emissions	0.62	0.68	0.66	0.64	0.64	0.62	0.64	0.57	0.64	0.62	0.58	0.53	0.60	0.55	0.502
Nitrous oxide emissions	0.008	0.009	0.009	0.008	0.009	0.008	0.008	0.008	0.009	0.008	0.008	0.007	0.008	0.007	0.009

Table 6.32 CH_4 and N_2O emission trends from field burning of agriculture residues (Gg)

6.6.4. Source-specific QA/QC and verification

As presented in Table 6.33, and in agreement with the QA/QC plan, improvements in parameters, which have been taken into consideration, are the following:

Category/sub category	Parameter	Year of submission 2006	2007	Activities
Activity data	Annual crop production	√		Update activity data from ISTAT publications
	% cereal crop residue burnt		√	Probably ISTAT elaboration from "SPA 2003 or SPA 2005" can be useful for obtaining regional information on cereal crop residue burnt

Table 6.33 Improvements for the field burning of agriculture residues category according to the QA/QC plan

6.6.5. Source-specific recalculations

Activity data (annual crop production) has been updated according to data available from ISTAT.

6.6.6. Source-specific planned improvements

In response to the Italian Individual Review, future improvements will consider the validation of parameter used for emissions assessment of cereal crop residue burnt. Probably, a better estimation could be carried out with the elaboration of basic data coming from the "farm and structure survey" from ISTAT.

Chapter 7: LAND USE, LAND USE CHANGE AND FORESTRY [CRF SECTOR 5]

7.1 Overview of sector

CO_2 emissions and removals occur as a result of changes in land-use and from forests. The sector is responsible for 105.9 Mt of CO_2 removals from the atmosphere in 2004.
The 2003 IPCC Good Practice Guidance for LULUCF have been entirely applied for all the categories of this sector as detailed data were available from national statistics and from researches at national and regional level, whereas for category 5A (Forest Land) estimates were supplied by a growth model, applied to national forestry inventory data, with country specific used emission factors.
In 2004, CO_2 emissions and removals from forest land remaining forest land, conversion to forest land, cropland remaining cropland and conversion to cropland are ranked among the top-20 level key categories of sources and sinks; CO_2 emissions and removals from forest land remaining forest land, cropland remaining cropland and conversion to cropland are also ranked among the top-10 trend key categories of sources and sinks.

CO_2 emissions from forest fires have been included in the calculation of the net carbon stocks reported in 5A.
Greenhouse gas removals and emissions in the main categories of the LULUCF sector in 2004 are shown in Figure 7.1:

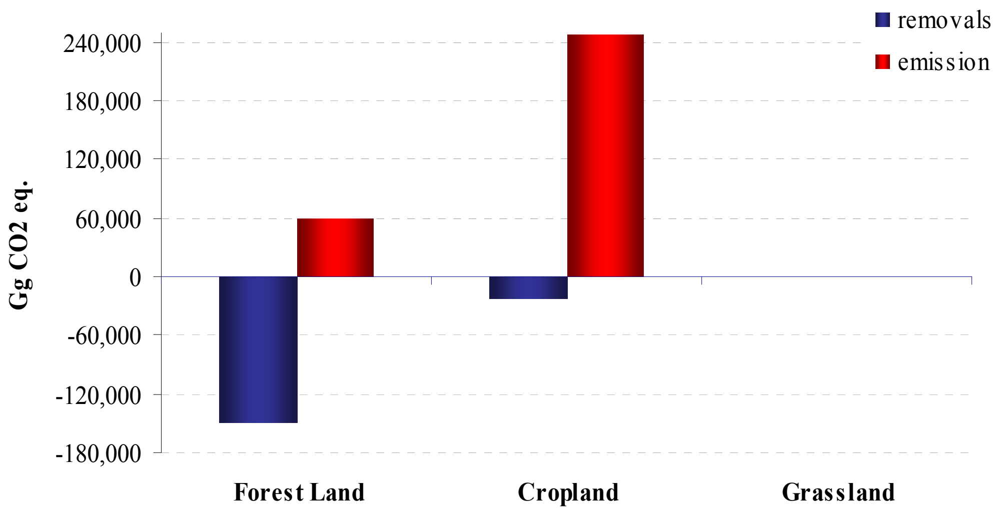

Figure 7.1 Greenhouse gas removals and emissions in LULUCF sector in 2004 [Gg CO_2 eq.]

In Table 7.1 emissions and removals time series is reported.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	(Gg)														
CO_2	**-79,913.74**	**-101,255.47**	**-97,397.29**	**-82,602.51**	**-98,217.34**	**-103,316.98**	**-106,129.73**	**-99,419.76**	**-96,258.95**	**-103,799.36**	**-100,027.88**	**-110,216.88**	**-114,369.06**	**-111,412.52**	**-105,920.21**
A. Forest Land	-58,945.70	-80,523.04	-76,872.96	-62,446.48	-78,766.80	-84,073.85	-86,957.74	-80,005.59	-77,894.99	-85,596.10	-81,772.30	-88,114.31	-94,591.00	-84,696.64	-92,600.16
B. Cropland	-22,248.32	-22,249.15	-22,006.60	-21,436.33	-20,730.84	-20,523.42	-20,150.90	-20,694.46	-19,644.26	-19,483.55	-19,535.88	-20,940.90	-20,799.49	-20,552.41	-14,600.34
C. Grassland	0.00	-1,010.75	-1,048.27	0.00	0.00	0.00	-1,593.17	0.00	0.00	0.00	0.00	-3,720.99	-1,538.07	-8,713.17	0.00
D. Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Settlements	1,280.29	2,527.47	2,530.54	1,280.29	1,280.29	1,280.29	2,572.08	1,280.29	1,280.29	1,280.29	1,280.29	2,559.32	2,559.50	2,549.70	1,280.29
F. Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
G. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH_4	**142.89**	**36.53**	**60.40**	**150.82**	**60.85**	**27.37**	**22.18**	**74.08**	**86.23**	**42.45**	**87.00**	**55.19**	**30.93**	**64.97**	**34.62**
A. Forest Land	142.89	36.53	60.40	150.82	60.85	27.37	22.18	74.08	86.23	42.45	87.00	55.19	30.93	64.97	34.62
B. Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C. Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F. Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
G. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N_2O	**49.26**	**3.71**	**6.13**	**54.96**	**106.41**	**83.18**	**2.25**	**27.76**	**169.01**	**231.73**	**229.83**	**5.60**	**3.14**	**6.59**	**778.11**
A. Forest Land	14.50	3.71	6.13	15.31	6.18	2.78	2.25	7.52	8.75	4.31	8.83	5.60	3.14	6.59	3.51
B. Cropland	34.76	0.00	0.00	39.65	100.23	80.40	0.00	20.24	160.25	227.42	221.00	0.00	0.00	0.00	774.59
C. Grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F. Other Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
G. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Land Use, Land-Use Change and Forestry (Gg CO_2 equivalent)	**-79,721.59**	**-101,215.23**	**-97,330.76**	**-82,396.73**	**-98,050.09**	**-103,206.42**	**-106,105.31**	**-99,317.92**	**-96,003.71**	**-103,525.18**	**-99,711.05**	**-110,156.09**	**-114,334.99**	**-111,340.95**	**-105,107.49**

Table 7.1 Trend in greenhouse gas emissions from the LULUCF sector 1990-2004

CO_2 emissions and removals in LULUCF sector, in the period 1990-2004, are shown in Figure 7.2:

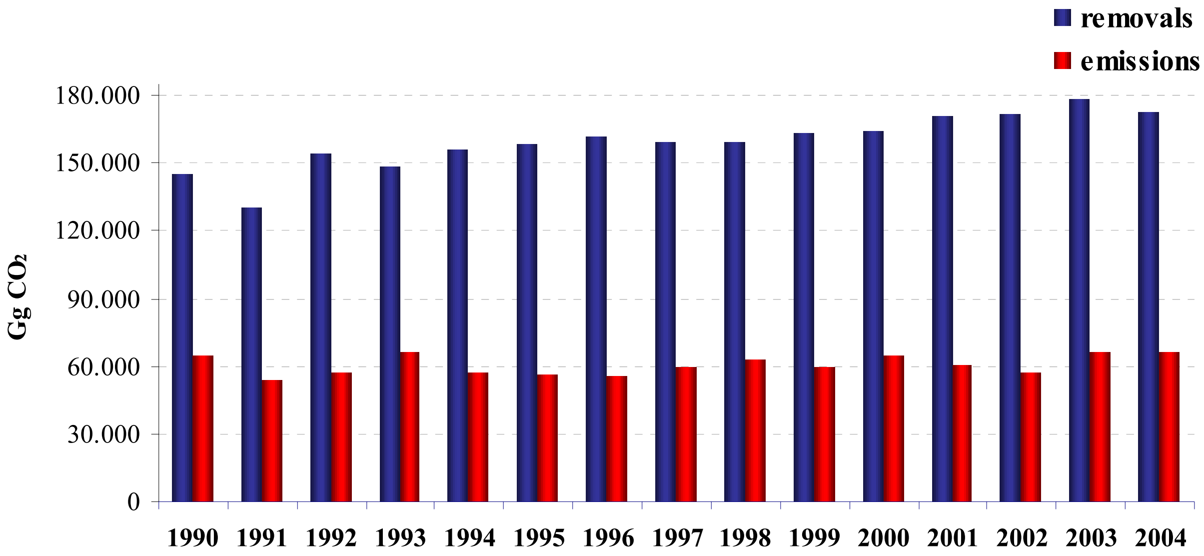

Figure 7.2 CO_2 removals and emissions in LULUCF sector in 2004 [Gg CO_2]

The outcome of the key category analysis, according to a level and/or trend assessment (*IPCC Tier 1 and Tier 2 approaches*), is listed in Table 7.2. CO_2 emissions and removals from forest land remaining forest land, conversion to forest land, cropland remaining cropland and conversion to cropland have been identified as key sources or sinks. Concerning CH_4 or N_2O emissions, no categories have resulted as a key source.

	gas	*categories*	
5.A.1	CO_2	Forest land remaining forest land	key (L, T)
5.A.2	CO_2	Conversion to forest land	key (L)
5.B.1	CO_2	Cropland remaining cropland	key (L, T)
5.B.2	CO_2	Conversion to cropland	key (L, T)
5.C	CO_2	Grassland	Non-key
5.D	CO_2	Wetlands	Non-key
5.E	CO_2	Settlements	Non-key
5.A.1	CH_4	Forest land remaining forest land	Non-key
5.A.1	N_2O	Forest land remaining forest land	Non-key
5.B.2	N_2O	Conversion to cropland	Non-key

Table 7.2 Key categories identification in LULUCF sector

For the land use conversion, land use change matrices have been used; the matrices have permitted to point out the average areas of transition land, separately for each initial and final land use (i.e. forest land, grassland, etc.).
LUC matrices for each year of the period 1990–2004 have been assembled based on the time series of national land use statistics for forest lands, croplands, grasslands, wetlands and settlement areas. Annual figures for areas in transition between different land uses have been derived by a hierarchy of basic assumptions (supplied by expert judgement) on known patterns of land-use changes in Italy with the constraint that the total national area remains constant. Growth in forest land area as detected by the National Forest Inventory is used as the basis. The rule then assumes that new forest land area can only come from grassland and no deforestation is

occurring. Settlements area can only come from grassland or cropland. New cropland area can only come from grassland area, as new grassland area can only come from cropland area.

Changes in carbon stocks associated with the transitions have been estimated only for a single year (i.e. the year of conversion). While this may be valid for losses of aboveground biomass due to some land conversions, soil carbon is in steady state equilibrium in natural ecosystems, therefore change in land use is expected to affect soil carbon sequestration dynamics and consequently soil carbon stocks. Current approaches assume that after a cultivation of a forest or grassland, there is an initial carbon loss over the first years which rapidly reduces to a lower subsequent loss rate in the following years (Davidson and Ackerman, 1993). This loss could be attributed to the response of the faster-cycling C pools that contribute mostly to the decomposition flux, commonly described by first-order decomposition kinetics (Olson, 1963). Soils are expected to gain carbon in cropland converted to grassland (Guo and Giffort, 2002, Post and Kwon, 2000) at fast rates in the first stages of the conversion (Reeder et al., 1998). However because the dynamics of soil carbon storage and release are complex and still not well understood, the magnitude and timing of the response of the soil carbon to change in land use should be considered affected by a large uncertainty.

On this basis and by considering the spatial resolution of data we used, we conclude that a reasonable approach, in calculating the effect of land use change, could be assuming that the changes in carbon stocks carbon occur in the first year after the land conversion, instead of considering them over the time period (20 years as default) specified by the IPCC GPG LULUCF (IPCC, 2003). From a technical point of view, we are confident to account, by this method, for the largest part of the total amount of carbon exchanged to the atmosphere; a severe effort and enhanced quality data would be required to obtain the necessary high degree of spatial disaggregation of areas affected by the land use change every year in a 20 years time period. The contribution from stock changes is thus applied in the first year following the relevant land-use change, and it is applied only once, for the year in which it is determined.

In the following Table 7.3, the land use matrices for each year of the period 1990–2004 are reported.

		1989						
		Forest	**Grassland**	**Cropland**	**Wetland**	**Settlements**	**Other Land**	*Initial sum*
	1990	9,145	7,691	11,013	57	1,340	887	*30,134*
1990	**Forest**	**9,145**						*9,145*
	Grassland	118	**7,691**	15		8		*7,691*
	Cropland		0	**11,013**		0		*11,013*
	Wetland				**57**			*57*
	Settlements					**1,340**		*1,340*
	Other Land						**887**	*887*
	Final sum	*9,263*	*7,550*	*11,028*	*57*	*1,348*	*887*	30,134

		1990						
		Forest	**Grassland**	**Cropland**	**Wetland**	**Settlements**	**Other Land**	*Initial sum*
	1991	9,263	7,550	11,028	57	1,348	887	*30,134*
1991	**Forest**	**9,263**						*9,263*
	Grassland	118	**7,550**	0		0		*7,550*
	Cropland		41	**11,028**		8		*11,028*
	Wetland				**57**			*57*
	Settlements					**1,348**		*1,348*
	Other Land						**887**	*887*
	Final sum	*9,380*	*7,474*	*10,979*	*57*	*1,356*	*887*	30,134

		1991						
		Forest	**Grassland**	**Cropland**	**Wetland**	**Settlements**	**Other Land**	*Initial sum*
1992	**1992**	9,380	7,474	10,979	57	1,356	887	*30,134*
	Forest	**9,380**						*9,380*
	Grassland	118	**7,474**	0		0		*7,474*
	Cropland		42	**10,979**		8		*10,979*
	Wetland				**57**			*57*
	Settlements					**1,356**		*1,356*
	Other Land						**887**	*887*
	Final sum	*9,498*	*7,398*	*10,928*	*57*	*1,365*	*887*	30,134

		1992						
		Forest	**Grassland**	**Cropland**	**Wetland**	**Settlements**	**Other Land**	*Initial sum*
1993	**1993**	9,498	7,398	10,928	57	1,365	887	*30,134*
	Forest	**9,498**						*9,498*
	Grassland	118	**7,398**	17		8		*7,398*
	Cropland		0	**10,928**		0		*10,928*
	Wetland				**57**			*57*
	Settlements					**1,365**		*1,365*
	Other Land						**887**	*887*
	Final sum	*9,616*	*7,256*	*10,945*	*57*	*1,373*	*887*	30,134

		1993						
		Forest	**Grassland**	**Cropland**	**Wetland**	**Settlements**	**Other Land**	*Initial sum*
1994	**1994**	9,616	7,256	10,945	57	1,373	887	*30,134*
	Forest	**9,616**						*9,616*
	Grassland	118	**7,256**	43		8		*7,256*
	Cropland		0	**10,945**		0		*10,945*
	Wetland				**57**			*57*
	Settlements					**1,373**		*1,373*
	Other Land						**887**	*887*
	Final sum	*9,733*	*7,087*	*10,988*	*57*	*1,381*	*887*	30,134

		1994						
		Forest	**Grassland**	**Cropland**	**Wetland**	**Settlements**	**Other Land**	*Initial sum*
1995	**1995**	9,733	7,087	10,988	57	1,381	887	*30,134*
	Forest	**9,733**						*9,733*
	Grassland	118	**7,087**	34		8		*7,087*
	Cropland		0	**10,988**		0		*10,988*
	Wetland				**57**			*57*
	Settlements					**1,381**		*1,381*
	Other Land						**887**	*887*
	Final sum	*9,851*	*6,927*	*11,022*	*57*	*1,389*	*887*	30,134

		1995						
		Forest	**Grassland**	**Cropland**	**Wetland**	**Settlements**	**Other Land**	*Initial sum*
1996	**1996**	9,851	6,927	11,022	57	1,389	887	*30,134*
	Forest	**9,851**						*9,851*
	Grassland	118	**6,927**	0		0		*6,927*
	Cropland		64	**11,022**		8		*11,022*
	Wetland				**57**			*57*
	Settlements					**1,389**		*1,389*
	Other Land						**887**	*887*
	Final sum	*9,968*	*6,874*	*10,949*	*57*	*1,398*	*887*	30,134

		1996						
		Forest	Grassland	Cropland	Wetland	Settlements	Other Land	*Initial sum*
	1997	9,968	6,874	10,949	57	1,398	887	*30,134*
1997	Forest	**9,968**						*9,968*
	Grassland	118	**6,874**	9		8		*6,874*
	Cropland		0	**10,949**		0		*10,949*
	Wetland				**57**			*57*
	Settlements					**1,398**		*1,398*
	Other Land						**887**	*887*
	Final sum	*10,086*	*6,739*	*10,958*	*57*	*1,406*	*887*	30,134

		1997						
		Forest	Grassland	Cropland	Wetland	Settlements	Other Land	*Initial sum*
	1998	10,086	6,739	10,958	57	1,406	887	*30,134*
1998	Forest	**10,086**						*10,086*
	Grassland	118	**6,739**	68		8		*6,739*
	Cropland		0	**10,958**		0		*10,958*
	Wetland				**57**			*57*
	Settlements					**1,406**		*1,406*
	Other Land						**887**	*887*
	Final sum	*10,203*	*6,545*	*11,026*	*57*	*1,414*	*887*	30,134

		1998						
		Forest	Grassland	Cropland	Wetland	Settlements	Other Land	*Initial sum*
	1999	10,203	6,545	11,026	57	1,414	887	*30,134*
1999	Forest	**10,203**						*10,203*
	Grassland	118	**6,545**	97		8		*6,545*
	Cropland		0	**11,026**		0		*11,026*
	Wetland				**57**			*57*
	Settlements					**1,414**		*1,414*
	Other Land						**887**	*887*
	Final sum	*10,321*	*6,323*	*11,123*	*57*	*1,422*	*887*	30,134

		1999						
		Forest	Grassland	Cropland	Wetland	Settlements	Other Land	*Initial sum*
	2000	10,321	6,323	11,123	57	1,422	887	*30,134*
2000	Forest	**10,321**						*10,321*
	Grassland	118	**6,323**	94		8		*6,323*
	Cropland		0	**11,123**		0		*11,123*
	Wetland				**57**			*57*
	Settlements					**1,422**		*1,422*
	Other Land						**887**	*887*
	Final sum	*10,438*	*6,103*	*11,217*	*57*	*1,431*	*887*	30,134

		2000						
		Forest	Grassland	Cropland	Wetland	Settlements	Other Land	*Initial sum*
	2001	10,438	6,103	11,217	57	1,431	887	*30,134*
2001	Forest	**10,438**						*10,438*
	Grassland	118	**6,103**	0		0		*6,103*
	Cropland		150	**11,217**		8		*11,217*
	Wetland				**57**			*57*
	Settlements					**1,431**		*1,431*
	Other Land						**887**	*887*
	Final sum	*10,556*	*6,136*	*11,059*	*57*	*1,439*	*887*	30,134

		2001						
		Forest	Grassland	Cropland	Wetland	Settlements	Other Land	*Initial sum*
	2002	10,556	6,136	11,059	57	1,439	887	*30,134*
2002	Forest	**10,556**						*10,556*
	Grassland	118	**6,136**	0		0		*6,136*
	Cropland		62	**11,059**		8		*11,059*
	Wetland				**57**			*57*
	Settlements					**1,439**		*1,439*
	Other Land						**887**	*887*
	Final sum	*10,674*	*6,080*	*10,988*	*57*	*1,447*	*887*	30,134

		2002						
		Forest	Grassland	Cropland	Wetland	Settlements	Other Land	*Initial sum*
	2003	10,674	6,080	10,988	57	1,447	887	*30,134*
2003	Forest	**10,674**						*10,674*
	Grassland	118	**6,080**	0		0		*6,080*
	Cropland		352	**10,988**		8		*10,988*
	Wetland				**57**			*57*
	Settlements					**1,447**		*1,447*
	Other Land						**887**	*887*
	Final sum	*10,791*	*6,314*	*10,628*	*57*	*1,455*	*887*	30,134

		2003						
		Forest	Grassland	Cropland	Wetland	Settlements	Other Land	*Initial sum*
	2004	10,791	6,314	10,628	57	1,455	887	*30,134*
2004	Forest	**10,791**						*10,791*
	Grassland	118	**6,314**	352		8		*6,314*
	Cropland		0	**10,628**		0		*10,628*
	Wetland				**57**			*57*
	Settlements					**1,455**		*1,455*
	Other Land						**887**	*887*
	Final sum	*10,909*	*5,837*	*10,980*	*57*	*1,464*	*887*	30,134

Table 7.3 Land use change matrices for the years 1990-2004

7.2 Forest Land (5A)

7.2.1 Source category description

Under this category, CO_2 emissions, from living biomass, dead organic matter and soils, from forest land remaining forest land and from land converted in forest land have been reported.
Net carbon stocks change by land converted in forest land, for the living biomass, dead organic matter and soils sectors, is included in the assessment of carbon stocks change in living biomass, dead organic matter and soils for forest land remaining forest land.
Forest land removals share 85% of total CO_2 2004 LULUCF emissions and removals, while the mean forest land removals for the years 1990-2004 is 77% of total mean CO_2 LULUCF emissions and removals; in particular the living biomass removals represent 47%, while the removals from dead organic matter and soils stand for 9% and 45% of total 2004 forest land CO_2 removals, respectively. In Table 7.4 percentage contribution of different carbon pools to forest land category, in the period 1990 – 2004, is reported. It's possible to note as the contribution of each pools doesn't dramatically change during the investigated period, even if disturbances as forest fires can decrease the weight of living biomass, as in 1990 or 1993, resulting in a seeming different contribution of soil carbon pool to forest land category.

Forest land	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
- living biomass	*36*	*44*	*43*	*39*	*44*	*45*	*46*	*44*	*44*	*45*	*43*	*46*	*47*	*45*	*47*
- dead organic matter	*9*	*8*	*9*	*9*	*9*	*8*	*8*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*
- soils	*55*	*48*	*49*	*52*	*48*	*47*	*46*	*47*	*47*	*46*	*48*	*45*	*44*	*46*	*45*

Table 7.4 Percentage contribution of carbon pools to forest land category, in 1990-2004

The major part of removals (89.1%) is due to forest land remaining forest land subcategory; the same subcategory is responsible for 98.8% of total emissions.
CO_2 removals from forest land remaining forest land have been identified as key category (sinks) in level and in trend assessment (Tier 1); CO_2 emissions and removals from land converting to forest land have been identified as key category in level assessment (Tier 1);
Concerning CH_4 or N_2O emissions, neither forest land nor land converting to forest land have resulted as a key source.

7.2.2 Methodological issues

Forest Land remaining Forest Land

All the data concerning the growing stock and the related carbon are assessed by a model (Federici et al., 2005), which estimates the evolution in time of the Italian forest carbon pools, according to the GPG classification and definition: living biomass, both aboveground and belowground, dead organic matter, including dead wood and litter, and soils as soil organic matter.
The model has been applied at regional scale (NUT2) because of availability of any forest-related statistical data: input data for the forest area, per region and inventory typologies[19], were the First Italian National Forest Inventory (IFN) data and the Second Italian National Forest Inventory data.
The Italian Ministry of Agriculture and Forests (MAF) and the Experimental Institute for Forest Management (ISAFA) carried out the first National Forest Inventory in 1985. As a result of the first IFN based on a regular sampling grid of 3 km by 3 km, the global Italian extent of forest resources was about 8.7 million hectares (MAF/ISAFA, 1988). A second national forest inventory, using a grid of 1 km by 1 km, had been launched in 2001. Preliminary results of the first inventory phase, consisting in interpretation of orthophotos, were used as input data for the model. This source of information refers to the year 2002 (MAF/ISAFA, 2004).
The estimation for 1990 was calculated through a linear interpolation between the 1985 and 2002 data. By assuming that the defined trend may well represent the near future, it was possible to extrapolate data for 2004.
Additional source of information is the National Institute of Statistics (ISTAT), which provides annual data on forest area extent. Unfortunately the forest definition adopted by ISTAT implies a minimum cover density of 50% and a minimum forest extent of 0.5 hectares. This leads to an underestimation of the actual forest resources, as less dense formations are not considered. This is the reason why such an important set of historical data was not used to estimate and forecast the forest area extent for the requested years.
To estimate the growing stock of Italian forest, from 1990 to 2003, the following methodology was applied:

[19]The inventory typologies are classified in 4 main categories: Stands, Coppices, Plantations and Protective Forests. The typologies for each category are:
Stands*: norway spruce, silver fir, larches, mountain pines, mediterranean pines, other conifers, European beech, turkey oak, other oaks, other broadleaves*.
Coppices: *european beech, sweet chestnut, hornbeams, other oaks, turkey oak, evergreen oaks, other broadleaves, conifers*.
Plantations: *eucalyptuses coppices, other broadleaves coppices, poplar stands, other broadleaves stands, conifers stands, others*.
Protective Forests: *rupicolous forest, riparian forests, shrublands*

1. the initial growing stock volume is the 1985 growing stock data (MAF/ISAFA, 1988)
2. starting from 1985, for each year, the current increment per hectare [m^3 ha-[1]] is computed with the derivative Richards function[20], for each forest typology by the Italian yield tables collection.
3. starting from 1986, for each year the growing stock per hectare [m^3 ha^{-1}] is computed, from the previous year growing stock volume, with the addition of the calculated increment ("y" value of the derivative Richards) for the current year and subtraction of the losses due to harvest, mortality and fire for the current year.

The relationship can be summarized as follows:

$$v_i = \frac{V_{i-1} + I_i - H_i - F_i - M_i - D_i}{A_i}$$

where

$$I_i = f\left(v_{i-1}\right) \cdot A_{i-1}$$

in which the current increment is estimated year by year applying the derived Richards function and

v_i is the volume per hectare of growing stock for the current year
V_{i-1} is the total previous year growing stock volume
I_i is the total current increment of growing stock for the current year
H_i is the total amount of harvested growing stock for the current year
F_i is the total amount of burned growing stock for the current year
Mi is the annual rate of mortality
D is the annual rate of drain and grazing for the protective forest
A_i is the total area referred to a specific forest typology for the current year
v_{i-1} is the previous year growing stock volume per hectare
A_{i-1} is the total area referred to a specific forest typology for the previous year
f is the Richards function reported above

The average rate of mortality, the fraction of standing biomass per year, used for the calculation was 0.0116, concerning the evergreen forest, and 0.00117, for deciduous forest, according to the GPG (IPCC, 2003).
The rate of draining and grazing, applied to protective forest, has been set as 3% following expert judgement (Federici et al., 2005) because of total absence of referable data.
Total commercial harvested wood, for construction and energy purposes, has been obtained from national statistics (ISTAT, several years [a]); data on biomass removed in commercial harvest

[20] In the followed approach the Richards function is fitted through the data of growing stock [m^3] and increment [$m^3\ y^{-1}$] obtained by the data of the national forestry inventory and yield tables collection. The independent variable, x, represents the growing stock of the stand, while the dependent variable y is the correspondent increment computed with the Richards function - first derivative.

$$\frac{dy}{dt} = \frac{k}{v} \cdot y \cdot \left[1 - \left(\frac{y}{a}\right)^v\right] + y_0 \qquad \text{(first derivative)}$$

where the general constrain for the parameters are the following:

$$a,k > 0 \quad -1 \le v \le \infty \text{ e } \ v \ne 0$$

The constant y_0 is derived from the data of age and volume reported in the yield tables: more precisely y_0 has the value of the volume for the age 1. After choosing the function, it is fitted to the measurements by non-linear regression. The minimization of the deviation is performed by the least squares method. The model performances were evaluated against the data by validation statistics according to Janssen and Heuberger (1995).

published by ISTAT are probably underestimated, particularly concerning fuelwood consumption (Ciccarese et al., 1999), but no other sources are currently available. Data of wood use for construction and energy purposes, reported in m^3, are disaggregated at NUT2 level, in sectoral statistics (ISTAT, several years [a]) or at NUT1 level for coppices and high forests in national statistics (ISTAT, several years [c]). These figures have been subtracted, as losses, to growing stock volume, as abovementioned.

Carbon amount released by forest fires has been included in the overall assessment of carbon stocks change. Not having data on the fraction of growing stock oxidised as consequence of fires, the most conservative hypothesis has been adopted; all growing stock of burned forest areas has been assumed to be completely oxidised and so released. Moreover, not having data on forest typologies of burned areas, the total value of burned forest area coming from national statistics has been subdivided and assigned to forest typologies based on their respective weight on total national forest area. Finally, the amount of burned growing stock has been calculated multiplying average growing stock per hectare of forest typology for the assigned burned area. Assessed value has been subtracted to total growing stock of respective typology, as aforesaid.

In Figure 7.3, losses of carbon due to harvest and forest fires, referred to forest land category and reported as percentage on total aboveground carbon, are shown.

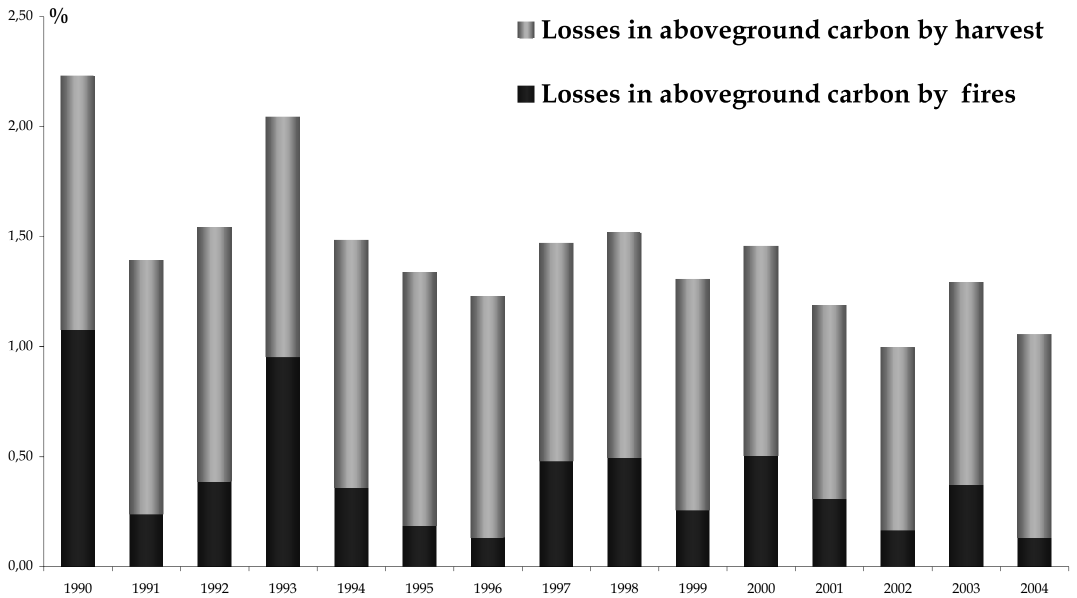

Figure 7.3 Losses by harvest and fires in relation to aboveground carbon

In the following Table 7.5, values of burned growing stocks and respective CO_2 released, for different categories (stands, coppices, plantations, protective forests), are shown.

Year	burned growing stock m^3					CO_2 released Gg				
	stands	*coppice*	*plantations*	*protective*	*total*	*stands*	*coppice*	*plantations*	*protective*	*total*
1990	3,592,811	4,999,612	562,109	1,312,728	10,467,260	4,471	7,252	591	1,985	14,080
1991	767,388	1,051,789	199,236	351,979	2,370,393	957	1,523	207	532	3,185
1992	1,188,788	1,874,998	265,415	604,804	3,934,005	1,484	2,710	273	913	5,280
1993	3,274,143	3,646,198	1,373,010	1,540,808	9,834,158	4,090	5,262	1,397	2,325	13,181
1994	1,255,143	910,314	891,202	723,258	3,779,916	1,570	1,312	899	1,091	5,062
1995	589,087	1,122,859	64,477	229,956	2,006,379	738	1,616	65	347	2,686
1996	606,893	572,713	86,190	196,597	1,462,392	762	823	86	296	1,957
1997	1,835,634	2,697,384	241,846	641,728	5,416,591	2,307	3,873	241	967	7,245
1998	2,261,677	1,816,295	656,886	945,449	5,680,308	2,846	2,605	654	1,424	7,596
1999	904,454	1,277,594	410,476	414,620	3,007,143	1,140	1,830	408	624	4,021
2000	2,295,235	2,197,860	618,149	910,445	6,021,689	2,895	3,146	613	1,370	8,050
2001	1,330,000	1,494,585	375,860	566,232	3,766,678	1,680	2,137	372	852	5,034
2002	613,174	1,039,330	69,351	351,051	2,072,906	775	1,485	69	528	2,771
2003	1,494,266	2,019,788	523,799	699,212	4,737,066	1,892	2,883	519	1,051	6,331
2004	531,829	768,592	62,287	331,883	1,694,591	674	1,096	62	499	2,265

Table 7.5 Burned growing stocks and CO_2 released for the years 1990-2004

Once estimated the growing stock, the amount of aboveground tree biomass (dry matter) belowground biomass (dry matter) and dead mass (dry matter), from 1990 to 2004, can be assessed. In the following, the default value of carbon fraction of dry matter (0.5 t d.m.) has been applied to obtain carbon amount from biomass.
With regard to the aboveground biomass:

1. starting from the 1985 growing stock data, reported in the IFN, the amount of aboveground woody tree biomass (d.m) [t] was calculated, for every forest typology, through the relation:

$$\text{Aboveground tree biomass(d.m.)} = GS \cdot BEF \cdot WBD \cdot A$$

where:
GS = volume of growing stock (MATT/ISAFA, 1988) [m^3 ha-^{1}]
BEF = Biomass Expansion Factors which expands growing stock volume to volume of aboveground woody biomass (ISAFA, 2004)
WBD = Wood Basic Density for conversions from fresh volume to dry weight (d.m) [t m^{-3}] (Giordano, 1980)
A = forest area occupied by specific typology [ha] (MATT/ISAFA, 1988)

The BEF were derived for each forest typology and wood basic density values were different for the main tree species.

2. starting from 1985, for each year, current increment per hectare [m^3 ha^{-1} y^{-1}] is computed with the derivative Richards function, for every specific forest typology by the Italian yield tables collection.
3. starting from 1986, for each year growing stock per hectare [m^3 ha^{-1}] is computed, from the previous year growing stock volume, adding the calculated increment ("y" value of the derivative Richards) for the current year and subtracting losses due to harvest, mortality and fire for the current year, as described above.

Re-applying the relation:

$$\text{Aboveground tree biomass} = GS \cdot BEF \cdot WBD \cdot A$$

it is possible to obtain the aboveground woody tree biomass (d.m) [t] for each forest typology, for each year, starting from the year 1986.

In the following Table 7.6 biomass expansion factors for the conversions of volume to aboveground tree biomass and wood basic densities are reported:

	Inventory typology	BEF *aboveground biomass / growing stock*	Wood Basic Density *Dry weigth t/ fresh volume*
stands	norway spruce	1.29	0.38
	silver fir	1.34	0.38
	larches	1.22	0.56
	mountain pines	1.33	0.47
	mediterranean pines	1.53	0.53
	other conifers	1.37	0.43
	european beech	1.36	0.61
	turkey oak	1.45	0.69
	other oaks	1.42	0.67
	other broadleaves	1.47	0.53
	partial total	*1.35*	*0.51*
coppices	european beech	1.36	0.61
	sweet chestnut	1.33	0.49
	hornbeams	1.28	0.66
	other oaks	1.39	0.65
	turkey oak	1.23	0.69
	evergreen oaks	1.45	0.72
	other broadleaves	1.53	0.53
	conifers	1.38	0.43
	partial total	*1.39*	*0.56*
plantations	eucalyptuses coppices	1.33	0.54
	other broadleaves coppices	1.45	0.53
	poplars stands	1.24	0.29
	other broadleaves stands	1.53	0.53
	conifers stands	1.41	0.43
	others	1.46	0.48
	partial total	*1.36*	*0.40*
protective	rupicolous forest	1.44	0.52
	riparian forest	1.39	0.41
	shrublands	1.49	0.63
	partial total	*1.46*	*0.56*
	Total	**1.38**	**0.53**

Table 7.6 Biomass Expansion Factors and Wood Basic Densities

Using the preliminary results of the *RiselvItalia Project* carried out by ISAFA (ISAFA, 2004), belowground biomass was estimated applying a BEF to the growing stock. The belowground biomass is computed, as:

$$\text{Belowground biomass(d.m.)} = GS \cdot WBD \cdot R \cdot A$$

where

GS = volume of growing stock [m^3 ha-[1]]

R = Root/Shoot ratio which converts growing stock biomass in belowground biomass
WBD = Wood Basic Density [t d.m. m^{-3}]
A = forest area occupied by specific typology [ha]
Also in this case, the BEFs and WBDs were derived for each forest typology:

	Inventory typology	R *weight of belowground biomass / weight of growing stock /*	Wood Basic Density *Dry weigth t/ fresh volume*
stands	norway spruce	0.29	0.38
	silver fir	0.28	0.38
	Larches	0.29	0.56
	mountain pines	0.36	0.47
	mediterranean pines	0.33	0.53
	other conifers	0.29	0.43
	european beech	0.20	0.61
	turkey oak	0.24	0.69
	other oaks	0.20	0.67
	other broadleaves	0.24	0.53
	partial total	*0.28*	*0.50*
coppices	european beech	0.20	0.61
	sweet chestnut	0.28	0.49
	Hornbeams	0.26	0.66
	other oaks	0.20	0.65
	turkey oak	0.24	0.69
	evergreen oaks	1.00	0.72
	other broadleaves	0.24	0.53
	Conifers	0.29	0.43
	partial total	*0.27*	*0.57*
plantations	eucalyptuses coppices	0.43	0.54
	other broadleaves coppices	0.24	0.53
	poplars stands	0.21	0.29
	other broadleaves stands	0.24	0.53
	conifers stands	0.29	0.43
	Others	0.28	0.48
	partial total	*0.25*	*0.40*
protective	rupicolous forest	0.42	0.52
	riparian forest	0.23	0.41
	Shrublands	0.62	0.63
	partial total	*0.50*	*0.58*
	Total	*0.30*	*0.54*

Table 7.7 Root/Shoot ratio and Wood Basic Densities

The net carbon stock change of living biomass has been calculated according to the GPG for LULUCF (IPCC, 2003), from the aboveground tree biomass and belowground biomass:

$$\Delta C_{\text{Living biomass}} = \Delta C_{\text{Aboveground biomass}} + \Delta C_{\text{Belowground biomass}}$$

where the total amount of carbon has been obtained from the biomass (d.m.), multiplying by the conversion factor carbon content / dry matter.

The deadwood biomass was estimated applying a dead mass conversion factor (DCF[21]) of 20%, as the only available national information refers to dead standing trees in high forest stands.
The dead mass [t] is:

$$\text{Dead mass (d.m.)} = \text{GS} \cdot BEF \cdot WBD \cdot DCF \cdot A$$

where
GS = volume of growing stock [m^3 ha^{-1}]
BEF = Biomass Expansion Factors for the conversions of volume to aboveground woody tree biomass
WBD = Wood Basic Density [t d.m. m^{-3}]
DCF = Dead mass Conversion Factor which converts aboveground woody biomass in dead mass
A = forest area occupied by specific typology [ha]

The total litter carbon amount is estimated from the aboveground carbon amount with linear relations, deduced from the results of the European project CANIF[22] (*CArbon and NItrogen cycling in Forest ecosystems)* which has reported such relations for a number of European forest stands. The total litter carbon amount has been estimated from aboveground carbon amount with linear relations differentiated per forestry use: stands (resinous, broadleaves, mixed stands) and coppices.
In Table 7.8 the different relations used to obtain litter carbon amount per ha [t C ha^{-1}] from the aboveground carbon amount per ha [t C ha^{-1}] have been reported:

[21] In accordance with the FAO –GFRA Update 2005 Specification of National Reporting Tables for FRA 2005 (FAO, 2004 [a] and [b])
[22] CANIF project: http://medias.obs-mip.fr/ricamare/interface/projet/canif.html

	Inventory typology	Relation litter – aboveground C per ha
stands	norway spruce	$y = 0.0659 \cdot x + 1.5045$
	silver fir	$y = 0.0659 \cdot x + 1.5045$
	larches	$y = 0.0659 \cdot x + 1.5045$
	mountain pines	$y = 0.0659 \cdot x + 1.5045$
	mediterranean pines	$y = 0.0659 \cdot x + 1.5045$
	other conifers	$y = 0.0659 \cdot x + 1.5045$
	european beech	$y = -0.0299 \cdot x + 9.3665$
	turkey oak	$y = -0.0299 \cdot x + 9.3665$
	other oaks	$y = -0.0299 \cdot x + 9.3665$
	other broadleaves	$y = -0.0299 \cdot x + 9.3665$
coppices	european beech	$y = -0.0299 \cdot x + 9.3665$
	sweet chestnut	$y = -0.0299 \cdot x + 9.3665$
	hornbeams	$y = -0.0299 \cdot x + 9.3665$
	other oaks	$y = -0.0299 \cdot x + 9.3665$
	turkey oak	$y = -0.0299 \cdot x + 9.3665$
	evergreen oaks	$y = -0.0299 \cdot x + 9.3665$
	other broadleaves	$y = -0.0299 \cdot x + 9.3665$
	conifers	$y = 0.0659 \cdot x + 1.5045$
plantations	eucalyptuses coppices	$y = -0.0299 \cdot x + 9.3665$
	other broadleaves coppices	$y = -0.0299 \cdot x + 9.3665$
	poplars stands	$y = -0.0299 \cdot x + 9.3665$
	other broadleaves stands	$y = -0.0299 \cdot x + 9.3665$
	conifers stands	$y = 0.0659 \cdot x + 1.5045$
	others	$y = -0.0165 \cdot x + 7.3285$
protective	rupicolous forest	$y = -0.0165 \cdot x + 7.3285$
	riparian forest	$y = -0.0299 \cdot x + 9.3665$
	shrublands	$y = -0.0299 \cdot x + 9.3665$

Table 7.8 Relations litter - aboveground carbon per ha

The dead organic matter carbon pool is defined, in the GPG, as the sum of the dead wood and the litter.

$$\Delta C_{\text{Dead Organic Matter}} = \Delta C_{\text{dead mass}} + \Delta C_{\text{litter}}$$

The total amount of carbon for dead organic matter has been obtained from the dead organic matter (d.m.), multiplying by the conversion factor carbon content / dry matter.

The total soil carbon amount is estimated from the aboveground carbon amount, with linear relations, deduced from national CONECOFOR Programme data (Corpo Forestale, 2005; Cutini, 2002), per forestry use – stands (resinous, broadleaves, mixed stands) and coppices. In Table 7.9 the different relations used to obtain soil carbon amount per ha [t C ha^{-1}] from the aboveground carbon amount per ha [t C ha^{-1}] have been reported:

	Inventory typology	Relation soil – aboveground C per ha
stands	norway spruce	$y = 0.4041 \cdot x + 57.874$
	silver fir	$y = 0.4041 \cdot x + 57.874$
	larches	$y = 0.4041 \cdot x + 57.874$
	mountain pines	$y = 0.4041 \cdot x + 57.874$
	mediterranean pines	$y = 0.4041 \cdot x + 57.874$
	other conifers	$y = 0.4041 \cdot x + 57.874$
	european beech	$y = 0.9843 \cdot x + 5.0746$
	turkey oak	$y = 0.9843 \cdot x + 5.0746$
	other oaks	$y = 0.9843 \cdot x + 5.0746$
	other broadleaves	$y = 0.9843 \cdot x + 5.0746$
	european beech	$y = 0.3922 \cdot x + 65.356$
coppices	sweet chestnut	$y = 0.3922 \cdot x + 65.356$
	hornbeams	$y = 0.3922 \cdot x + 65.356$
	other oaks	$y = 0.3922 \cdot x + 65.356$
	turkey oak	$y = 0.3922 \cdot x + 65.356$
	evergreen oaks	$y = 0.3922 \cdot x + 65.356$
	other broadleaves	$y = 0.3922 \cdot x + 65.356$
	conifers	$y = 0.4041 \cdot x + 57.874$
plantations	eucalyptuses coppices	$y = 0.3922 \cdot x + 65.356$
	other broadleaves coppices	$y = 0.3922 \cdot x + 65.356$
	poplars stands	$y = 0.9843 \cdot x + 5.0746$
	other broadleaves stands	$y = 0.9843 \cdot x + 5.0746$
	conifers stands	$y = 0.4041 \cdot x + 57.874$
	others	$y = 0.7647 \cdot x + 33.638$
protective	rupicolous forest	$y = 0.7647 \cdot x + 33.638$
	riparian forest	$y = 0.9843 \cdot x + 5.0746$
	shrublands	$y = 0.3922 \cdot x + 65.356$

Table 7.9 Relations soil - aboveground carbon per ha

Land converted in Forest Land

The area of land converted to forest land is always coming from grassland. There is no occurrence for other conversion. Carbon stocks change due to grassland converting to forest land has been estimated and reported in 2006 CRF submission, as requested by the "*Report of the*

individual review of the greenhouse gas inventory of Italy submitted in 2005[23]" covering the in-country review of the 2005 GHG inventory Italian submission, coordinating by the United Framework Convention on Climate Change (UNFCCC) secretariat [chap. VI.B.2.126].
The carbon stock change of living biomass has been calculated taking into account the increase and the decrease of carbon stock related to the areas in transition to forest land. Net carbon stock changes in dead organic matter and soil have been calculated as well.
The total amount of carbon for dead organic matter has been obtained from the dead organic matter (d.m.), multiplying by the conversion factor carbon content-dry matter.
In Table 7.10 carbon stock changes due to conversion to forest land, for the living biomass, dead organic matter and soil pools, have been reported:

	Carbon stock change in living biomass			**Net C stock change in dead organic matter**	**Net C stock change in soils**
	Increase	***Decrease***	***Net change***		
year			*Gg C*		
1990	293.53	-804.52	-510.99	17.89	3572.26
1991	294.41	-636.72	-342.31	23.13	3596.52
1992	295.07	-674.16	-379.09	22.11	3616.65
1993	295.57	-788.90	-493.33	19.59	3619.84
1994	295.81	-668.70	-372.88	22.46	3639.62
1995	296.00	-636.76	-340.76	22.83	3665.33
1996	296.26	-619.37	-323.11	23.63	3692.19
1997	296.30	-675.90	-379.59	21.85	3711.72
1998	296.15	-691.80	-395.65	21.26	3727.70
1999	296.27	-644.85	-348.58	23.03	3751.09
2000	296.43	-690.40	-393.97	21.74	3767.26
2001	296.42	-635.75	-339.33	23.12	3791.42
2002	296.36	-595.63	-299.27	24.16	3820.96
2003	296.37	-670.18	-373.81	24.16	3841.25
2004	296.36	-621.85	-325.49	21.97	3868.31

Table 7.10 Carbon stock changes in land converting to forest land

CO_2 emissions due to wildfires in forest land remaining forest land are included in Table 5.A.1, carbon stocks change in living biomass, decrease.
Values of burned growing stocks and respective CO_2 released, for different categories (stands, coppices, plantations, protective forests), are reported in the previous Table 7.5.

7.2.3 Uncertainty and time-series consistency

Estimates of removals by forest land are based on application of the above-described model. To assess the overall uncertainty related to the years 1990–2004, the Tier 1 approach has been followed. The uncertainty linked to the year 1985 has been computed (the first National Forest Inventory was carried out in 1985) with the relation:

$$E_{1985}=\frac{\sqrt{\left(E_{AG_{1985}}\cdot V_{AG_{1985}}\right)^2+\left(E_{BG_{1985}}\cdot V_{BG_{1985}}\right)^2+\left(E_{D_{1985}}\cdot V_{D_{1985}}\right)^2+\left(E_{L_{1985}}\cdot V_{L_{1985}}\right)^2+\left(E_{S_{1985}}\cdot V_{S_{1985}}\right)^2}}{\left|V_{AB_{1985}}+V_{BG_{1985}}+V_{D_{1985}}+V_{L_{1985}}+V_{S_{1985}}\right|}$$

[23]UNFCCC 2005, Inventory Review Reports 2005: http://unfccc.int/resource/docs/2005/arr/ita.pdf

where the terms $V_{AG_{1985}}$, $V_{BG_{1985}}$, $V_{D_{1985}}$, $V_{L_{1985}}$ e $V_{S_{1985}}$ stand for the 1985 carbon stocks of the five pools, aboveground, belowground, dead mass, litter and soil, while, with the letter E, the related uncertainties have been indicated. In Table 7.11 the relations for assessing the overall uncertainties associated to the carbon pools have been reported:

Carbon pool	Relation for uncertainty assessing
Aboveground	$E_{AG_{1985}} = \sqrt{E_{NFI}^2 + E_{BEF_1}^2 + E_{BD}^2 + E_{CF}^2}$
Belowground	$E_{BG_{1985}} = \sqrt{E_{NFI}^2 + E_{BEF_2}^2 + E_{BD}^2 + E_{CF}^2}$
Dead mass	$E_{D_{1985}} = \sqrt{E_{AG_{1985}}^2 + E_{DEF_{1985}}^2}$
Litter	$E_{L_{1985}} = \sqrt{E_{LS_{1985}}^2 + E_{LR_5}^2}$
Soil	$E_{S_{1985}} = \sqrt{E_{SS_{1985}}^2 + E_{SR_5}^2}$

Table 7.11 Relations for assessing uncertainties of the C pools

where the term E_{NFI} stands for the uncertainty associated to the growing stock data given by the first National Forest Inventory, E_{BEF_1} points to uncertainty related to biomass expansion factors for the aboveground biomass, E_{BD} is the basic density uncertainty and the term E_{CF} indicates the conversion factor uncertainty, where GPG default values have been used (IPCC, 2003). In the relation for the belowground carbon pool, the term E_{BEF_2} stands for the uncertainty related to the expansion factor used in the assessing of belowground biomass from growing stock data; GPG default value have been used (IPCC, 2003). Concerning the dead mass relation, E_{DEF} is the uncertainty of dead mass expansion factor, from the GPG (IPCC, 2003), while $E_{LS_{1985}}$ and $E_{SS_{1985}}$ are the uncertainties related to the litter and soil carbon stock data deduced from the CANIF Project[24] data and the CONECOFOR Programme (Corpo Forestale, 2005) respectively. Finally the terms $E_{LR_{1985}}$ and $E_{SR_{1985}}$ are defined as the uncertainties related to linear regressions used to assessing the litter and soil carbon stocks. In Table 7.12, the values of carbon stocks in the five pools, for the year 1985, and the abovementioned uncertainties are reported:

[24] CANIF project: http://medias.obs-mip.fr/ricamare/interface/projet/canif.html

Carbon stocks $t\ CO_2\ eq.\ ha^{-1}$	*Aboveground biomass*	V_{AG}	137.8
	Belowground biomass	V_{BG}	31.5
	Dead mass	V_D	20.8
	Litter	V_L	27.4
	Soil	V_S	264.7
Uncertainty	*Growing stock*	E_{NFI}	3.2%
	BEF_1	E_{BEF1}	30%
	BEF_2	E_{BEF2}	30%
	DEF	E_{DEF}	30%
	Litter (stock + regression)	E_L	161%
	Soil (stock + regression)	E_S	152%
	Basic Density	E_{BD}	30%
	C Conversion Factor	E_{CF}	2%

Table 7.12 Carbon stocks and uncertainties for the year 1985

The uncertainties related to the carbon pools and the overall uncertainty for 1985 have been computed and shown in Table 7.13, using the relations in Table 7.11.

Aboveground biomass	E_{AG}	42.59%
Belowground biomass	E_{BG}	42.59%
Dead mass	E_D	52.10%
Litter	E_L	161.22%
Soil	E_S	152.05%
Overall uncertainty	$\mathbf{E_{1985}}$	**84.91%**

Table 7.13 Uncertainties for the year 1985

The overall uncertainty related to 1985 (the year of the first National Forest Inventory) has been propagated through the years, till 2004, following Tier 1 approach. The equation for the estimates of 1986 overall uncertainty is shown:

$$E_{1986}=\frac{\sqrt{\left(E_{AG_{1986}}\cdot V_{AG_{1986}}\right)^2+\left(E_{BG_{1986}}\cdot V_{BG_{1986}}\right)^2+\left(E_{D_{1986}}\cdot V_{D_{1986}}\right)^2+\left(E_{L_{1986}}\cdot V_{L_{1986}}\right)^2+\left(E_{S_{1986}}\cdot V_{S_{1986}}\right)^2}}{\left|V_{AG_{1986}}+V_{BG_{1986}}+V_{D_{1986}}+V_{L_{1986}}+V_{S_{1986}}\right|}$$

The abovementioned relation is similar to the equation for 1985 uncertainty, apart from the terms linked to aboveground biomass: the biomass increment has been computed with the methodology described in 7.2.2. Methodological issues with reference to the forest land remaining forest land. Therefore the equation for the estimate of the aboveground biomass uncertainty is:

$$E_{AG_{1986}}=\sqrt{\left(\frac{\sqrt{\left(E_{NFI}\cdot V_{NFI}\right)^2+\left(E_I\cdot V_I\right)^2+\left(E_H\cdot V_H\right)^2+\left(E_F\cdot V_F\right)^2+\left(E_D\cdot V_D\right)^2+\left(E_M\cdot V_M\right)^2}}{\left|V_{NFI}+V_I+\left(-V_H\right)+\left(-V_F\right)+\left(-V_D\right)+\left(-V_{MOR}\right)\right|}\right)^2+E_{BEF_1}{}^2+E_{BD}{}^2+E_{CF}{}^2}$$

In Table 7.14 the quantities and related uncertainties required from the equation for the estimate of the overall aboveground biomass uncertainty are reported:

Growing stock uncertainty (NFI 1985)	E_{NFI}	3.2%
Current increment (Richards)[25]	E_{NFI}	51.6%
Harvest[26]	E_H	30%
Fire[27]	E_F	30%
Drain and grazing	E_D	30%
Mortality	E_M	30%
BEF_1	E_{BEF1}	30%
BEF_2	E_{BEF2}	30%
DEF	E_{DEF}	30%
Litter (stock + regression)	E_L	161%
Soil (stock + regression)	E_S	152%
Basic Density	E_{BD}	30%
C Conversion Factor	E_{CF}	2%

Table 7.14 Uncertainties for the aboveground biomass for the year 1986

The uncertainties related to the carbon pools and the overall uncertainty for 1986 are shown in Table 7.15:

Aboveground biomass	E_{AG}	42.67%
Belowground biomass	E_{BG}	42.67%
Dead mass	E_D	52.16%
Litter	E_L	161.22%
Soil	E_S	152.05%
Overall uncertainty	E_{1985}	84.81%

Table 7.15 Uncertainties for the year 1986

Following the Tier 1 approach and the abovementioned methodology, the overall uncertainty in the estimates produced by the described model has been quantified; in Table 7.16 the uncertainties of the 1990-2004 period are reported:

[25] The current increment is estimated by the derived Richards function (see 7.2.2. Methodological issues - *Forest Land remaining Forest Land.*; Uncertainty has been assessed considering the standard error of the linear regression between the estimated values and the corresponding current increment values reported in the National Forest Inventory

[26] Good Practice Guidance default value (IPCC, 2003)

[27] Good Practice Guidance default value (IPCC, 2003)

1985	84.91%
1986	84.81%
1987	88.10%
1988	88.33%
1989	88.27%
1990	88.26%
1991	88.16%
1992	87.99%
1993	87.95%
1994	87.86%
1995	87.67%
1996	87.48%
1997	87.34%
1998	87.24%
1999	87.09%
2000	86.95%
2001	86.80%
2002	86.59%
2003	86.43%
2004	86.29%

Table 7.16 Overall uncertainties 1985 - 2004

The overall uncertainty in the model estimates between 1990 and 2004 has been assessed with the following relation:

$$E_{1990-2004} = \frac{\sqrt{(E_{1990} \cdot V_{1990})^2 + (E_{2004} \cdot V_{2004})^2}}{|V_{1990} + V_{2004}|}$$

where the term V stands for the growing stock [$m^3\ ha^{-1}\ CO^2\ eq$] while the uncertainties have been indicated with the letter E. The overall uncertainty related to the years 1990–2004 is equal to 61.76%.
The table reporting the uncertainties referring to all the categories (Forest Land, Cropland, Grassland, Wetlands, Settlements, Other Land) is shown in Annex 1.

7.2.4 Source-specific QA/QC and verification

Systematic quality control activities have been carried out in order to ensure completeness and consistency in time series and correctness in the sum of sub-categories; where possible, activity data comparison among different sources (FAO database[28], ISTAT data[29]) has been made. Data entries have been checked several times during the compilation of the inventory; particular attention has been focused on the categories showing significant changes between two years in succession. The in-country review of the 2005 GHG inventory Italian submission, coordinated by the United Framework Convention on Climate Change (UNFCCC) secretariat, has detected an error in the reporting of area converted from one land-use category to another in land use matrices[30]: in 2006 submission land use matrices have been accurately checked and cross-checked to ensure that data were properly reported.
Further identification of critical issues and uncertainties in the estimations derived from the participation at workshops and pilot projects (MATT, 2002). Specifically, the European pilot project to harmonise the estimation and reporting of EU member states, in 2003, led to a

[28] FAO, 2005. FAOSTAT, http://faostat.fao.org
[29] ISTAT, several years [a], [b], [c]
[30] UNFCCC 2005, Inventory Review Reports 2005: http://unfccc.int/resource/docs/2005/arr/ita.pdf - [chap. VI.a.4.121].

comparison among national approaches and problems related to the estimation methodology and basic data needed (JRC, 2004).

7.2.5 Source-specific recalculations

Recalculations of emissions and removals have been carried out on the basis of the new IPCC Good Practice Guidance for LULUCF (IPCC, 2003). Deviations from the precedent sectoral estimates occurred, essentially because of changes in the new values available used to model the litter carbon amount, resulting in a mean increase of 25% in dead organic matter carbon pool estimate, and in mean increase of 1.6% in total forest land category, as shown in Figure 7.4. Little variation is perceptible in living biomass and soil carbon pools mainly due the improvement of land use matrices development.

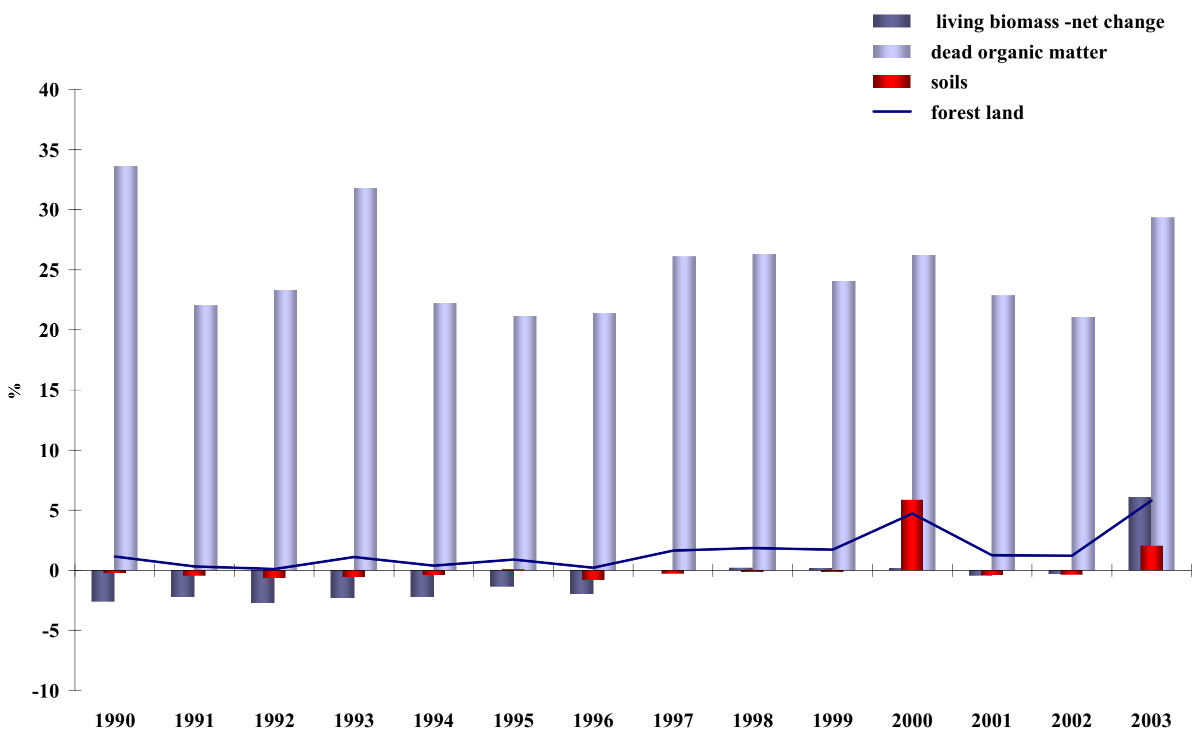

Figure 7.4 Difference between current and 2005 submission carbon pools estimates

7.2.6 Source-specific planned improvements

The final result of the new forest inventory, available in 2006, will allow a more precise evaluation of the estimated time series, in order to reduce the related uncertainty.

Improvements will be also related to the outcome of European research projects on carbon stock inventories in Europe. Specifically for Italy, two projects are in progress: “INFOCARB- Carbon fluxes and Pools in Forest Ecosystems” and “Progetto Kyoto” which should estimate the carbon amount in the Lombardy region. Details of the projects can be found at the website links: http://www.cealp.it/, http://www.flanet.org/ricerca/kyoto.asp.

The fraction of CO_2 emissions due to forest fires, now included in the estimate of the forest land remaining forest land, will be pointed out.

In the next submissions an upgrade of the used model is foreseen to achieve the above cited improvements and to obtain more accurate estimates of the carbon stored in the dead wood, litter and soil pools, using the outcomes of research projects on carbon stocks inventories, with a special focus on the Italian territory.

7.3 Cropland (5B)

7.3.1 Source category description

Under this category, CO_2 emissions from living biomass, dead organic matter and soils, from cropland remaining cropland and from land converted in cropland have been reported.
Cropland removals share 13.5% of total CO_2 LULUCF emissions and removals, in particular the living biomass removals represent 75%, while the emissions from soils stand for 25% of total cropland CO_2 emissions and removals.
Removals are almost entirely due to cropland remaining cropland, while only land converting to cropland category is responsible for emissions.
CO_2 emissions and removals from cropland remaining cropland and from land converting to cropland have been identified as key category in level and in trend assessment (Tier 1); concerning N_2O emissions, the category land converting to cropland has not resulted as a key source.

7.3.2 Methodological issues

Cropland remaining Cropland

Cropland includes all annual and perennial crops; the change in biomass has been estimated only for perennial woody crops, since, for annual crops, increase in biomass stocks in a single year is assumed equal to biomass losses from harvest and mortality in that same year. Activity data for cropland remaining cropland has been subdivided into annual and perennial woody crops.
The estimates of carbon stocks changes are applied to aboveground biomass only, according to the GPG (IPCC, 2003), as there is not sufficient information to estimate carbon stocks change in dead organic matter pools. To assess change in carbon in cropland biomass, the Tier 1 based on highly aggregated area estimates for generic perennial woody crops, has been used; therefore default factors of aboveground biomass carbon stock at harvest, harvest/maturity cycle, biomass accumulation rate, biomass carbon loss, for the temperate climatic region have been applied, even though they are not very representative of the Mediterranean area, where the most common woody crops are crops like olive groves or vineyards that have, for instance, different harvest/maturity cycles.
Furthermore these crops are unlikely totally removed after an amount of time equal to a nominal harvest/maturity cycle (30 years for temperate climate region), as implied by the basic assumption of the Tier 1, since croplands are abandoned or consociated with annual crops. The biomass clearing is relatively unusual. This is the reason why no biomass carbon loss is estimated, since no data about biomass clearing, in wooden cropland, are available.
Net changes in cropland C stocks obtained are equal to 6.134 Tg C for 1990, and 5.560 Tg C for 2004, as concern living biomass pool.
According to the LULUCF GPG (IPCC, 2003), the change in soil C stocks (Equation 3.3.4) is the result of a change in practices or management between the two time periods and concentration of soil carbon is only driven by the change in practice or management. It wasn't possible to point out different sets of relative stock change factors [F_{LU} (land use), F_{MG} (management), F_I (input factor)] for the period 1990-2004 under investigation; therefore, as no management changes can be documented, resulting change in carbon stock has been reported as zero.
CO_2 emissions from organic soils or from application of carbonate containing lime or dolomite to agricultural soils have not occurred.

Land converted to Cropland

In accordance with the GPG methodology, estimates of carbon stock change in living biomass have been provided, since there is not sufficient information to estimate carbon stock change in dead organic matter pool. Concerning soil carbon pool, changes in carbon stocks associated with the transitions have been estimated only for a single year (i.e. the year of conversion): dynamics of soil carbon storage and release are complex and still not well understood, even if current approaches assume that after a cultivation of a forest or grassland, there is an initial carbon loss over the first years which rapidly reduces to a lower subsequent loss rate in the following years (Davidson and Ackerman, 1993). On this basis and by considering the spatial resolution of data we used, we conclude that a reasonable approach, in calculating the effect of transition to cropland, could be assuming that the changes in carbon stocks carbon occur in the first year after the land conversion, instead of considering them over the time period (20 years as default) specified by the IPCC GPG LULUCF (IPCC, 2003).

N_2O emissions arising from the conversion of land to cropland have been also estimated, and reported in the Common Reporting Format - Table 5(III) - N_2O emissions from disturbance associated with land-use conversion to cropland.

The carbon stocks change, for land converted to cropland, is equal to the carbon stocks change due to the removal of biomass from the initial land use plus the carbon stocks from one year of growth in cropland following the conversion.

The Tier 1 has been followed, assuming that the amount of biomass is cleared and some type of cropland system is planted soon thereafter. At Tier 1, carbon stocks in biomass immediately after the conversion are assumed to be zero.

The average area of land undergoing a transition from non cropland, only grassland in Italian case, to cropland, during each year, from 1990 to 2004, has been estimated through the construction of the land use change matrices, one for each year; the matrices allow to point out the average areas of transition land separately for each initial and final land use (i.e. forest land, grassland, etc.). The GPG equation 3.3.8 (IPCC, 2003) has been used to estimate the change in carbon stocks resulting from the land use change.

The carbon stocks change per area for land converted to cropland is assumed, following the Tier1, equal to loss in carbon stocks in biomass immediately before conversion to cropland.

For the Italian territory, only conversion from grassland to cropland has occurred; therefore the default estimates for standing biomass grassland, as dry matter, reported in Table 3.4.2 of GPG (IPCC, 2003) for warm temperate – dry have been used, equal to 1.6 t d.m. ha^{-1}. Changes in carbon stocks from one year of cropland growth have been obtained by the default biomass carbon stocks reported in Table 3.3.8, for temperate region. In accordance with national expert judgement, it has been assumed that the final crop type, for the areas of transition land, is annual cropland.

As pointed out in the land use matrices reported above, in Table 7.3, conversion of lands into cropland has taken place only in a few years during the period 1990- 2004. C emissions [Gg C] due to change in carbon stocks in living biomass in land converted to cropland are reported in Table 7.17:

year	Conversion Area kha	$\Delta C_{converted\ land}$ Gg C
1990	15	19.24
1991	0	0
1992	0	0
1993	17	21.95
1994	43	55.49
1995	34	44.51
1996	0	0.00
1997	9	11.20
1998	68	88.71
1999	97	125.89
2000	94	122.34
2001	0	0
2002	0	0
2003	0	0
2004	352	457.37

Table 7.17 Change in carbon stock in living biomass in land converted to cropland

Changes in carbon stocks in mineral soils in land converted to cropland have been estimated following land use changes, resulting in a change of the total soil carbon content. Initial land use soil carbon stock [$SOC_{(0-T)}$] and soil carbon stock in the inventory year [SOC_0] for the cropland area have been estimated from the reference carbon stocks. According to the indications of national experts, the carbon content of one hectare of grassland or cropland, at the default depth of 30cm has been estimated as equal to 44,5 ± 10t (Ciccarese et al*.,* 2000).
As above mentioned, only conversion from grassland to cropland has occurred in the Italian territory; different stock change factors (F_{LU}, F_{MG}, F_I) have been used for the different management activities on grassland, initial land use, and cropland, final land use.
With the stock change factors, the cropland soil carbon stock [t C] for the inventory year [SOC_0] and the grassland land use soil carbon stock [$SOC_{(0-T)}$] have been estimated, starting from the soil carbon stock per unit of area [t C ha^{-1}]. The inventory time period has been established, as abovementioned, in 1 year. The annual change in carbon stocks in mineral soils has been, at last, assessed as described in the equation 3.3.3 of the GPG (IPCC, 2003), only for the years where conversion has taken place. C emissions [Gg C] due to change in carbon stocks in soils in land converted to cropland are reported in Table 7.18.

year	Conversion Area k ha	Carbon stock Gg C yr-
1990	15	-85.6
1991	0	0.0
1992	0	0.0
1993	17	-97.7
1994	43	-246.9
1995	34	-198.1
1996	0	0.0
1997	9	-49.9
1998	68	-394.8
1999	97	-560.2
2000	94	-544.4
2001	0	0.0
2002	0	0.0
2003	0	0.0
2004	352	-2,035.3

Table 7.18 Change in carbon stock in soil in land converted to cropland

CO_2 emissions from organic soils or from application of carbonate containing lime or dolomite to agricultural soils have not occurred.

7.3.3 Source-specific recalculations

In response to the review process and in agreement with the GPG LULUCF, soil emissions from cropland remaining cropland previously calculated on the only basis of changes in area surfaces and not taking into account changes in management practices have been deleted because not related to a real change in carbon content in soils. As a result strong differences are observable between the old and the new estimates, as well concern soil carbon pool, with a mean decrease of 195% of removals in the period 1990-2004
Minor source of recalculation, resulting in mean increase of 3.2% of the removals of cropland category, has been represented by a slight revision of perennial woody crops activity data, done mainly to homogenize the used time series. The revision outcome has been a mean difference of 1% the old and the new activity data.

7.3.4 Source-specific planned improvements

The carbon losses from aboveground biomass on perennial woody crops have not been estimated because of a lack of activity data – only the carbon gain from woody biomass growth is reported. Additional researches will be made to collect more country-specific data on woody crops.
Improvements will concern the implementation of the estimate of carbon change in cropland biomass at a higher disaggregate level, with the subdivision of the activity data in the main categories of woody cropland (orchards, citrus trees, vineyards, olive groves) and the application of different biomass accumulation rates and harvest/maturity cycles for the various categories.
Further investigation will be made to obtain ancillary information about the final crop types, concerning the areas in transition to cropland, in order to obtain a more precise estimate of the carbon stocks change.

7.4 Grassland (5C)

7.4.1 Source category description

Under this category, CO_2 emissions, from living biomass, dead organic matter and soils, from grassland remaining grassland and from land converted in grassland have been reported.
No emissions from grassland have occurred in 2004, because of the choice of the inventory time and the method applied (Tier 1) for the estimates of living biomass emissions. In the period 1990-2004 mean grassland emissions share 1% of absolute CO_2 LULUCF emissions and removals, in particular the living biomass emissions represent 18.3%, while the emissions from soils stand for 81.7% of total grassland CO_2 emissions.

7.4.2 Methodological issues

Grassland remaining Grassland

Forage crops, permanent pastures, and lands once used for agriculture purposes, but in fact set-aside since 1970, have been considered as grasslands.
To assess change in carbon in grassland biomass, the Tier 1 has been used; therefore no change in carbon stocks in the living biomass pool has been assumed; in accordance with the GPG no data regarding the dead organic matter pool have been provided, since not enough information is available.
According to the IPCC GPG LULUCF (IPCC, 2003), the estimation method is based on changes in soil C stocks over a finite period following changes in management that impact soil C (Equation 3.4.8). Soil C concentration for grassland systems is driven by the change in practice or management, reflecting in different specific climate, soil and management combination, applied for the respective time points. It wasn't possible to point out different sets of relative stock change factors [F_{LU} (land use), F_{MG} (management), F_I (input factor)] for the period 1990-2004 under investigation; therefore, as no management changes can be documented, resulting change in carbon stock has been reported as zero.
No CO_2 emissions from organic soils or from application of carbonate containing lime have occurred.

Land converted to Grassland

In accordance with the GPG methodology, estimate of carbon stocks change in living biomass and soils have been provided, since there is not sufficient information to estimate carbon stocks change in dead organic matter pool. Only conversion from cropland to grassland has occurred.
The assessment of emissions and removals of carbon due to conversion of other land uses to grassland requires estimates of the carbon stocks prior to and following conversion and the estimates of land converted during the period over which the conversion has an effect.
In accordance with the GPG methodology, estimates of carbon stock change in living biomass have been provided, since there is not sufficient information to estimate carbon stock change in dead organic matter pool. Concerning soil carbon pool, changes in carbon stocks associated with the transitions have been estimated only for a single year (i.e. the year of conversion), assuming, as for the other categories in transition, that the changes in carbon stocks carbon occur in the first year after the land conversion, instead of considering them over the time period (20 years as default) specified by the IPCC GPG LULUCF (IPCC, 2003).
As a result of conversion to grassland, it is assumed that the dominant vegetation is removed entirely, after which some type of grass is planted or otherwise established; alternatively grassland can result from the abandonment of the preceding land use, and the area is taken over by grassland. The Tier 1 has been followed, assuming that carbon stocks in biomass immediately after the conversion are equal to 0 t C ha^{-1}.
The annual area of land undergoing a transition from non grassland, only cropland in Italian case, to grassland during each year, from 1990 to 2004, has been pointed out, for each initial and

final land use, through the use of the land use change matrices, one for each year. Changes in biomass carbon stocks have been accounted for in the year of conversion.
The GPG equation 3.4.13 (IPCC, 2003) has been used to estimate the change in carbon stocks, resulting from the land use change. Concerning the Italian territory, only conversion from cropland to grassland has occurred; therefore the default biomass carbon stocks present on land converted to grassland, as dry matter, as supplied by Table 3.4.9 of the GPG for warm temperate – dry, have been used, equal to 6.1 t d.m. ha^{-1}. Since, according to national expert judgement, it has been assumed that lands in conversion to grassland are mostly annual crops, carbon stocks in biomass immediately before conversion have been obtained by the default values reported in Table 3.3.8 of the GPG, for annual cropland.
As pointed out above in the land use matrices, see Table 7.3, the conversion of lands into grassland have taken place only in a few years during the period 1990-2004. C emissions [Gg C] due to change in carbon stocks in living biomass in land converted to grassland are reported in Table 7.19:

	Conversion Area	C_{before}	ΔC_{growth}	ΔC
year	*k ha*	*t C ha^{-1}*	*t C ha^{-1}*	*Gg C*
1989				
1990	0	5	3.05	0
1991	41	5	3.05	-79.6
1992	42	5	3.05	-82.5
1993	0	5	3.05	0
1994	0	5	3.05	0
1995	0	5	3.05	0
1996	64	5	3.05	-125.4
1997	0	5	3.05	0
1998	0	5	3.05	0
1999	0	5	3.05	0
2000	0	5	3.05	0
2001	150	5	3.05	-293.0
2002	62	5	3.05	-121.1
2003	352	5	3.05	-686.1
2004	0	6	3.05	0

Table 7.19 Change in carbon stock in living biomass in land converted to grassland

Changes in carbon stocks in mineral soils in land converted to grassland have been estimated following land use changes, resulting in a change of the total soil carbon content. Initial land use soil carbon stock [$SOC_{(0-T)}$] and soil carbon stock in the inventory year [SOC_0] for the grassland have been estimated from the reference carbon stocks. According to the indications of national experts, the carbon content of one hectare of grassland or cropland, at the default depth of 30cm, has been estimated as equal to 44,5 ± 10t (Ciccarese et al., 2000).
As above mentioned, only conversion cropland to grassland has occurred in the Italian territory; different stock change factors (F_{LU}, F_{MG}, F_I) have been used for the diverse management activities on cropland, initial land use, and grassland, final land use.
With the stock change factors, the grassland soil carbon stock [t C] for the inventory year [SOC_0] and the cropland land use soil carbon stock [$SOC_{(0-T)}$] have been estimated, starting from the soil carbon stock for unit of area [t C ha^{-1}]. The inventory time period has been established, as abovementioned, in 1 year. The annual change in carbon stocks in mineral soils has been, at last, assessed as described in the equation 3.3.3 of the GPG, only for the years where conversion has taken place. C emissions [Gg C], due to change in carbon stocks in soils in land converted to grassland, are reported in Table 7.20:

year	Conversion Area k ha	Carbon stock Gg C
1990	0	0
1991	41	355.2
1992	42	368.4
1993	0	0
1994	0	0
1995	0	0
1996	64	559.9
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	150	1,307.8
2002	62	540.6
2003	352	3,062.4
2004	0	0

Table 7.20 Change in carbon stock in soil

7.4.3 Source-specific recalculations

In response to the review process and in agreement with the GPG LULUCF, emissions from grassland remaining grassland previously calculated on the only basis of changes in area surfaces and not taking into account changes in management practices have been deleted because not related to a real change in carbon content in soils. As a result, strong differences are observable between the old and the new estimates, resulting in a mean difference of 100% in the period 1990-2004, concerning the soil carbon pool.
Recalculations of emissions and removals have been carried out on the basis of the LULUCF Good Practice Guidance (IPCC, 2003). Deviations from the precedent land converted to grassland living biomass estimates occurred, essentially because of improvement of land use matrices development, outcoming with an average decrease of 71% of living biomass carbon pool emissions and removals, in the 1990-2004 period.

7.4.4 Source-specific planned improvements

Concerning land in transition to grassland, further investigation will be made to obtain additional information about different types of management activities on grassland, and the crop types of land converting to grassland, to obtain a more accurate estimate of the carbon stocks change.

7.5 Wetlands (5D)

7.5.1 Source category description

Under this category, activity data from wetlands remaining wetlands are reported.

7.5.2 Methodological issues

Lands covered or saturated by water, all or part of year, which harmonize with the definitions of the Ramsar Convention on Wetlands[31] have been included in this category (MAMB, 1992). No data were available on flooded lands, therefore reservoirs or water bodies regulated by human activities have not been considered. Concerning land converted to wetland, during the period 1990-2004, no land has been in transition to wetlands.

[31] Ramsar Convention on Wetlands: http://www.ramsar.org/ (Ramsar, 2005)

7.5.3 Source-specific planned improvements

Improvements will concern the acquirement of data about flooded lands and the implementation of the GPG method to estimate CO_2, CH_4 and N_2O emissions from flooded lands.

7.6. Settlements (5E)

7.6.1 Source category description

Under this category, activity data from settlements and from land converted to settlements are reported; CO_2 emissions, from living biomass and soil, from land converted in settlements have been also reported. In the period 1990-2004 mean settlements emissions share 1.7% of absolute CO_2 LULUCF emissions and removals.

7.6.2 Methodological issues

Up to now there is a lack of data concerning urban tree formations. Therefore it is not possible to give estimates on the carbon stocks changes in living biomass, dead organic matter and soil for this category. Therefore only activity data have been reported. Settlements time series have been developed through a linear interpolation between the 1990 and 2000 data, obtained by the Corine Land Cover[32] maps, relatively to the class "*Artificial surfaces*". By assuming that the defined trend may well represent the near future, it was possible to extrapolate data for the years 2001-2004.

Land converted to Settlements

The average area of land undergoing a transition from non-settlements to settlements during each year, from 1990 to 2004, has been estimated with the land use change matrices that have also permitted to specify the initial and final land use. The GPG equation 3.6.1 approach (IPCC, 2003) has been used to estimate the change in carbon stocks, resulting from the land use change.
The annual change in carbon stocks, for land converted to settlements, is assumed equal to carbon stocks in living biomass immediately following conversion to settlements minus the carbon stocks in living biomass in land immediately before conversion to settlements, multiplied for the area of land annually converted. The default assumption, for Tier 1, is that carbon stocks in living biomass following conversion are equal to zero.
As reported in Table 7.3, only conversions from grassland and cropland to settlements have occurred in the 1990-2004 period. Concerning grassland converted to settlements, no change in carbon stocks has been computed as, in the Tier 1, no change in carbon stocks in the grassland living biomass pool has been assumed. For what concerns cropland in transition to settlements, carbon stocks, for each year and for crops type (annual or perennial), have been estimated, using as default coefficients the factors shown in the following Table 7.21:

	Biomass carbon stock *t C ha^{-1}*
Annual cropland	5
Perennial woody cropland	63

Table 7.21 Stock change factors for cropland

As indicated in the land use matrices of Table 7.3, the conversion of lands into settlements has taken place only in a few years during the period 1990-2004. In Table 7.22 C stocks [Gg C] related to change in carbon stocks in living biomass in cropland (annual and perennial) converted to settlements are reported:

[32] Corine Land Cover, http://www.clc2000.sinanet.apat.it/cartanetclc2000/ (APAT, 2004)

	annual crops to settlements		perennial crops to settlements		
Year	*Conversion Area*	*Carbon stock*	*Conversion Area*	*Carbon stock*	*Total Carbon stock*
	k ha	*Gg C*	*k ha*	*Gg C*	*Gg C*
1990	0	0	0	0	0
1991	2.17	-10.9	6.09	-383.4	-394.3
1992	2.16	-10.8	6.10	-384.3	-395.1
1993	0	0	0	0	0
1994	0	0	0	0	0
1995	0	0	0	0	0
1996	1.97	-9.9	6.29	-396.0	-405.9
1997	0	0	0	0.0	0.0
1998	0	0	0	0	0
1999	0	0	0	0	0
2000	0	0	0	0	0
2001	2.03	-10.2	6.23	-392.4	-402.5
2002	2.03	-10.2	6.23	-392.4	-402.6
2003	2.07	-10.4	6.19	-389.7	-400.0
2004	0	0	0	0	0

Table 7.22 Change in carbon stocks in living biomass in cropland converted to settlements

Change in soil carbon stocks from land converting to settlements has been also estimated. In Table 7.23 soil C stocks [Gg C] of cropland (annual and perennial) and grassland converted to settlements are reported:

	annual crops to settlements		perennial crops to settlements		grassland to settlements	
Year	*Conversion Area*	*Carbon stock*	*Conversion Area*	*Carbon stock*	*Conversion Area*	*Carbon stock*
	k ha	*Gg C*	*k ha*	*Gg C*	*k ha*	*Gg C*
1990	0	0	0	0	8.26	-349.17
1991	2.17	-72.98	6.09	-222	0	0
1992	2.16	-72.52	6.10	-223	0	0
1993	0	0	0	0	8.26	-349.17
1994	0	0	0	0	8.26	-349.17
1995	0	0	0	0	8.26	-349.17
1996	1.97	-66.27	6.29	-229	0	0
1997	0	0	0	0	8.26	-349.17
1998	0	0	0	0	8.26	-349.17
1999	0	0	0	0	8.26	-349.17
2000	0	0	0	0	8.26	-349.17
2001	2.03	-68.19	6.23	-227	0	0
2002	2.03	-68.16	6.23	-227	0	0
2003	2.07	-69.64	6.19	-226	0	0
2004	0	0	0	0	8.26	-349.17

Table 7.23 Change in carbon stocks in soil in cropland and grassland converted to settlements

7.6.3 Source-specific recalculations

In the current submission estimates of soil carbon stock changes resulting from transition of cropland and grassland to settlement have been provided. As a consequence, the total amount of settlements emissions and removals is not comparable with the 2005 estimates, which included only carbon stock change from living biomass. A recalculation have been prepared, comparing 2005 estimates and current living biomass carbon stock changes estimates, resulting in a mean difference of 21% in the period 1990-2003, mainly due improvement in of land use matrices development.

7.6.4 Source-specific planned improvements

Further investigation will be made to obtain additional statistics about settlements, comparing the added information with the time series developed from Corine Land Cover data (APAT, 2004). Urban tree formations will be investigated for information, in order to estimate carbon stocks. Moreover improvements will concern acquirement of data sufficient to give estimates of carbon stocks changes in dead organic matter for land in transition to settlements.

7.7 Other Land (5F)

Under this category, CO_2 emissions, from living biomass, dead organic matter and soils, from land converted in other land should be accounted for; no data are reported since the conversion to other land is not occurring.

7.8 Direct N_2O emissions from N fertilization (5(I))

N_2O emissions from N fertilization of cropland and grassland are reported in the agriculture sector; therefore only forest land should be included in this table; no data have been reported, since no fertilizers are applied to forest land.

7.9 N_2O emissions from drainage of soils (5(II))

N_2O emissions from N drainage of forest or wetlands soils no data have been reported, since no drainage is applied to forest or wetlands soils.

7.10 N_2O emissions from disturbance associated with land-use conversion to Cropland (5(III))

7.10.1 Source category description

Under this category, N_2O emissions from disturbance of soils associated with land-use conversion to cropland, according to the GPG (IPCC, 2003). N_2O emissions from cropland remaining cropland are included in the agriculture sector of the good practice guidance. The good practice guidance provides methodologies only for mineral soils.

7.10.2 Methodological issues

N_2O emissions from land use conversions are derived from mineralization of soil organic matter resulting from conversion of land to cropland. The average area of land undergoing a transition from non-cropland to cropland during each year, from 1990 to 2004, has been estimated with the land use change matrices; as abovementioned, only conversion from grassland to cropland has occurred in the Italian territory. The GPG equation 3.3.14 has been used to estimate the emissions of N_2O from mineral soils, resulting from the land use change.
Changes in carbon stocks in mineral soils in land converted to cropland have been estimated following land use changes, resulting in a change of the total soil carbon content. Assuming the GPG default values, 15 for the C/N ratio and 0.0125 kg N_2O-N/kg N in order to calculate N_2O emissions from N in the soil, N_2O emissions have been estimated.
In Table 7.24 N_2O emissions resulting from the disturbance associated with land-use conversion to cropland are reported:

Year	Conversion Area	Carbon stock	$N_{net-min}$	$N_2O_{net-min}$ -N	N_2O emissions
	k ha	*Gg C*	*kt N*	*kt N_2O-N*	*Gg N_2O*
1990	15	86	6	0.071	0.112
1991	0	0	0	0.000	0.000
1992	0	0	0	0.000	0.000
1993	17	98	6.5	0.081	0.128
1994	43	247	16.5	0.206	0.323
1995	34	198	13.2	0.165	0.259
1996	0	0	0.0	0.000	0.0000
1997	9	50	3	0.0415	0.0652
1998	68	395	26.3	0.329	0.517
1999	97	560	37.3	0.467	0.734
2000	94	544	36.3	0.454	0.713
2001	0	0	0	0.000	0.00
2002	0	0	0	0.000	0.00
2003	0	0	0	0.000	0.00
2004	352	2,035	127	1.590	2.50

Table 7.24 N_2O emissions from land-use conversion to cropland

7.10.4 Source-specific recalculations

As reported in the "*2005 Quality Assurance/Quality Control plan for the Italian Inventory*[33]", in the background table for the reporting of nitrous oxide emissions from disturbance associated with land-use conversion to Cropland, in 2005 submission, emissions were incorrectly reported as negative. In the 2006 submission values have been reported with the correct sign, resulting in strong variation with previous submission values.

7.11 Carbon emissions from agricultural lime application (5(IV))

Carbon emissions from agricultural lime application are not estimated, since no lime application is occurring.

7.12 Biomass Burning (5(V))

7.12.1 Source category description

Under this source category, CH_4 and N_2O emissions from forest fires are estimated, in accordance with the IPCC method.

National statistics on areas affected by fire per region and forestry use, high forest (resinous, broadleaves, resinous and associated broadleaves) and coppice (simple, compound and degraded), were used (ISTAT, several years [a]).

CO_2 emissions due to forest fires in forest land remaining forest land are included in table 5.A.1 of the CRF, under carbon stock change in living biomass - decrease.

7.12.2 Methodological issues

In Italy, in consideration of national regulations, forest fires do not result in changes in land use; therefore conversion of forest and grassland does not take place. Anyway CO_2 emissions due to forest fires in forest land remaining forest land are included in table 5.A.1 of the CRF, under carbon stock change in living biomass - decrease. The total biomass reduction due to forest fires, and subsequent emissions, has been estimated following the methodology reported in paragraph 7.2.2.

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[33] APAT 2005, *Quality Assurance/Quality Control plan for the Italian Inventory*

The IPCC method was followed for CH_4 and N_2O emissions, multiplying the amount of C released from 1990 to 2004, calculated on the basis of regional parameters (Bovio, 1996), by the emission factors suggested in the IPCC guidelines (IPCC, 1997).
In Table 7.25 CH_4 and N_2O emissions resulting from biomass burning are reported:

year	CH_4 emissions *Gg*	N_2O emissions *Gg*
1990	6.804	0.047
1991	1.740	0.012
1992	2.876	0.020
1993	7.182	0.049
1994	2.897	0.020
1995	1.304	0.009
1996	1.056	0.007
1997	3.528	0.024
1998	4.106	0.028
1999	2.022	0.014
2000	4.143	0.028
2001	2.628	0.018
2002	1.473	0.010
2003	3.094	0.021
2004	1.648	0.011

Table 7.25 CH_4 and N_2O emissions from biomass burning

7.12.3 Source-specific planned improvements

Further investigations will be made to acquire data on grassland fires, in order to provide estimate of CO_2 emissions.

7.12.4 Source-specific recalculations

Little variations are noticeable between previous and current submission of CH_4 and N_2O emissions from forest fires; the recalculation resulted in a mean difference of 0.001% concerning CH_4 emissions and a decrease of 1.42% of N_2O emissions in the period 1990-2003.

Chapter 8: WASTE [CRF sector 6]

8.1 Overview of sector

The waste sector comprises four source categories:

1. solid waste disposal on land (6A);
2. wastewater handling (6B);
3. waste incineration (6C);
4. other waste (6D).

The waste sector share of GHG emissions in the national greenhouse total is presently 3.45% (and was 3.25% in the base year 1990).

The trends in greenhouse gas emissions from the waste sector are summarised in Table 8.1. It clearly shows that methane emissions from solid waste disposal sites (landfills) are by far the largest source category within this sector; in fact these emissions rank among the top-10 key level and key trend sources.

Emissions from waste incineration facilities without energy recovery are reported under category 6C, whereas emissions from waste incineration facilities, which produce electricity or heat for energetic purposes, are reported under category 1A4a (according to the IPCC reporting guidelines).

Under 6D, CH_4 and NMVOC emissions from compost production are reported.

Emissions from methane recovered, used for energy purposes, in landfills and wastewater treatment plants are estimated and reported under category 1A4a.

GAS/SUBSOURCE	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2 (Gg)											
6C. Waste incineration	496.36	475.09	464.03	507.76	504.42	393.47	201.57	222.26	244.97	215.76	210.57
CH_4 (Gg)											
6A. Solid waste disposal on land	625.08	742.04	753.52	767.02	780.59	782.60	830.21	835.17	805.79	787.86	762.85
6B. Wastewater handling	93.74	104.46	105.49	106.97	107.47	107.74	108.66	109.77	110.23	109.57	110.11
6C. Waste incineration	7.65	12.91	10.89	13.24	11.76	14.38	11.87	12.93	12.53	12.80	16.13
6D. Other (compost production)	0.01	0.02	0.02	0.05	0.06	0.08	0.10	0.12	0.16	0.18	0.18
N_2O (Gg)											
6B. Wastewater handling	3.37	3.39	3.40	3.41	3.40	3.41	3.41	3.41	3.42	3.42	3.44
6C. Waste incineration	0.28	0.42	0.36	0.43	0.39	0.45	0.36	0.39	0.38	0.38	0.47

Table 8.1 Trend in greenhouse gas emissions from the waste sector 1990 – 2004 (Gg)

In the following box, key and non-key sources of the waste sector are presented based on level, trend or both. Methane emissions from landfills result as a key source according to both level and trend assessment, calculated with Tier 1 and Tier 2; methane emission from wastewater handling is a key source at level and trend assessment, when taking into account uncertainty; finally, nitrous oxide emission from wastewater handling is a key source at trend assessment including uncertainty.

Key-source identification in the waste sector with the IPCC Tier 1 and Tier 2 approaches

6A	CH_4	Emissions from solid waste disposal sites	Key (L, T)
6B	CH_4	Emissions from wastewater handling	Key (L2, T2)
6B	N_2O	Emissions from wastewater handling	Key (T2)
6C	CO_2	Emissions from waste incineration	Non-key
6C	CH_4	Emissions from waste incineration	Non-key
6C	N_2O	Emissions from waste incineration	Non-key
6D	CH_4	Emissions from other waste (compost production)	Non-key

8.2 Solid waste disposal on land (6A)

8.2.1. Source category description

As mentioned above, methane from landfills is a major key source, both in terms of level and trend. Its share of CH_4 emissions in the national methane total is presently 38.3% (and was 31.5% in the base year 1990).

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.

From 2000, municipal solid wastes are disposed only into managed landfills, due to the enforcement of regulations.

The Landfill European Directive (EC, 1999), transposed by the Legislative Decree 13 January 2003 n. 36, has been applied to the Italian landfill since July 2005, but the effectiveness of the policies will be significant in the future.

Actually, the municipal solid wastes are still disposed into the 1st category landfills, whereas the inert wastes are disposed into the 2nd category, type A, landfills; other industrial wastes with different toxicity are disposed into the 2nd category, type B and C, and into the 3rd category landfills. In Italy methane emissions are expected only from 1st category landfills due to biodegradability of wastes disposed; in fact law's disposition, forces only this category to have a collecting gas system. In response to the review process, further investigation has been carried out on waste inert landfills to prove that inert typology do not generate methane emissions. No references demonstrating methane emissions from other than 1st category landfills have been found.

For the year 2004, the 1st category landfills in Italy are 401, disposing 21,020 Mt of wastes.

8.2.2. Methodological issues

In order to calculate CH_4 emissions from all the landfill sites in Italy, the assumption that all the landfills started operation in the same year, and have the same parameters, has been considered, although characteristics of individual sites can vary substantially; the First Order Decay Model has been applied. Thus, the IPCC Tier 2 methodology has been followed for the emission estimation.

Basic data on waste production and landfills system used for the emission inventory are those provided by the Waste Cadastre. The Waste Cadastre is formed by a national branch, hosted by APAT, and by regional and provincial branches. The basic information for the Cadastre is mainly represented by the data reported through the Uniform Statement Format (MUD), complemented by those provided by regional permits, provincial communications and by registrations in the national register of companies involved in waste management activities.

The complete database from 1975 of waste production, waste disposal in managed and unmanaged landfills and sludge disposal in landfills is reconstructed on the basis of different sources (MATT, several years; ANPA-ONR, 1999 [a]; ANPA-ONR, 2001 [b]; APAT-ONR, 2002; APAT-ONR, 2003; APAT-ONR, 2004; APAT-ONR, 2005; APAT, 2002; ANPA-ONR, 1999 [b]; AUSITRA-Assoambiente, 1995; FEDERAMBIENTE, 1992), national legislation (Legislative Decree 5 February 1997, n.22), and regression models based on population (Colombari et al, 1998).

On the basis of the recommendations of the in-country review process, in order to avoid an underestimation of CH_4 emissions, it has been assumed that waste landfilling started in 1950, instead of 1975 as previously considered. Since waste production data are not available before 1975, they have been reconstructed on the basis of proxy variables. Gross Domestic Product data have been collected from 1950 (ISTAT, several years; ISTAT, 2005 [a]) and a correlation

function between GDP and waste production has been derived for the period 1975 – 2004; thus, the exponential equation has been applied from 1975 back to 1950.
Consequently the amount of waste disposed into landfills has been estimate, assuming that from 1975 backwards the percentage of waste landfilled is constant and equal to 80%.
Apart from municipal solid waste, sludge from urban wastewater handling plants has also been considered. Sludge disposed in landfill sites has been estimated from the equivalent inhabitants treated in wastewater treatment plants, distinguished in primary and secondary plants (MATT, 1989; ISTAT, 1991; ISTAT, 1993; ISTAT, 1998 [a] and [b]), applying the specific per capita sludge production (Masotti, 1996; ANPA, 2001; ApS, 1997). The total amount of sludge per year can be treated by incineration or composting, or once digested disposed to soil for agricultural purpose or to landfills (ISTAT, 1998 [a] and [b]; De Stefanis et al., 1998). As for the waste production, also sludge landfilled has been reconstructed from 1950. Starting from the number of wastewater treatment plants in Italy in 1950, 1960, 1970 and 1980 (ISTAT, 1987), the equivalent inhabitants have been derived and consequently the amount of sludge disposed in landfill sites, assuming 80 kg $inhab.^{-1}\ yr^{-1}$ sludge production and 75% as the fraction of sludge that goes to landfill.
The share of waste disposed of into uncontrolled landfills has gradually decreased, thanks to the enforcement of new regulations, and in the year 2000 it has been assumed equal to 0; emissions still occur due to the waste disposed in the past years. The unmanaged sites have been considered 50% deep and 50% shallow.
Parameter values used in the landfill emissions model are:

1. total amount of waste disposed;
2. fraction of Degradable Organic Carbon (DOC);
3. fraction of DOC dissimilated (DOC_F);
4. fraction of methane in landfill gas (F);
5. oxidation factor (O_X);
6. methane correction factor (MCF);
7. methane generation rate constant (k);
8. landfill gas recovered (R).

An in-depth survey has been carried out, in order to diversify waste composition over the years.
Three slots (1950 – 1970; 1971 – 1990; 1991 – 2004) have been individuated to which different waste composition has been assigned. On the basis of data available on waste composition (Tecneco, 1972; CNR, 1980; Ferrari, 1995), the moisture content, the organic carbon content and the fraction of biodegradable organic carbon for each waste stream (Andreottola and Cossu, 1988; Muntoni and Polettini, 2002), the DOC contents and the methane generation potential values (L_0) have been generated.
The fraction of DOC dissimilated and the MCF are IPCC default values. The MCF value for unmanaged landfill is the average of the default IPCC values reported for deep and shallow sites.
On the basis of the waste composition, waste stream have been categorized in three main types: rapidly biodegradable waste, moderately biodegradable waste and slowly biodegradable waste, as reported in Table 8.2. Methane emissions have been estimated separately for each mentioned biodegradable class and the results have been consequently added up. It is assumed that landfill gas composition is 50% carbon dioxide and 50% methane.

Waste biodegradability	Rapidly biodegradable	Moderately biodegradable	Slowly biodegradable
Food	X		
Sewage sludge	X		
Garden and park		X	
Paper, paperboard			X
Textile, leather			X
Wood and straw			X

Table 8.2 Waste biodegradability for each waste component

The following Tables 8.3, 8.4, 8.5 and 8.6 summarize the different waste composition by weight assigned to each slot (1950 – 1970; 1971 – 1990; 1991 – 2004), the moisture content for each waste stream, the organic carbon content for each waste stream and methane generation potential values (L_0) generated, distinguished for managed and unmanaged landfills.

Waste composition landfilled by weight (KgRSUi 100Kg^{-}1wet RSU)	**1950 - 1970**	**1971 - 1990**	**1991 - 2004**
Rapidly biodegradable	37.0%	45.5%	36.3%
Moderately biodegradable	3.6%	3.7%	3.9%
Slowly biodegradable	29.6%	19.6%	30.5%
Non biodegradable	29.7%	31.2%	29.3%
Σ	100.0%	100.0%	100.0%

Table 8.3 Waste composition by weight for Rapidly, Moderately and Slowly biodegradable fractions

Moisture content (%)	**Rapidly biodegradable**	**Moderately biodegradable**	**Slowly biodegradable**
Food	60%		
Sewage sludge	75%		
Garden and park		50%	
Paper, paperboard			8%
Textile, leather			10%
Wood and straw			20%

Table 8.4 Moisture content for each waste component

Organic carbon content (KgC Kg^{-1} dry RSU)	**Rapidly biodegradable**	**Moderately biodegradable**	**Slowly biodegradable**
Food	0.48		
Sewage sludge	0.48		
Garden and park		0.48	
Paper, paperboard			0.44
Textile, leather			0.55
Wood and straw			0.495

Table 8.5 Organic carbon content for each waste component

L_0 (m^3CH_4 $tRSU^{-1}$)	**1950 - 1970**	**1971 - 1990**	**1991 - 2004**
Rapidly biodegradable			
- Managed landfill	82.6	77.7	74.4
- Unmanaged landfill	49.5	46.6	44.6
Moderately biodegradable			
- Managed landfill	108.1	108.1	108.1
- Unmanaged landfill	64.9	64.9	64.9
Slowly biodegradable			
- Managed landfill	205.0	205.0	188.3
- Unmanaged landfill	123.0	123.0	113.0

Table 8.6 Methane generation potential values by waste composition and landfill typology

The methane generation rate constant *k* in the FOD method is related to the time taken for DOC in waste to decay to half its initial mass (the 'half life' or t½).
The maximum value of *k* applicable to any single SWDS is determined by a large number of factors associated with the composition of the waste and the conditions at the site. The most rapid rates are associated with high moisture conditions and rapidly degradable material such as food waste. The slowest decay rates are associated with dry site conditions and slowly

degradable waste such as wood or paper. Thus, for each rapidly, moderately and slowly biodegradable fraction, a different maximum methane generation rate constant has been assigned, as reported in Table 8.7. National half-life values are suggested by Andreottola and Cossu (Andreottola and Cossu, 1988).
Landfill gas recovered data have been reconstructed on the basis of information on extraction plants (De Poli and Pasqualini, 1997; Acaia et al., 2004; Asja, 2003) and electricity production (GRTN, several years).
For NMVOC emissions, it has been assumed that non-methane volatile organic compounds are 1.3 weight per cent of methane (Gaudioso et al., 1993): this assumption refers to US EPA data (US EPA, 1990).

	National	*National*	*IPCC*	*IPCC*
	Half life	**Methane generation rate constant**	**Half life**	**Methane generation rate constant**
Rapidly biodegradable	1 year	0.69	3 year	0.23
Moderately biodegradable	5 years	0.14	14 years	0.05
Slowly biodegradable	15 years	0.05	23 years	0.03

Table 8.7 Half-life values and related methane generation rate constant, national and IPCC values

8.2.3. Uncertainty and time-series consistency

The combined uncertainty in CH_4 emissions from solid waste disposal sites is estimated to be 36.1% in annual emissions, 20% and 30% for activity data and emission factors, respectively, as suggested by the IPCC Good Practice Guidance (IPCC, 2000).
Due to importance of the sub-sector, the time series of activity data is also reported (Table 8.8), followed by the CH_4 emission trend (Table 8.9) and a detail on methane recovery (Figure 8.1); emissions from the amount used for energy purposes are estimated and reported under category 1A4a.

ACTIVITY DATA	**1990**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
MSW Production (Gg)	22,231	25,780	25,960	26,605	26,847	28,364	28,959	29,409	29,864	30,034	31,150
MSW Landfilled (%)	91.1	85.5	83.3	80.0	77.4	76.7	75.7	68.0	63.1	59.9	57.0
- in managed landfills	62.1	70.6	72.1	73.0	73.9	74.8	75.7	68.0	63.1	59.9	57.0
Sewage Sludge Landfilled (Gg)	2,765	3,170	3,194	3,022	3,117	3,194	3,170	3,194	3,022	3,117	3,278
Total MSW to landfills (Gg)	23,025	25,214	24,818	24,298	23,885	24,939	25,087	23,197	21,870	21,113	21,020

Table 8.8 Activity Data Solid Waste Disposal on Land, 1990 – 2004 (Gg)

EMISSIONS	**1990**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Managed Landfills											
Methane produced (Gg)	576.1	772.3	804.5	840.7	878.6	917.1	967.2	1014.4	1028.5	1030.4	1031.3
Methane recovered (Gg)	119.0	155.6	161.3	167.1	172.2	190.2	171.9	199.2	236.6	251.1	273.9
Methane recovered (%)	20.7	20.2	20.0	19.9	19.6	20.7	17.8	19.6	23.0	24.4	26.6
CH_4 net emissions (Gg)	406.0	547.7	571.4	598.4	627.5	645.7	706.5	724.1	703.5	692.3	672.8
NMVOC net emissions (Gg)	5.3	7.2	7.5	7.9	8.3	8.5	9.3	9.5	9.3	9.1	8.9
Unmanaged Landfills											
Methane produced (Gg)	222.0	196.8	184.6	170.9	155.1	138.7	125.4	112.5	103.6	96.8	91.2
Methane recovered (Gg)	0	0	0	0	0	0	0	0	0	0	0
CH_4 net emissions (Gg)	219.1	194.3	182.2	168.6	153.1	136.9	123.8	111.1	102.3	95.6	90.1
NMVOC net emissions (Gg)	2.9	2.6	2.4	2.2	2.0	1.8	1.6	1.5	1.3	1.3	1.2

Table 8.9 Methane produced, recovered and CH_4 and NMVOC net emissions, 1990 – 2004 (Gg)

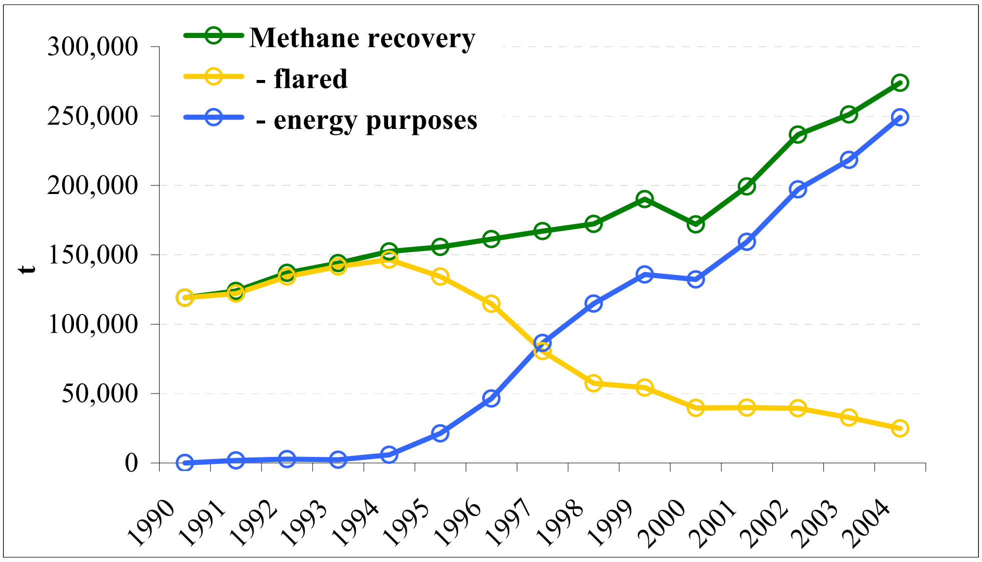

Figure 8.1 Methane recovery distinguished in flared amount and energy purposes

Whereas waste production continuously increases, from 2001 solid waste disposal on land has decreased as a consequence of waste management policies. At the same time, the increase in the methane- recovered percentage has led to a reduction in net emissions.
Further reduction is expected in the future because of the increasing in waste recycling.

8.2.4. Source-specific QA/QC and verification

This source category is covered by the general QA/QC procedures.
Moreover, the Waste Cadastre system, as reported above, requires continuous and systematic knowledge exchange and QA/QC checks in order to ensure homogeneity of information concerning waste production and management throughout the entire Italian territory.

8.2.5. Source-specific recalculations

As reported above, in response to the review process, many improvements have been carried out.
In order to avoid underestimation of CH_4 emissions, the assumption was made that waste landfilling started in 1950, instead of 1975 as previously considered.
Waste composition has been diversified within three periods (1950 – 1970; 1971 – 1990; 1991 – 2004), as well as the categorization in three main types: rapidly biodegradable waste, moderately biodegradable waste and slowly biodegradable waste. Thus, for each biodegradable fraction, a different maximum methane generation rate constant has been assigned; methane emissions have been estimated separately for each biodegradable class and the results have been added up, in order to yield a better estimate.
Moreover, the methodology used to estimate the methane generation potential (L_0) has been corrected because it led to underestimation of CH_4 emissions and the normalization factor has been applied.
Other modification, requested by the review process, regarded CH_4 recovering: figures have been estimated on the basis of data on landfill gas flared available from 1987 to 1990 (De Poli and Pasqualini, 1997) and data on energy recovered from landfill gas published yearly from 1990 by the Italian Independent System Operator (GRTN, several years).
A comparison with the previous estimation, in percentage terms, is reported in Table 8.10.

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003
Managed Landfills										
Methane produced	30.4%	22.9%	23.1%	24.1%	25.5%	25.9%	28.5%	34.0%	37.1%	39.4%
Methane recovered	387.5%	-6.3%	-5.7%	-5.0%	-4.7%	2.5%	-9.8%	3.5%	4.0%	4.2%
CH_4 net emissions	9.5%	33.4%	33.3%	34.3%	36.0%	34.0%	41.5%	44.4%	51.5%	56.4%
NMVOC net emissions	9.5%	33.4%	33.3%	34.3%	36.0%	34.0%	41.5%	44.4%	51.5%	56.4%
Unmanaged Landfills										
Methane produced	79.6%	82.5%	91.6%	106.8%	128.7%	154.0%	198.5%	248.2%	316.9%	406.4%
Methane recovered	-	-	-	-	-	-	-	-	-	-
CH_4 net emissions	79.6%	82.5%	91.6%	106.8%	128.7%	154.0%	198.5%	248.2%	316.9%	406.4%
NMVOC net emissions	79.6%	82.5%	91.6%	106.8%	128.7%	154.0%	198.5%	248.2%	316.9%	406.4%

Table 8.10 Differences in percentages between time series reported in the updated time series and 2005 submission

8.2.6. Source-specific 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 (EEA, 2005).

8.3 Wastewater handling (6B)

8.3.1. Source category description

In Italy wastewater handling is managed mainly using aerobic treatment plants, where the complete-mix activated sludge process is more frequently designed. It is assumed that domestic and commercial wastewaters are treated 95% aerobically and 5% anaerobically, whereas industrial wastewaters are treated 85% aerobically and 15% anaerobically.

N_2O emissions from domestic and commercial wastewater treatment are reported in human sewage.

CH_4 emissions from sludge generated by domestic and commercial wastewater treatment have been calculated; the stabilization of sludge occurs in aerobic or anaerobic reactors; where anaerobic digestion is used, the reactors are covered and provided of gas recovery. Emissions from methane recovered, used for energy purposes, in wastewater treatment plants are estimated and reported under category 1A4a.

A percentage of 3% of domestic and commercial wastewater is actually treated in Imhoff tanks, where the digestion of sludge occurs anaerobically without gas recovery. Therefore, very few emissions from sludge disposal do occur.

CH_4 emissions from sludge generated from industries are included in the industrial wastewaters.

8.3.2. Methodological issues

Regarding N_2O emissions, the default approach suggested by the IPCC Guidelines (IPCC, 1997), and updated in the Good Practice Guidance (IPCC, 2000), based on population and per capita intake protein has been followed. Fraction of nitrogen protein (Frac $_{NPR}$) 0.16 kg N kg^{-1} protein and emission factor (EF_6) 0.01 kg N-N_2O kg^{-1} N produced have been used, whereas the value 60 g capita^{-1} d^{-1} of protein intake have been used, as indicate in a survey by the National Research Centre on Nutrition (INRAN, 1997).

The methane estimation concerning industrial wastewaters makes use of the IPCC method based on wastewater output and the respective Degradable Organic Carbon for each major industrial wastewater source. No country specific emission factors of methane per Chemical Oxygen

Demand are available so the default value of 0.25 kg CH_4 kg^{-1} DC, suggested in the IPCC Good Practice Guidance (IPCC, 2000), has been used for the whole time series.
As recommended by the Good Practice Guidance (IPCC, 2000) for key source categories, data have been collected for several industrial sectors (iron and steel, refineries, organic chemicals, food and beverage, paper and pulp, textiles and leather industry). The total amount of organic material for each industry selected has been calculated multiplying the annual production (t $year^{-1}$) by the amount of wastewater consumption per unit of product (m^3 t^{-1}) and by the degradable organic component (kg COD $(m^3)^{-1}$). Moreover, the fraction of industrial degradable organic component removed as sludge has been assumed equal to zero. The yearly industrial productions are reported in the national statistics (ISTAT, 2005 [a] and [b]), whereas the wastewater consumption factors and the degradable organic component are either from Good Practice Guidance (IPCC, 2000) or from national references. National data have been used in the calculation of the total amount of both COD produced and wastewater output specified as follows: refineries (UP, 2005), organic chemicals (FEDERCHIMICA, several years), beer (Assobirra, several years), wine, milk and sugar sectors (ANPA-ONR, 2001 [a]), pulp and paper sector (ANPA-FLORYS, 2001; Assocarta, several years), and leather sector (ANPA-FLORYS, 2000; UNIC, 2004).
CH_4 emissions from sludge generated by domestic and commercial wastewater treatment have been calculated using the IPCC default method on the basis of national information on anaerobic sludge treatment system (IPCC, 1997; IPCC 2000).
A recent survey by the National Institute of Statistics (ISTAT, 2004) has provided information on urban wastewater treatment plants in Italy for the year 1999: an investigation on previous references has been done and data on primary treatment plants using Imhoff tanks are also available for 1987 (ISTAT, 1991; ISTAT, 1993) and 1993 (ISTAT, 1998 [a] and [b]).
CH_4 emissions have been calculated on the basis of the equivalent inhabitants treated in Imhoff tanks, the organic loading 60 g BOD_5 $capita^{-1}$ d^{-1}, as defined by national legislation and expert estimations (Legislative Decree 11 May 1999, no.152; Masotti, 1996; Metcalf and Eddy, 1991), the fraction of BOD_5 that readily settles equal to 0.3 (ANPA, 2001; Masotti, 1996), and the IPCC emission factor default value of 0.5 g CH_4 g^{-1} BOD_5.

8.3.3. Uncertainty and time-series consistency

The combined uncertainty in CH_4 emissions from wastewater handling is estimated to be about 104% in annual emissions 100% and 30% for activity data and emission factor respectively , as derived by the IPCC Good Practice Guidance (IPCC, 2000). The uncertainty in N_2O emissions is 30% both for activity data and emission factor as suggested in the GPG (IPCC, 2000).
The amount of total industrial wastewater production is reported, for each sector, in Table 8.11; as previously noted only the 15% of industrial flows are treated anaerobically (IRSA-CNR, 1998).
CH_4 emission trend for industrial wastewater handling for different sectors is shown in Table 8.12, whereas the emission trend for N_2O emissions both from industrial wastewater handling and human sewage is shown in Table 8.12.
Concerning CH_4 emissions from industrial wastewater, neither wastewater flow nor average COD value change much over time, therefore emissions are stable and mainly related to the production data. For 2004 the following COD values, expressed in grams per litre, have been used: 0.1 g l^{-1} (Iron and steel); 3.0 g l^{-1} (Organic chemicals); 3.61 g l^{-1} (Food and beverages); 0.07 g l^{-1} (Pulp and paper); 1.0 g l^{-1} (Textile industry); 4.03 g l^{-1} (Leather industry). Data on organic load for oil refinery is available only as total annual amount.

Wastewater production (1000 m^3)	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Iron and steel	9,534	7,778	7,443	7,829	7,788	7,485	6,756	7,244	6,098	5,741	6,093
Oil refinery	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Organic chemicals	210,936	212,317	212,717	213,850	213,987	214,336	215,049	214,670	214,525	214,637	214,915
Food and beverage	170,621	168,998	172,447	171,635	171,386	175,134	173,942	175,692	173,972	169,412	177,692
Pulp and paper	377,167	402,952	415,144	421,885	401,111	413,947	386,584	324,330	337,695	340,687	345,422
Textile industry	108,460	103,047	103,480	105,449	104,416	95,672	101,572	100,120	93,714	86,021	79,079
Leather industry	23,623	25,002	26,519	26,755	26,376	24,428	27,218	25,580	24,875	22,310	19,805
Total	900,341	920,095	937,750	947,403	925,065	931,003	911,122	847,637	850,879	838,807	843,005

Table 8.11 Total industrial wastewater production by sector, 1990 – 2004 (1000 m^3)

CH_4 Emissions (Gg)	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Iron and steel	0.036	0.029	0.028	0.029	0.029	0.028	0.025	0.027	0.023	0.022	0.023
Oil refinery	5.850	5.625	5.000	4.800	4.925	4.580	4.250	4.750	4.750	4.750	4.750
Organic chemicals	23.794	23.911	23.938	24.044	24.043	24.104	24.173	24.205	24.210	24.181	24.210
Food and beverage	22.022	21.200	21.597	22.035	21.484	21.944	21.915	22.362	22.579	21.709	22.372
Pulp and paper	0.923	0.986	0.974	1.007	1.045	1.097	1.053	0.883	0.920	0.928	0.941
Textile industry	4.067	3.864	3.881	3.954	3.916	3.588	3.809	3.755	3.514	3.226	2.965
Leather industry	3.192	3.378	3.583	3.615	3.564	3.301	3.678	3.456	3.361	3.368	2.990
Total	59.88	58.99	59.00	59.48	59.01	58.64	58.90	59.44	59.36	58.18	58.25

Table 8.12 CH_4 emissions from anaerobic industrial wastewater treatment, 1990 – 2004 (Gg)

N_2O Emissions (Gg)	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industrial Wastewater	0.225	0.230	0.234	0.237	0.231	0.233	0.228	0.212	0.213	0.210	0.211
Human Sewage	3.144	3.157	3.164	3.170	3.172	3.176	3.185	3.194	3.204	3.215	3.226
Total	3.37	3.39	3.40	3.41	3.40	3.41	3.41	3.41	3.42	3.42	3.44

Table 8.13 N_2O emissions from industrial wastewater handling and human sewage, 1990 – 2004 (Gg)

8.3.4. Source-specific QA/QC and verification

This source category is covered by the general QA/QC procedures. Where information is available, wastewater flows and COD concentrations are checked with those reported yearly by the industrial sectoral reports or technical documentation developed in the framework of the Integrated Pollution and Prevention Control (IPPC) Directive of the European Union (http://eippcb.jrc.es).

8.3.5. Source-specific recalculations

As described previously, it has been assumed that domestic and commercial wastewaters are treated 95% aerobically and 5% anaerobically. As the last in-country review recommended, even if the complete-mix activated sludge process is more frequently domestic and commercial wastewater system, the assumption of 100 per cent of the wastewater treated aerobically is not totally correct: some methane emissions can occur due to not well managed processes or overload problems.

As suggested by relevant experts, it has been assumed that 5% of domestic and commercial wastewater is treated anaerobically.

Moreover, pulp and paper industry activity data have been revised for the entire time series, due to new available information. The amount of wastewater consumed in the leather industry has been updated for the year 2003 (UNIC, 2004; GIADA, 2006).

The CH_4 emission trend from wastewater and sludge generated by domestic and commercial wastewater treatment is reported in Table 8.14, whereas a comparison with the previous estimation of the total methane for wastewater handling, in percentage terms, is reported in Table 8.15.

Domestic and Commercial Wastewater	**1990**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Wastewater (5% treated anaerobically)											
Organic loading in wastewater (t year^{-1})	49.83	63.83	64.78	65.74	66.70	67.78	68.84	69.94	71.05	72.17	73.30
CH_4 emissions (Gg)	29.90	38.30	38.87	39.44	40.02	40.67	41.31	41.97	42.63	43.30	43.98
Sludge (generated by Imhoff tanks)											
Eq. inhabitants treated in Imhoff tanks (10^3 millions)	1,005	1,818	1,933	2,042	2,142	2,139	2,144	2,123	2,091	2,050	1,999
Organic loading in sludge (t year^{-1})	6,606	11,942	12,701	13,414	14,073	14,050	14,087	13,946	13,739	13,468	13,132
CH_4 emissions (Gg)	3.96	7.17	7.62	8.05	8.44	8.43	8.45	8.37	8.24	8.08	7.88

Table 8.14 CH_4 emissions from sludge generated by domestic and commercial wastewater treatment, 1990 – 2004 (Gg)

Wastewater Handling	**1990**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Total CH_4 emissions	754.3%	534.5%	510.1%	490.1%	474.0%	482.4%	495.6%	510.6%	528.3%	549.1%

Table 8.15 Differences in percentages between CH_4 emissions from wastewater handling reported the updated time series and the 2005 submission

8.3.6. Source-specific planned improvements

No specific activities are planned.

8.4 Waste incineration (6C)

8.4.1. Source category description

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 waste oils, whereas there are few plants that treat residual waste from waste treatments, as well as sewage sludge.

As mentioned above, emissions from waste incineration facilities with energy recovery are reported under category 1A4a (Combustion activity, commercial/institutional sector), whereas emissions from other types of waste incineration facilities are reported under category 6C (Waste incineration). For 2004, 95% of the total amount of waste incinerated is treated in plants with energy recovery system.

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 APAT (APAT-ONR, 2005).

Emissions from removable residues from agricultural production are included in the IPCC category 6C: the total residues amount and carbon content have been estimated by both IPCC and national factors. The detailed methodology is reported in Chapter 6 (6.6.2).

CH_4 emissions from biogenic, plastic and other non-biogenic wastes have been calculated.

8.4.2. Methodological issues

Regarding GHG emissions from incinerators, the methodology reported in the IPCC Good Practice Guidance (IPCC, 2000) has been applied, combined with that reported in the CORINAIR Guidebook (EMEP/CORINAIR, 2005). A single emission factor for each pollutant has been used combined with plant specific waste activity data.

Emissions have been calculated for each type of waste: municipal, industrial, hospital, sewage sludge and waste oils.

A complete data base of these plants has been built, on the basis of various sources available for the period of the entire time series, extrapolating data for the years for which there was no information (MATT, several years; ANPA-ONR, 1999 [a]; ANPA-ONR, 2001 [b]; APAT-ONR, 2002; APAT-ONR, 2003; APAT-ONR, 2004; APAT-ONR, 2005; APAT, 2002; ANPA-ONR, 1999 [b]; AUSITRA-Assoambiente, 1995; Morselli, 1998; FEDERAMBIENTE, 1998; FEDERAMBIENTE, 2001; AMA-Comune di Roma, 1996; Ambiente, 2001; COOU, 2006).

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.).

Different procedures were used to estimate emission factors, according to the data available for each type of waste.

Specifically:

1. for municipal waste, emission data from a large sample of Italian incinerators were used (FEDERAMBIENTE, 1998);
2. for industrial waste and waste oil, emission factors have been estimated on the basis of the allowed levels authorized by the Ministerial Decree 19 November 1997, n. 503 of the Ministry of Environment;
3. for hospital waste, which is usually disposed of alongside municipal waste, the emission factors used for industrial waste were also applied;
4. for sewage sludge, in absence of specific data, reference was made to the emission limits prescribed by the Guidelines for the authorisation of existing plants issued on the Ministerial Decree 12 July 1990.

As regards municipal waste, on the basis of the IPCC Guidelines (IPCC, 1997) and referring to the average content analysis on a national scale (FEDERAMBIENTE, 1992), a distinction was made between CO_2 from fossil fuels (generally plastics) and CO_2 from renewable organic sources (paper, wood, other organic materials). Only emissions from fossil fuels, which are equivalent to 35% of the total, were included in the inventory.

On the other hand, CO_2 emissions from the incineration of sewage sludge were not included at all, while all emissions relating to the incineration of hospital and industrial waste were considered.

CH_4 and N_2O emissions from agriculture residues removed, collected and burnt 'off-site', as a way to reduce the amount of waste residues, are reported in the waste incineration sub-sector. Removable residues from agriculture production are estimated for each crop type (cereal, green crop, permanent cultivation) taking into account the amount of crop produced, the ratio of removable residue in the crop, the dry matter content of removable residue, the ratio of removable residue burned, the fraction of residues oxidised in burning, the carbon and nitrogen content of the residues. Most of these wastes refer especially to the prunes of olives and wine, because of the typical national cultivation. The methodology is the same used to calculate emissions from residues burned on fields, reported in the category 4F, described in details in Chapter 6.

On the basis of carbon and nitrogen content of the residues, CH_4 and N_2O emissions have been calculated, accounting the first nearly for 100% of the whole emissions from waste incineration, and the latter for a little bit less. CO_2 emissions have been calculated but not included in the inventory as biomass. All these parameters refer both to the IPCC Guidelines (IPCC, 1997) and country-specific values (CESTAAT, 1988; Borgioli, 1981).

8.4.3. Uncertainty and time-series consistency

The combined uncertainty in CO_2 emissions from waste incineration is estimated to be about 25.5% in annual emissions, 5% and 25% for activity data and emission factors respectively. As regards N_2O and CH_4 emissions, the combined uncertainty is estimated to be about 100% and 20.6% in annual emissions.

The time series of activity data, distinguished in Municipal Solid Waste and other, is shown in Table 8.16; CO_2 emission trends for each type of waste category are reported in Table 8.17, both for plants without energy recovery, reported under 6C, and plants with energy recovery, reported under 1A4a.

In Table 8.18 N_2O and CH_4 emissions are summarized, including those from open burning.

In the period 1990-2004, total CO_2 emissions have more than doubled, but whereas emissions from plants with energy recovery have increased by nearly 300%, emissions from plants without energy recovery decreased by nearly 60%.

While CO_2 emission trend reported in 6C is influenced by the amount of waste incinerated in plant without energy recovery, CH_4 and N_2O emission trend are related to the open burning, as already reported above.

SUBSOURCE	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
MSW Production (Gg)	22,231	25,780	25,960	26,605	26,847	28,364	28,959	29,409	29,864	30,034	31,150
MSW Incinerated (%)	4.6%	5.6%	6.1%	6.4%	7.1%	7.5%	8.0%	8.8%	9.0%	9.5%	9.9%
- in energy recovery plants	2.8%	4.6%	5.2%	5.3%	6.1%	6.6%	7.5%	8.3%	8.7%	9.3%	9.7%
MSW to incineration (Gg)	1,026	1,437	1,572	1,714	1,899	2,123	2,325	2,599	2,698	2,853	3,081
Industrial, Sanitary, Sewage Sludge and Waste Oil to incineration (Gg)	691	773	789	807	821	746	737	930	883	1,134	1,540
Total Waste to incineration (6C and 1A4a) (Gg)	1,716	2,209	2,361	2,520	2,721	2,869	3,062	3,528	3,581	3,987	4,621

Table 8.16 Waste incineration activity data, 1990 – 2004 (Gg)

SUBSOURCE	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Incineration of domestic or municipal wastes (Gg)	115.47	72.64	64.36	85.08	76.21	74.64	47.30	43.63	31.04	18.21	14.46
Incineration of industrial wastes (except flaring) (Gg)	257.20	272.85	267.50	282.69	290.78	255.92	113.09	140.84	183.64	151.11	150.34
Incineration of hospital wastes (Gg)	121.03	128.19	130.91	138.66	136.21	61.79	40.36	37.11	29.86	45.78	45.26
Incineration of waste oil (Gg)	2.66	1.41	1.26	1.33	1.24	1.13	0.82	0.67	0.43	0.65	0.51
Waste incineration (6C) (Gg)	496	475	464	508	504	393	202	222	245	216	211
Waste incineration reported under 1A4a (Gg)	609	842	911	930	1,005	1,093	1,331	1,598	1,546	1,923	2,482
Total waste incineration (Gg)	1,105	1,318	1,375	1,438	1,509	1,486	1,532	1,820	1,791	2,139	2,692

Table 8.17 CO_2 emissions from waste incineration (without and with energy recovery), 1990 – 2004 (Gg)

GAS/SUBSOURCE	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
N_2O (Gg)											
Waste incineration (6C)	0.28	0.42	0.36	0.43	0.39	0.45	0.36	0.39	0.38	0.38	0.47
MSW incineration reported under 1A4a	0.06	0.08	0.09	0.09	0.10	0.11	0.13	0.16	0.16	0.19	0.24
CH_4 (Gg)											
Waste incineration (6C)	7.65	12.91	10.89	13.24	11.76	14.38	11.87	12.93	12.53	12.80	16.13
MSW incineration reported under 1A4a	0.03	0.05	0.05	0.06	0.06	0.07	0.08	0.10	0.09	0.11	0.14

Table 8.18 N_2O and CH_4 emissions from waste incineration, 1990 – 2004 (Gg)

8.4.4. Source-specific QA/QC and verification

This source category is covered by the general QA/QC procedures. For the incineration plants reported in the EPER register, verification on emissions has been carried out.

8.4.5. Source-specific recalculations

For the year 2003, activity data from the incineration plants, which treat industrial waste, not previously available, have been published by APAT (APAT-ONR, 2005) and so update.
Two new incineration plants that treat waste oils have been added to the database from 2003, due to new available information (COOU, 2006).
Moreover, other minor modifications are due to the rationalization and optimization of the working sheet of incineration plants database.
In Table 8.19 differences with GHG emissions reported last year in percentages are reported.

GAS/SUBSOURCE	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003
CO_2										
Waste incineration (6C)	0.6%	-14.0%	-8.7%	0.0%	50.2%	0.4%	-7.9%	-5.4%	32.5%	28.7%
MSW incineration reported under 1A4a	21.5%	35.3%	59.2%	59.2%	62.4%	55.1%	56.5%	64.8%	52.5%	63.5%
N_2O										
Waste incineration (6C)	-0.8%	-2.8%	-1.2%	0.0%	3.8%	0.0%	-0.3%	-0.2%	1.3%	4.0%
MSW incineration reported under 1A4a	-60.5%	-59.5%	-52.4%	-52.2%	-51.4%	-53.4%	-52.8%	-51.3%	-54.4%	-51.7%
CH_4										
Waste incineration (6C)	0.0%	-0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	3.0%
MSW incineration reported under 1A4a	-53.7%	-57.9%	-50.8%	-50.7%	-50.5%	-52.6%	-51.6%	-50.5%	-53.7%	-50.7%

Table 8.19 Differences in percentages between the updated time series and the 2005 submission

8.4.6. Source-specific planned improvements

As reported for solid waste disposal on land, the waste composition is very important to improve CO_2 emission factor on the basis of carbon content.

8.5 Other waste (6D)

8.5.1. Source category description

Under this source category CH_4 emissions from compost production have been reported. The amount of waste treated in composting plants has shown a great increase from 1990 to 2004 (363,319 tons to 6,010,865 tons).
Information on input waste to composting plants are published yearly by APAT since 1996, including data for 1993 and 1994 (ANPA, 1998; ANPA-ONR, 2001 [b]; APAT-ONR, 2002;

APAT-ONR, 2003; APAT-ONR, 2004; APAT-ONR, 2005), while for 1987 and 1995 only data on compost production are available (MATT, 1989; AUSITRA-Assoambiente, 1995); on the basis of this information the whole time series has been reconstructed.

8.5.2. Methodological issues

The composting plants are classified in two different kinds: the plants that treat a selected waste (food, market, garden waste, sewage sludge and other organic waste, mainly from the agro-food industry); and the mechanical-biological treatment plants, that treat the unselected waste to produce compost, refuse derived fuel (RDF), and a waste with selected characteristics for landfilling or incinerating system.

It is assumed that 100% of the input waste to the composting plants from selected waste is treated as compost, while in mechanical-biological treatment plants 30% of the input waste is treated as compost on the basis of national studies and references (Favoino and Cortellini, 2001; Favoino and Girò, 2001).

Since no methodology is provided by the IPCC for these emissions, literature data (Hogg, 2001) have been used for the emission factor, 0.029 g CH4 kg^{-1} treated waste, equivalent to compost production.

NMVOC emissions have also been estimated: emission factor (51 g NMVOC kg^{-1} treated waste) is from international scientific literature too (Finn and Spencer, 1997).

In Table 8.20 CH_4 and NMVOC emissions are reported.

GAS	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CH_4 (Gg)											
Compost production (6D)	0.011	0.023	0.021	0.048	0.058	0.078	0.097	0.125	0.157	0.179	0.176
NMVOC (Gg)											
Compost production (6D)	0.018	0.040	0.036	0.083	0.100	0.136	0.168	0.216	0.272	0.309	0.305

Table 8.20 CH_4 and NMVOC emissions from compost production, 1990 – 2004 (Gg)

8.5.3. Uncertainty and time-series consistency

The uncertainty in CH_4 emissions from compost production is estimated to be about 100% in annual emissions, 10% and 100% concerning activity data and emission factors respectively.

8.5.4. Source-specific QA/QC and verification

This source category is covered by the general QA/QC procedures.

8.5.5. Source-specific recalculations

No recalculation has been done.

8.5.6. Source-specific planned improvements

No specific activities are planned.

Chapter 9: RECALCULATIONS AND IMPROVEMENTS

9.1 Explanations and justifications for 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 and changes due to error corrections. Revisions apply to the entire time series.
The complete revised CRFs from 1990 to 2003 has been submitted as well as the CRF for the year 2004 and recalculation tables have been filled in terms of quantity values for each year. Explanatory information on the major recalculations between the 2005 and 2006 submissions are reported in Table 9.1.
The revisions that lead to relevant changes in GHG emissions have been already pointed out in the specific sectoral chapters and summarized in the following section 9.4.1.

9.2 Implications for emission levels

The time series reported in the 2005 submission and the series reported this year (2006 submission) are shown in Table 9.2 by gas and sector. Specifically, by gas, the comparison and differences in emission levels are reported in Table 9.3.
Improvements in the calculation of emission estimates have led to a recalculation of the entire time series of the national inventory. Considering the total GHG emissions without CO_2 from LULUCF, the emission levels of the base year increased by 1.8% in comparison with the last year submission, whereas emissions for the year 2003 showed an increase by 1.3%.

Detailed explanations of these recalculations are provided in the sectoral chapters. In general, it should be noted that Italy has set the year 1990 as the base year for F-gases; the previous choice of 1995 has been rejected due to the latest revised inventory information and is not to be considered valid anymore. The most relevant changes affected CO_2 emissions from the iron and steel sector. The full carbon cycle has been accounted for and emissions have been balanced between the energy and the industrial processes sectors; a complete balance of energy and carbon has been carried out as well. In addition in the industrial processes, N_2O emissions from nitric acid have been recalculated on account of new emission factor figures. Other important recalculations regarded the agriculture sector for a revision of CH_4 and N_2O emissions from manure management and rice cultivation and the waste sector for CH_4 from solid waste disposal.

TABLE 8(b) RECALCULATION - EXPLANATORY INFORMATION
(Sheet 1 of 1)

Italy
2003
2005

Specify the sector and source/sink category[1] where changes in estimates have occurred:		GHG	RECALCULATION DUE TO			
			CHANGES IN:			Addition/removal/ replacement of source/sink categories
			Methods [2]	Emission factors [2]	Activity data [2]	
1A	Iron and Steel	CO2	Emissions from the iron and steel sector have been revised in response to the review process. The full carbon cycle has been accounted for and emissions have been balanced between the energy and the industrial processes sectors. A complete balance of energy and carbon has been carried out.			
2A	Mineral products	CO2	Emissions from limestone and dolomite use have been revised in response to the review process; emissions from sinter have been removed from this sector and included in the metal production sector			
2B	Chemical industry	N2O		In response to the review process emission factors for nitric acid production from 1990 to 1999 have been revised on the basis of new information by industry	Activity data for 2002 and 2003 have been revised on the basis of new information by industry	
2C	Metal production	CO2	Emissions from the iron and steel sector have been revised in response to the review process. The full carbon cycle has been accounted for and emissions have been balanced between the energy and the industrial processes sectors. A complete balance of energy and carbon has been carried out.			
2C3	Aluminium Production	PFC		Emission factors from 1992 to 1995 have been revised on the basis of more accurate information on cell typology provided by industry	Activity data (years 1994, 1995 and 2003) have been revised on the basis of new information by industry	
2F1	Mobile Air Conditioning	HFC134a			Activity data (years 2002 and 2003) have been revised on the basis of new information by industry	
2F3	Fire extinguishers	HFC227ea			Activity data from 2001 have been revised	
3D	Other	CO2	Emission estimates from domestic solvent use have been changed from the method based on population to a more detailed method	Efs for printing industry and glues application have been revised on the basis of new information		
5	LUCF	CO2	In response to the review process and in agreement with the GPGLULUCF, emissions from cropland and grassland remaining cropland and grassland previously	New values available for carbon content in forest soil have been used.		
6A	Solid Waste Disposal	CH4	In response to the review process, the methane generation potential (L0) estimate has been revised.	Emission factors have been revised on the basis of national information on waste composition and half time of	In response to the review process, the amount of waste landfilled has been collected from 1950. Moreover, CH4 recovered data	
6B	Domestic Wastewater Handling	CH4				In response to the review process, it has been assumed that 95% of wastewater is treated aerobically and 5% anaerobically.
6B	Industrial Wastewater Handling	CH4, N2O			Activity data related to pulp and paper industry have been revised. Moreover, for the year 2003, wastewater production from leather industry has been updated.	
6C	Waste incineration	CO2, CH4, N2O			Activity data have been revised: some data may have changed in the amount of incinerated wastes treated with/without energy recovering due to new information about the plants, a razionalization of the database of incineration plants, or to errors occurred.	
4A	Enteric fermentation	CH4	Tier 2 approach has been applied for the buffalo livestock category	Some parameters (Ym, weight, % pasture) used for the calculation of the EF for the dairy cattle category has been updated according to new national statistics received from ISTAT.	Milk production has been updated	
4.B	Manure management	CH4		The production of manure and slurry for cattle and buffalo livestock category, which are used for the estimation of the emission factor, has been updated, according to new information available from a research study.		
4.B	Manure management	N2O		Nitrogen excretion rates and average weight from the different livestock categories have been updated, according to new information available from a research study.		
4.C	Rice cultivation	CH4		New parameters have been used for the estimation of methane emissions from rice paddies, according to new national references	Distribution of surfaces according to IPCC classification have been updated	
4.D	Agricultural soils	N2O		FRACgasm and FRACgraz have been updated in response to the review process.		
1B2	Fugitive emissions from liquid and g	CH4	Methodology of estimation of fugitive emissions from production of gas and oil has been revised following the Good Practice Guidance and on the basis of information supplied by industry			

(1) Enter the identification code of the source/sink category (e.g. 1.B.1) in the first column and the name of the category (e.g. Fugitive Emissions from Solid Fuels) in the second column of the table (see Table 8(a)) .
(2) Explain changes in methods, emission factors and activity data that have resulted in recalculation of the estimate of the source/sink as indicated in Table 8(a). Include relevant changes in the assumptions and coefficients under the "Methods" column.

Documentation box: Use the documentation box to report the justifications of the changes as to improvements in the accuracy, completeness and consistency of the inventory.
Other minor modifications of the time series or single years may result from the updating of basic data.

Table 9.1 Explanations of the main recalculations in the 2006 submission (CRF 2004)

TABLE 10 EMISSION TRENDS (SUMMARY)
(Sheet 5 of 5)

Italy
2004
2006

GREENHOUSE GAS EMISSIONS	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO2 equivalent (Gg)															
Net CO2 emissions/removals	354,575.15	354,575.15	332,699.44	336,212.98	344,813.63	322,179.91	342,066.59	332,712.94	343,636.26	357,772.52	355,251.66	363,282.90	358,845.36	356,452.00	374,713.04	383,669.80
CO2 emissions (without LUCF) (6)	434,488.88	434,488.88	433,954.91	433,610.27	427,416.15	420,397.26	445,383.57	438,842.67	443,056.02	454,031.47	459,051.02	463,310.79	469,062.24	470,821.06	486,125.56	489,590.01
CH4	41,664.86	41,664.86	42,863.79	42,251.22	42,637.08	43,229.06	44,102.62	44,223.64	44,713.40	44,818.60	44,911.77	45,098.81	44,368.49	42,870.16	42,574.95	41,857.82
N2O	41,147.30	41,147.30	42,061.49	41,261.64	41,697.72	40,548.97	41,503.22	41,157.56	42,378.41	42,350.29	43,433.68	43,672.96	43,910.52	43,413.36	43,221.91	45,176.97
HFCs	351.00	351.00	355.43	358.78	355.42	481.90	671.29	450.17	755.33	1,180.96	1,451.82	2,005.50	2,761.41	3,568.02	4,589.89	5,699.29
PFCs	1,807.65	1,807.65	1,451.54	849.56	707.47	476.84	490.80	243.39	252.08	270.43	258.00	345.85	452.37	413.58	484.46	406.62
SF6	332.92	332.92	356.39	358.26	370.40	415.66	601.45	682.56	728.64	604.81	404.51	493.43	795.34	738.35	485.63	602.38
Total (with net CO2 emissions/removals)	**439,878.88**	**439,878.88**	**419,788.09**	**421,292.44**	**430,581.73**	**407,332.33**	**429,435.98**	**419,470.25**	**432,464.11**	**446,997.61**	**445,711.45**	**454,899.45**	**451,133.49**	**447,455.47**	**466,069.88**	**477,412.88**
Total (without CO2 from LUCF) (6) (8)	**519,792.62**	**519,792.62**	**521,043.56**	**518,689.73**	**513,184.24**	**505,549.67**	**532,752.96**	**525,599.98**	**531,883.87**	**543,256.57**	**549,510.80**	**554,927.33**	**561,350.37**	**561,824.53**	**577,482.40**	**583,333.09**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO2 equivalent (Gg)															
1. Energy	422,600.35	422,600.35	422,491.22	421,557.35	418,046.91	411,635.46	435,279.90	431,176.98	435,367.89	446,496.54	451,986.18	455,538.96	460,373.18	462,400.61	477,126.77	479,955.11
2. Industrial Processes	36,544.50	36,544.50	36,164.73	35,572.01	32,735.90	31,399.43	34,589.69	31,555.53	32,031.58	32,488.74	32,817.02	34,979.32	37,206.40	37,460.46	38,955.40	41,982.44
3. Solvent and Other Product Use	2,394.46	2,394.46	2,337.86	2,337.58	2,294.75	2,216.86	2,181.88	2,284.23	2,283.92	2,370.60	2,354.43	2,297.40	2,220.68	2,229.58	2,178.66	2,124.31
4. Agriculture	41,177.35	41,177.35	41,962.85	41,420.33	41,712.07	41,192.52	40,888.22	40,661.66	41,767.35	41,068.62	41,487.84	40,456.72	39,971.98	38,775.44	38,636.43	38,361.89
5. Land-Use Change and Forestry (7)	-79,721.59	-79,721.59	-101,215.23	-97,330.76	-82,396.73	-98,050.09	-103,206.42	-106,104.29	-99,317.92	-96,003.71	-103,525.18	-99,711.05	-110,156.09	-114,334.99	-111,340.95	-105,107.08
6. Waste	16,883.81	16,883.81	18,046.66	17,735.93	18,188.83	18,938.14	19,702.72	19,896.14	20,331.29	20,576.83	20,591.15	21,338.10	21,517.34	20,924.37	20,513.57	20,096.20
7. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(6) The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report CO2 emissions and removals from Land-Use Change and Forestry.
(7) Net emissions.
(8) The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table Summary2 if Parties report non-CO2 emissions from LUCF.

TABLE 10 EMISSION TRENDS (SUMMARY)
(Sheet 5 of 5)

Italy
2003
2005

GREENHOUSE GAS EMISSIONS	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	CO2 equivalent (Gg)														
Net CO2 emissions/removals	369,752.09	369,752.09	347,343.91	350,338.62	359,646.86	335,700.02	360,859.13	349,329.99	362,660.89	372,197.82	371,040.27	385,746.46	386,503.29	375,622.18	405,381.94
CO2 emissions (without LUCF) (6)	430,635.79	430,635.79	430,495.57	429,474.73	424,411.88	417,250.73	446,659.92	438,857.66	443,122.08	452,983.52	460,271.54	467,548.23	472,005.00	471,401.88	487,281.90
CH4	38,319.71	38,319.71	38,971.34	37,823.64	38,030.09	38,037.79	38,293.56	38,211.82	38,471.27	38,328.10	38,466.02	38,050.72	37,145.04	35,852.68	34,637.28
N2O	39,924.14	39,924.14	41,164.37	40,613.86	40,871.23	39,828.34	41,025.27	40,774.95	42,010.19	41,837.52	42,877.30	42,994.77	43,000.28	43,005.39	42,353.46
HFCs	671.29	351.00	355.43	358.78	355.42	481.90	671.29	450.17	755.33	1,180.96	1,451.82	2,005.50	2,758.80	3,560.52	4,575.46
PFCs	336.71	1,807.65	1,422.87	798.94	630.85	354.77	336.71	243.39	252.08	270.43	258.00	345.85	452.37	413.58	493.56
SF6	601.45	332.92	356.39	358.26	370.40	415.66	601.45	682.56	728.64	604.81	404.51	493.43	795.34	738.35	485.94
Total (with net CO2 emissions/removals)	**449,605.40**	**450,487.51**	**429,614.31**	**430,292.10**	**439,904.84**	**414,818.48**	**441,787.42**	**429,692.87**	**444,878.39**	**454,419.64**	**454,497.92**	**469,636.73**	**470,655.12**	**459,192.69**	**487,927.63**
Total (without CO2 from LUCF) (6) (8)	**510,489.10**	**511,371.22**	**512,765.97**	**509,428.21**	**504,669.86**	**496,369.18**	**527,588.21**	**519,220.55**	**525,339.58**	**535,205.34**	**543,729.19**	**551,438.49**	**556,156.84**	**554,972.40**	**569,827.59**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	CO2 equivalent (Gg)														
1. Energy	418,964.45	418,964.45	419,069.03	417,401.18	414,934.95	408,191.11	436,004.87	430,316.30	434,274.06	444,319.86	451,530.22	457,825.06	461,681.51	461,520.65	476,888.49
2. Industrial Processes	34,731.85	35,613.97	35,252.97	34,644.74	31,587.78	30,319.23	33,660.28	31,040.59	31,876.13	32,500.36	33,305.08	35,709.20	37,476.54	37,664.68	39,210.33
3. Solvent and Other Product Use	2,543.53	2,543.53	2,486.09	2,407.87	2,353.48	2,279.29	2,251.94	2,357.61	2,362.40	2,451.27	2,434.65	2,401.50	2,276.30	2,250.29	2,180.40
4. Agriculture	40,618.04	40,618.04	41,877.49	41,610.38	41,928.80	41,480.06	41,395.48	41,191.39	42,279.48	41,590.71	41,874.74	40,981.46	40,334.33	40,176.07	38,747.07
5. Land-Use Change and Forestry (7)	-60,726.31	-60,726.31	-83,111.42	-79,069.58	-64,603.72	-81,490.08	-85,777.03	-89,512.49	-80,379.59	-80,710.02	-89,200.01	-81,705.93	-85,440.93	-95,745.64	-81,828.39
6. Waste	13,473.84	13,473.84	14,040.16	13,297.50	13,703.54	14,038.88	14,251.89	14,299.48	14,465.91	14,267.46	14,553.25	14,425.44	14,327.37	13,326.64	12,729.74
7. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(6) The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report CO2 emissions and removals from Land-Use Change and Forestry.
(7) Net emissions.
(8) The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry. Note that these totals will differ from the totals reported in Table Summary2 if Parties report non-CO2 emissions from LUCF.

Table 9.2 Comparison between the 2006 and 2005 submitted time series by gas and sector

		Base year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Net CO_2 emissions/removals (Gg CO_2-eq.)	2005 submission	369,752	369,752	347,344	350,339	359,647	335,700	360,859	349,330	362,661	372,198	371,040	385,746	386,503	375,622	405,382
	2006 submission	354,575	354,575	332,699	336,213	344,814	322,180	342,067	332,713	343,636	357,773	355,252	363,283	358,845	356,452	374,713
Difference		*-4.1%*	*-4.1%*	*-4.2%*	*-4.0%*	*-4.1%*	*-4.0%*	*-5.2%*	*-4.8%*	*-5.2%*	*-3.9%*	*-4.3%*	*-5.8%*	*-7.2%*	*-5.1%*	*-7.6%*
CO_2 emissions (without LULUCF) (Gg CO2-eq.)	2005 submission	430,636	430,636	430,496	429,475	424,412	417,251	446,660	438,858	443,122	452,984	460,272	467,548	472,005	471,402	487,282
	2006 submission	434,489	434,489	433,955	433,610	427,416	420,397	445,384	438,843	443,056	454,031	459,051	463,311	469,062	470,821	486,126
Difference		*0.9%*	*0.9%*	*0.8%*	*1.0%*	*0.7%*	*0.8%*	*-0.3%*	*0.0%*	*0.0%*	*0.2%*	*-0.3%*	*-0.9%*	*-0.6%*	*-0.1%*	*-0.2%*
CH_4 (Gg CO_2-eq.)	2005 submission	38,320	38,320	38,971	37,824	38,030	38,038	38,294	38,212	38,471	38,328	38,466	38,051	37,145	35,853	34,637
	2006 submission	41,665	41,665	42,864	42,251	42,637	43,229	44,103	44,224	44,713	44,819	44,912	45,099	44,368	42,870	42,575
Difference		*8.7%*	*8.7%*	*10.0%*	*11.7%*	*12.1%*	*13.6%*	*15.2%*	*15.7%*	*16.2%*	*16.9%*	*16.8%*	*18.5%*	*19.4%*	*19.6%*	*22.9%*
N_2O (Gg CO_2-eq.)	2005 submission	39,924	39,924	41,164	40,614	40,871	39,828	41,025	40,775	42,010	41,838	42,877	42,995	43,000	43,005	42,353
	2006 submission	41,147	41,147	42,061	41,262	41,698	40,549	41,503	41,158	42,378	42,350	43,434	43,673	43,911	43,413	43,222
Difference		*3.1%*	*3.1%*	*2.2%*	*1.6%*	*2.0%*	*1.8%*	*1.2%*	*0.9%*	*0.9%*	*1.2%*	*1.3%*	*1.6%*	*2.1%*	*0.9%*	*2.1%*
HFCs (Gg CO_2-eq.)	2005 submission	671	351	355	359	355	482	671	450	755	1,181	1,452	2,005	2,759	3,561	4,575
	2006 submission	351	351	355	359	355	482	671	450	755	1,181	1,452	2,005	2,761	3,568	4,590
Difference		*-47.7%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.1%*	*0.2%*	*0.3%*
PFCs (Gg CO_2-eq.)	2005 submission	337	1,808	1,423	799	631	355	337	243	252	270	258	346	452	414	494
	2006 submission	1,808	1,808	1,452	850	707	477	491	243	252	270	258	346	452	414	484
Difference		*436.9%*	*0.0%*	*2.0%*	*6.3%*	*12.1%*	*34.4%*	*45.8%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*-1.8%*
SF_6 (Gg CO_2-eq.)	2005 submission	601	333	356	358	370	416	601	683	729	605	405	493	795	738	486
	2006 submission	333	333	356	358	370	416	601	683	729	605	405	493	795	738	486
Difference		*-44.6%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*-0.1%*
Total (with net CO_2 emissions/removals) (Gg CO2-eq.)	2005 submission	449,605	450,488	429,614	430,292	439,905	414,818	441,787	429,693	444,878	454,420	454,498	469,637	470,655	459,193	487,928
	2006 submission	439,879	439,879	419,788	421,292	430,582	407,332	429,436	419,470	432,464	446,998	445,711	454,899	451,133	447,455	466,070
Difference		*-2.2%*	*-2.4%*	*-2.3%*	*-2.1%*	*-2.1%*	*-1.8%*	*-2.8%*	*-2.4%*	*-2.8%*	*-1.6%*	*-1.9%*	*-3.1%*	*-4.1%*	*-2.6%*	*-4.5%*
Total (without CO_2 from LULUCF) (Gg CO2-eq.)	2005 submission	510,489	511,371	512,766	509,428	504,670	496,369	527,588	519,221	525,340	535,205	543,729	551,438	556,157	554,972	569,828
	2006 submission	519,793	519,793	521,044	518,690	513,184	505,550	532,753	525,600	531,884	543,257	549,511	554,927	561,350	561,825	577,482
Difference		*1.8%*	*1.6%*	*1.6%*	*1.8%*	*1.7%*	*1.8%*	*1.0%*	*1.2%*	*1.2%*	*1.5%*	*1.1%*	*0.6%*	*0.9%*	*1.2%*	*1.3%*

Table 9.3 Differences in time series between the 2006 and 2005 submissions due to recalculations

9.3 Implications for emission trends, including time series consistency

Recalculations account for an improvement in the overall emission trend and consistency in time series.

In comparison with the time series submitted in 2005, emission levels of the base year, total emissions in CO_2 equivalent without CO_2 emissions from LULUCF, increased by 1.8%. Specifically, CH_4 levels have increased by 8.7% and N_2O by 3.1% while CO_2 levels have increased by 0.9%. It should be noted that the differences in F-gas figures is due to the fact that the base year has been changed from 1995 to 1990.

If considering CO_2 emission levels with LULUCF, a decrease by 2.2% is observed between the 2005 and 2006 total figures in CO_2 equivalent, mainly due to the revision of CO_2 emissions from cropland and grassland remaining cropland and grassland which have been deleted because not related to a real change in carbon content in soils.

For the year 2003, changes affected negatively CO_2 (-0.2%) as well as PFCs (-1.8%) and SF_6 (–0.1%) whereas CH_4, N_2O and HFCs show an increase (+22.9%, +2.1% and 0.3% respectively).

Due to these recalculations the trend ‘base year- year 2003’ shows an increase by 11.1% in this year submission, while the increase for the same period was by 11.6% in the previous submission.

Improvements in methodologies used to compile the inventory guarantee better estimates and minor changes from one year to another for the entire time series.

9.4 Recalculations, response to the review process and planned improvements

This chapter summarises the recalculations and improvements made to the Italian GHG inventory since the 2005 submission.

In addition to a new year, the inventory is updated annually by a revision of the existing activity data and emission factors in order to include new information available; the update could also reflect the revision of methodologies. Revisions always apply to the whole time series.

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.

9.4.1 Recalculations

The key differences that have occurred in emission estimates since the last year submission are reported in Table 9.2 and Table 9.3. A more detailed recalculation for the year 2003 is summarised in Table 9.4

Besides the usual updating of activity data, recalculations may be distinguished in methodological changes, source allocation and error corrections.

All sectors were involved in methodological changes. Specifically:

Energy. CO_2 emissions from the iron and steel sector have been revised. The full carbon cycle has been accounted for and emissions have been balanced between the energy and the industrial processes sectors. A complete balance of energy and carbon has been carried out.

CH_4 fugitive emissions from production of gas and oil post mining activities have been revised following the Good Practice Guidance and new information supplied by industry

Industrial sector. Most of the relevant recalculations affected the industrial processes sector.

CO_2 emissions from mineral products and metal production have been recalculated. For mineral products changes has concerned the revision of activity data time series on lime production. The revision which affected metal production has already been explained by a more accurate split of emissions from iron and steel between the energy and industrial processes sectors. N_2O emissions from nitric acid production, in the chemical industry, have been revised and recalculated on account of new information made available by industry.

Solvent and other product use sector. CO_2 emissions have been revised on the basis of new information made available by industry. A specific recalculation has been carried out for emissions from domestic solvent use applying a detailed methodology which is based on the VOC content per type of consumer product.

Agriculture. N_2O and CH_4 emission factors have been revised for enteric fermentation, manure management and rice cultivation on the basis of new information on relevant parameters available from updated references and research studies.

LULUCF. The entire time series has been recalculated deleting CO_2 emissions from cropland and grassland remaining cropland and grassland because not related to a real change in carbon content in soils. Moreover, estimates of soil carbon stock changes resulting from transition of cropland and grassland to settlement have been provided.

Waste sector. CH_4 emissions from solid waste disposal have been recalculated on the basis of an in depth analysis on basic parameters used for estimation.

Source allocation was improved in the framework of the implementation of the EU emissions trading directive, meetings with the industry sector were held. This results in a better understanding of emissions allocation particularly in the refineries, iron and steel, lime and cement and non ferrous metal sectors.

9.4.2 Response to the UNFCCC review process

In 2005 the Italian GHG inventory was subject to an in-country review by the Climate Change Secretariat.

Following the recommendations of the review process, lots of improvements in the inventory have been carried out. CO_2 emissions from the energy and the industrial processes sectors have been revised. Specifically, the full carbon cycle has been accounted for and emissions from iron and steel have been balanced between the energy and the industrial processes sectors. A complete balance of energy and carbon has been carried out. Recalculations also affected figures from limestone and dolomite use; emissions from sinter have been removed from this sector and included in the metal production sector. In addition for the chemical industry, the N_2O emission factor for nitric acid production has been checked with the relevant industry and the entire time series revised.

For the agriculture sector, parameters to draw up N_2O emission estimates in the agriculture soils category have been updated.

Regarding the LULUCF sector, CO_2 emissions from cropland and grassland remaining cropland and grassland have been deleted because not related to a real change in carbon content in soils.

CH_4 emissions from the waste sector have been revised on account of the review process. Specifically, for solid waste disposal, the estimate of methane generation potential has been revised and emissions have been estimated accounting for specific different waste types. Moreover, the amount of waste landfilled has been collected from 1950 and also CH_4 recovered data have been revised. Finally, for domestic waste water handling, a different split in the treatment process of wastewater has been assumed, specifically 95% aerobically and 5% anaerobically, as suggested by the relevant reviewer.

In addition, particular attention has been paid to check information and values with the relevant references and to the archiving of all the material used for the 2006 submission.

Figures to draw up uncertainty analysis have been checked with the sectoral experts and are consistent with the IPCC Good Practice Guidance.

The description of country specific methods and the rationale behind the choice of emission factors, activity data and other related parameters should have improved the transparency of the present NIR.

9.4.3 Planned improvements (e.g., institutional arrangements, inventory preparation)

The main priority will concern the completion of a National System in order to comply with the additional requirements of the Kyoto protocol and the European Monitoring Mechanism. The implementation of the programme is the responsibility of the Ministry for the Environment and Territory, while co-ordination is delegated to APAT.

The elaboration of an inventory QA/QC plan which describes specific QC procedures to be implemented during the inventory development process and facilitate the QA procedures including the establishment of quality objectives has been already developed.

The basic independent review of the inventory before its submission is still under consideration.

Other specific functions are already part of the good practices followed for the inventory preparation.

Sector specific improvements are identified in the relevant chapters and specified in the 2006 QA/QC plan.

Generally, improvements will be related to the availability of new and updated information on emission factors, activity data as well as parameters necessary to carry out the estimates. Further efforts will concern the collection of statistical data and information to estimate uncertainty in specific sectors by implementing the Tier 2 approach of the IPCC Good Practice Guidance. In particular for the agriculture sector, an update of the information on the basis of a specific survey ‘farm and structure’ by the National Institute of Statistics, which APAT has collaborated with,

will improve emissions from manure management; for the waste sector, improvements will concern the results from a survey by a relevant operator on off site plant for wastewater handling; more accurate estimates of carbon stored in different pools are also expected for the LULUCF sector following the results of different European projects. Finally for the energy and industrial processes sectors, basic data reported in the European emissions trading scheme will improve the knowledge on the specific sectors involved.
There are only few emission values missing, such as potential PFCs, but at the moment no information is available to fill these gaps.

TABLE 8(a) RECALCULATION - RECALCULATED DATA

Recalculated year: 2003

(Sheet 1 of 2)

Italy
2003
2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO2			CH4			N2O		
		Previous submission	Latest submission	Difference(1)	Previous submission	Latest submission	Difference(1)	Previous submission	Latest submission	Difference(1)
		CO_2 equivalent (Gg)		(%)	CO_2 equivalent (Gg)		(%)	CO_2 equivalent (Gg)		(%)
Total National Emissions and Removals		**405,381.94**	**374,713.04**	**-7.57**	**34,637.28**	**42,574.95**	**22.92**	**42,353.46**	**43,221.91**	**2.05**
1. Energy		**459,254.37**	**458,807.46**	**-0.10**	**6,800.63**	**7,487.18**	**10.10**	**10,833.49**	**10,832.13**	**-0.01**
1.A.	Fuel Combustion Activities	456,755.10	456,310.58	-0.10	1,713.39	1,620.96	-5.39	10,833.49	10,832.13	-0.01
1.A.1.	Energy Industries	160,882.83	158,591.88	-1.42	469.08	390.68	-16.71	2,030.25	2,010.53	-0.97
1.A.2.	Manufacturing Industries and Construction	85,034.51	86,005.03	1.14	147.13	128.54	-12.64	1,672.76	1,679.61	0.41
1.A.3.	Transport	126,015.47	126,035.14	0.02	615.12	619.76	0.75	3,769.40	3,773.47	0.11
1.A.4.	Other Sectors	84,162.14	85,018.38	1.02	480.00	479.93	-0.01	3,322.30	3,329.73	0.22
1.A.5.	Other	660.15	660.15	0.00	2.06	2.06	0.00	38.78	38.78	0.00
1.B.	Fugitive Emissions from Fuels	2,499.27	2,496.88	-0.10	5,087.25	5,866.22	15.31	0.00	0.00	0.00
1.B.1.	Solid fuel	0.00	0.00	0.00	94.53	94.53	0.00	0.00	0.00	0.00
1.B.2.	Oil and Natural Gas	2,499.27	2,496.88	-0.10	4,992.72	5,771.69	15.60	0.00	0.00	0.00
2. Industrial Processes		**26,536.23**	**25,780.48**	**-2.85**	**58.10**	**57.91**	**-0.32**	**7,061.04**	**7,557.02**	**7.02**
2.A.	Mineral Products	23,483.28	22,985.79	-2.12	0.00	0.00	0.00	0.00	0.00	0.00
2.B.	Chemical Industry	1,243.32	1,243.32	0.00	6.49	6.49	0.00	7,061.04	7,557.02	7.02
2.C.	Metal Production	1,809.62	1,551.37	-14.27	51.61	51.42	-0.36	0.00	0.00	0.00
2.D.	Other Production	0.00	NA	-100.00						
2.G.	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Solvent and Other Product Use		**1,323.60**	**1,321.86**	**-0.13**				**856.80**	**856.80**	**0.00**
4. Agriculture		**0.00**	**0.00**	**0.00**	**16,326.77**	**15,846.51**	**-2.94**	**22,420.30**	**22,789.92**	**1.65**
4.A.	Enteric Fermentation				10,933.14	11,055.33	1.12			
4.B.	Manure Management				3,820.67	3,318.12	-13.15	3,972.42	4,272.28	7.55
4.C.	Rice Cultivation				1,561.64	1,461.59	-6.41			
4.D.	Agricultural Soils (2)	0.00	0.00	0.00	0.00	0.00	0.00	18,444.30	18,514.00	0.38
4.E.	Prescribed Burning of Savannas				0.00	0.00	0.00	0.00	0.00	0.00
4.F.	Field Burning of Agricultural Residues				11.32	11.47	1.33	3.58	3.64	1.62
4.G.	Other				0.00	0.00	0.00	0.00	0.00	0.00
5. Land-Use Change and Forestry (net) (3)		**-81,899.96**	**-111,412.52**	**36.03**	**64.97**	**64.97**	**0.00**	**6.59**	**6.59**	**0.00**
5.A.	Changes in Forest and Other Woody Biomass Stocks	-80,044.43	-84,696.64	5.81						
5.B.	Forest and Grassland Conversion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.C.	Abandonment of Managed Lands	0.00	0.00	0.00						
5.D.	CO2 Emissions and Removals from Soil	0.00	0.00	0.00						
5.E.	Other	-1,855.53	-26,715.88	1,339.79	64.97	64.97	0.00	6.59	6.59	0.00

(1) Estimate the percentage change due to recalculation with respect to the previous submission (Percentage change = 100% x [(LS-PS)/PS], where LS = Latest submission and PS = Previous submission.
All cases of recalculation of the estimate of the source/sink category, should be addressed and explained in Table 8(b) of this common reporting format.
(2) See footnote 4 to Summary 1.A of this common reporting format.
(3) Net CO_2 emissions/removals to be reported

TABLE 8(a) RECALCULATION - RECALCULATED DATA

Recalculated year: 2003

(Sheet 2 of 2)

Italy
2003
2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO2			CH4			N2O		
		Previous submission	Latest submission	Difference(1)	Previous submission	Latest submission	Difference(1)	Previous submission	Latest submission	Difference(1)
		CO_2 equivalent (Gg)		(%)	CO_2 equivalent (Gg)		(%)	CO_2 equivalent (Gg)		(%)
6. Waste		**167.70**	**215.76**	**28.66**	**11,386.81**	**19,118.37**	**67.90**	**1,175.23**	**1,179.44**	**0.36**
6.A.	Solid Waste Disposal on Land	0.00	0.00	0.00	9,690.34	16,544.99	70.74			
6.B.	Wastewater Handling				1,431.71	2,300.87	60.71	1,061.90	1,061.55	-0.03
6.C.	Waste Incineration	167.70	215.76	28.66	261.01	268.75	2.97	113.33	117.89	4.03
6.D.	Other	0.00	0.00	0.00	3.75	3.75	0.00	0.00	0.00	0.00
7. Other (please specify)		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
				0.00			0.00			0.00
Memo Items:										
International Bunkers		**13,695.42**	**13,656.58**	**-0.28**	**17.26**	**17.22**	**-0.24**	**84.81**	**84.65**	**-0.19**
Multilateral Operations		**NE**	**NE**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
CO2 Emissions from Biomass		**14,000.05**	**12,983.37**	**-7.26**						

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		HFCs			PFCs			SF_6		
		Previous submission	Latest submission	Difference(1)	Previous submission	Latest submission	Difference(1)	Previous submission	Latest submission	Difference(1)
		CO_2 equivalent (Gg)		(%)	CO_2 equivalent (Gg)		(%)	CO_2 equivalent (Gg)		(%)
Total Actual Emissions		**4,575.46**	**4,589.89**	**0.32**	**493.56**	**484.46**	**-1.84**	**485.94**	**485.63**	**-0.06**
2.C.3.	Aluminium Production				276.73	267.63	-3.29	135.51	135.20	-0.23
2.E.	Production of Halocarbons and SF6	22.80	22.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.F.	Consumption of Halocarbons and SF6	4,552.66	4,567.09	0.32	216.83	216.83	0.00	350.43	350.43	0.00
	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potential Emissions from Consumption of HFCs/PFCs and SF_6		**5,004.55**	**5,004.55**	0.00	**0.00**	**0.00**	0.00	**3,202.60**	**3,202.60**	0.00

	Previous submission	Latest submission	Difference(1)
	CO_2 equivalent (Gg)		(%)
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry (3)	459,192.69	466,069.88	1.50
Total CO_2 Equivalent Emissions without Land-Use Change and Forestry (3)	554,972.40	577,482.40	4.06

Table 9.4 Recalculated data of the year 2003

Chapter 10: REFERENCES

References for the main chapters and the annexes are listed here and are organised by chapter and annex.

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ANNEX 1: KEY CATEGORIES AND UNCERTAINTY

A1.1 Introduction

The IPCC Good Practice Guidance (IPCC, 2000) recommends as good practice the identification of *key source categories* in national GHG inventories. A *key source category* is defined as an emission source that has a significant influence on a country's GHG inventory in terms either of the absolute relative level of emissions or the trend in emissions, or both. The concept of key sources was originally derived for emissions excluding the LULUCF sector and expanded in the IPCC Good Practice Guidance for LULUCF (IPCC, 2003) to cover also LULUCF emissions by sources and removals by sinks. In this document whenever the term *key category* is used, it includes both sources and sinks.

The *key (source) categories* have been identified for the inventory excluding LULUCF, following the guidance in *GPG2000*. The *key category* analysis has then been repeated for the full inventory including the LULUCF categories.

Key categories therefore are those found in the accumulative 95% of the total annual emissions in the last reported year or belonging to the total trend, when ranked in descending order of magnitude.

The assessment of national key categories is important because key categories should receive special consideration in terms of methodological aspects and quality assurance and quality control verification.

Two different approaches are reported in the Good Practice according to whether or not a country has performed an uncertainty analysis of the inventory: the Tier 1 and Tier 2.

When using the Tier 1, key categories are identified by means of a pre-determined cumulative emissions threshold, usually fixed at 95% of the total. The threshold is based on an evaluation of several inventories and is aimed at establishing a general level where key categories should cover up to 90% of inventory uncertainty.

If an uncertainty analysis is carried out at category level for the inventory, the Tier 2 can be used to identify key categories. The Tier 2 approach is a more detailed analysis that builds on the Tier 1; in fact, the results of the Tier 1 are multiplied by the relative uncertainty of each source/sink category. Key categories are those that represent 95% of the uncertainty contribution, instead of applying the pre-determined cumulative emissions threshold.

So the factors which make a source or a sink a key category are a high contribution to the total, a high contribution to the trend and a high uncertainty.

If both the Tier 1 and Tier 2 are applied it is good practice to use the results of the Tier 2 analysis.

For the Italian inventory, a key category analysis has been carried out according to both the Tier 1 and Tier 2 methods. National emissions have been disaggregated, as far as possible, into the categories proposed in the Good Practice; other categories have been added to reflect specific national circumstances. Both level and trend analysis have been applied.

Summary of the results of the key category analysis is reported in Table 1.3 and Table 1.4 of chapter 1.

The same categorisation and the same estimates of uncertainty as performed in Table A1. have been used. The table indicates whether a key category arises from the level assessment or the trend assessment.

Regarding the Tier 1 approach, 18 sources were individuated accounting for 95% of the total emissions, without LULUCF; for the trend 17 key sources were selected. Jointly for both the Tier 1 level and trend, 29 key sources were totally individuated.

Repeating the *key category* analysis for the full inventory including the LULUCF categories, 20 categories were individuated accounting for 95% of the total emissions and removals, while, in trend assessment, 21 key categories were selected. Jointly for both the Tier 1 level and trend, 28 key categories were totally individuated.

A1.2 Tier 1 key category assessment

As described in the IPCC Good Practice Guidance (IPCC, 2000), the Tier 1 method for identifying key categories assesses the impacts of various categories on the level and the trend of the national emission inventory. Both level and trend assessment should be applied to an emission GHG inventory.

As concerns the level assessment, the contribution of each source or sink category to the total national inventory level is calculated as follows:

$$\text{Key Category Level Assessment} = \frac{|\text{Source or Sink Category Estimate}|}{\text{Total Contribution}}$$

Therefore, key categories are those which, when summed in descending order of magnitude, add up to over 95% of the total emission.

As far as the trend assessment is concerned, the contribution of each source and sink category's trend can be assessed by the following equation:

$$\text{Source or Sink Category Trend Assessment} = (\text{Source or Sink Category Level Assessment}) \cdot |\text{Source or Sink Category Trend - Total Trend}|$$

where the source or sink category trend is the change in the category emissions over time, computed by subtracting the base year estimate for a generic category from the current year estimate and dividing by the current year estimate; the total trend is the change in the total inventory emissions over time, computed by subtracting the base year estimate for the total inventory from the current year estimate and dividing by the current year estimate.

As differences in trend are more significant to the overall inventory level for larger source categories, the results of the trend difference is multiplied by the results of the level assessment to provide appropriate weighting.

Thus, key categories will be those where the category trend diverges significantly from the total trend, weighted by the emission level of the category.

Both level and trend assessments have been carried out for the Italian GHG inventory.

The results of the Tier 1 method are shown in Table A1.1, reporting level and trend assessment without LULUCF categories, and in Table A1.2 where results of the key categories analysis with the LULUCF categories are reported.

Regarding the trend assessment, as already mentioned, the equation reported above does not enable quantification in case the emission or removal estimates for the current year are equal to zero. In this case, since it is important to investigate into the trend and the transparency of the estimate, the results of the level assessment or other qualitative criteria can be taken into account. In the Italian inventory this occurs only for N_2O from other production in the chemical industry and SF_6 from the production of SF_6.

TIER 1						
CATEGORIES	2004 Gg CO_2eq	Level assessment	Cumulative Percentage	CATEGORIES	% Contribution to trend	Cumulative Percentage
CO2 stationary combustion gaseous fuels	150,721	0.26	0.26	CO2 stationary combustion liquid fuels	0.37	0.37
CO2 Mobile combustion: Road Vehicles	118,387	0.20	0.46	CO2 stationary combustion gaseous fuels	0.34	0.71
CO2 stationary combustion liquid fuels	113,917	0.20	0.66	CO2 Mobile combustion: Road Vehicles	0.08	0.79
CO2 stationary combustion solid fuels	65,725	0.11	0.77	HFC, PFC substitutes for ODS	0.03	0.82
CO2 Cement production	17,846	0.03	0.80	CH4 Enteric Fermentation in Domestic Livestock	0.02	0.84
CH4 from Solid waste Disposal Sites	16,020	0.03	0.83	CH4 Fugitive emissions from Oil and Gas Operations	0.02	0.85
CH4 Enteric Fermentation in Domestic Livestock	10,831	0.02	0.85	CO2 Iron and Steel production	0.01	0.87
Direct N2O Agricultural Soils	9,308	0.02	0.86	N2O Mobile combustion: Road Vehicles	0.01	0.88
Indirect N2O from Nitrogen used in agriculture	7,773	0.01	0.88	PFC Aluminium production	0.01	0.89
N2O stationary combustion	7,137	0.01	0.89	CO2 Fugitive emissions from Oil and Gas Operations	0.01	0.90
N2O Adipic Acid	6,638	0.01	0.90	N2O Adipic Acid	0.01	0.91
CO2 Mobile combustion: Waterborne Navigation	6,132	0.01	0.91	Direct N2O Agricultural Soils	0.01	0.92
HFC, PFC substitutes for ODS	5,671	0.01	0.92	CH4 from Solid waste Disposal Sites	0.01	0.93
CH4 Fugitive emissions from Oil and Gas Operations	5,623	0.01	0.93	Indirect N2O from Nitrogen used in agriculture	0.01	0.94
N2O Manure Management	4,125	0.01	0.94	CO2 Ammonia production	0.01	0.94
N2O Mobile combustion: Road Vehicles	3,877	0.01	0.94	N2O Manure Management	0.01	0.95
CH4 Manure Management	3,235	0.01	0.95	CO2 Mobile combustion: Aircraft	0.01	0.95
CO2 Lime production	2,686	0.00	0.95	CO2 stationary combustion solid fuels	0.01	0.96
CO2 Mobile combustion: Aircraft	2,668	0.00	0.96	CH4 Manure Management	0.00	0.96
CO2 Limestone and Dolomite Use	2,514	0.00	0.96	N2O Nitric Acid	0.00	0.97
CH4 Emissions from Wastewater Handling	2,312	0.00	0.97	CO2 Emissions from solvent use	0.00	0.97
CO2 Mobile combustion: Other	1,913	0.00	0.97	N2O stationary combustion	0.00	0.97
CO2 Fugitive emissions from Oil and Gas Operations	1,822	0.00	0.97	N2O from animal production	0.00	0.97
N2O Nitric Acid	1,805	0.00	0.98	CO2 Lime production	0.00	0.98
CO2 Other industrial processes	1,798	0.00	0.98	HFC-23 from HCFC-22 Manufacture and HFCs fugitive	0.00	0.98
N2O from animal production	1,545	0.00	0.98	CO2 Other industrial processes	0.00	0.98
CH4 from Rice production	1,527	0.00	0.98	CO2 Emissions from Waste Incineration	0.00	0.98
CO2 Emissions from solvent use	1,325	0.00	0.99	PFC, HFC, SF6 Semiconductor manufacturing	0.00	0.98
CO2 Iron and Steel production	1,179	0.00	0.99	CH4 stationary combustion	0.00	0.99
CH4 stationary combustion	1,135	0.00	0.99	CH4 from Rice production	0.00	0.99
N2O Emissions from Wastewater Handling	1,065	0.00	0.99	CH4 Mobile combustion: Road Vehicles	0.00	0.99
N2O Emissions from solvent use	799	0.00	0.99	CO2 Mobile combustion: Other	0.00	0.99
CO2 Ammonia production	748	0.00	1.00	SF6 Electrical Equipment	0.00	0.99
CH4 Mobile combustion: Road Vehicles	622	0.00	1.00	CO2 Cement production	0.00	0.99
SF6 Electrical Equipment	439	0.00	1.00	CH4 Emissions from Waste Incineration	0.00	0.99
CH4 Emissions from Waste Incineration	339	0.00	1.00	CO2 Limestone and Dolomite Use	0.00	0.99
PFC, HFC, SF6 Semiconductor manufacturing	329	0.00	1.00	SF6 Production of SF6	0.00	1.00
CO2 Emissions from Waste Incineration	211	0.00	1.00	N2O Emissions from Wastewater Handling	0.00	1.00
PFC Aluminium production	157	0.00	1.00	CH4 Emissions from Wastewater Handling	0.00	1.00
N2O Emissions from Waste Incineration	146	0.00	1.00	SF6 Magnesium production	0.00	1.00
N2O Mobile combustion: Other	112	0.00	1.00	N2O Emissions from solvent use	0.00	1.00
SF6 Magnesium production	94	0.00	1.00	CO2 Mobile combustion: Waterborne Navigation	0.00	1.00
CH4 Fugitive emissions from Coal Mining and Handling	64	0.00	1.00	CH4 Fugitive emissions from Coal Mining and Handling	0.00	1.00
CH4 Industrial Processes	61	0.00	1.00	CH4 Industrial Processes	0.00	1.00
N2O Mobile combustion: Waterborne Navigation	45	0.00	1.00	N2O Emissions from Waste Incineration	0.00	1.00
CH4 Mobile combustion: Waterborne Navigation	32	0.00	1.00	N2O Mobile combustion: Other	0.00	1.00
N2O Mobile combustion: Aircraft	19	0.00	1.00	N2O Other industrial processes	0.00	1.00
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	18	0.00	1.00	N2O Mobile combustion: Aircraft	0.00	1.00
CH4 Agricultural Residue Burning	14	0.00	1.00	CH4 Emissions from Other Waste	0.00	1.00
N2O Agricultural Residue Burning	4	0.00	1.00	CH4 Mobile combustion: Other	0.00	1.00
CH4 Emissions from Other Waste	4	0.00	1.00	N2O Mobile combustion: Waterborne Navigation	0.00	1.00
CH4 Mobile combustion: Other	4	0.00	1.00	CH4 Agricultural Residue Burning	0.00	1.00
CH4 Mobile combustion: Aircraft	2	0.00	1.00	CH4 Mobile combustion: Aircraft	0.00	1.00
N2O Other industrial processes	0	0.00	1.00	CH4 Mobile combustion: Waterborne Navigation	0.00	1.00
SF6 Production of SF6	0	0.00	1.00	N2O Agricultural Residue Burning	0.00	1.00
SF6 Other sources of SF6	0	0.00	1.00	SF6 Other sources of SF6	0.00	1.00

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Table A1.1 Results of the key categories analysis (Tier1) without LULUCF categories

TIER 1			
CATEGORIES	2004 Gg CO_2eq	Level assessment	Cumulative Percentage
CO2 stationary combustion gaseous fuels	150,721	0.21	0.21
CO2 Mobile combustion: Road Vehicles	118,387	0.17	0.38
CO2 stationary combustion liquid fuels	113,917	0.16	0.55
CO2 Forest land	77,866	0.11	0.66
CO2 stationary combustion solid fuels	65,725	0.09	0.75
CO2 Cropland	20,386	0.03	0.78
CO2 Cement production	17,846	0.03	0.80
CH4 from Solid waste Disposal Sites	16,020	0.02	0.83
CO2 Land converted to Forest Land	14,734	0.02	0.85
CH4 Enteric Fermentation in Domestic Livestock	10,831	0.02	0.86
Direct N2O Agricultural Soils	9,308	0.01	0.88
Indirect N2O from Nitrogen used in agriculture	7,773	0.01	0.89
N2O stationary combustion	7,137	0.01	0.90
N2O Adipic Acid	6,638	0.01	0.91
CO2 Mobile combustion: Waterborne Navigation	6,132	0.01	0.92
CO2 Land converted to Cropland	5,786	0.01	0.92
HFC, PFC substitutes for ODS	5,671	0.01	0.93
CH4 Fugitive emissions from Oil and Gas Operations	5,623	0.01	0.94
N2O Manure Management	4,125	0.01	0.95
N2O Mobile combustion: Road Vehicles	3,877	0.01	0.95
CH4 Manure Management	3,235	0.00	0.96
CO2 Lime production	2,686	0.00	0.96
CO2 Mobile combustion: Aircraft	2,668	0.00	0.96
CO2 Limestone and Dolomite Use	2,514	0.00	0.97
CH4 Emissions from Wastewater Handling	2,312	0.00	0.97
CO2 Mobile combustion: Other	1,913	0.00	0.97
CO2 Fugitive emissions from Oil and Gas Operations	1,822	0.00	0.98
N2O Nitric Acid	1,805	0.00	0.98
CO2 Other industrial processes	1,798	0.00	0.98
N2O from animal production	1,545	0.00	0.98
CH4 from Rice production	1,527	0.00	0.99
CO2 Emissions from solvent use	1,325	0.00	0.99
CO2 Land converted to Settlements	1,280	0.00	0.99
CO2 Iron and Steel production	1,179	0.00	0.99
CH4 stationary combustion	1,135	0.00	0.99
N2O Emissions from Wastewater Handling	1,065	0.00	0.99
N2O Emissions from solvent use	799	0.00	1.00
CO2 Ammonia production	748	0.00	1.00
CH4 Mobile combustion: Road Vehicles	622	0.00	1.00
SF6 Electrical Equipment	439	0.00	1.00
CH4 Emissions from Waste Incineration	339	0.00	1.00
PFC, HFC, SF6 Semiconductor manufacturing	329	0.00	1.00
CO2 Emissions from Waste Incineration	211	0.00	1.00
PFC Aluminium production	157	0.00	1.00
N2O Emissions from Waste Incineration	146	0.00	1.00
N2O Mobile combustion: Other	112	0.00	1.00
SF6 Magnesium production	94	0.00	1.00
CH4 Fugitive emissions from Coal Mining and Handling	64	0.00	1.00
CH4 Industrial Processes	61	0.00	1.00
N2O Mobile combustion: Waterborne Navigation	45	0.00	1.00
CH4 Forest land	35	0.00	1.00
CH4 Mobile combustion: Waterborne Navigation	32	0.00	1.00
N2O Mobile combustion: Aircraft	19	0.00	1.00
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	18	0.00	1.00
CH4 Agricultural Residue Burning	14	0.00	1.00
N2O Agricultural Residue Burning	4	0.00	1.00
CH4 Emissions from Other Waste	4	0.00	1.00
CH4 Mobile combustion: Other	4	0.00	1.00
N2O Forest land	4	0.00	1.00
N2O Land converted to Cropland	2	0.00	1.00
CH4 Mobile combustion: Aircraft	2	0.00	1.00
N2O Other industrial processes	0	0.00	1.00
SF6 Production of SF6	0	0.00	1.00
SF6 Other sources of SF6	0	0.00	1.00

CATEGORIES	% Contribution to trend	Cumulative Percentage
CO2 stationary combustion liquid fuels	0.33	0.33
CO2 stationary combustion gaseous fuels	0.25	0.58
CO2 Forest land	0.12	0.70
CO2 Mobile combustion: Road Vehicles	0.04	0.74
CO2 Cropland	0.03	0.77
HFC, PFC substitutes for ODS	0.03	0.80
CO2 Land converted to Cropland	0.03	0.82
CO2 stationary combustion solid fuels	0.02	0.84
CH4 Enteric Fermentation in Domestic Livestock	0.02	0.86
CH4 Fugitive emissions from Oil and Gas Operations	0.01	0.87
CO2 Iron and Steel production	0.01	0.88
N2O Mobile combustion: Road Vehicles	0.01	0.89
Direct N2O Agricultural Soils	0.01	0.90
PFC Aluminium production	0.01	0.91
CO2 Fugitive emissions from Oil and Gas Operations	0.01	0.92
Indirect N2O from Nitrogen used in agriculture	0.01	0.93
N2O Adipic Acid	0.01	0.93
CO2 Ammonia production	0.01	0.94
N2O Manure Management	0.01	0.94
CO2 Land converted to Forest Land	0.00	0.95
CO2 Cement production	0.00	0.95
CO2 Mobile combustion: Aircraft	0.00	0.96
CH4 Manure Management	0.00	0.96
N2O stationary combustion	0.00	0.97
CH4 from Solid waste Disposal Sites	0.00	0.97
N2O Nitric Acid	0.00	0.97
CO2 Emissions from solvent use	0.00	0.97
N2O from animal production	0.00	0.98
CO2 Other industrial processes	0.00	0.98
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	0.00	0.98
CO2 Emissions from Waste Incineration	0.00	0.98
PFC, HFC, SF6 Semiconductor manufacturing	0.00	0.98
CO2 Lime production	0.00	0.99
CH4 from Rice production	0.00	0.99
CO2 Mobile combustion: Other	0.00	0.99
CO2 Limestone and Dolomite Use	0.00	0.99
CH4 Mobile combustion: Road Vehicles	0.00	0.99
CH4 stationary combustion	0.00	0.99
CO2 Land converted to Settlements	0.00	0.99
SF6 Electrical Equipment	0.00	0.99
CO2 Mobile combustion: Waterborne Navigation	0.00	0.99
N2O Emissions from Wastewater Handling	0.00	1.00
CH4 Emissions from Waste Incineration	0.00	1.00
SF6 Production of SF6	0.00	1.00
CH4 Forest land	0.00	1.00
N2O Emissions from solvent use	0.00	1.00
SF6 Magnesium production	0.00	1.00
CH4 Fugitive emissions from Coal Mining and Handling	0.00	1.00
CH4 Industrial Processes	0.00	1.00
N2O Emissions from Waste Incineration	0.00	1.00
N2O Mobile combustion: Other	0.00	1.00
CH4 Emissions from Wastewater Handling	0.00	1.00
N2O Forest land	0.00	1.00
N2O Other industrial processes	0.00	1.00
N2O Mobile combustion: Aircraft	0.00	1.00
CH4 Emissions from Other Waste	0.00	1.00
N2O Land converted to Cropland	0.00	1.00
CH4 Mobile combustion: Waterborne Navigation	0.00	1.00
CH4 Mobile combustion: Other	0.00	1.00
CH4 Agricultural Residue Burning	0.00	1.00
N2O Mobile combustion: Waterborne Navigation	0.00	1.00
CH4 Mobile combustion: Aircraft	0.00	1.00
N2O Agricultural Residue Burning	0.00	1.00
SF6 Other sources of SF6	0.00	1.00

	L, T
	L1, T1
	L, T2
	L2,T2
	L2
	T2
	L
	T1
	L1
	L2, T

Table A1.2 Results of the key categories analysis (Tier1) with LULUCF categories

The application of the Tier 1, excluding LULUCF categories, gives as a result 18 key sources accounting for the 95% of the total levels uncertainty; when applying the trend analysis, excluding LULUCF categories, the key sources decreased to 17 with some differences with respect to the previous list (Table A1.1).

The Tier 1 *key category* level assessment, repeated for the full inventory including the LULUCF categories, results in 20 key categories (sources and sinks) while 21 key categories outcome from the trend analysis, with LULUCF categories, presenting some differences with respect to the list resulting from level assessment (Table A1.2).

A1.3 Uncertainty assessment (IPCC Tier 1)

The Tier 2 method for the identification of key categories implies the assessment of the uncertainty analysis to an emission inventory.

As already mentioned, the IPCC Tier 1 has been applied to the Italian GHG inventory to estimate uncertainties in national greenhouse gas inventories.

The results of the approach are reported in Table A1.3 excluding the LULUCF sector.

The uncertainty analysis has also been repeated including the LULUCF sector in the national totals. Details on the Tier 1 method used for LULUCF are described in the relevant chapter, chapter 7; in the following Table A1.4, the results by category, concerning only CO_2 emissions and removals, are reported whereas in Table A1.5, the results include CO_2, CH_4, N_2O emissions and removals. Finally, in Table A1.6 figures of inventory total uncertainty, including the LULUCF sector, are shown.

Tier 1 Uncertainty calculation and reporting

IPCC Sorce category	Gas	Base year emissions 1990	Year t emissions 2004	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
CO_2 stationary combustion liquid fuels	CO_2	155,117	113,917	3%	3%	0.042	0.008	-0.115	0.219	-0.003	0.009	0.010
CO_2 stationary combustion solid fuels	CO_2	59,395	65,725	3%	3%	0.042	0.005	-0.002	0.126	0.000	0.005	0.005
CO_2 stationary combustion gaseous fuels	CO_2	85,065	150,721	3%	3%	0.042	0.011	0.106	0.290	0.003	0.012	0.013
CH_4 stationary combustion	CH_4	770	1,135	3%	50%	0.501	0.001	0.001	0.002	0.000	0.000	0.000
N_2O stationary combustion	N_2O	6,744	7,137	3%	50%	0.501	0.006	-0.001	0.014	0.000	0.001	0.001
CO_2 Mobile combustion: Road Vehicles	CO2	93,616	118,387	3%	3%	0.042	0.009	0.026	0.228	0.001	0.010	0.010
CH_4 Mobile combustion: Road Vehicles	CH_4	743	622	3%	10%	0.104	0.000	0.000	0.001	0.000	0.000	0.000
N2O Mobile combustion: Road Vehicles	N_2O	1,605	3,877	3%	50%	0.501	0.003	0.004	0.007	0.002	0.000	0.002
CO2 Mobile combustion: Waterborne Navigation	CO_2	5,401	6,132	3%	3%	0.042	0.000	0.000	0.012	0.000	0.001	0.001
CH4 Mobile combustion: Waterborne Navigation	CH_4	29	32	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
N2O Mobile combustion: Waterborne Navigation	N_2O	39	45	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Mobile combustion: Aircraft	CO_2	1,597	2,668	3%	3%	0.042	0.000	0.002	0.005	0.000	0.000	0.000
CH4 Mobile combustion: Aircraft	CH_4	1	2	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
N2O Mobile combustion: Aircraft	N_2O	12	19	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Mobile combustion: Other	CO_2	1,888	1,913	3%	5%	0.058	0.000	0.000	0.004	0.000	0.000	0.000
CH4 Mobile combustion: Other	CH_4	5	4	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
N2O Mobile combustion: Other	N_2O	131	112	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
CH4 Fugitive emissions from Coal Mining and Handling	CH_4	122	64	3%	300%	3.000	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Fugitive emissions from Oil and Gas Operations	CO_2	3,048	1,822	3%	25%	0.252	0.001	-0.003	0.004	-0.001	0.000	0.001
CH4 Fugitive emissions from Oil and Gas Operations	CH_4	7,273	5,623	3%	25%	0.252	0.002	-0.005	0.011	-0.001	0.000	0.001
CO2 Cement production	CO_2	16,084	17,846	3%	10%	0.104	0.003	0.000	0.034	0.000	0.001	0.001
CO2 Lime production	CO_2	2,042	2,686	3%	10%	0.104	0.000	0.001	0.005	0.000	0.000	0.000
CO2 Limestone and Dolomite Use	CO_2	2,375	2,514	3%	10%	0.104	0.000	0.000	0.005	0.000	0.000	0.000
CO2 Iron and Steel production	CO_2	3,124	1,179	3%	10%	0.104	0.000	-0.004	0.002	0.000	0.000	0.000
CO2 Ammonia production	CO_2	1,710	748	3%	10%	0.104	0.000	-0.002	0.001	0.000	0.000	0.000
CO2 Other industrial processes	CO_2	1,933	1,798	3%	10%	0.104	0.000	-0.001	0.003	0.000	0.000	0.000
N2O Adipic Acid	N_2O	4,579	6,638	3%	10%	0.104	0.001	0.003	0.013	0.000	0.001	0.001
N2O Nitric Acid	N_2O	2,086	1,805	3%	10%	0.104	0.000	-0.001	0.003	0.000	0.000	0.000
N2O Other industrial processes	N_2O	11	0	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.000
CH4 Industrial Processes	CH_4	108	61	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
PFC Aluminium production	PFC	1,673	157	5%	10%	0.112	0.000	-0.003	0.000	0.000	0.000	0.000
SF6 Magnesium production	SF_6	0	94	5%	5%	0.071	0.000	0.000	0.000	0.000	0.000	0.000
SF6 Electrical Equipment	SF_6	213	439	5%	10%	0.112	0.000	0.000	0.001	0.000	0.000	0.000
SF6 Production of SF6	SF_6	120	0	5%	10%	0.112	0.000	0.000	0.000	0.000	0.000	0.000
PFC, HFC, SF6 Semiconductor manufacturing	'FC-HF(	0	329	30%	50%	0.583	0.000	0.001	0.001	0.000	0.000	0.000
HFC, PFC substitutes for ODS	HFC	134	5,671	30%	50%	0.583	0.006	0.011	0.011	0.005	0.005	0.007
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	HFC	351	18	5%	10%	0.112	0.000	-0.001	0.000	0.000	0.000	0.000
CH4 Enteric Fermentation in Domestic Livestock	CH_4	12,178	10,831	20%	20%	28%	0.005	-0.005	0.021	-0.001	0.006	0.006
CH4 Manure Management	CH_4	3,462	3,235	20%	100%	102%	0.006	-0.001	0.006	-0.001	0.002	0.002
N2O Manure Management	N_2O	4,518	4,125	20%	100%	102%	0.007	-0.002	0.008	-0.002	0.002	0.003
CH4 Agricultural Residue Burning	CH_4	13	14	50%	20%	54%	0.000	0.000	0.000	0.000	0.000	0.000
N2O Agricultural Residue Burning	N_2O	4	4	50%	20%	54%	0.000	0.000	0.000	0.000	0.000	0.000
Direct N2O Agricultural Soils	N_2O	9,609	9,308	20%	100%	102%	0.016	-0.003	0.018	-0.003	0.005	0.006
Indirect N2O from Nitrogen used in agriculture	N_2O	8,096	7,773	20%	100%	102%	0.014	-0.003	0.015	-0.003	0.004	0.005
CH4 from Rice production	CH_4	1,562	1,527	3%	20%	20%	0.001	0.000	0.003	0.000	0.000	0.000
N2O from animal production	N_2O	1,736	1,545	20%	100%	102%	0.003	-0.001	0.003	-0.001	0.001	0.001
CH4 from Solid waste Disposal Sites	CH_4	13,127	16,020	20%	30%	0.361	0.010	0.003	0.031	0.001	0.009	0.009
CH4 Emissions from Wastewater Handling	CH_4	1,969	2,312	100%	30%	1.044	0.004	0.000	0.004	0.000	0.006	0.006
N2O Emissions from Wastewater Handling	N_2O	1,045	1,065	30%	30%	0.424	0.001	0.000	0.002	0.000	0.001	0.001
CO2 Emissions from Waste Incineration	CO_2	496	211	5%	25%	0.255	0.000	-0.001	0.000	0.000	0.000	0.000
CH4 Emissions from Waste Incineration	CH_4	161	339	5%	20%	0.206	0.000	0.000	0.001	0.000	0.000	0.000
N2O Emissions from Waste Incineration	N_2O	87	146	5%	100%	1.001	0.000	0.000	0.000	0.000	0.000	0.000
CH4 Emissions from Other Waste	CH_4	0	4	10%	100%	1.005	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Emissions from solvent use	CO_2	1,598	1,325	30%	50%	0.583	0.001	-0.001	0.003	0.000	0.001	0.001
N2O Emissions from solvent use	N_2O	796	799	50%	10%	0.510	0.001	0.000	0.002	0.000	0.001	0.001
TOTAL		**519,600**	**582,520**				***0.033***					***0.026***

Table A1.3 Results of the uncertainty analysis (Tier1)

Tier 1 Uncertainty calculation and reporting: CO_2

IPCC Sorce category	Gas	Base year emissions 1990	Year t emissions 2004	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total LULUCF emissions in the year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in LULUCF emissions introduced by emission factor uncertainty	Uncertainty in trend in LULUCF emissions introduced by activity data uncertainty	Uncertainty introduced into trend in total LULUCF emissions
		Gg CO_2 eq	*Gg CO_2 eq*	%	%	%	%	%	%	%	%	%
A. Forest Land	CO_2	-58,946	-92,600	-	-	62%	54%	18%	116%	10%	49%	50%
B. Cropland	CO_2	-22,248	-14,600	*75%*	*75%*	106%	15%	-19%	18%	-14%	19%	24%
- *living biomass*	CO_2	*-22,562*	*-22,063*	*75%*	*75%*	*106%*	22%	-10%	28%	-7%	29%	30%
- *soils*	CO_2	*314*	*7,463*	*75%*	*75%*	*106%*	7%	-9%	9%	-7%	10%	12%
C. Grassland	CO_2	0	0	*75%*	*75%*	106%	0%	0%	0%	0%	0%	0%
- *living biomass*	CO_2	*0*	*0*	*75%*	*75%*	106%	0%	0%	0%	0%	0%	0%
- *soils*	CO_2	*0*	*0*	*75%*	*75%*	106%	0%	0%	0%	0%	0%	0%
D. Wetlands	CO_2	0	0			0%	0%	0%	0%	0%	0%	0%
E. Settlements	CO_2	1,280	1,280	*75%*	*75%*	106%	1%	1%	2%	0%	2%	2%
F. Other Land	CO_2	0	0			0%	0%	0%	0%	0%	0%	0%
G. Other	CO_2	0	0			0%	0%	0%	0%	0%	0%	0%
TOTAL		**-79,914**	**-105,920**				**56%**					**56%**

[a] the combined uncertainty has been calculated as explained in Chapter 7, 7.2.3 Uncertainty and time series consistency; in order to provide estimate of uncertainties in trend in national emissions introduced by emission factor and activity data, values for the uncertainty related to activity data and emission factor have been assigned by expert judgment, taking into account the final combined uncertainty

Table A1.4 Results of the uncertainty analysis for the LULUCF sector – CO_2 (Tier1)

Tier 1 Uncertainty calculation and reporting: CO_2+CH_4+N_2O

IPCC Sorce category	Gas	Base year emissions 1990	Year t emissions 2004	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total LULUCF emissions in the year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in LULUCF emissions introduced by emission factor uncertainty	Uncertainty in trend in LULUCF emissions introduced by activity data uncertainty	Uncertainty introduced into trend in total LULUCF emissions
		Gg CO_2 eq	*Gg CO_2 eq*	%	%	%	%	%	%	%	%	%
A. Forest Land	CO_2	-58,788	-92,562	-	-	62%	54%	19%	116%	10%	49%	50%
B. Cropland	CO_2	-22,214	-13,826	*75%*	*75%*	106%	14%	-19%	17%	-15%	18%	23%
- *living biomass*	CO_2	*-22,562*	*-22,063*	*75%*	*75%*	*106%*	22%	-10%	28%	-7%	29%	30%
- *soils*	CO_2	*349*	*8,237*	*75%*	*75%*	*106%*	8%	-10%	10%	-7%	11%	13%
C. Grassland	CO_2	0	0	*75%*	*75%*	106%	0%	0%	0%	0%	0%	0%
- *living biomass*	CO_2	*0*	*0*	*75%*	*75%*	106%	0%	0%	0%	0%	0%	0%
- *soils*	CO_2	*0*	*0*	*75%*	*75%*	106%	0%	0%	0%	0%	0%	0%
D. Wetlands	CO_2	0	0			0%	0%	0%	0%	0%	0%	0%
E. Settlements	CO_2	1,280	1,280	*75%*	*75%*	106%	1%	1%	2%	0%	2%	2%
F. Other Land	CO_2	0	0			0%	0%	0%	0%	0%	0%	0%
G. Other	CO_2	0	0			0%	0%	0%	0%	0%	0%	0%
TOTAL		**-79,722**	**-105,107**				**56%**					**55%**

Table A1.5 Results of the uncertainty analysis for the LULUCF sector – CO_2, CH_4, N_2O (Tier1)

Tier 1 Uncertainty calculation and reporting													
IPCC Sorce category	**Gas**	**Base year emissions 1990**	**Year t emissions 2004**	**Activity data uncertainty**	**Emission factor uncertainty**	**Combined uncertainty**	**Combined uncertainty as % of total national emissions in year t**	**Type A sensitivity**	**Type B sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor uncertainty**	**Uncertainty in trend in national emissions introduced by activity data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
CO2 stationary combustion liquid fuels	CO2	155,117	113,917	3%	3%	0.042	0.007	-0.111	0.189	-0.003	0.008	0.009
CO2 stationary combustion solid fuels	CO2	59,395	65,725	3%	3%	0.042	0.004	-0.006	0.109	0.000	0.005	0.005
CO2 stationary combustion gaseous fuels	CO2	85,065	150,721	3%	3%	0.042	0.009	0.085	0.250	0.003	0.011	0.011
CH4 stationary combustion	CH4	770	1,135	3%	50%	0.501	0.001	0.000	0.002	0.000	0.000	0.000
N2O stationary combustion	N2O	6,744	7,137	3%	50%	0.501	0.005	-0.001	0.012	-0.001	0.001	0.001
CO2 Mobile combustion: Road Vehicles	CO2	93,616	118,387	3%	3%	0.042	0.007	0.015	0.196	0.000	0.008	0.008
CH4 Mobile combustion: Road Vehicles	CH4	743	622	3%	10%	0.104	0.000	0.000	0.001	0.000	0.000	0.000
N2O Mobile combustion: Road Vehicles	N2O	1,605	3,877	3%	50%	0.501	0.003	0.003	0.006	0.002	0.000	0.002
CO2 Mobile combustion: Waterborne Navigation	CO2	5,401	6,132	3%	3%	0.042	0.000	0.000	0.010	0.000	0.000	0.000
CH4 Mobile combustion: Waterborne Navigation	CH4	29	32	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
N2O Mobile combustion: Waterborne Navigation	N2O	39	45	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Mobile combustion: Aircraft	CO2	1,597	2,668	3%	3%	0.042	0.000	0.001	0.004	0.000	0.000	0.000
CH4 Mobile combustion: Aircraft	CH4	1	2	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
N2O Mobile combustion: Aircraft	N2O	12	19	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Mobile combustion: Other	CO2	1,888	1,913	3%	5%	0.058	0.000	0.000	0.003	0.000	0.000	0.000
CH4 Mobile combustion: Other	CH4	5	4	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
N2O Mobile combustion: Other	N2O	131	112	3%	100%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
CH4 Fugitive emissions from Coal Mining and Handling	CH4	122	64	3%	300%	3.000	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Fugitive emissions from Oil and Gas Operations	CO2	3,048	1,822	3%	25%	0.252	0.001	-0.003	0.003	-0.001	0.000	0.001
CH4 Fugitive emissions from Oil and Gas Operations	CH4	7,273	5,623	3%	25%	0.252	0.002	-0.005	0.009	-0.001	0.000	0.001
CO2 Cement production	CO2	16,084	17,846	3%	10%	0.104	0.003	-0.001	0.030	0.000	0.001	0.001
CO2 Lime production	CO2	2,042	2,686	3%	10%	0.104	0.000	0.001	0.004	0.000	0.000	0.000
CO2 Limestone and Dolomite Use	CO2	2,375	2,514	3%	10%	0.104	0.000	0.000	0.004	0.000	0.000	0.000
CO2 Iron and Steel production	CO2	3,124	1,179	3%	10%	0.104	0.000	-0.004	0.002	0.000	0.000	0.000
CO2 Ammonia production	CO2	1,710	748	3%	10%	0.104	0.000	-0.002	0.001	0.000	0.000	0.000
CO2 Other industrial processes	CO2	1,933	1,798	3%	10%	0.104	0.000	-0.001	0.003	0.000	0.000	0.000
N2O Adipic Acid	N2O	4,579	6,638	3%	10%	0.104	0.001	0.002	0.011	0.000	0.000	0.001
N2O Nitric Acid	N2O	2,086	1,805	3%	10%	0.104	0.000	-0.001	0.003	0.000	0.000	0.000
N2O Other industrial processes	N2O	11	0	3%	10%	0.104	0.000	0.000	0.000	0.000	0.000	0.000
CH4 Industrial Processes	CH4	108	61	3%	50%	0.501	0.000	0.000	0.000	0.000	0.000	0.000
PFC Aluminium production	PFC	1,673	157	5%	10%	0.112	0.000	-0.003	0.000	0.000	0.000	0.000
SF6 Magnesium production	SF6	0	94	5%	5%	0.071	0.000	0.000	0.000	0.000	0.000	0.000
SF6 Electrical Equipment	SF6	213	439	5%	10%	0.112	0.000	0.000	0.001	0.000	0.000	0.000
SF6 Other sources of SF6	SF6	0	0			0.000	0.000	0.000	0.000	0.000	0.000	0.000
SF6 Production of SF6	SF6	120	0	5%	10%	0.112	0.000	0.000	0.000	0.000	0.000	0.000
PFC, HFC, SF6 Semiconductor manufacturing	PFC-H	0	329	30%	50%	0.583	0.000	0.001	0.001	0.000	0.000	0.000
HFC, PFC substitutes for ODS	HFC	134	5,671	30%	50%	0.583	0.005	0.009	0.009	0.005	0.004	0.006
HFC-23 from HCFC-22 Manufacture and HFCs fugitive	HFC	351	18	5%	10%	0.112	0.000	-0.001	0.000	0.000	0.000	0.000
CH4 Enteric Fermentation in Domestic Livestock	CH4	12,178	10,831	20%	20%	28%	0.004	-0.006	0.018	-0.001	0.005	0.005
CH4 Manure Management	CH4	3,462	3,235	20%	100%	102%	0.005	-0.001	0.005	-0.001	0.002	0.002
N2O Manure Management	N2O	4,518	4,125	20%	100%	102%	0.006	-0.002	0.007	-0.002	0.002	0.003
CH4 Savanna Burning	CH4	0	0			0%	0.000	0.000	0.000	0.000	0.000	0.000
N2O Savanna Burning	N2O	0	0			0%	0.000	0.000	0.000	0.000	0.000	0.000
CH4 Agricultural Residue Burning	CH4	13	14	50%	20%	54%	0.000	0.000	0.000	0.000	0.000	0.000
N2O Agricultural Residue Burning	N2O	4	4	50%	20%	54%	0.000	0.000	0.000	0.000	0.000	0.000
Direct N2O Agricultural Soils	N2O	9,609	9,308	20%	100%	102%	0.014	-0.003	0.015	-0.003	0.004	0.005
Indirect N2O from Nitrogen used in agriculture	N2O	8,096	7,773	20%	100%	102%	0.011	-0.003	0.013	-0.003	0.004	0.005
CH4 from Rice production	CH4	1,562	1,527	3%	20%	20%	0.000	0.000	0.003	0.000	0.000	0.000
CH4 from Other agriculture	CH4	0	0			0%	0.000	0.000	0.000	0.000	0.000	0.000
N2O from animal production	N2O	1,736	1,545	20%	100%	102%	0.002	-0.001	0.003	-0.001	0.001	0.001
N2O from Other agricultural soils (wetlands, waters)	N2O	0	0			0.000	0.000	0.000	0.000	0.000	0.000	0.000
CH4 from Solid waste Disposal Sites	CH4	13,127	16,020	20%	30%	0.361	0.008	0.001	0.027	0.000	0.008	0.008
CH4 Emissions from Wastewater Handling	CH4	1,969	2,312	100%	30%	1.044	0.003	0.000	0.004	0.000	0.005	0.005
N2O Emissions from Wastewater Handling	N2O	1,045	1,065	30%	30%	0.424	0.001	0.000	0.002	0.000	0.001	0.001
CO2 Emissions from Waste Incineration	CO2	496	211	5%	25%	0.255	0.000	-0.001	0.000	0.000	0.000	0.000
CH4 Emissions from Waste Incineration	CH4	161	339	5%	20%	0.206	0.000	0.000	0.001	0.000	0.000	0.000
N2O Emissions from Waste Incineration	N2O	87	146	5%	100%	1.001	0.000	0.000	0.000	0.000	0.000	0.000
CH4 Emissions from Other Waste	CH4	0	4	10%	100%	1.005	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Emissions from solvent use	CO2	1,598	1,325	30%	50%	0.583	0.001	-0.001	0.002	0.000	0.001	0.001
N2O Emissions from solvent use	N2O	796	799	50%	10%	0.510	0.001	0.000	0.001	0.000	0.001	0.001
CO2 Forest land	N2O	45,510	77,866	30%	54%	0.618	0.068	0.041	0.129	0.022	0.055	0.059
CH4 Forest land	CH4	143	35	30%	54%	0.618	0.000	0.000	0.000	0.000	0.000	0.000
N2O Forest land	N2O	15	4	30%	54%	0.618	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Cropland	CO2	22,492	20,386	75%	75%	1.061	0.031	-0.010	0.034	-0.007	0.036	0.037
CO2 Land converted to Forest Land	CO2	13,436	14,734	75%	75%	1.061	0.022	-0.002	0.024	-0.001	0.026	0.026
CO2 Land converted to Cropland	CO4	243	5,786	75%	75%	1.061	0.009	0.009	0.010	0.007	0.010	0.012
N2O Land converted to Cropland	N2O	0	2	75%	75%	1.061	0.000	0.000	0.000	0.000	0.000	0.000
CO2 Land converted to Settlements	CO2	1,280	1,280	75%	75%	1.061	0.002	0.000	0.002	0.000	0.002	0.002
TOTAL		**602,719**	**702,613**				***0.083***					***0.079***

Table A1.6 Results of the uncertainty analysis (Tier1)

Emission sources of the Italian inventory are disaggregated into a detailed level, 60 sources, according to the IPCC list in the Good Practice Guidance, which has been slightly revised taking into account national circumstances and importance. Considering the LULUCF, sources and sinks of the Italian inventory are disaggregated into 67 categories. Uncertainties are therefore estimated for these categories. To estimate uncertainty for both activity data and emission factors, information provided in the IPCC Good Practice Guidance as well as expert judgement has been used; standard deviations have also been considered whenever measurements were available.

The general approach followed for quantifying a level of uncertainty to activity data and emission factors is to set values within a range low, medium and high according to the confidence the expert relies on the value. For instance, a low value (e.g. 3-5%) has been attributed to activity data derived from the energy balance and statistical yearbooks, medium-high values within a range of 20-50% for all the data which are not directly or only partially derived from census or sample surveys or data which are simple estimations. For emission factors, the uncertainties set are usually higher than those for activity data; figures suggested by the IPCC good practice guidance (IPCC, 2000) are used when the emission factor is a default value, low values are attributed to measured data whereas the uncertainty values are high in all other cases. Details of the figures can be found in Table A1.3.

The Tier 1 approach suggests an uncertainty of 3.3% in the combined GWP total emissions in 2004. The analysis also estimates an uncertainty of 2.6 % in the trend between 1990 and 2004.

Specifically, for the LULUCF sector, the uncertainty value resulting from Tier 1 approach is 56% in the combined GWP total emissions for the year 2004, whereas the uncertainty in the trend is 55%. Similar values result from Tier 1 approach in uncertainty related to CO_2 total emissions for the year 2004, and uncertainty in the trend. Details of the figures are shown in Tables A1.3. and A1.4.
Including the LULUCF sector in the total uncertainty assessment, the Tier 1 approach shows an uncertainty of 8.3% in the combined GWP total emissions for the year 2004, whereas the uncertainty in the trend between 1990 and 2004 is equal to 7.9%.

Further investigation is needed to better quantify the uncertainty values for some specific source, nevertheless it should be noted that a conservative approach has been followed.

A1.4 Tier 2 key source assessment
The Tier 2 method can be used to identify key categories when an uncertainty analysis has been carried out on the inventory. It is helpful in prioritising activities to improve inventory quality and reduce overall uncertainty.
Under the Tier 2, the source or sink category uncertainties are incorporated by weighting the Tier 1 level and trend assessment results with the source category's relative uncertainty.
Therefore the following equations:

Level Assessment, with Uncertainty = Tier 1 Level Assessment · Relative Category Uncertainty

Trend Assessment, with Uncertainty = Tier 1 Trend Assessment · Relative Category Uncertainty

The results of the Tier 2 key category analysis, without LULUCF categories, are provided in Table A1.7, while in Table A1.8 results of the analysis, including LULUCF categories, are reported.
The application of the Tier 2 gives as a result 21 key categories accounting for the 95% of the total levels uncertainty; when applying the trend analysis the key categories increased to 22 with differences with respect to the previous list.
The application of the Tier 2 to full inventory including the LULUCF categories results in 21 key categories accounting for the 95% of the total levels uncertainty; for the trend analysis including LULUCF categories, the key categories decreased to 20 with differences with respect to the previous list.

TIER 2

CATEGORIES	Level assessment with uncertainty	Relative level assessment with uncertainty	Cumulative Percentage	CATEGORIES	Trend assessment with uncertainty	Relative Trend assessment with uncertainty	Cumulative Percentage
Direct N2O Agricultural Soils	0.0163	0.13	0.13	CO2 stationary combustion gaseous fuels	0.01	0.13	0.13
Indirect N2O from Nitrogen used in agriculture	0.0136	0.11	0.23	CO2 stationary combustion liquid fuels	0.01	0.10	0.23
CO2 stationary combustion gaseous fuels	0.0110	0.09	0.32	CO2 Mobile combustion: Road Vehicles	0.01	0.10	0.33
CH4 from Solid waste Disposal Sites	0.0099	0.08	0.39	CH4 from Solid waste Disposal Sites	0.01	0.09	0.42
CO2 Mobile combustion: Road Vehicles	0.0086	0.07	0.46	HFC, PFC substitutes for ODS	0.01	0.07	0.49
CO2 stationary combustion liquid fuels	0.0083	0.06	0.52	CH4 Emissions from Wastewater Handling	0.01	0.06	0.56
N2O Manure Management	0.0072	0.06	0.58	CH4 Enteric Fermentation in Domestic Livestock	0.01	0.06	0.62
N2O stationary combustion	0.0061	0.05	0.63	Direct N2O Agricultural Soils	0.01	0.06	0.68
HFC, PFC substitutes for ODS	0.0057	0.04	0.67	CO2 stationary combustion solid fuels	0.01	0.06	0.73
CH4 Manure Management	0.0057	0.04	0.72	Indirect N2O from Nitrogen used in agriculture	0.00	0.05	0.79
CH4 Enteric Fermentation in Domestic Livestock	0.0053	0.04	0.76	N2O Manure Management	0.00	0.03	0.81
CO2 stationary combustion solid fuels	0.0048	0.04	0.79	CH4 Manure Management	0.00	0.02	0.84
CH4 Emissions from Wastewater Handling	0.0041	0.03	0.83	N2O Mobile combustion: Road Vehicles	0.00	0.02	0.86
N2O Mobile combustion: Road Vehicles	0.0033	0.03	0.85	CO2 Cement production	0.00	0.01	0.87
CO2 Cement production	0.0032	0.02	0.88	CH4 Fugitive emissions from Oil and Gas Operations	0.00	0.01	0.89
N2O from animal production	0.0027	0.02	0.90	CO2 Emissions from solvent use	0.00	0.01	0.90
CH4 Fugitive emissions from Oil and Gas Operations	0.0024	0.02	0.92	N2O from animal production	0.00	0.01	0.91
CO2 Emissions from solvent use	0.0013	0.01	0.93	N2O Emissions from solvent use	0.00	0.01	0.92
N2O Adipic Acid	0.0012	0.01	0.94	N2O Emissions from Wastewater Handling	0.00	0.01	0.93
CH4 stationary combustion	0.0010	0.01	0.94	CO2 Fugitive emissions from Oil and Gas Operations	0.00	0.01	0.94
CO2 Fugitive emissions from Oil and Gas Operations	0.0008	0.01	0.95	N2O stationary combustion	0.00	0.01	0.95
N2O Emissions from Wastewater Handling	0.0008	0.01	0.96	N2O Adipic Acid	0.00	0.01	0.95
N2O Emissions from solvent use	0.0007	0.01	0.96	CO2 Mobile combustion: Waterborne Navigation	0.00	0.01	0.96
CH4 from Rice production	0.0005	0.00	0.96	CO2 Iron and Steel production	0.00	0.00	0.96
CO2 Lime production	0.0005	0.00	0.97	CH4 Fugitive emissions from Coal Mining and Handlir	0.00	0.00	0.97
CO2 Limestone and Dolomite Use	0.0005	0.00	0.97	PFC, HFC, SF6 Semiconductor manufacturing	0.00	0.00	0.97
CO2 Mobile combustion: Waterborne Navigation	0.0004	0.00	0.98	PFC Aluminium production	0.00	0.00	0.97
CH4 Fugitive emissions from Coal Mining and Handlin	0.0003	0.00	0.98	CH4 stationary combustion	0.00	0.00	0.98
PFC, HFC, SF6 Semiconductor manufacturing	0.0003	0.00	0.98	CO2 Ammonia production	0.00	0.00	0.98
N2O Nitric Acid	0.0003	0.00	0.98	CO2 Lime production	0.00	0.00	0.98
CO2 Other industrial processes	0.0003	0.00	0.99	CO2 Mobile combustion: Aircraft	0.00	0.00	0.98
N2O Emissions from Waste Incineration	0.0003	0.00	0.99	CO2 Limestone and Dolomite Use	0.00	0.00	0.99
CO2 Iron and Steel production	0.0002	0.00	0.99	N2O Nitric Acid	0.00	0.00	0.99
CO2 Mobile combustion: Aircraft	0.0002	0.00	0.99	CO2 Emissions from Waste Incineration	0.00	0.00	0.99
N2O Mobile combustion: Other	0.0002	0.00	0.99	CO2 Other industrial processes	0.00	0.00	0.99
CO2 Mobile combustion: Other	0.0002	0.00	0.99	CO2 Mobile combustion: Other	0.00	0.00	0.99
CO2 Ammonia production	0.0001	0.00	0.99	CH4 from Rice production	0.00	0.00	0.99
CH4 Emissions from Waste Incineration	0.0001	0.00	1.00	N2O Emissions from Waste Incineration	0.00	0.00	0.99
CH4 Mobile combustion: Road Vehicles	0.0001	0.00	1.00	CH4 Emissions from Waste Incineration	0.00	0.00	1.00
CO2 Emissions from Waste Incineration	0.0001	0.00	1.00	HFC-23 from HCFC-22 Manufacture and HFCs fugitiv	0.00	0.00	1.00
SF6 Electrical Equipment	0.0001	0.00	1.00	SF6 Electrical Equipment	0.00	0.00	1.00
N2O Mobile combustion: Waterborne Navigation	0.0001	0.00	1.00	N2O Mobile combustion: Other	0.00	0.00	1.00
CH4 Industrial Processes	0.0001	0.00	1.00	CH4 Mobile combustion: Road Vehicles	0.00	0.00	1.00
N2O Mobile combustion: Aircraft	0.0000	0.00	1.00	CH4 Industrial Processes	0.00	0.00	1.00
PFC Aluminium production	0.0000	0.00	1.00	SF6 Production of SF6	0.00	0.00	1.00
CH4 Mobile combustion: Waterborne Navigation	0.0000	0.00	1.00	CH4 Agricultural Residue Burning	0.00	0.00	1.00
CH4 Agricultural Residue Burning	0.0000	0.00	1.00	SF6 Magnesium production	0.00	0.00	1.00
SF6 Magnesium production	0.0000	0.00	1.00	N2O Mobile combustion: Aircraft	0.00	0.00	1.00
CH4 Emissions from Other Waste	0.0000	0.00	1.00	CH4 Emissions from Other Waste	0.00	0.00	1.00
N2O Agricultural Residue Burning	0.0000	0.00	1.00	N2O Agricultural Residue Burning	0.00	0.00	1.00
HFC-23 from HCFC-22 Manufacture and HFCs fugitiv	0.0000	0.00	1.00	N2O Mobile combustion: Waterborne Navigation	0.00	0.00	1.00
CH4 Mobile combustion: Other	0.0000	0.00	1.00	CH4 Mobile combustion: Waterborne Navigation	0.00	0.00	1.00
CH4 Mobile combustion: Aircraft	0.0000	0.00	1.00	N2O Other industrial processes	0.00	0.00	1.00
SF6 Production of SF6	0.0000	0.00	1.00	CH4 Mobile combustion: Other	0.00	0.00	1.00
N2O Other industrial processes	0.0000	0.00	1.00	CH4 Mobile combustion: Aircraft	0.00	0.00	1.00

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Table A1.7 Results of the key categories analysis (Tier2) without LULUCF categories

TIER 2

CATEGORIES	Level assessment with uncertainty	Relative level assessment with uncertainty	Cumulative Percentage	CATEGORIES	Trend assessment with uncertainty	Relative Trend assessment with uncertainty	Cumulative Percentage
CO2 Forest land	0.0685	0.29	0.29	CO2 Forest land	0.06	0.27	0.27
CO2 Cropland	0.0308	0.13	0.41	CO2 Cropland	0.04	0.16	0.43
CO2 Land converted to Forest Land	0.0222	0.09	0.51	CO2 Land converted to Forest Land	0.03	0.12	0.55
Direct N2O Agricultural Soils	0.0135	0.06	0.56	CO2 Land converted to Cropland	0.01	0.06	0.60
Indirect N2O from Nitrogen used in agriculture	0.0113	0.05	0.61	CO2 stationary combustion gaseous fuels	0.01	0.05	0.65
CO2 stationary combustion gaseous fuels	0.0091	0.04	0.65	CO2 stationary combustion liquid fuels	0.01	0.04	0.69
CO2 Land converted to Cropland	0.0087	0.04	0.69	CO2 Mobile combustion: Road Vehicles	0.01	0.04	0.73
CH4 from Solid waste Disposal Sites	0.0082	0.03	0.72	CH4 from Solid waste Disposal Sites	0.01	0.03	0.76
CO2 Mobile combustion: Road Vehicles	0.0071	0.03	0.75	HFC, PFC substitutes for ODS	0.01	0.03	0.79
CO2 stationary combustion liquid fuels	0.0069	0.03	0.78	CH4 Emissions from Wastewater Handling	0.01	0.02	0.81
N2O Manure Management	0.0060	0.03	0.80	Direct N2O Agricultural Soils	0.01	0.02	0.84
N2O stationary combustion	0.0051	0.02	0.83	CH4 Enteric Fermentation in Domestic Livestock	0.01	0.02	0.86
HFC, PFC substitutes for ODS	0.0047	0.02	0.85	CO2 stationary combustion solid fuels	0.00	0.02	0.88
CH4 Manure Management	0.0047	0.02	0.86	Indirect N2O from Nitrogen used in agriculture	0.00	0.02	0.90
CH4 Enteric Fermentation in Domestic Livestock	0.0044	0.02	0.88	N2O Manure Management	0.00	0.01	0.92
CO2 stationary combustion solid fuels	0.0040	0.02	0.90	CO2 Land converted to Settlements	0.00	0.01	0.93
CH4 Emissions from Wastewater Handling	0.0034	0.01	0.91	CH4 Manure Management	0.00	0.01	0.94
N2O Mobile combustion: Road Vehicles	0.0028	0.01	0.93	N2O Mobile combustion: Road Vehicles	0.00	0.01	0.94
CO2 Cement production	0.0027	0.01	0.94	CO2 Cement production	0.00	0.01	0.95
N2O from animal production	0.0022	0.01	0.95	CH4 Fugitive emissions from Oil and Gas Operations	0.00	0.01	0.95
CH4 Fugitive emissions from Oil and Gas Operations	0.0020	0.01	0.95	N2O from animal production	0.00	0.00	0.96
CO2 Land converted to Settlements	0.0019	0.01	0.96	CO2 Emissions from solvent use	0.00	0.00	0.96
CO2 Emissions from solvent use	0.0011	0.00	0.97	N2O Emissions from solvent use	0.00	0.00	0.97
N2O Adipic Acid	0.0010	0.00	0.97	N2O stationary combustion	0.00	0.00	0.97
CH4 stationary combustion	0.0008	0.00	0.97	N2O Emissions from Wastewater Handling	0.00	0.00	0.98
CO2 Fugitive emissions from Oil and Gas Operations	0.0007	0.00	0.98	CO2 Fugitive emissions from Oil and Gas Operations	0.00	0.00	0.98
N2O Emissions from Wastewater Handling	0.0006	0.00	0.98	N2O Adipic Acid	0.00	0.00	0.98
N2O Emissions from solvent use	0.0006	0.00	0.98	CO2 Mobile combustion: Waterborne Navigation	0.00	0.00	0.98
CH4 from Rice production	0.0004	0.00	0.98	CO2 Iron and Steel production	0.00	0.00	0.98
CO2 Lime production	0.0004	0.00	0.99	CH4 Fugitive emissions from Coal Mining and Handlir	0.00	0.00	0.99
CO2 Limestone and Dolomite Use	0.0004	0.00	0.99	PFC, HFC, SF6 Semiconductor manufacturing	0.00	0.00	0.99
CO2 Mobile combustion: Waterborne Navigation	0.0004	0.00	0.99	PFC Aluminium production	0.00	0.00	0.99
CH4 Fugitive emissions from Coal Mining and Handlin	0.0003	0.00	0.99	CO2 Ammonia production	0.00	0.00	0.99
PFC, HFC, SF6 Semiconductor manufacturing	0.0003	0.00	0.99	CH4 stationary combustion	0.00	0.00	0.99
N2O Nitric Acid	0.0003	0.00	0.99	CO2 Lime production	0.00	0.00	0.99
CO2 Other industrial processes	0.0003	0.00	0.99	CO2 Mobile combustion: Aircraft	0.00	0.00	0.99
N2O Emissions from Waste Incineration	0.0002	0.00	0.99	CO2 Limestone and Dolomite Use	0.00	0.00	0.99
CO2 Iron and Steel production	0.0002	0.00	1.00	N2O Nitric Acid	0.00	0.00	0.99
CO2 Mobile combustion: Aircraft	0.0002	0.00	1.00	CO2 Emissions from Waste Incineration	0.00	0.00	1.00
N2O Mobile combustion: Other	0.0002	0.00	1.00	CO2 Other industrial processes	0.00	0.00	1.00
CO2 Mobile combustion: Other	0.0002	0.00	1.00	CH4 from Rice production	0.00	0.00	1.00
CO2 Ammonia production	0.0001	0.00	1.00	CO2 Mobile combustion: Other	0.00	0.00	1.00
CH4 Emissions from Waste Incineration	0.0001	0.00	1.00	CH4 Forest land	0.00	0.00	1.00
CH4 Mobile combustion: Road Vehicles	0.0001	0.00	1.00	N2O Emissions from Waste Incineration	0.00	0.00	1.00
CO2 Emissions from Waste Incineration	0.0001	0.00	1.00	N2O Mobile combustion: Other	0.00	0.00	1.00
SF6 Electrical Equipment	0.0001	0.00	1.00	HFC-23 from HCFC-22 Manufacture and HFCs fugitiv	0.00	0.00	1.00
N2O Mobile combustion: Waterborne Navigation	0.0001	0.00	1.00	CH4 Emissions from Waste Incineration	0.00	0.00	1.00
CH4 Industrial Processes	0.0000	0.00	1.00	SF6 Electrical Equipment	0.00	0.00	1.00
CH4 Forest land	0.0000	0.00	1.00	CH4 Mobile combustion: Road Vehicles	0.00	0.00	1.00
N2O Mobile combustion: Aircraft	0.0000	0.00	1.00	CH4 Industrial Processes	0.00	0.00	1.00
PFC Aluminium production	0.0000	0.00	1.00	SF6 Production of SF6	0.00	0.00	1.00
CH4 Mobile combustion: Waterborne Navigation	0.0000	0.00	1.00	CH4 Agricultural Residue Burning	0.00	0.00	1.00
CH4 Agricultural Residue Burning	0.0000	0.00	1.00	SF6 Magnesium production	0.00	0.00	1.00
SF6 Magnesium production	0.0000	0.00	1.00	N2O Forest land	0.00	0.00	1.00
CH4 Emissions from Other Waste	0.0000	0.00	1.00	N2O Mobile combustion: Aircraft	0.00	0.00	1.00
N2O Land converted to Cropland	0.0000	0.00	1.00	CH4 Emissions from Other Waste	0.00	0.00	1.00
N2O Agricultural Residue Burning	0.0000	0.00	1.00	N2O Land converted to Cropland	0.00	0.00	1.00
N2O Forest land	0.0000	0.00	1.00	N2O Agricultural Residue Burning	0.00	0.00	1.00
HFC-23 from HCFC-22 Manufacture and HFCs fugitiv	0.0000	0.00	1.00	N2O Mobile combustion: Waterborne Navigation	0.00	0.00	1.00
CH4 Mobile combustion: Other	0.0000	0.00	1.00	CH4 Mobile combustion: Waterborne Navigation	0.00	0.00	1.00
CH4 Mobile combustion: Aircraft	0.0000	0.00	1.00	N2O Other industrial processes	0.00	0.00	1.00
SF6 Production of SF6	0.0000	0.00	1.00	CH4 Mobile combustion: Other	0.00	0.00	1.00
N2O Other industrial processes	0.0000	0.00	1.00	CH4 Mobile combustion: Aircraft	0.00	0.00	1.00
SF6 Other sources of SF6	0.0000	0.00	1.00	SF6 Other sources of SF6	0.00	0.00	1.00

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Table A1.8 Results of the key categories analysis (Tier2) with LULUCF categories

ANNEX 2: DETAILED TABLES OF ENERGY CONSUMPTION FOR POWER GENERATION

The detailed breakdown of total fuels consumed for electricity generation in the years 2003 and 2004 is reported in the attached tables A2.1 and A2.2. Data for year 2003 have been updated according to new additional information submitted by GRTN, in particular the consumption of municipal solid waste (MSW) has been separated from the biomass consumption, since the use of this fuel for electricity generation is expanding. A specific EF is used to estimate CO2 emissions from this source, see table 3.7. Energy data of previous years (1990, 1995, 1999-2002) have not been changed, please refer to NIR 2005 for them. Emissions of MSW in the electricity sector have been estimated back to the year 2000 and the corresponding total emissions of table 3.4 have been updated. For previous years this source is marginal for the power sector and its emissions are included in Table 1.A(a)s4, commercial sector.

In each table each year data from three different sources are reported:

- output of the model used to estimate consumption and emissions for each plant type;
- detailed report by GRTN;
- data available in BEN.

For each source three types of data are presented: electricity produced physical quantities of consumed fuels and amount of energy used.

As one can notice from the following tables, there are not negligible differences in total consumption figures between GRTN and BEN. Both data sets are supposed to be based on the same data. As already said in paragraph 3.4, differences can be explained by the process of adapting GRTN data to BEN methodology: BEN considers for each fuel always the same heat value, adjusting the physical quantities accordingly. This calculation process combined with the reduction of fuel types from 17 to 12 add rounding errors and this may be responsible for the small difference between the energy consumption value, 0.6% (refer to last row of each table, last value).

Differences between those two data sets and the model output are also present, they can be improved (i.e. reduced) and depend on the modeller choice: a compromise between GRTN and the BEN data according to cross check done with other sources (UP or point source data). In the case of power generation the consumption expressed in energy units is the reference value that is optimised, since EF refer to the energy content of each fuel.

There are also discrepancies in the estimates of the total electricity produced, refer to last row of each table, first value. They are rather small and can be due to different evaluation of the kind of fuel used. The data for year 2004 are much closer than previous year one’s. The total electricity produced (not shown in the table, see also Annex 5) is the same for both estimates.

In conclusion the main question of the accuracy of the underlining energy data of three key sources is connected to the discrepancies between BEN and GRTN in the estimates of electricity produced and of the energy content of the used fuels. The difference is small but it should not occur because both data sets are derived from the same source. On the basis of this consideration, we decided to base the inventory on GRTN data that are expected to be more reliable. In particular because the EF used are based on the energy content of the fuel we have made an effort to reproduce with the model the GRTN energy consumption figure and ignored discrepancies in the electricity production or in the physical quantities of fuel used.

Table A2.1 - Energy consumption for electricity production, year 2003

Fuels		Model output			GRTN			BEN		
		Gwe, gross	kt	TJ	Gwe, gross	kt	T.o.e./TJ	Gwe, gross	kt / Mmc	kcal / TJ
Coal		38802	14010	3.721E+08	38813	14252	3.713E+08	35449	12855	3.415E+08
Coke oven gas		1544	741	1.317E+07	1544.5	701	1.314E+07	1384	646	2746
Blast furnace gas		3382	9374	3.138E+07	3381.3	9351	3.142E+07	3341	8152	7337
Oxi converter gas		377	414	3.434E+06	377.7	426	3.431E+06	276		2.213E+06
sum		5303	10529	4.798E+07	5303.5	10478	4.799E+07	5000	8690	4.440E+07
Coal, sum							4.193E+08			3.859E+08
Light distillates		168	21	9.386E+05	167.9	21	9.205E+05	170	21	218
Diesel		2047	429	1.810E+07	2046.7	419	1.799E+07	1601	316	3223
Fuel oil	atz	54703	12233	4.980E+08	54688.4	12050	4.990E+08	32659	6839	67022
	btz							48169	10489	102792
Refinery gas		2173	360	1.584E+07	2172	341	1.594E+07	2386	350	4200
Petroleum coke		1019	249	8.631E+06	1019.6	249	8.661E+06	1081	270	2241
Oriemulsion		5677	1914	5.257E+07	5676.5	1912	5.263E+07			
sum		65787	15207	5.941E+08	65771	14992	5.952E+08	86066	7.518E+08	7.846E+06
Gas from chemical proc.		699	1286	5.749E+06	699.2	1303	5.774E+06	579		7.518E+08
Heavy residuals/ tar		9297	6415	5.770E+07	9295.8	6414	5.770E+07			
Others		184	275	1.877E+06	164.3	112	1.799E+06			
sum		10181	7976	6.533E+07	10159.3	7829	6.527E+07	579	7829	7.846E+06
Oil+residuals, sum		75968	23183	6.594E+08	75930	22821	6.604E+08	86645	18285	7.597E+08
Natural gas		117320	25624	8.939E+08	117301	25534	8.887E+08	99413	22577	7.793E+08
Biogas		1179		1.067E+07	1170.2	828	1.059E+07			
Biomass		2185		2.487E+07	2190.4	2678	2.493E+07	3360	3319	4.03E+07
Municipal waste		2278		3.213E+07	2276.6	2111	3.212E+07	2277	3453	3.61E+07
Grand total		245,179		2.070E+09	245,176		2.070E+09	242,591		2.058E+09
BEN/ GRTN differences								1.1%		0.6%

Table A2.2 - Energy consumption for electricity production, year 2004

Fuels, 2004		Model output			GRTN			BEN		
		Gwe, gross	kt	TJ	Gwe, gross	kt	T.o.e./TJ	Gwe, gross	kt / Mmc	kcal / TJ
Coal		45511	16678	4.429E+08	45518	17031	4.428E+08	45519	16668	4.428E+08
Coke oven gas		1548	692	1.326E+07				1522	708	3011
Blast furnace gas		3492	8897	3.127E+07				3502	8527	7674
Oxi converter gas		342	457	3.007E+06		457	3.004E+06	407		1.020E+03
sum		5382	10046	4.754E+07	5382	10640	4.795E+07	5431	8690	4.471E+07
Coal, sum				4.905E+08			4.908E+08			4.810E+08
Light distillates		68	10	4.386E+05				112	15	157
Diesel		1896	452	1.906E+07				967	215	2189
Fuel oil	atz	41994	9484	3.865E+08				15547	2733	26785
	btz							38210	8598	84258
Refinery gas			379	1.663E+07				2065	308	3691
Petroleum coke			249	8.631E+06				1069	240	1990
Oriemulsion		0	0	2.013E+03						
sum		47250	10573	4.313E+08	47253	10522	4.315E+08	57970	12109	4.982E+08
Gas from chemical proc.			1286	5.749E+06	83	955	2.339E+06	539		
Heavy residuals/ tar		10760	8525	7.669E+07	11530.3	15031	8.174E+07			
Others		168	252	1.721E+06						
sum		11627	10063	8.416E+07	11613.3		8.407E+07	539	0	
Oil + residuals, sum		58876	20636	5.155E+08	58866		5.156E+08	58509	12109	4.955E+08
Natural gas		129768	28629	9.963E+08	129772	28768	9.959E+08	129772	28852	9.959E+08
Biogas		1179		1.067E+07	1170.2		1.059E+07			
Biomass		2185		2.487E+07	2190.4		2.493E+07	3360	3319	4.03E+07
Municipal waste		2278		3.213E+07	2276.6		3.212E+07	2277	3453	3.61E+07
Grand total		245,179		2.070E+09	245,176		2.070E+09	242,591		2.058E+09
BEN/ GRTN differences								1.1%		0.6%

ANNEX 3: ESTIMATION OF CARBON CONTENT OF COALS USED IN INDUSTRY

The preliminary use of the CRF software in 2001 underlined an unbalance of emissions in the solid fuel rows above 20%. A detailed verification pointed out to an already known fact for Italy: the combined use of standard IPCC emission factors for coals, national emission factors for coal gases and CORINAIR methodology emission factors for steel works processes produces double counting of emissions.

The main reason for this is the specific national circumstance of extensive recovery of coal gases from blast furnaces, coke ovens and oxygen converters for electricity generation. The emissions from those gasses are separately accounted for and reported in the electricity generation section.

Another specific national circumstance is the concentration of steel works, since the year 2001, in two sites, with integrated steel plants, coke ovens and electricity self-production. Limited quantities of pig iron are produced also in one additional location. This has allowed for careful check of the processes involved and the emissions estimates at site level and, with reference to other countries, may or may not have exacerbated the unbalances in carbon emissions due to the use of standard EF developed for other industrial sites.

To avoid the double counting a specific methodology has been developed: it balances energy and carbon content of coking coals used by steelworks, industry, for non energy purposes and coal gasses used for electricity generation.

A balance is made between the coal used for coke production and the quantities of derived fuels used in various sectors. The iron and steel sector gets the resulting quantities of energy and carbon after subtraction of what is used for electricity generation, non energy purposes and other industrial sectors.

The base statistical data are all reported in the BEN (with one exception) and the methodology starts with a verification of the energy balance reported in the BEN, see also Annex 5, table A5.3/.4, that seldom presents problems, and then apply the standard EFs to the energy carriers, trying to balance the carbon inputs with emissions. The exception mentioned refers to the recovered gasses of BOFs (Basic Oxygen Furnace) that are used to produce electricity but were not accounted for by BEN from the year 1990 up to 1999. From the year 2000 those gasses are (partially, only in one plant) included in the estimate of blast furnace gas. The data used to estimate the emissions from 1990 to 1999 are reported by GRTN - ENEL. The consideration of the BOF gasses does not change the following discussion, because its contribution to the total emissions is quite limited.

Table A3.1 summarises the quantities of coal and coal by-products used by the energy system in the year 2004, all the data mentioned can be found in “enclosures 1/a, 2/a and 3/a” of BEN, see also Annex 5.

In the first box from top of the table we can see the quantities of coke, coke gas and blast furnace gas uses by the different sectors. In the second box are reported the quantities of the same energy carriers that are self-used, used for the production of coke of wasted.

Then in the final part of the table, the two coloured groups of cells report the verification of the input-output of two processes: coke ovens and the blast furnaces. The input –output is generally balanced for all the considered years, the small differences can be explained by statistical discrepancies. The following data are just memo summary of the quantities of fuels imported or exported by the system.

If we now look at Table A3.2, in the first two boxes from the top we find the same energy data of table A3.1 valuated for their carbon content, according to the standard EF reported in Table 3.6 of the NIR. Then in the coloured cells we find the balance of carbon inputs and outputs of two processes coke oven and blast furnaces. In this case there is no balance at all, and while the coke production process keep the balance within reasonable percentages, the blast furnaces shows an unbalance of more than 60%, it seems that it produces carbon. For the other years we find similar unbalances.

The rationale of the industrial process does not justify a similar increase in carbon emissions. There is usually no carbon in the iron ore used or in other additives used in the process, on the contrary a limited quantities of the input of carbon (max 2%) is stocked in the produced steel (not considered here) and small quantities are also contained in the solid slag produced by the process.
All those data are produced with the energy statistical data and standard EF, if we add to this the process EF considered by the CORINAIR methodology, based on the quantities of steel or iron produced, we should add other quantities of carbon emissions to the already unbalanced total just described.
If the physical quantities of the coal by products reported by BEN are correct, as shows the energy balance, then the EFs have to be verified. In the meantime APAT decided to report according to the following principle: total carbon emissions at a certain location cannot be higher than carbon inputs from the imported coals. A sort of "bubble" concept applied to carbon emissions at sectoral level.
Of the three main processes involved, coke ovens, blast furnaces and electricity production, the first and the latter appear to be balanced and/or are well monitored, so, pending further investigation of EF, the changes have to be made in the blast furnaces estimates.

coke	coke gas	Blast furnace gas	NOTES
8,211			For blast furnace
0	3,011	7,674	For electricity production
26,446	166	166	For steel industries
259	0	0	For other industries use
0	0		For domestic use
34,916	3,177	7,840	Total consumption
451	124	18	Consumption for production of secondary fuels
0	-2	0	Losses of transformation
35,367	3,299	7,858	Total consumption + losses and prod.
Energy balance coke ovens		Energy balance, blast furnace	
719		-353	Difference in energy consumption
2.3%		-4.5%	Unbalance in %
31,465			Coke oven output
4,277			Transformation losses, coke ovens
1,421			non energy use
37,163			sub total
37,163			Coke input to coke ovens
10,493			Blast furnace coal input
6,482			import + stock change

Table A3.1 Energy balance, 2004, 10^9kcal

So in the end the methodology actually foresees as a first step the calculation of the total carbon inputs (imported fuels plus standard IPCC EFs), see table A3.1 column "total according to BEN". A second step foresee the use for the electric sector of the value directly calculated from the coal gasses used and the calculation of a "balance" quantity for blast furnaces, reference to column "total used for CRF" in table A3.1 . The "balance is the resulting quantity of emissions after subtraction of carbon emissions estimated for coke ovens, electricity production, other coal uses and non energy uses.

The resulting carbon quantities are correct but, when reported in the CRF format, they seem to be produced using very low EFs for coal produced CO_2, near to the natural gas EF, for the steel making process and quite high carbon emissions for the coal use to produce electricity.

Further investigations are planned, with a verification of the carbon content of the imported coals and of the coal gasses produced at various stages of the process, coke gas, blast furnace gas and BOF gas.

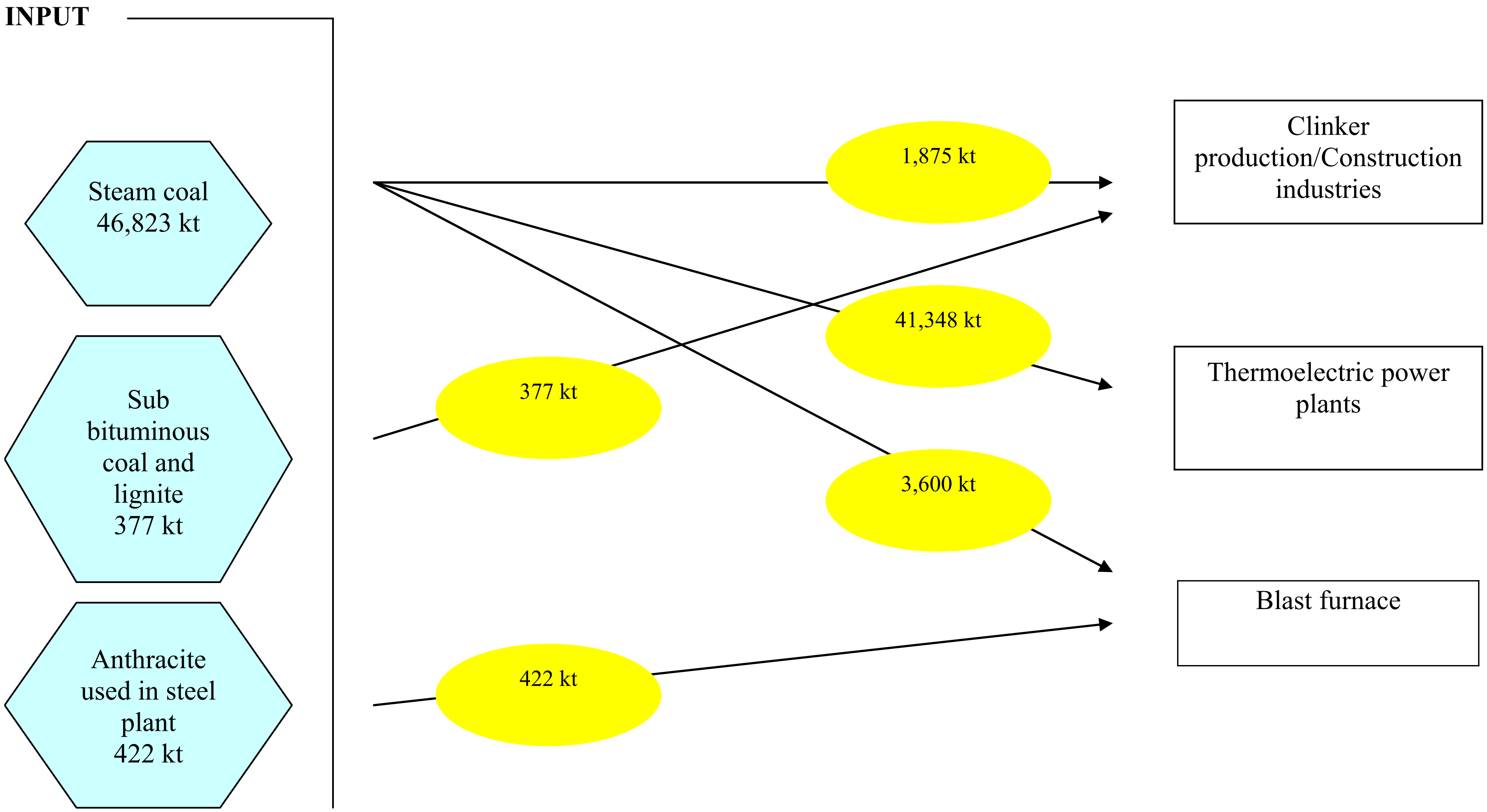
coke	coke gas	Blast furnace gas + oxi gas	NOTES	Total according to BEN	Total used for CRF
3.64			Emission factor, t CO2 / tep		
0.00	0.59	8.56	From blast furnace (no direct emissions, transformed in coal gasses)		
11.72	0.18	0.18	From electricity prod.	9.15	10.72
0.11	0.00	0.00	From steel industries	12.09	10.50
0.00	0.00		From other industries use	0.11	0.11
15.47	0.78	8.74	From domestic use	0.00	0.00
			Total emissions, final uses	24.99	21.33
0.17	0.04	0.02			
0.00	0.00	0.00	Consumption for production of secondary fuels	0.24	-
15.65	0.82	8.76	Losses of transformation	0.00	-
			Total consumption + losses and prod.	25.23	
Carbon balance, coke ovens		Carbon balance, blast furnace			
1.0		5.1	Difference in physical emissions		
8%		58%	Unbalance in %		

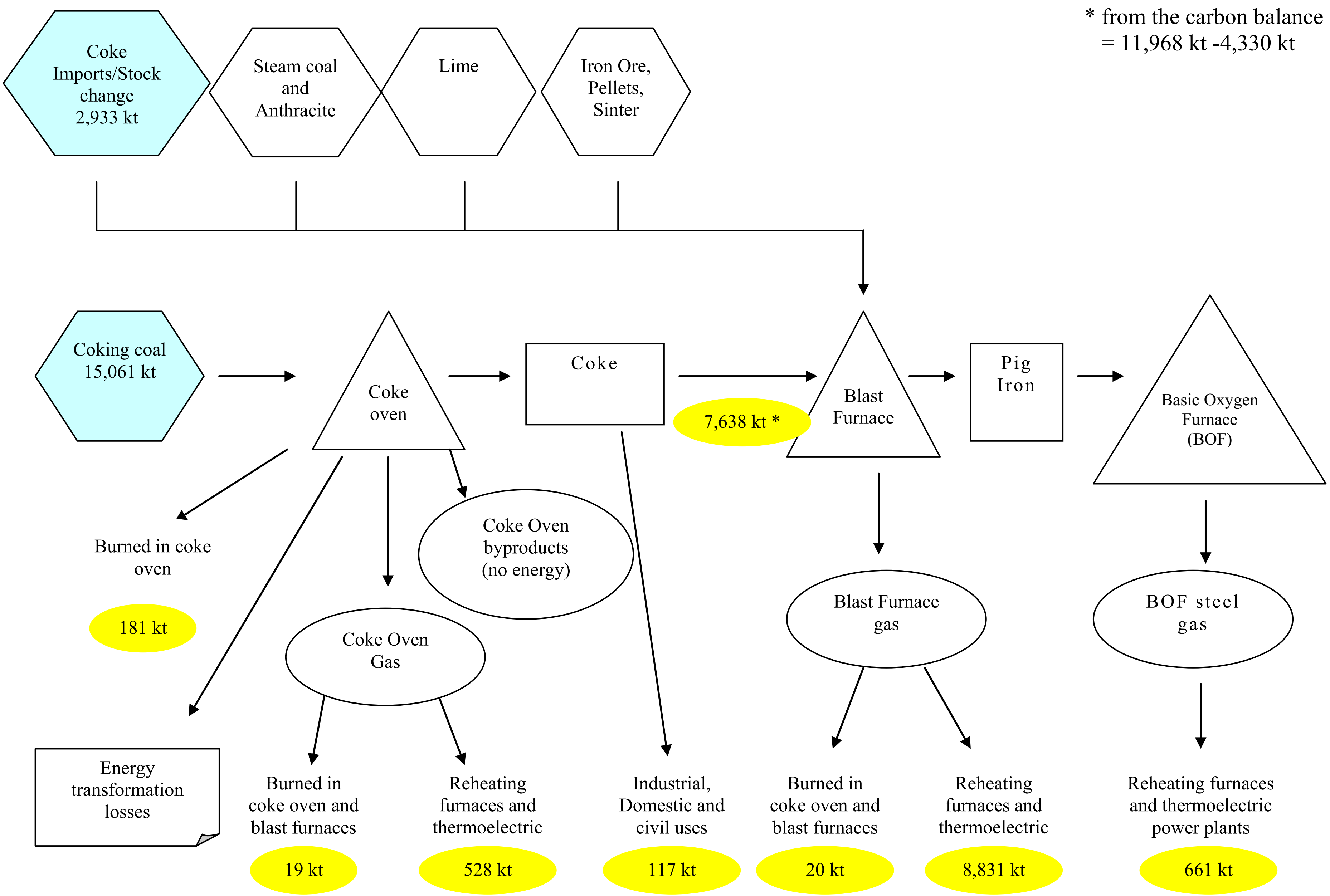
Emissions	EFs				
12.60	4.525		Carbon in produced coke		
1.71	4.004		Transformation losses		
0.57	4.004		non energy use	0.57	0.57
14.88			sub total		
14.40	4.004		Coal input to coke ovens		
4.64	4.004		Coal input to blast furnace		
2.87	4.525		Coke import + stock change		
21.91			Total carbon input	26.39	21.91

Table A3.2 Carbon balance, 2004, Mt CO_2

The flowchart of carbon cycle for the year 2004 is reported below. CO_2 emissions from primary input fuels and from final fuel consumptions are compared. Emissions related to fuel input data are enhanced in light-blue whereas emissions estimated from final fuel consumptions are highlighted in yellow. Emissions from the use of coke in blast furnaces result from differences between emissions from final consumption of coke and the value of the carbon balance for 2004.

CO2 emissions
Year 2004




* from the carbon balance
= 11,968 kt -4,330 kt
Coke Imports/Stock change 2,933 kt
Steam coal and Anthracite
Lime
Iron Ore, Pellets, Sinter
Coking coal 15,061 kt
Coke oven
Coke
7,638 kt *
Blast Furnace
Pig Iron
Basic Oxygen Furnace (BOF)
Burned in coke oven
181 kt
Coke Oven byproducts (no energy)
Coke Oven Gas
Blast Furnace gas
BOF steel gas
Energy transformation losses
Burned in coke oven and blast furnaces
19 kt
Reheating furnaces and thermoelectric
528 kt
Industrial, Domestic and civil uses
117 kt
Burned in coke oven and blast furnaces
20 kt
Reheating furnaces and thermoelectric
8,831 kt
Reheating furnaces and thermoelectric power plants
661 kt

ANNEX 4: CO_2 REFERENCE APPROACH

A4.1 Introduction

The IPCC Reference Approach is a 'top down' inventory based on data on production, imports, exports and stock changes of crude oils, feedstock, natural gas and solid fuels. Estimates are made of the carbon stored in manufactured products, the carbon consumed as international bunker fuels and the emissions from biomass combustion.

The methodology followed is that outlined in the IPCC Guidelines (IPCC, 1997); table 1.A(b) of the Common Reporting Format "Sectoral background data for energy" - CO_2 from Fuel Combustion Activities - Reference Approach is a self sustaining explanation of the methodology.

However it was necessary to make a few adaptations to allow full use of Italian energy and emission factor data (ENEA, 2002 [a]), and these are described in the following. The BEN (MAP, 2006 [a]) reports the energy balances for all primary and secondary fuels, with data on imports, exports and production. Refer to Annex 5, Tables A5.1-A5.8, for an example of the year 2004 and to the web site of the Ministry of Production Activities for the whole time series https://dgerm.attivitaproduttive.gov.it/dgerm/

Starting from those data and using the emission factors reported in chapter 3, Table 3.7, it is possible to estimate the total carbon entering in the national energy system. With time it has been developed a direct connection between relevant cells of the CRF tables and the BEN tables and a procedure to insert some additional activity data needed.

The 'missing' data refer to import – export of lubricants, petrol additives, asphalt, other chemical products with energy content, energy use of exhausted lubricants and the evaluation of marine and aviation bunkers fuels used for national traffic.

Those 'missing' data are in fact reported in the BEN but all mixed up together with other substances as sulphur and petrochemicals. The aggregate data do not allow the use of the proper emission factor so inventory is based on more detailed statistics from foreign trade surveys.

The carbon stored in products is estimated according to the procedure illustrated in the paragraph 3.9 and directly subtracted to the emission balance by the CRF software in the current version used by Italy. It may be the case to underline that no direct subtraction of the energy content of the feedstock is performed by CRF. In the cases, as Italy, where those products are not considered in the energy balances this bring to an unbalanced control sheet, as discussed in the following.

With reference to table 1.A(b) of the CRF 2004, we make reference to the BEN tables reported in Annex 5. In particular the following data are reported in BEN tables and used for the *Reference Approach*:

1) crude oil imports and production;
2) natural gas data import;
3) import-export data of petrol, aviation fuel, other kerosene, diesel, fuel oil, LPG and virgin naphtha;
4) import-export data of bitumen and motor oil derive from foreign trade statistics, estimated by an ENEA consultant for the period 1990-1998. BPT data (MAP, 2006 [b]) are used from 1999 onwards;
5) import-export data of petroleum coke and refinery feedstock are also found in BEN; it has to be underlined that the data reported as "feedstock production" have been ignored up to year 2003 because it is explicitly excluded by the IPCC methodology. From 2004 onward a careful check with the team in charge to prepare the energy balances induced the inventory team to revise its position on this matter ([1]).

[1] The feedstock production data refers to petrochemical feedstock and other fuel streams coming back to the refineries from the internal market. Those quantities do not contain additional carbon inputs but because those quantities are not properly subtracted to the final fuel consumption section of the energy balances they

6) all coal data are available in BEN, coke import-export included;
7) total natural gas import-export balance reflects BEN estimate (energy section), but the detailed quantities coming from different countries (relevant for the carbon EF estimate, see paragraph 3.9) are from foreign trade statistics or "Rete Gas", the national gas grid monopoly, fiscal budgets; the estimated quantities of natural gas used by various sectors show not negligible variations from source to source, with particular reference to the underground stocked quantities; when available we uses the estimates of AEEG (Authority for electricity and gas) for consumption of the distribution / storage system and BEN for final consumption;
8) from 1990 to 2004 biomass consumption data are those reported in the BEN; it is well known that other estimates show much bigger, up to 50% more, quantities of used biomass, for example ENEA (ENEA, 2006); but the same source quotes BEN biomass consumption estimates as official statistics up to the year 2004, pending further investigations; the inventory follows the same methodology.

The following additional information is needed to complete table 1.A(b) of CRF 2004 and it is found in other sources:

1) Orimulsion, this fuel is mixed up with imported fuel oil (on the base of the energy content), the quantities used for electricity generation are reported by ENEL (ENEL, 2005), the former electricity monopoly, presently the only user of this fuel, in their environmental report. This fuel is not used any more since 2004.
2) Motor oils and bitumen.
   a) Data on those materials are mixed up in the no energy use by BEN, detailed data are available in BPT (MAP, 2006 [b]). The quantities of those materials are quite relevant for the no energy use of oil.
   b) In the BEN those materials are estimated in bulk with other products to have an energy content of about 5100 kcal/kg. Average OECD data 9000 kcal/kg for bitumen and 9800 kcal/kg for motor oils. In the CRF those products are estimated with the OECD energy contend and this may explain part of the unbalance between imported oil and used products.

For further information please refer to the paper by ENEA (ENEA, 2002 [b]) in Italian.

A4.2 Comparison of the sectoral approach with the reference approach

The detailed inventory contains a number of sources not accounted for in the IPCC Reference Approach and so gives a higher estimate of CO_2 emissions. The unaccounted sources are:

- Land use change and forestry
- Offshore flaring and well testing
- Waste incineration
- Non-Fuel industrial processes

In principal the IPCC Reference total can be compared with the IPCC Table 1A total plus the fugitive emissions arising from fuel consumption reported in 1B1 Solid Fuel Transformation and

should be accounted for as inputs. A more precise solution would be to reduce the quantities of fuels consumed by the industrial sector, but this is not possible because the team in industry Ministry has only a few details about the origin of those fuel streams returned to refineries. Since 2004 those fuel streams are needed to close the energy balances, which now are much more precise than before. Not considering them in the CRF as input will increase the difference between reference and sectoral approach in the oil section, while with those fuels as inputs the difference is nearly zero. The inventory team proposes to consider those fuels as "stock changes" of petrochemical input.

Table 2 Industrial Processes (Iron and Steel and Ammonia Production). Results show the IPCC Reference totals are between 0-4 % lower than the comparable 'bottom up' totals.

Differences between emissions estimated by the reference and sectoral approach are reported in the following Table A4.1.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Sectoral approach	402.1	402.0	401.2	397.8	391.9	415.2	411.2	415.1	426.2	431.9	435.4	440.4	442.6	456.3	459.5
Reference approach	396.3	393.3	398.5	391.3	385.0	406.2	404.4	407.0	416.3	415.8	429.5	430.1	436.5	448.5	455.2
Δ %	-1.43	-2.16	-0.69	-1.63	-1.75	-2.16	-1.67	-1.96	-2.31	-3.72	-1.35	-2.34	-1.37	-1.72	-0.93

Table A4.1 Reference and sectoral approach CO_2 emission estimates 1990-2004 (Mt) and percentage differences

There are a number of reasons why the totals differ and these arise from differences in the methodologies and the statistics used.

Explanations for the discrepancies:
1. The IPCC Reference Approach is based on statistics of production, imports, exports and stock changes of fuels whilst the 'bottom-up' approach uses fuel consumption data. The two sets of statistics can be related using mass balances (MAP, 2006 [a]), but these show that some fuel is unaccounted for. This fuel is reported under 'statistical differences' which consist of measurement errors and losses. A significant proportion of the discrepancy between the IPCC Reference approach and the 'bottom up' approach arises from these statistical differences particularly with liquid fuels.
2. In the power sector in the detailed approach statistics from producers are used, instead for the reference approach the BEN data are used. The two data sets are not connected; in the BEN sections used only the row data of imports-exports are contained. But if one considers the process of "balancing" the import – production data with the consumption ones and the differences between the two data sets, a sizable part of the discrepancy may be connected to this reason only. An investigation is planned as soon as resources became available.
3. The 'bottom up' approach only includes emissions from the no energy use of fuel where they can be specifically identified and estimated such as with fertilizer production and iron and steel production. The IPCC Reference approach implicitly treats the non-energy use of fuel as if it were combustion. A correction is then applied by deducting an estimate of carbon stored from non-energy fuel use. The carbon stored is estimated from an approximate procedure which does not identify specific processes. The result is that the IPCC Reference approach is based on a higher estimate of non-energy use emissions than the 'bottom-up' approach.

The IPCC Reference Approach uses data on primary fuels such as crude oil and natural gas liquids which are then corrected for imports, exports and stock changes of secondary fuels. Thus the estimates obtained will be highly dependent on the default carbon contents used for the primary fuels.
The 'bottom-up' approach is based wholly on the consumption of secondary fuels where the carbon contents are known with greater certainty. In particular the carbon contents of the primary liquid fuels are likely to vary more than those of secondary fuels. Carbon content of solid fuels and of natural gas is quite precisely accounted for, a specific methodology for estimate carbon content of liquid fuel imports is at the moment only planned.

ANNEX 5: NATIONAL ENERGY BALANCE, YEAR 2004

The following table reproduces the part expressed in amount of energy consumed of the National Energy Balance (BEN) of the year 2004.

The complete balance, containing the physical quantities as well as the amount of energy and a consistent time series from the year 1994 onwards, is also available on the web site: https://dgerm.attivitaproduttive.gov.it/dgerm/

Sectors and fuel definition have been translated here in English, but, of course, the tables on Internet are in Italian language. Definitions are very similar to their English equivalents so this should not be an obstacle to independent verifications of energy data sources for previous years.

The national energy balance is comprised of two “sets” of tables: from page 6 to page 14 the energy vectors are represented in physical quantities (kt) while from page 16 to page 24 they are expressed in energy equivalents (10^9 kcal).
Recalling what already said in Annex 2 related to the BEN reporting methodology (that prefers to use always the same lower heat value for each primary fuel in various years, to better follow the variable energy content of each shipment), we make reference here to the second set of tables. This means, for example, that the primary fuel quantities of two shipments of imported coal are “adjusted” using their energy content as the main reference (see Table A5.1) and the value reported in page 6 of the national energy balance (non reproduced here) is an “adjusted” quantity of kt. This process is routinely applied for most primary sources, including imported and nationally produced natural gas.
For the final uses of energy (Tables A5.7-8 and Tables A5.9-10) the same methodology is applied but is runs the other way: the physical quantities of energy vectors are the only values actually measured on the market and the energy content is actually estimated using fixed average estimates of lower heat value. Experience on the measure of the actual energy content of fuels shows minor variations from one to another year, especially for liquid fuels.

In the case of natural gas the use of a fixed heat value to summarize all transactions was particularly complicated due to the fact that we use fuel from four main different sources: Russia, Netherlands, Algeria and national production. From 2003-2004 onwards Norway and Libya have also been added to the supply list. The big customers where actually billed according to the measured heat value of the natural gas delivered. After the end of the state monopoly on this marked the system has recently been changed. From 2004 onwards, the price makes reference to the energy content of natural gas and the metered physical quantities of gas delivered to all final customers are billed according to an energy content variable from site to site and from year to year. The BEN still tries to summarize all production and consumption using only one conventional heat value.

So for the estimations of liquid fuels used in the civil and transportation sector the most reliable data is the physical quantity and this is used to calculate emissions, using updated data for the emission factors, estimated from samples of marketed fuels.
For this reason we attach also the copies of tables, page 12 and 13 of BEN (see Tables A5.9-10), mirror sheet of the tables, page 22 and 23 of BEN (see Tables A5.7-8), that are the base for our emission calculation in the civil and transport sectors.

Table A5.1- National Energy Balance, year 2004, Primary fuels, 10^9 kcal

BALANCE	PRIMARY SOURCES													
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy	Geothermal Energy	Wind and Photovoltaic Energy	Waste	Biomass	TOTAL PRIMARY SOURCES
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Conversion factor (c)	*7.400*	*6.350*	*7.400*	*2.500*	*2.500*	*8.250*	*10.000*	*10.000*	*2.200*	*2.200*	*2.200*	*2.500*	*2.900*	
1. PRODUCTIONS (d)		622			4,938	106,928	54,450	21,190	94,038	11,962	4,071	8,632	24,588	331,419
2. IMPORTS	37,548	122,612	2,094	23		560,241	868,670	64,820					8,799	1,664,807
3. EXPORTS						3258.75	5,300.0	8,850					12	17,421
4. Stock changes (e)	-67	3,092	44			-1,114	610	4,020						6,585
5. TOTAL RESOURCES	**37,614**	**120,142**	**2,050**	**23.0**	**4,938**	**665,024**	**917,210**	**73,140**	**94,038**	**11,962**	**4,071**	**8,632**	**33,375**	**1,972,220**
6. Transformations (Enclosure 1/a)	37,163	105,842			4,938	238,029	990,350		94,038	11,962	4,071	8,632	11,144	1,506,168
7. Consumptions and Losses (Encl.2/a)	452	5	0.4	0.5		8173							2	8,633
8. Final Consumptions (Enclosure 3/a)		14,294	2050	23		418,823							22,229	457,419
a) Agriculture						1,403							1,931	3,334
b) Industry		14,294	1961	23		171,249							2,900	190,427
c) Services						3,638							2,545	6,183
d) Domestic and civil uses			89			233,087							14,835	248,029
Total (a+b+c+d)		14,294	2,050	23		409,377							22,229	447,973
e) Non energy uses						9,446								9,446
TOTAL ENERGY CONSUMPTIONS (7+8)	**452**	**14,299**	**2,050**	**23**	**0.0**	**426,996**							**22,331**	**466,052**
9. Non energy final uses														
10. BUNKERS														
12. TOTAL USES	**37,615**	**120,141**	**2,050**	**23**	**4,938**	**665,024**	**990,350**	**0**	**94,038**	**11,962**	**4,071**	**8,632**	**33,375**	**1,972,220**

(a) - Including secondary products, heat recovered, oxygen furnace gas and compressed gas expansion evaluated at the thermic equivalent of 2200 kcal/kWh, used by electric energy production.
(c) - Lower heat value has been adopted for all fuels
(d) - Oil products include: returns from petrolchimical industry, some reclassification of feedstocks and regeneration of lubricant oils.

Table A5.2 – National Energy Balance, year 2004, Secondary fuels, 10^9 kcal

BALANCE	SECONDARY SOURCES																		
	Electric Energy	Char-coal	Coke	Coke oven gas	Blast furnace Gas	Non energy use of coal products	Gas works Gas	L. P. G.	Refinery gas (f)	Light Distillates (naphtha)	Gasoline	Jet fuel	Kerosene	Gas Oil / Diesel Oil	Residual Oil, HS	Residual Oil, LS	Petroleum Coke	Non energy use of petroleum products	TOTAL SECONDARY SOURCES
	15	16	17	18	20	21	19	22	23	24	25	26	27	28	29	30	31	32	33
Conversion factor (c)	*0.860*	*7.500*	*7.000*	*4.250*	*0.900*	*8.729*	*4.250*	*11.000*	*12.000*	*10.400*	*10.500*	*10.400*	*10.300*	*10.200*	*9.800*	*9.800*	*8.300*	*6.241*	
1. PRODUCTIONS (d)	254,695	750	28,434	3,115	7,858	1,676		28,743	35,460	31,699	217,298	39,385	2,616	406,184	87,445	84,476	11,579	39,466	1,280,878
2. IMPORTS	39,926	375	7,602					17,600		21,656	3,559	1,466	3,626	10,312	8,869	46,256	27,017	4,193	192,455
3. EXPORTS	680		1,708			428.0		6,325		13,447	60,386	3,994	1,566	97,359	30,762	5,890	930	15,349	238,824
4. Stock changes (e)			-588					242		260	1,239	-697	1,236	-2,264	510	-5,674	996	2,278	-2,462
5. TOTAL RESOURCES	**293,941**	**1,125**	**34,916**	**3,115**	**7,858**	**1,248**		**39,776**	**35,460**	**39,648**	**159,233**	**37,554**	**3,440**	**321,401**	**65,042**	**130,524**	**36,670**	**26,022**	**1,236,963**
6. Transformations (Enclosure 1/a)			8,211	3,011	7,674				3,691	157				2,189	26,785	84,258	1,990		137,966
7. Consumptions and Losses (Encl.2/a)	39,850			104	18			374	25,649	540	209			2,654	10,454	7,304	7,954	106	95,216
8. Final Consumptions (Enclosure 3/a)	254,092	1,125	26,705		166	1,248		39,402	6,120	38,948	159,024	37,554	3,440	309,581	5,655	34,535	26,726	892	969,852
a) Agriculture	4,459							726			200			25,235					30,620
b) Industry	118,643	285	26,705		166			4,565	888		3,129	166	51	5,591	5,234	28,860	26,726	892	221,901
c) Services	35,270							12,199			152,492	37,388		233,070					470,419
d) Domestic and civil uses	95,720	840						21,549					309	35,975		2,538			156,931
Total (a+b+c+d)	254,092	1,125	26,705		166			39,039	888		155,821	37,554	360	299,871	5,234	31,398	26,726	892	879,871
e) No energetic uses						1,246		363	5,232	38,948	3,203		3,080	9,710	421	3,136		24,642	89,981
TOTAL ENERGY CONSUMPTIONS (7+8)	**293,942**	**1,125**	**26,705**	**104**	**184**	**1,248**		**39,776**	**31,769**	**39,488**	**1,592,333**	**37,554**	**3,440**	**312,235**	**16,109**	**41,839**	**34,680**	**998**	**1,040,428**
9. Non energy final uses																		24,642	24,647
10. BUNKERS														6,977	22,148	4,420		381	33,926
12. TOTAL USES	**293,942**	**1,125**	**34,916**	**3,115**	**7,858**	**1,248**		**39,776**	**35,776**	**39,645**	**159,233**	**37,554**	**3,440**	**321,401**	**65,042**	**130,516**	**36,670**	**26,021**	**1,236,962**

(e) - In the "TOTAL RESOURCES", this entry is considered negative.

Table A5.3 – National Energy Balance, year 2003, Primary fuels used by transformation industries, “Enclosure 1/a”, 10^9 kcal

TRANSFORMATIONS	PRIMARY SOURCES													
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy	Geothermal Energy	Wind and Photovoltaic Energy	Waste	Biomass	TOTAL PRIMARY SOURCES
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Conversion factor (b)	*7.400*	*6.350*	*7.400*	*2.500*		*8.250*	*10.000*	*10.000*	*2.200*	*2.200*	*2.200*	*2.500*	*2.900*	
1) INPUT QUANTITY														
a) Charcoal pit													1,520	1,520
b) Coking	37,163													37,163
c) Town gas Workshop														
d) Blast furnaces														
e) Petroleum refineries							990,350							990,350
f) Hydroelectric power plants									94,038					94,038
g) Geothermal power plants										11,962				11,962
h) Thermoelectric power plants		105,843			4,937	238,028						8,632	9,624	367,064
i) Wind / Photovoltaic power plants						-					4,071			4,071
TOTAL	**37,163**	**105,843**			**4,937**	**238,028**	**990,350**		**94,038**	**11,962**	**4,071**	**8,632**	**11,144**	**1,506,168**
2) OUTPUT QUANTITY (b)														
A) Obtained sources														
a) Charcoal pit													760	760
b) Coking	31,465													31,465
c) Town gas Workshop														
d) Blast furnaces														
e) Petroleum refineries							944,884							944,884
f) Hydroelectric power plants									36,760					36,760
g) Geothermal power plants										4,676			0	4,676
h) Thermoelectric power plants		39,146			1,895	111,604						1,958	2,890.0	157,493
i) Wind / Photovoltaic power plants											1,591			1,591
Sub-Total A	**31,465**	**39,146**			**1,895**	**111,604**	**944,884**		**36,760**	**4,676**	**1,591**	**1,958**	**3,650**	**1,177,639**
B) Losses of transformation														

a) Charcoal pit													760	626
b) Coking	4,277													4,277
c) Town gas Workshop														
d) Blast furnaces														
e) Petroleum refineries							6,000							6,000
f) Hydroelectric power plants									57,278					57,278
g) Geothermal power plants										7,286				7,286
h) Thermoelectric power plants		66,697			3,042	126,424						6,674	6,734	209,571
i) Wind / Photovoltaic power plants											2,480			2,480
Sub-Total B	**4,277**	**66,697**			**3,042**	**126,424**	**6,000**		**57,278**	**7,286**	**2,480**	**6,674**	**7,360**	**287,652**
C) Non energy products														
a) Coke ovens (d)	1,421													1,421
b) Town Gas Workshop														
c) Petroleum refineries (e)							39,456							39,456
Sub-Total C	1,421						39,456							40,887
TOTAL A+B+C	**37,163**	**105,842**			**4,937**	**238,028**	**990,350**		**94,038**	**11,961**	**4,071**	**8,632**	**11,144**	**1,506,168**

Table A5.4 – National Energy Balance, year 2004, Secondary fuels used by transformation industries, “Enclosure 1/a”, 10^9 kcal

TRANSFORMATIONS	SECONDARY SOURCES																		
	Electric Energy	Char-coal	Coke	Coke oven gas	Blast furnace Gas	Non energy use of coal products	Gas works Gas	L. P. G.	Refinery gas (f)	Light Distillates (naphtha)	Gasoline	Jet fuel	Kerosene	Gas Oil / Diesel Oil	Residual Oil, HS	Residual Oil, LS	Petroleum Coke	Non energy use of petroleum products (d)	TOTAL SECONDARY SOURCES
	15	16	17	18	20	21	19	20	21	22	23	24	25	26	27	28	29	30	31
Conversion factor (b)	*0.860*	*7.500*	*7.000*	*4.250*	*0.900*	*8.729*	*4.250*	*11.000*	*12.000*	*10.400*	*10.500*	*10.400*	*10.300*	*10.200*	*9.800*	*9.800*	*8.300*	*6.241*	
1) INPUT QUANTITY																			
a) Charcoal pit																			
b) Coking																			
c) Town gas Workshop																			
d) Blast furnaces			8,211																8,211
e) Petroleum refineries																			
f) Hydroelectr.power plants (c)																			
g) Geothermal power plants																			
h) Thermoelectr.power plants				3,011	7,674				3,691	157				2,189	26,785	84,258	1,990		129,755
i) Wind/Photovoltaic power pl.																			
TOTAL			**8,211**	**3,011**	**7,674**				**3,691**	**157**				**2,189**	**26,785**	**84,258**	**1,990**		**137,966**
2) OUTPUT QUANTITY (b)																			
A) Obtained sources																			
a) Charcoal pit																			
b) Coking																			
c) Town gas Workshop																			
d) Blast furnaces			8,211																8,211
e) Petroleum refineries																			
f) Hydroelectric power plants																			
g) Geothermal power plants																			
h) Thermoelectric power plants				1,309	3,012				1,776	96				832	13,370	32,861	919		54,175
i) Wind / Photovoltaic power pl.																			
Sub-Total A			8,211	1,309	3,012				1,776	96				832	13,370	32,861	919		62,386

B) Losses of transformation										
a) Charcoal pit										
b) Coking										
c) Town gas Workshop										
d) Blast furnaces										
e) Petroleum refineries										
f) Hydroelectric power plants										
g) Geothermal power plants										
h) Thermoelectric power plants		1,702	4,662	1,915	61	1,357	13,415	51,397	1,071	75,580
i) Wind / Photovoltaic power plants										
Sub-Total B		**1,702**	**4,662**	**1,915**	**61**	**1,357**	**13,415**	**51,397**	**1,071**	**75,580**
C) Non energy products										
a) Coking										
b) Town Gas Workshop										
c) Petroleum refineries										
Sub-Total C										
TOTAL A+B+C	**8,211**	**3,011**	**7,674**	**3,691**	**157**	**2,189**	**26,785**	**84,258**	**1,990**	**137,966**

(d) - Including tars, benzol and ammonic sulphate.

(e) - Including solvent gasoline, turpentine, lubricants, white oils, insulating oils, vaseline, paraffin, bitumen and other products.

Table A5.5 – National Energy Balance, year 2004, Primary fuels losses, “Enclosure 2/a”, 10^9 kcal

CONSUMPTIONS AND LOSSES	PRIMARY SOURCES													
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy	Geothermal Energy	Wind and Photovoltaic Energy	Waste	Biomass	TOTAL PRIMARY SOURCES
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Conversion factor (b)	*7.400*	*6.350*	*7.400*	*2.500*		*8.250*	*10.000*	*10.000*	*2.200*	*2.200*			*2.900*	
1) Consumptions for production of primary sources														
a) Biomass														
b) Coal														
c) Lignite														
d) Nuclear fuels														
e) Natural Gas						635								635
f) Natural gas liquids														
g) Crude oil														
h) Hydraulic Energy														
i) Geothermal Energy														
Sub-total						**635**								**635**
2) Consumptions for production of secondary sources (c)														
a) Charcoal pit														
b) Coke ovens	451													451
c) Town Gas Workshop														
d) Blast furnaces														
e) Petroleum refineries														
f) Hydraulic power plants														
g) Geothermal power plants														
h) Thermoelectric power plants														
i) Nuclear power plants														

Sub-total	**451**													**451**
3) Consumptions and Losses of														
transport and distribution						7,541								7,541
4) Differences :														
- Statistics		6												6
- of conversion	1	-1			1	-3							2	
TOTAL (1+2+3+4)	**452**	**5**			**1**	**8,173**							**2**	**8,633**

(a) Excluding losses of transformation considered in the balance of transformations

(b) Lower heat value has been adopted for all fuels

Table A5.6 – National Energy Balance, year 2004, Secondary fuels losses, "Enclosure 2/a", 10^9 kcal

CONSUMPTIONS AND LOSSES	SECONDARY SOURCES																		
	Electric Energy	Char-coal	Coke	Coke oven gas	Blast furnace Gas	Non energy use of coal products	Gas works Gas	L. P. G.	Refinery gas (f)	Light Distillates (naphtha)	Gasoline	Jet fuel	Kerosene	Gas Oil / Diesel Oil	Residual Oil, HS	Residual Oil, LS	Petroleum Coke	Non energy use of petroleum products (d)	TOTAL SECONDARY SOURCES
	15	16	17	18	20	21	19	20	21	22	23	24	25	26	27	28	29	30	31
Conversion factor (b)	*0.860*	*7.500*	*7.000*	*4.250*	*0.900*	*8.729*	*4.250*	*11.000*	*12.000*	*10.400*	*10.500*	*10.400*	*10.300*	*10.200*	*9.800*	*9.800*	*8.300*	*6.241*	
1) Consumptions for production of primary sources																			
a) Biomass																			
b) Coal	32																		32
c) Lignite	-																		
d) Nuclear fuels	4																		4
e) Natural Gas	312																		312
f) Natural gas liquids																			
g) Crude oil																			
h) Hydraulic Energy	2,698(d)																		2,698
i) Geothermal Energy	-																		
Sub-total	**3,046**																		**3,046**
2) Consumptions for production of secondary sources (c)																			
a) Charcoal pit																			
b) Coke ovens	131			106	18														255
c) Town Gas Workshop	194																		194
d) Blast furnaces	65																		65
e) Petroleum refineries	5,050							374	25,644	541	210			2,652	10,457	7,301	7,951,4	106,1	60,286
f) Hydraulic power plants	537																		537
g) Geothermal power plants	267																		267
h) Thermoelectric power plants	10,630																		10,630

i) Wind / Photovoltaic power plants	2															
Sub-total	16,876		106	18		374	25,644	541	210		2,652	10,457	7,301	7,951	106	72,234
3) Consumptions and Losses of																
transport and distribution	19,928															19,928
4) Differences :																
- Statistics															-1	-1
- of conversion			-2		2		5	-1	1		2	-3	3	3	1	9
TOTAL (1+2+3+4)	**39,850**		**104**	**18**	**2**	**374**	**25,649**	**540**	**209**		**2,661**	**10,454**	**73,014**	**7,954**	**106**	**95,216**

(c) Consumptions for internal uses of energy industries

Table A5.7 – National Energy Balance, year 2004, Primary fuels used by end use sectors, "Enclosure 3/a", 10^9 kcal

FINAL CONSUMPTIONS	PRIMARY SOURCES													
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy	Geothermal Energy	Wind and Photovoltaic Energy	Waste	Biomass	TOTAL PRIMARY SOURCES
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Conversion factor (a)	*7.400*	*6.350*	*7.400*	*2.500*	*2.500*	*8.250*	*10.000*	*10.000*	*2.200*	*2.200*	*2.200*	*2.500*	*2.900*	
1) AGRICULTURE AND FISHING														
I- Agriculture						1403							1931	3334
II- Fishing														
Sub-Total						**1403**							**1931**	**3334**
2) INDUSTRY														
I- Iron and steel industry		9398	1095			19619								30112
II- Other industry		4896	866	23		151630							2900	160315
a) Mining industry						281								281
b) Non-Ferrous Metals			15			4010								4025
c) Metal works factories						23257								23257
d) Food Processing, Beverages						19272								19272
e) Textile and clothing						12796								12796
f) Construction industries (cement, bricks)		4896	829	23		11080							2900	19728
g) Glass and pottery						25831								25831
h) Chemical			22			29288								29310
i) Petrochemical														
l) Pulp, paper and print						16979								16979
m) Other industries						8836								8836
n) Building and civil works														
Sub-Total		**14294**	**19611**	**23**		**171249**							**2900**	**190427**
3) SERVICES														
I - Railways														
II - Navigation														
III - Road transportation						3638							2545	6183

IV - Civil aviation														
V - Other transportation														
VI - Public Service														
Sub-Total						**3638**							**2545**	**6183**
4) DOMESTIC AND COMMERCIAL USES			89			233087							14853	248029
TOTAL (1+2+3+4)		14294	2050	23		409377							22229	447973
5) NON ENERGY USE (a)														
I - Chemical industry						9446								9446
II - Petrochemical														
III - Agriculture														
IV - Other sectors														
Sub-Total						**9446**								**9446**
TOTAL (1+2+3+4+5)		**14294**	**2050**	**23**		**418823**							**22229**	**457419**

(a) - Lower heat value has been adopted for all fuels

Table A5.8 – National Energy Balance, year 2004, Secondary fuels used by end use sectors, “Enclosure 3/a”, 10^9 kcal

FINAL CONSUMPTIONS	SECONDARY SOURCES																		
	Electric Energy	Char-coal	Coke	Coke oven gas	Blast furnace Gas	Non energy use of coal products	Gas works Gas	L. P. G.	Refinery gas	Light Distillates (naphtha)	Gasoline	Jet fuel	Kerosene	Gas Oil / Diesel Oil	Residual Oil, HS	Residual Oil, LS	Petroleum Coke	Non energy use of petroleum products	TOTAL SECONDARY SOURCES
	15	16	17	18	20	21	19	20	21	22	23	24	25	26	27	28	29	30	31
Conversion factor	*0.860*	*7.500*	*7.000*	*4.250*	*0.900*	*8.729*	*4.250*	*11.000*	*12.000*	*10.400*	*10.500*	*10.400*	*10.300*	*10.200*	*9.800*		*8.300*	*6.241*	
1) AGRICULTURE AND FISHING																			
I- Agriculture	4459							704			189			22736					28088
II- Fishing								22			11			2499					2532
Sub-Total	**4459**							**726**			**200**			**25235**					**30620**
2) INDUSTRY																			
I- Iron and steel industry	17174		26446		166			275						92		921	25		45099
II- Other industry	101469	286	259					4290	888		3130	166	51	5499	5234	27039	26702	892	176805
a) Mining industry	969							44						235	59	147			1454
b) Non-Ferrous Metals	4740		49					220					10	71		519			5609
c) Metal works factories	23455							825			326	166	41	1510	1196	3469			30988
d) Food Processing, Beverages	10924	218						495						602	274	6733			19246
e) Textile and clothing	9280							352						530	88	2724			12974
f) Construction industries (cement, bricks)	7598		91					935						449	1000	294	26577	892	37836
g) Glass and pottery	4963							770						194		2813			8740
h) Chemical	21216	68	28					66						408		1411	125		23322
i) Petrochemical	1576							198	888		2804				1392	5429			12287
l) Pulp, paper and print	9294							99						306		1911			11610
m) Other industries	6071		91					286						541	1225	2489			10703
n) Building and civil works	1383													653					2036
Sub-Total	**118643**	**285**	**26705**		**166**			**4565**	**888**		**3129**	**166**	**51**	**5591**	**5234**	**28860**	**26726**	**893**	**221901**
3) SERVICES																			
I - Railways	4585													1173					5758

II - Navigation	22											2499					2521
III - Road transportation	3560					12166			152061			225542					393329
IV - Civil aviation	92								147	35963							36202
V - Other transportation	18335																18335
VI - Public Service	8676					33			284	1425		(b) 3856					14724
Sub-Total	**35270**					**12199**			**152492**	**37388**		**233070**					**470419**
4) DOMESTIC AND COMMERCIAL USES	95720	840				21549					309	35975		2538			156931
TOTAL (1+2+3+4)	254092	1125	26705	166		39039	888		155821	37554	360	299871	5234	31398	26726	892	879871
5) NON ENERGY USE (a)																	
I - Chemical industry																	
II - Petrochemical						363	5232	38948	3203		3080	9710	421	3136		318	64411
III - Agriculture					166												166
IV - Other sectors					1080											24324	245404
Sub-Total					**1246**	**363**	**5232**	**38948**	**3203**		**3080**	**9710**	**421**	**3136**		**24642**	**89981**
TOTAL (1+2+3+4+5)	**254092**	**1125**	**26705**	**166**	**1246**	**39402**	**6120**	**38948**	**159024**	**37554**	**3456**	**309581**	**5655**	**34535**	**26726**	**25534**	**696852**

(b) 816 10E9 kcal of diesel used for heating for Public Service

Table A5.9 – National Energy Balance, year 2004, Primary fuels used by end use sectors, "Enclosure 3/a", quantity

Enclousure 3/a (numbers expressed in quantity)

FINAL CONSUMPTIONS	PRIMARY SOURCES													
	Coking coal	Steam coal	Coal other uses	Lignite	Subproducts (a)	Natural Gas	Crude oil	Refinery feedstocks	Hydraulic Energy	Geothermal Energy	Wind and Photovoltaic Energy	Waste	Biomass	TOTAL PRIMARY SOURCES
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Unit of measurement	*kt*	*kt*	*kt*	*kt*		*Mmc*	*kt*	*kt*	*GWh*	*GWh*	*GWh*	*kt*	*kt*	
1) AGRICULTURE AND FISHING														
I- Agriculture						170							666	
II- Fishing														
Sub-Total						**170**							**666**	
2) INDUSTRY														
I- Iron and steel industry		1480	148			2378								
II- Other industry		771	117	9		18379							1000	
a) Mining industry						34								
b) Non-Ferrous Metals			2			486								
c) Metal works factories						2819								
d) Food Processing, Beverages						2336								
e) Textile and clothing						1551								
f) Construction industries (cement, bricks)		771	112	9		1343							1000	
g) Glass and pottery						3131								
h) Chemical			3			3550								
i) Petrochemical						0								
l) Pulp, paper and print						2058								
m) Other industries						1071								
n) Building and civil works						0								
Sub-Total		**2251**	**265**	**9**		**20757**							**1000**	
3) SERVICES														
I - Railways														
II - Navigation														

III - Road transportation						441							286
IV - Civil aviation													
V - Other transportation													
VI - Public Service													
Sub-Total						**441**							**286**
4) DOMESTIC AND COMMERCIAL USES			12			28253							5039
TOTAL (1+2+3+4)	0	2251	277	9		49621							6991
5) NON ENERGY USE (a)													
I - Chemical industry						1145							
II - Petrochemical													
III - Agriculture													
IV - Other sectors													
Sub-Total						**1145**							
TOTAL (1+2+3+4+5)		**2251**	**277**	**9**		**50766**							**6991**

(a) - Non energy uses of energetic sources

(b) - Biodiesel for road transport: 257 kt; biodiesel for domestic and commercial uses: 40 kt

Table A5.10 – National Energy Balance, year 2004, Secondary fuels used by end use sectors, “Enclosure 3/a”, quantity

Continued:Enclousure 3/a (numbers expressed in quantity)

FINAL CONSUMPTIONS	SECONDARY SOURCES																		
	Electric Energy	Char-coal	Coke	Coke oven gas	Blast furnace Gas	Non energy use of coal products	Gas works Gas	L. P. G.	Refinery gas (f)	Light Distillates (naphtha)	Gasoline	Jet fuel	Kerosene	Gas Oil / Diesel Oil	Residual Oil, HS	Residual Oil, LS	Petroleum Coke	Non energy use of petroleum products	TOTAL SECONDARY SOURCES
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Unit of measurement	*GWh*	*kt*	*kt*	*Mmc*	*Mmc*	*Mmc*	*kt*	*kt*	*kt*	*kt*		*kt*	*kt*	*kt*	*kt*		*kt*	*kt*	
1) AGRICULTURE AND FISHING																			
I- Agriculture	5,185							64			18			2,229					
II- Fishing								2			1			245					
Sub-Total	**5,185**							**66**			**19**			**2,474**					
2) INDUSTRY																			
I- Iron and steel industry	19,970		3,778		184			25						9		94	3		
II- Other industry	117,987	38	37					390	74		298	16	5	539	534	2,851	3,217	143	
a) Mining industry	1,126							4						23	6	15			
b) Non-Ferrous Metals	5,511		7					20					1	7		53			
c) Metal works factories	27,275							75			31	16	4	148	122	354			
d) Food Processing, Beverages	12,702	29						45						59	28	687			
e) Textile and clothing	10,791							32						52	9	278			
f) Construction industries (cement, bricks)	8,835		13					85						44	102	30	3,202	143	
g) Glass and pottery	5,771							70						19		287			
h) Chemical	24,699	9	4					6						40		144	15		
i) Petrochemical	1,832							18	74		267				142	554			
l) Pulp, paper and print	10,807							9						30		195			
m) Other industries	7,060		13					26					1	53	125	254			
n) Building and civil works	1,608							0						64					
Sub-Total	**137,987**	**38**	**3,815**		**184**			**415**	**74**	**0**	**298**	**16**	**6**	**548**	**534**	**2,945**	**3,220**	**143**	
3) SERVICES																			
I - Railways	5,331													115					

II - Navigation	25											245				
III - Road transportation	4,139					1,106			14,482			22,112				
IV - Civil aviation	107								14	3,458						
V - Other transportation	21,321															
VI - Public Service	10,088					(a) 3			27	136		(a) 378				
Sub-Total	**41,011**					**1,109**			**14,523**	**3,595**		**22,850,0**				
4) DOMESTIC AND COMMERCIAL USES	111,302	112				1,959					30	3,527		259		
TOTAL (1+2+3+4)	295,485	150	3,815	184		3,549	74		14,840	3,611	35,0	29,399	534	3,204	3,220	143
5) NON ENERGY USE																
I - Chemical industry																
II - Petrochemical						33	436	3,745	305		299	952	43	320		51
III - Agriculture					19											
IV - Other sectors					124											3,898
Sub-Total					**143**	**33**	**436**	**3,745**	**305**		**299**	**952**	**43**	**320**		**3,949**
TOTAL (1+2+3+4+5)	**295,455**	**150**	**3,815**	**184**	**143**	**3,582**	**510**	**3,745**	**15,145**	**3,611**	**335**	**30,351**	**577**	**3,524**	**3,220**	**4,092**

(a) 80 kt of gas oil and 3 kt of LPG used for heating for Public Service

ANNEX 6: NATIONAL EMISSION FACTORS

Monitoring of the carbon content of the fuels used nationally is an ongoing activity at APAT. The principle is to analyse regularly the chemical composition of the used fuel or relevant activity statistics, to estimate the carbon content and the emission factor. For each primary fuel (natural gas, oil, coal) a specific procedure has been established.

Natural gas

IPCC methodology reports an emission factor for this energy carrier. Initially to estimate the methane content of the fuel, so that the correct emission factor for fugitive emissions could be evaluated a proper investigation has been performed among main users. Routine checks are performed by final uses to estimate chemical composition of natural gas and its energy value.

It has been found that the national marked is characterized by the commercialisation of natural gas of highly variable composition. Since 1990 natural gas has been produced nationally or imported by pipelines from Russia, Algeria and Netherlands. Moreover an NGL facility is importing gas from Algeria and Libya. From 2003-2004 onwards Norway and Libya have also been added to the supply list, thank to updated pipeline connection. Sizeable additional NGL facilities are under construction. Each of those natural gasses has peculiar properties and it is regularly analysed at the import gates, for budgetary reasons. Energy content for cubic meters and percentage of methane can vary considerably: national produced gas sold to the grid is almost 99% methane (% moles), the one coming from Algeria has less than 85% of methane and significant quantities of propane-butane. Carbon content varies significantly also.

Natural gas properties are quite stable with reference to the country of origin and chemical composition and speciation of gas from each country is regularly published by SNAM, the main national operators. Other information is also available from the final distribution companies.

So, for each year, the average methane and carbon content of the natural gas used in Italy are estimated using the international trade statistical data and a national emission factor is estimated. The list of factors for the years of interest is reported in Table A6.1.

	t CO_2 / TJ	t CO_2 / std cubic mt	t CO_2 / tep
Natural gas (dry) IPCC	55.780	1.925	2.334
Natural gas (dry) '1990	55.327	1.941	2.315
Natural gas (dry) '1995	55.422	1.961	2.319
Natural gas (dry) '2000	55.315	1.966	2.314
Natural gas (dry) '2003	55.287	1.950	2.313
Natural gas (dry) '2004	55.559	1.960	2.325

Table A6.1 Natural gas carbon emission factors

Diesel oil, petrol and LPG, national production

APAT has made an investigation of the carbon content of the main transportation fuels sold in Italy: petrol, diesel and LPG.

The job has been aimed to test the average fuels sold in the year 2000 and to collect the available information on previous years fuels. The aim of this work is the verification of CO_2 emission factors of the Italian energy system and specifically of the transportation sector. The results of analysis of fuel samples performed by "Stazione Sperimentale Combustibili" (APAT, 2003) are checked against the emission factors used in the Reference Approach of the Intergovernmental Panel for Climate Change (IPCC, 1997) and the emission factors considered in the COPERT III programme of the European Environment Agency (EEA, 2000).

Those two methodologies are widely used to prepare data at the international level but, when applied to the Italian data set produces results with significant differences, around 2-4%. The reason has been traced back to the emission factors that is referred to the energy content of the fuel for IPCC and to the physical quantities for the COPERT methodology.
The results of the study performed by APAT link the chemical composition of the fuel to the LHV for a series of fuels representative of the national production in the years 2000-2001, allowing for more precise evaluations of the emission factors.
IPCC-OECD emission factors for diesel fuels and LPG are almost identical to the experimental results (less than 1% difference), and it has been decided to use IPCC emission factors for the period 1990-1999 and the measured EF from the year 2000 onwards.
Relevant quantities (about 50%) of LPG used in Italy are imported. The measured values refer only to the products produced in Italy, IPCC emission factors is used as a default.
For petrol instead the IPCC-OECD emission factors is quite low and it has to be upgraded, the reason may be linked to the extensive use of additives in recent years to reach a high octane number after the lead has been phased out. For 2000 and the following years the experimental factor will be used, for the period 1990-1999 it has been decided to use an interpolate factor between IPCC emission factors and the measured value, using the LHV as the link between the national products and the international database. No other information was available.
The list of emission factors for the different years is reported in Table A6.2.

	t CO_2 / TJ	t CO_2 / t	t CO_2 / tep
Petrol, 1990-'99, IPCC /OECD	68.531	3.015	2.872
Petrol, test data, 2000	71.145	3.109	2.977
Gasoil, 1990-'99, IPCC / OECD	73.274	3.127	3.066
Gasoil, engines, test data, 2000	73.153	3.137	3.061
Gasoil, heating, test data.	73.693	3.141	3.083
LPG, 1990-'99, IPCC	62.392	2.872	2.610
LPG, test data, 2000	64.936	2.994	2.717

Table A6.2 Fuels, national production, carbon emission factors

Fuel oil, imported and produced
With reference to fuel oil the main information available was a sizable difference in carbon content between high sulphur and light sulphur brands. IPCC emission factors generally refer to the light sulphur product.
The data where elaborated from literature and from an extensive series of samples (more than 400) analysed by ENEL and made available to APAT.
Carbon content varies to a certain extent also between the medium sulphur content and the very low sulphur products, but the main discrepancies refer to the high sulphur type.
According to the available statistical data, it was possible to trace back to the year 1990 the produced and imported quantities of fuel oil, divided between high and low sulphur products and to estimate the average carbon emission factor for the years of interest, see Table A6.3 for details.

	t CO_2 / TJ	t CO_2 / tep
Fuel oil, 1990 average	76.539	3.202
Fuel oil, 1990 average	76.565	3.203
Fuel oil, 1995 average	76.650	3.207
Fuel oil, 2000 average	76.699	3.209
Fuel oil, 2004 average	76.715	3.210

Table A6.3 Fuel oil, average of national and imported products, carbon emission factors

Coal imports

Italy has only negligible national production of coal, most is imported from various countries and there are not negligible differences in carbon content. The variations in carbon content can be linked to the hydrogen content and to the LHV of the coal.

An additional national circumstance refers to the absence of long term import contracts. The quantities shipped by the main exporters change considerably from year to year; moreover new suppliers have been added to the list in the last few years.

So an attempt was made to find out a methodology that allow for a more precise estimation of the carbon content of this fuel. It is possible, using literature data for the coals and detailed statistical records of international trade, to find out the weighted average of carbon content and of the LHV of the fuel imported to Italy each year. The actually still unresolved problem is how to properly link statistical data, referred to the coal “as is” without specifying the moisture and ash content of the product, to the literature data that refer to sample coals.

We envisage improving the quality of the collected statistical data including moisture content of coals but presently we overcome this obstacle with the following procedure:

- using an ample set of experimental data on coals imported in a couple of years on an extensive series of samples, more than 200, analysed by ENEL (the main electricity producing company in Italy) it was possible to correlate "as is" LHV and carbon content to the average properties of the coals imported in the same period of time and calculated from literature data (EMEP/CORINAIR, 2005);
- for each inventory year it is possible to calculate the weighted average of LHV and carbon content of imported coals using available literature data;
- using this calculated data and the correlation found out it is possible to estimate the carbon content of the average “as is” coal reported in the statistics.

Using this methodology and the available statistical data, it was possible to trace back to the year 1990 the average LHV of the imported coal and estimate the average carbon EF for each year, see table A6.4 for same details. The results do not show impressive changes from year to year, any way a noticeable difference of about 1.5% in the emission factor is highlighted in the table.

This methodology can be questioned and certainly can be improved; we continue to use it because, in our view, its use improves the quality of our reporting.

	t CO_2 / TJ	t CO_2 / tep
Solid fuels		
Sub bitumious coal, IPCC	96.234	4.026
Steam coal '90	94.582	3.960
Steam coal '95	94.007	3.936
Steam coal '00	91.446	3.826
Steam coal '04	93.370	3.907

Table A6.4 – Coal, average carbon emission factors

ANNEX 7: CRF TREND TABLES FOR GREENHOUSE GASES

This appendix shows a copy of Tables 10s1-10s5 from the Common Reporting Format 2004, submitted in 2006, in which time series of emission estimates for the following gases are reported:

- CO_2
- CH_4
- N_2O
- HFCs, PFCs, SF_6
- All gases and sources categories

Table A7.1 CO_2 emissions trends, CRF year 2004

TABLE 10 EMISSIONS TRENDS (CO_2)
(Sheet 1 of 5)

Italy
2004
2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	(Gg)															
1. Energy	**405,126.32**	**405,126.32**	**405,019.63**	**404,140.27**	**400,891.11**	**394,813.58**	**418,008.07**	**413,903.50**	**418,000.23**	**428,976.47**	**433,984.81**	**437,669.45**	**442,628.94**	**444,477.76**	**458,807.46**	**461,283.84**
A. Fuel Combustion (Sectoral Approach)	402,078.43	402,078.43	402,029.38	401,214.24	397,807.26	391,900.13	415,164.70	411,211.11	415,125.68	426,208.32	431,893.77	435,371.69	440,446.35	442,553.89	456,310.58	459,462.28
1. Energy Industries	134,091.89	134,091.89	128,409.75	128,308.61	122,891.69	125,531.32	137,973.15	133,477.31	135,233.44	145,628.98	141,708.59	147,775.00	150,930.41	157,781.46	158,591.88	160,902.73
2. Manufacturing Industries and Construction	88,936.88	88,936.88	85,985.17	84,303.00	84,765.91	85,540.83	87,823.05	85,608.36	88,673.34	82,777.77	86,492.66	87,888.78	85,138.29	81,108.59	86,005.03	85,351.22
3. Transport	101,460.54	101,460.54	104,331.10	108,652.13	110,377.89	110,204.84	112,005.28	113,173.47	114,898.38	118,710.40	119,965.96	120,430.92	122,771.95	124,886.28	126,035.14	128,008.19
4. Other Sectors	76,548.17	76,548.17	82,111.55	78,674.32	78,328.59	69,167.89	75,927.61	77,774.28	75,098.63	78,055.13	82,619.59	78,470.89	81,251.75	78,463.99	85,018.38	84,109.17
5. Other	1,040.95	1,040.95	1,191.81	1,276.17	1,443.18	1,455.26	1,435.61	1,177.69	1,221.89	1,036.05	1,106.97	806.10	353.94	313.56	660.15	1,090.98
B. Fugitive Emissions from Fuels	3,047.89	3,047.89	2,990.25	2,926.03	3,083.86	2,913.45	2,843.37	2,692.39	2,874.55	2,768.15	2,091.04	2,297.76	2,182.59	1,923.87	2,496.88	1,821.56
1. Solid Fuels																
2. Oil and Natural Gas	3,047.89	3,047.89	2,990.25	2,926.03	3,083.86	2,913.45	2,843.37	2,692.39	2,874.55	2,768.15	2,091.04	2,297.76	2,182.59	1,923.87	2,496.88	1,821.56
2. Industrial Processes	**27,268.15**	**27,268.15**	**26,826.54**	**27,360.17**	**24,488.16**	**23,607.28**	**25,474.31**	**23,091.61**	**23,165.00**	**23,218.83**	**23,335.81**	**24,153.07**	**24,905.81**	**24,781.91**	**25,780.48**	**26,770.31**
A. Mineral Products	21,099.66	21,099.66	21,051.69	21,863.21	19,407.30	18,913.76	20,768.08	19,075.78	19,320.39	19,575.62	20,383.81	21,265.81	22,095.84	22,088.70	22,985.79	23,831.78
B. Chemical Industry	2,185.80	2,185.80	2,089.16	2,051.07	1,461.33	1,196.91	1,222.91	962.27	1,034.92	1,040.80	958.46	1,061.65	1,033.79	1,081.56	1,243.32	1,327.72
C. Metal Production	3,982.69	3,982.69	3,685.69	3,445.89	3,619.53	3,496.61	3,483.32	3,053.57	2,809.68	2,602.41	1,993.54	1,825.61	1,776.18	1,611.66	1,551.37	1,610.81
D. Other Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Production of Halocarbons and SF_6																
F. Consumption of Halocarbons and SF_6																
G. Other																
3. Solvent and Other Product Use	**1,598.05**	**1,598.05**	**1,587.96**	**1,589.83**	**1,536.76**	**1,469.61**	**1,426.10**	**1,383.53**	**1,383.03**	**1,331.75**	**1,336.93**	**1,286.70**	**1,305.24**	**1,316.41**	**1,321.86**	**1,325.28**
4. Agriculture	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation																
B. Manure Management																
C. Rice Cultivation																
D. Agricultural Soils [2]																
E. Prescribed Burning of Savannas																
F. Field Burning of Agricultural Residues																
G. Other																
5. Land-Use Change and Forestry [3]	**-79,913.74**	**-79,913.74**	**-101,255.47**	**-97,397.29**	**-82,602.51**	**-98,217.34**	**-103,316.98**	**-106,129.73**	**-99,419.76**	**-96,258.95**	**-103,799.36**	**-100,027.88**	**-110,216.88**	**-114,369.06**	**-111,412.52**	**-105,920.21**
A. Changes in Forest and Other Woody Biomass Stocks	-58,945.70	-58,945.70	-80,523.04	-76,872.96	-62,446.48	-78,766.80	-84,073.85	-86,957.74	-80,005.59	-77,894.99	-85,596.10	-81,772.30	-88,114.31	-94,591.00	-84,696.64	-92,600.16
B. Forest and Grassland Conversion																
C. Abandonment of Managed Lands																
D. CO_2 Emissions and Removals from Soil																
E. Other	-20,968.03	-20,968.03	-20,732.43	-20,524.33	-20,156.04	-19,450.55	-19,243.13	-19,171.99	-19,414.17	-18,363.96	-18,203.26	-18,255.58	-22,102.56	-19,778.05	-26,715.88	-13,320.04
6. Waste	**496.36**	**496.36**	**520.78**	**520.00**	**500.12**	**506.79**	**475.09**	**464.03**	**507.76**	**504.42**	**393.47**	**201.57**	**222.26**	**244.97**	**215.76**	**210.57**
A. Solid Waste Disposal on Land																
B. Waste-water Handling																
C. Waste Incineration	496.36	496.36	520.78	520.00	500.12	506.79	475.09	464.03	507.76	504.42	393.47	201.57	222.256	244.973	215.756	210.574
D. Other																
7. Other *(please specify)*	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Emissions/Removals with LUCF [4]	**354,575.15**	**354,575.15**	**332,699.44**	**336,212.98**	**344,813.63**	**322,179.91**	**342,066.59**	**332,712.94**	**343,636.26**	**357,772.52**	**355,251.66**	**363,282.90**	**358,845.36**	**356,452.00**	**374,713.04**	**383,669.80**
Total Emissions without LUCF [4]	**434,488.88**	**434,488.88**	**433,954.91**	**433,610.27**	**427,416.15**	**420,397.26**	**445,383.57**	**438,842.67**	**443,056.02**	**454,031.47**	**459,051.02**	**463,310.79**	**469,062.24**	**470,821.06**	**486,125.56**	**489,590.01**
Memo Items:																
International Bunkers	**8,505.47**	**8,505.47**	**8,528.14**	**8,350.39**	**8,707.84**	**8,961.84**	**9,647.67**	**8,871.86**	**9,193.85**	**9,742.74**	**10,388.81**	**11,673.42**	**11,413.27**	**11,950.47**	**13,656.58**	**14,165.60**
Aviation	4,116.27	4,116.27	4,939.82	4,887.96	5,028.48	5,296.22	5,612.84	6,016.25	6,134.14	6,665.86	7,313.89	7,835.84	7,054.73	6,957.04	8,053.75	8,068.20
Marine	4,389.20	4,389.20	3,588.32	3,462.43	3,679.36	3,665.62	4,034.83	2,855.61	3,059.71	3,076.88	3,074.92	3,837.59	4,358.54	4,993.42	5,602.84	6,097.40
Multilateral Operations																
CO_2 Emissions from Biomass	**5,243.86**	**5,243.86**	**5,962.78**	**6,286.98**	**6,217.06**	**7,216.52**	**7,833.37**	**7,695.94**	**8,464.10**	**7,572.41**	**8,897.95**	**9,362.29**	**10,318.00**	**11,282.86**	**12,983.37**	**15,425.51**

Table A7.2 CH_4 emission trends, CRF year 2004

TABLE 10 EMISSIONS TRENDS (CH_4)
(Sheet 2 of 5)

Italy
2004
2006

REENHOUSE GAS SOURCE AND SINK CATEGORI	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	(Gg)															
Total Emissions	**1,984.04**	**1,984.04**	**2,041.13**	**2,011.96**	**2,030.34**	**2,058.53**	**2,100.12**	**2,105.89**	**2,129.21**	**2,134.22**	**2,138.66**	**2,147.56**	**2,112.79**	**2,041.44**	**2,027.38**	**1,993.31**
1. Energy	**425.84**	**425.84**	**426.87**	**431.83**	**426.60**	**420.12**	**411.98**	**407.13**	**407.54**	**404.67**	**398.39**	**387.00**	**366.52**	**357.00**	**356.53**	**356.31**
A. Fuel Combustion (Sectoral Approach)	73.71	73.71	77.11	80.16	80.18	82.46	86.65	86.74	88.40	81.98	85.21	80.14	75.33	74.28	77.19	85.52
1. Energy Industries	15.10	15.10	14.74	14.33	14.06	13.68	16.02	16.06	16.81	11.81	12.97	11.12	11.24	16.00	18.60	21.31
2. Manufacturing Industries and Construction	6.83	6.83	6.74	6.57	6.80	6.80	7.21	6.69	6.91	6.69	6.31	6.02	6.10	5.97	6.12	6.18
3. Transport	36.88	36.88	39.11	42.11	43.12	44.24	45.19	45.98	44.95	43.60	43.72	40.07	34.08	31.02	29.51	31.27
4. Other Sectors	14.73	14.73	16.34	16.95	15.99	17.54	18.01	17.82	19.56	19.72	22.04	22.81	23.82	21.22	22.85	26.62
5. Other	0.17	0.17	0.19	0.20	0.22	0.21	0.22	0.19	0.17	0.16	0.18	0.13	0.09	0.07	0.10	0.14
B. Fugitive Emissions from Fuels	352.13	352.13	349.75	351.67	346.42	337.66	325.33	320.39	319.14	322.69	313.18	306.86	291.19	282.72	279.34	270.80
1. Solid Fuels	5.79	5.79	5.33	5.31	3.90	3.39	3.07	2.88	2.85	2.63	2.52	3.48	3.85	3.72	4.50	3.05
2. Oil and Natural Gas	346.34	346.34	344.43	346.36	342.52	334.27	322.25	317.51	316.29	320.06	310.66	303.38	287.34	279.00	274.84	267.75
2. Industrial Processes	**5.16**	**5.16**	**4.95**	**4.83**	**4.87**	**5.07**	**5.36**	**2.99**	**3.23**	**3.11**	**3.05**	**3.01**	**2.83**	**2.71**	**2.76**	**2.90**
A. Mineral Products																
B. Chemical Industry	2.45	2.45	2.43	2.40	2.28	2.49	2.65	0.60	0.62	0.59	0.59	0.40	0.33	0.33	0.31	0.33
C. Metal Production	2.71	2.71	2.51	2.43	2.59	2.58	2.71	2.39	2.61	2.52	2.46	2.61	2.50	2.38	2.45	2.57
D. Other Production																
E. Production of Halocarbons and SF_6																
F. Consumption of Halocarbons and SF_6																
G. Other																
3. Solvent and Other Product Use																
4. Agriculture	**819.75**	**819.75**	**829.66**	**808.08**	**805.23**	**808.54**	**822.05**	**824.79**	**827.63**	**822.46**	**830.39**	**802.57**	**782.81**	**751.54**	**754.60**	**743.18**
A. Enteric Fermentation	579.89	579.89	592.76	574.76	568.70	573.83	584.11	586.77	589.35	585.29	591.80	579.26	555.54	525.21	526.44	515.77
B. Manure Management	164.86	164.86	165.13	158.79	158.42	154.85	158.42	158.73	157.91	159.31	161.02	157.27	160.93	158.10	158.01	154.03
C. Rice Cultivation	74.39	74.39	71.09	73.86	77.48	79.23	78.90	78.65	79.79	77.22	76.95	65.46	65.80	67.63	69.60	72.71
D. Agricultural Soils																
E. Prescribed Burning of Savannas																
F. Field Burning of Agricultural Residues	0.62	0.62	0.68	0.66	0.64	0.64	0.62	0.64	0.57	0.64	0.62	0.58	0.53	0.60	0.55	0.67
G. Other																
5. Land-Use Change and Forestry	**6.80**	**6.80**	**1.74**	**2.88**	**7.18**	**2.90**	**1.30**	**1.06**	**3.53**	**4.11**	**2.02**	**4.14**	**2.63**	**1.47**	**3.09**	**1.65**
A. Changes in Forest and Other Woody Biomass Stocks																
B. Forest and Grassland Conversion																
C. Abandonment of Managed Lands																
D. CO_2 Emissions and Removals from Soil																
E. Other	6.80	6.80	1.74	2.88	7.18	2.90	1.30	1.06	3.53	4.11	2.02	4.14	2.63	1.47	3.09	1.65
6. Waste	**726.48**	**726.48**	**777.91**	**764.35**	**786.45**	**821.90**	**859.43**	**869.92**	**887.28**	**899.87**	**904.80**	**950.84**	**958.00**	**928.71**	**910.40**	**889.27**
A. Solid Waste Disposal on Land	625.08	625.08	665.59	652.17	669.99	705.52	742.04	753.52	767.02	780.59	782.60	830.21	835.17	805.79	787.86	762.85
B. Waste-water Handling	93.74	93.74	97.53	100.55	103.83	104.54	104.46	105.49	106.97	107.47	107.74	108.66	109.77	110.23	109.57	110.11
C. Waste Incineration	7.65	7.65	14.78	11.61	12.61	11.81	12.91	10.89	13.24	11.76	14.38	11.87	12.93	12.53	12.80	16.13
D. Other	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.05	0.06	0.08	0.10	0.12	0.16	0.18	0.18
7. Other *(please specify)*	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:																
International Bunkers	**0.54**	**0.54**	**0.47**	**0.47**	**0.50**	**0.50**	**0.55**	**0.45**	**0.49**	**0.51**	**0.53**	**0.63**	**0.69**	**0.75**	**0.82**	**0.88**
Aviation	0.12	0.12	0.12	0.14	0.14	0.15	0.16	0.18	0.20	0.21	0.24	0.27	0.28	0.27	0.28	0.30
Marine	0.42	0.42	0.34	0.33	0.35	0.35	0.39	0.27	0.29	0.29	0.29	0.37	0.42	0.48	0.54	0.58
Multilateral Operations																
CO_2 Emissions from Biomass																

Table A7.3 N_2O emission trends, CRF year 2004

TABLE 10 EMISSIONS TRENDS (N_2O)
(Sheet 3 of 5)

Italy
2004
2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[(1)]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	(Gg)															
Total Emissions	**132.73**	**132.73**	**135.68**	**133.10**	**134.51**	**130.80**	**133.88**	**132.77**	**136.70**	**136.61**	**140.11**	**140.88**	**141.65**	**140.04**	**139.43**	**145.77**
1. Energy	**27.52**	**27.52**	**27.44**	**26.93**	**26.44**	**25.80**	**27.81**	**28.14**	**28.42**	**29.10**	**31.08**	**31.43**	**32.41**	**33.63**	**34.94**	**36.14**
A. Fuel Combustion (Sectoral Approach)	27.52	27.52	27.44	26.93	26.44	25.80	27.81	28.14	28.42	29.10	31.08	31.43	32.41	33.63	34.94	36.14
1. Energy Industries	5.43	5.43	5.16	4.90	4.56	4.74	5.33	5.13	5.08	5.20	5.13	5.40	5.67	6.25	6.49	6.87
2. Manufacturing Industries and Construction	5.23	5.23	5.21	5.24	4.89	4.87	4.98	4.90	4.98	4.94	5.00	5.21	5.24	5.26	5.42	5.55
3. Transport	5.54	5.54	5.61	5.79	6.03	6.44	7.01	7.58	8.11	9.16	9.95	10.31	10.77	11.83	12.17	12.80
4. Other Sectors	11.09	11.09	11.23	10.75	10.68	9.50	10.27	10.34	10.03	9.63	10.86	10.38	10.71	10.27	10.74	10.64
5. Other	0.23	0.23	0.24	0.24	0.28	0.25	0.21	0.18	0.21	0.17	0.14	0.14	0.03	0.02	0.13	0.28
B. Fugitive Emissions from Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid Fuels																
2. Oil and Natural Gas																
2. Industrial Processes	**21.54**	**21.54**	**22.81**	**21.11**	**21.65**	**20.36**	**23.35**	**22.66**	**22.78**	**23.06**	**23.56**	**25.54**	**26.55**	**25.49**	**24.38**	**27.24**
A. Mineral Products																
B. Chemical Industry	21.54	21.54	22.81	21.11	21.65	20.36	23.35	22.66	22.78	23.06	23.56	25.54	26.55	25.49	24.38	27.24
C. Metal Production																
D. Other Production																
E. Production of Halocarbons and SF_6																
F. Consumption of Halocarbons and SF_6																
G. Other																
3. Solvent and Other Product Use	**2.57**	**2.57**	**2.42**	**2.41**	**2.45**	**2.41**	**2.44**	**2.91**	**2.91**	**3.35**	**3.28**	**3.26**	**2.95**	**2.95**	**2.76**	**2.58**
4. Agriculture	**77.30**	**77.30**	**79.16**	**78.87**	**80.01**	**78.11**	**76.21**	**75.29**	**78.67**	**76.76**	**77.58**	**76.14**	**75.91**	**74.17**	**73.52**	**73.40**
A. Enteric Fermentation																
B. Manure Management	14.57	14.57	14.50	13.87	13.73	13.60	13.80	13.93	14.11	14.33	14.51	14.07	14.71	13.88	13.78	13.31
C. Rice Cultivation																
D. Agricultural Soils	62.71	62.71	64.65	64.99	66.27	64.50	62.40	61.35	64.54	62.42	63.06	62.06	61.19	60.28	59.72	60.08
E. Prescribed Burning of Savannas																
F. Field Burning of Agricultural Residues	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
G. Other																
5. Land-Use Change and Forestry	**0.16**	**0.16**	**0.01**	**0.02**	**0.18**	**0.34**	**0.27**	**0.01**	**0.09**	**0.55**	**0.75**	**0.74**	**0.02**	**0.01**	**0.02**	**2.51**
A. Changes in Forest and Other Woody Biomass Stocks																
B. Forest and Grassland Conversion																
C. Abandonment of Managed Lands																
D. CO_2 Emissions and Removals from Soil																
E. Other	0.16	0.16	0.01	0.02	0.18	0.34	0.27	0.01	0.09	0.55	0.75	0.74	0.02	0.01	0.02	2.51
6. Waste	**3.65**	**3.65**	**3.84**	**3.76**	**3.78**	**3.78**	**3.81**	**3.75**	**3.84**	**3.79**	**3.86**	**3.77**	**3.80**	**3.80**	**3.80**	**3.91**
A. Solid Waste Disposal on Land																
B. Waste-water Handling	3.37	3.37	3.35	3.36	3.37	3.38	3.39	3.40	3.41	3.40	3.41	3.41	3.41	3.42	3.42	3.44
C. Waste Incineration	0.28	0.28	0.49	0.39	0.42	0.39	0.42	0.36	0.43	0.39	0.45	0.36	0.39	0.38	0.38	0.47
D. Other																
7. Other *(please specify)*	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:																
International Bunkers	**0.17**	**0.17**	**0.15**	**0.15**	**0.16**	**0.16**	**0.18**	**0.16**	**0.17**	**0.18**	**0.19**	**0.22**	**0.24**	**0.25**	**0.27**	**0.29**
Aviation	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.12	0.13	0.14
Marine	0.11	0.11	0.09	0.09	0.09	0.09	0.10	0.07	0.08	0.08	0.08	0.10	0.11	0.13	0.14	0.16
Multilateral Operations																
CO_2 Emissions from Biomass																

Table A7.4 HFC, PFC and SF_6 emission trends, CRF year 2004

TABLE 10 EMISSION TRENDS (HFCs, PFCs and SF_6)
(Sheet 4 of 5)

Italy
2004
2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	(Gg)															
Emissions of HFCs[5] - CO_2 equivalent (Gg)	**351.00**	**351.00**	**355.43**	**358.78**	**355.42**	**481.90**	**671.29**	**450.17**	**755.33**	**1,180.96**	**1,451.82**	**2,005.50**	**2,761.41**	**3,568.02**	**4,589.89**	**5,699.29**
HFC-23	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.08	0.14	0.23	0.35	0.52
HFC-41																
HFC-43-10mee																
HFC-125	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.05	0.07	0.14	0.24	0.37	0.55	0.77
HFC-134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.29	0.43	0.68	0.83	1.00	1.20	1.37	1.53	1.65
HFC-152a																
HFC-143																
HFC-143a	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.03	0.06	0.10	0.15	0.20	0.26
HFC-227ea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02
HFC-236fa																
HFC-245ca																
Emissions of PFCs[5] - CO_2 equivalent (Gg)	**1,807.65**	**1,807.65**	**1,451.54**	**849.56**	**707.47**	**476.84**	**490.80**	**243.39**	**252.08**	**270.43**	**258.00**	**345.85**	**452.37**	**413.58**	**484.46**	**406.62**
CF_4	0.21	0.21	0.17	0.10	0.08	0.06	0.06	0.03	0.03	0.03	0.03	0.04	0.05	0.04	0.05	0.04
C_2F_6	0.05	0.05	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01
C_3F_8																
C_4F_{10}																
$c\text{-}C_4F_8$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_5F_{12}																
C_6F_{14}																
Emissions of SF_6[5] - CO_2 equivalent (Gg)	**332.92**	**332.92**	**356.39**	**358.26**	**370.40**	**415.66**	**601.45**	**682.56**	**728.64**	**604.81**	**404.51**	**493.43**	**795.34**	**738.35**	**485.63**	**602.38**
SF_6	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.02	0.03

Table A7.5 Total emission trends, CRF year 2004

TABLE 10 EMISSION TRENDS (SUMMARY)
(Sheet 5 of 5)

Italy
2004
2006

GREENHOUSE GAS EMISSIONS	Base year[(1)]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO_2 equivalent (Gg)															
Net CO_2 emissions/removals	354,575.15	354,575.15	332,699.44	336,212.98	344,813.63	322,179.91	342,066.59	332,712.94	343,636.26	357,772.52	355,251.66	363,282.90	358,845.36	356,452.00	374,713.04	383,669.80
CO_2 emissions (without LUCF) [(6)]	434,488.88	434,488.88	433,954.91	433,610.27	427,416.15	420,397.26	445,383.57	438,842.67	443,056.02	454,031.47	459,051.02	463,310.79	469,062.24	470,821.06	486,125.56	489,590.01
CH_4	41,664.86	41,664.86	42,863.79	42,251.22	42,637.08	43,229.06	44,102.62	44,223.64	44,713.40	44,818.60	44,911.77	45,098.81	44,368.49	42,870.16	42,574.95	41,859.41
N_2O	41,147.30	41,147.30	42,061.49	41,261.64	41,697.72	40,548.97	41,503.22	41,157.56	42,378.41	42,350.29	43,433.68	43,672.96	43,910.52	43,413.36	43,221.91	45,188.94
HFCs	351.00	351.00	355.43	358.78	355.42	481.90	671.29	450.17	755.33	1,180.96	1,451.82	2,005.50	2,761.41	3,568.02	4,589.89	5,699.29
PFCs	1,807.65	1,807.65	1,451.54	849.56	707.47	476.84	490.80	243.39	252.08	270.43	258.00	345.85	452.37	413.58	484.46	406.62
SF_6	332.92	332.92	356.39	358.26	370.40	415.66	601.45	682.56	728.64	604.81	404.51	493.43	795.34	738.35	485.63	602.38
Total (with net CO_2 emissions/removals)	**439,878.88**	**439,878.88**	**419,788.09**	**421,292.44**	**430,581.73**	**407,332.33**	**429,435.98**	**419,470.25**	**432,464.11**	**446,997.61**	**445,711.45**	**454,899.45**	**451,133.49**	**447,455.47**	**466,069.88**	**477,426.45**
Total (without CO_2 from LUCF) [(6) (8)]	**519,792.62**	**519,792.62**	**521,043.56**	**518,689.73**	**513,184.24**	**505,549.67**	**532,752.96**	**525,599.98**	**531,883.87**	**543,256.57**	**549,510.80**	**554,927.33**	**561,350.37**	**561,824.53**	**577,482.40**	**583,346.66**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[(1)]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO_2 equivalent (Gg)															
1. Energy	422,600.35	422,600.35	422,491.22	421,557.35	418,046.91	411,635.46	435,279.90	431,176.98	435,367.89	446,496.54	451,986.18	455,538.96	460,373.18	462,400.61	477,126.77	479,968.68
2. Industrial Processes	36,544.50	36,544.50	36,164.73	35,572.01	32,735.90	31,399.43	34,589.69	31,555.53	32,031.58	32,488.74	32,817.02	34,979.32	37,206.40	37,460.46	38,955.40	41,982.44
3. Solvent and Other Product Use	2,394.46	2,394.46	2,337.86	2,337.58	2,294.75	2,216.86	2,181.88	2,284.23	2,283.92	2,370.60	2,354.43	2,297.40	2,220.68	2,229.58	2,178.66	2,124.31
4. Agriculture	41,177.35	41,177.35	41,962.85	41,420.33	41,712.07	41,192.52	40,888.22	40,661.66	41,767.35	41,068.62	41,487.84	40,456.72	39,971.98	38,775.44	38,636.43	38,361.89
5. Land-Use Change and Forestry [(7)]	-79,721.59	-79,721.59	-101,215.23	-97,330.76	-82,396.73	-98,050.09	-103,206.42	-106,104.29	-99,317.92	-96,003.71	-103,525.18	-99,711.05	-110,156.09	-114,334.99	-111,340.95	-105,107.08
6. Waste	16,883.81	16,883.81	18,046.66	17,735.93	18,188.83	18,938.14	19,702.72	19,896.14	20,331.29	20,576.83	20,591.15	21,338.10	21,517.34	20,924.37	20,513.57	20,096.20
7. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ANNEX 8: METHODOLOGIES, DATA SOURCES AND EMISSION FACTORS

This appendix shows a copy of Tables I-1 - I-4 on methodologies, data sources and emission factors used for the Italian inventory communicated to the European Commission under the implementing provisions for the compilation of The European Community Inventory.

Table A8.1 Methods, activity data and emission factors used for the Italian Inventory

ANNEX I

Table for methodologies, data sources and emission factors used by Member States for EC key sources for the purpose of Article 4(1)(b)

Information on methods used could be the tier method, the model or a country-specific approach. Activity data could be from national statistics or plant-specific. Emission factors could be the IPCC default emission factors as outlined in the revised 1996 IPCC guidelines for national greenhouse gas inventories and in the IPCC good practice guidance, country-specific emission factors, plant-specific emission factors or CORINAIR emission factors developed under the 1979 Convention on Long-Range Transboundary Air Pollution.

Table I -1: Community summary report for methods, activity data and emission factors used (Energy)

GREENHOUSE GAS SOURCE AND SINK	CO_2				CH_4				N_2O			
CATEGORIES	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)
1. Energy												
A. Fuel Combustion												
1. Energy Industries												
a. Public Electricity and Heat Production	Yes	T3	NS, PS	CS	No				Yes	T3	NS, PS	D
Liquid fuels	Yes	T3	NS, PS	CS	No				No			
Solid fuels	Yes	T3	NS, PS	CS	No				Yes	T3	NS, PS	D
Gaseous fuels	Yes	T3	NS, PS	CS	No				No			
Other fuels	Yes	T3	NS, PS	CS	No				No			
b. Petroleum Refining	Yes	T3	NS, PS	CS	No				No			
Liquid fuels	Yes	T3	NS, PS	CS	No				No			
c. Manufacture of Solid Fuels and Other Energy Industries	Yes	T2	NS	CS	No				No			
Solid fuels	Yes	T2	NS	CS	No				No			
Gaseous fuels	Yes	T2	NS	CS	No				No			
2. Manufacturing Industries and Construction	Yes	T2	NS	CS	No				No			
Liquid fuels	Yes	T2	NS	CS	No				No			
Solid fuels	Yes	T2	NS	CS	No				No			
Gaseous fuels	Yes	T2	NS	CS	No				No			
Other fuels	Yes	T2	NS	CS	No				No			

a. Iron and Steel	No				No				No			
b. Non-Ferrous Metals	No				No				No			
c. Chemicals	No				No				No			
d. Pulp, Paper and Print	No				No				No			
e. Food Processing, Beverages and Tobacco	No				No				No			
f. Other *(as specified in table 1.A(a)s2)*	No				No				No			
3. Transport	Yes				No				Yes			
a. Civil Aviation	Yes	T1, T2a	NS	CS	No				No			
Jet kerosene	Yes	T1, T2a	NS	CS	No				No			
b. Road Transportation	***Yes***	COPERT 3	NS, AS	CS	***No***				Yes	COPERT 3	NS, AS	CS
Gasoline	***Yes***	COPERT 3	NS, AS	CS	***No***				Yes	COPERT 3	NS, AS	CS
Diesel	***Yes***	COPERT 3	NS, AS	CS	***No***				Yes	COPERT 3	NS, AS	CS
Other fuels	***Yes***	COPERT 3	NS, AS	CS	***No***				No			
c. Railways	Yes	D	NS	CS	No				No			
Liquid fuels	Yes	D	NS	CS	No				No			
d. Navigation	***Yes***	T1, T2	NS	CS	No				No			
Gas/Diesel oil	***Yes***	T1, T2	NS	CS	No				No			
e. Other Transportation *(as specified in table 1.A(a)s3)*	No				No				No			
4. Other Sectors	Yes				No				No			
a. Commercial/Institutional	***Yes***	T2	NS	CS	No				No			
Liquid fuels	***Yes***	T2	NS	CS	No				No			
Solid fuels	***Yes***	T2	NS	CS	No				No			
Gaseous fuels	***Yes***	T2	NS	CS	No				No			
b. Residential	Yes	T2	NS	CS	No				No			
Liquid fuels	Yes	T2	NS	CS	No				No			
Solid fuels	Yes	T2	NS	CS	No				No			
Gaseous fuels	Yes	T2	NS	CS	No				No			
c. Agriculture/Forestry /Fisheries	Yes	T2	NS	CS	No				No			
Liquid fuels	Yes	T2	NS	CS	No				No			
Solid fuels	Yes	T2	NS	CS	No				No			
Gaseous fuels	Yes	T2	NS	CS	No				No			

5. Other	Yes	T2	NS	CS	No				No			
Liquid fuels	Yes	T2	NS	CS	No				No			
Solid fuels	Yes	T2	NS	CS	No				No			
a. Stationary	No				No				No			
b. Mobile	No				No				No			
B. Fugitive Emissions from Fuels	No				No				No			
1. Solid Fuels	No				Yes				No			
a. Coal Mining	No				***Yes***	T1	NS	D,CS	No			
b. Solid Fuel Transformation	No				No				No			
c. Other *(as specified in table 1.B.1)*	No				No				No			
2. Oil and Natural Gas	Yes				Yes				No			
a. Oil	Yes				***No***				No			
b. Natural Gas	No				***Yes***	T2	NS	CS	No			
c. Venting and Flaring	***Yes***	T2	NS	CS	No				No			
d. Other *(as specified in table 1.B.2)*	No				No				No			

Table I -2: Community summary report for methods, activity data and emission factors used (industrial processes)

GREENHOUSE GAS SOURCE AND SINK	CO_2				CH_4				N_2O				HFCs				PFCs				SF_6			
CATEGORIES	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)
2. Industrial Processes																								
A. Mineral Products	Yes				No				No															
1. Cement Production	*Yes*	T2	NS	CS, PS	No				No															
2. Lime Production	Yes	D	NS	CS, PS	No				No															
3. Limestone and Dolomite Use	No				No				No															
4. Soda Ash Production and Use	No				No				No															
5. Asphalt Roofing	No				No				No															
6. Road Paving with Asphalt	No				No				No															
7. Other *(as specified in table 2(I)A-G)*	No				No				No															
B. Chemical Industry	Yes				No				Yes				No				No				No			
1. Ammonia Production	*Yes*	D	NS, PS	C, PS	No				No				No				No				No			
2. Nitric Acid Production	No				No				Yes	D	NS, PS	D, PS	No				No				No			
3. Adipic Acid Production	No				No				Yes	D	PS	PS	No				No				No			
4. Carbide Production	No				No				No				No				No				No			
5. Other *(as specified in table 2(I)A-G)*	No				No				Yes	D	NS, AS	C, PS	No				No				No			
C. Metal Production	Yes				No				No								Yes				No			
1. Iron and Steel Production	*Yes*	D	NS	C, CS	No				No								No				No			
2. Ferroalloys Production	No				No				No								No				No			
3. Aluminium Production	No				No				No								Yes	T1, T2	PS	PS	No			
4. SF_6 Used in Aluminium and	No				No				No								No				No			

Magnesium Foundries																								
5. Other *(as specified in table 2(I)A-G)*	No				No				No								No				No			
D. Other Production	No																							
1. Pulp and Paper	No																							
2. Food and Drink	No																							
E. Production of Halocarbons and SF_6													Yes	CS	PS	PS	Yes	CS	PS	PS	No			
1. By-product Emissions													No				No				No			
2. Fugitive Emissions													No				No				No			
3. Other *(as specified in table 2(II)*													No				No				No			
F. Consumption of Halocarbons and SF_6													Yes	T2a ,CS	AS , PS	CS, PS	No				Yes	CS, T3c	AS, PS	CS, PS
1. Refrigeration and Air Conditioning Equipment													No				No				No			
2. Foam Blowing													No				No				No			
3. Fire Extinguishers													No				No				No			
4. Aerosols/ Metered Dose Inhalers													No				No				No			
5. Solvents													No				No				No			
6. Other applications using ODS substitutes													No				No				No			
7. Semiconductor Manufacture													No				No				No			
8. Electrical Equipment													No				No				No			
9. Other *(as specified in table 2(II)*													No				No				No			
G. Other	***No***				No				No				No				No				No			

Table I -3: Community summary report for methods, activity data and emission factors used (solvent and other product use, agriculture)

GREENHOUSE GAS SOURCE AND SINK	CO_2				CH_4				N_2O			
CATEGORIES	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)	Key source (1)	Method applied (2)	Activity data (3)	Emission factor (4)
3. Solvent and Other Product Use												
A. Paint Application	No								No			
B. Degreasing and Dry Cleaning	No								No			
C. Chemical Products, Manufacture and Processing	No								No			
D. Other	No								No			
4. Agriculture												
A. Enteric Fermentation					Yes							
1. Cattle					***Yes***	T2	NS	D, CS				
2. Buffalo					No							
3. Sheep					***Yes***	T1	NS	D, CS				
4. Other					No							
B. Manure Management					Yes				Yes			
1. Cattle					***Yes***	T2	NS	D, CS	No			
2. Buffalo					No				No			
3. Sheep					No				No			
4. Other					No				No			
8. Swine					Yes	T2	NS	D, CS	No			
12. Solid Storage and Dry Lot					No				Yes	D	NS	D, CS
13. Other					No				No			
C. Rice Cultivation					No							
D. Agricultural Soils	No				No				Yes			
1. Direct Soil Emissions	No				No				Yes	D	NS	D, CS
2. Pasture, range and paddock manure	No				No				Yes	D	NS	D, CS
3. Indirect Emissions	No				**No**				Yes	D	NS	D, CS
4. Other *(as specified in table 4.D)*	No				No				No			
E. Prescribed Burning of Savannas					No				No			
F. Field Burning of Agricultural Residues					No				No			
G. Other					No				No			

Table I -4: Community summary report for methods, activity data and emission factors used (land-use change and forestry, waste, other)

GREENHOUSE GAS SOURCE AND SINK	CO_2				CH_4				N_2O			
CATEGORIES	Key source [1]	Method applied [2]	Activity data [3]	Emission factor [4]	Key source [1]	Method applied [2]	Activity data [3]	Emission factor [4]	Key source [1]	Method applied [2]	Activity data [3]	Emission factor [4]
5. Land-Use, Land-Use Change and Forestry												
A. Forest Land	No				No				No			
1. Forest Land remaining Forest Lands	No				No				No			
2. Land converted to Forest Lands	No				No				No			
B. Cropland	No				No				No			
1. Cropland remaining Cropland	No				No				No			
2. Land converted to Cropland	No				No				No			
C. Grassland	No				No				No			
1. Grassland remaining Grassland	No				No				No			
2. Land converted to Grassland	No				No				No			
D. Wetlands	No				No				No			
1. Wetlands remaining Wetlands	No				No				No			
2. Land converted to Wetlands	No				No				No			
E. Settlements	No				No				No			
1. Settlements remaining Settlements	No				No				No			
2. Land converted to Settlements	No				No				No			
F. Other Land	No				No				No			
1. Other Land remaining Other Land					No				No			
2. Land converted to Other Land	No				No				No			
G. Other (please specify)	No				No				No			
Harvested Wood Products	No				No				No			
6. Waste												
A. Solid Waste Disposal on Land	No				Yes							
1. Managed Waste Disposal on Land	No				Yes	T2	NS	D, CS				
2. Unmanaged Waste Disposal Sites	No				Yes	T2	NS	D, CS				
3. Other *(as specified in table 6.A)*	No				No							
B. Wastewater Handling					Yes				Yes			
1. Industrial Wastewater					No				No			
2. Domestic and Commercial Wastewater					Yes	D	NS	D	Yes	D	NS	D

3. Other *(as specified in table 6.B)*					No				No			
C. Waste Incineration	No				No				No			
D. Other	No				No				No			
7. Other (as specified in Summary 1.A)												
Memo Items: (8)												
International Bunkers	No				No				No			
Aviation	No				No				No			
Marine	No				No				No			
CO_2 Emissions from Biomass	No				No				No			

Legend for tables I -1 to I -4

(1) Key sources of the Community. To be completed by Commission/EEA with results from key category analysis from previous inventory submission.

(2) Use the following notation keys to specify the method applied:

D (IPCC default), **T1a, T1b, T1c** (IPCC Tier 1a, Tier 1b and Tier 1c, respectively), **C** (CORINAIR), **COPERT X** (Copert Model X = Version)

RA (Reference Approach), **T2** (IPCC Tier 2), **CS** (Country Specific).

T1 (IPCC Tier 1), **T3** (IPCC Tier 3), **M** (Model)

If using more than one method within one source category, enumerate the relevant methods. Explanations regarding country-specific methods or any modifications to the default IPCC methods, as well as information regarding the use of

Different methods per source category where more than one method is indicated, should be provided in the documentation box.

(3) Use the following notation keys to specify the sources of activity data used :

NS (national statistics), **IS** (International statistics), **AS** (associations, business organizations)

RS (regional statistics), **PS** (Plant Specific data). **Q** (specific questionnaires, surveys)

If keys above are not appropriate for national circumstances, use additional keys and explain those in the documentation box.

Where a mix of AD sources has been used, use different notations in one and the same cells with further explanations in the documentation box.

(4) Use the following notation keys to specify the emission factor used:

D (IPCC default), **CS** (Country Specific),

C (CORINAIR), **PS** (Plant Specific).

Where a mix of emission factors has been used, use different notations in one and the same cells with further explanations in the documentation box.

Documentation box:

* The full information on methodological issues, such as methods, activity data and emission factors used, can be found in the relevant sector sections of chapter 5 of the NIR. If any additional information is needed

To understand the content of this table, use this documentation box to provide references to the relevant section of the NIR where further details can be found.

* Where a mix of methods/ emission factors has been used within one source category, use this documentation box to specify those methods/emission factors for the various sub-sources where they have been applied

(see also footnotes 2 to 4 to this table).

ANNEX 9: INDICATORS

This appendix shows a list of priority indicators (Table A9.1), additional priority indicators (Table A9.2) and supplementary indicators (Table A9.2) referring to the year 2004. Indicators for projections to monitor and evaluate progress with policies and measures are also provided (Table A9.4).

Table A9.1 List of priority indicators – year 2004

N°	Indicator		Numerator	Denominator	Guidance/definitions
1	Total CO_2 intensity of GDP, t/Mio EUR	t/Mio EUR 398.04	kt 489,590.01	Bio euro 1,230.01	*Numerator:* **CRF** Summary 1.B total national CO2 emissions (in questo file, foglio prod.inustria) *Denominator:* **ISTAT** - Conto economico delle risorse e degli impieghi PIL valori concatenati anno 2000 in Mio (in questo file, foglio PIL 2000)
2	Energy related CO_2 intensity of GDP, t/Mio EUR	t/Mio EUR 373.54	Kt 459,462.28	Bio euro 1,230.01	*Numerator:* **CRF** Table 1.A CO2 emissions from fuel combustion (in questo file, foglio prod.inustria) *Denominator:* **ISTAT** - Conto economico delle risorse e degli impieghi PIL valori concatenati anno 2000 in Mio (in questo file, foglio PIL 2000)
3	CO_2 emissions from passenger cars, Kt	Kt 70,997.22			Cartella trasporti, file **Serie Storica Trasporti - Inquinanti.xls**, foglio Serie Copert Sector (in questo file, foglio poll_road trans.)
3a	Number of kilometres by passenger cars, Mkm	Mkm 390,538.42			Cartella trasporti, file **Serie_perc_saija_2005.xls**, foglio veicoli km (in questo file, foglio veicoli km)
4	Energy related CO_2 intensity of industry, t/Mio EUR	t/Mio EUR 298.61	kt 85,351.22	Bio euro 285.83	*Numerator:* **CRF** Table 1.A2 CO2 emissions from manufactoring industries and construction (in questo file, foglio prod.inustria) *Denominator:* **ISTAT** - Valore aggiunto ai prezzi al produttore -Valori concatenati - anno di riferimento 2000 Settore Industria (in questo file foglio va_agg prezzi produttore 2000)
5	Specific CO_2 emissions of households, t/dwelling	t/dwelling 2.34	kt 51,312.94	1000 dwelling 21,967.52	*Numerator:* **CRF** Table 1.A4b CO2 emissions from residential sector (in questo file, foglio prod.inustria) *Denominator:* **ISTAT 14° Censimento** popolazione e abitazioni - abitazioni occupate anno 2001 (in questo file, foglio abitazioni)
6	CO_2 intensity of the commercial and institutional sector, t/Mio EUR	t/Mio EUR 34.28	kt 24,499.50	Bio euro 714.60	*Numerator:* **CRF** Table 1.A4a CO2 emissions from commercial/institutional sector (in questo file, foglio prod.inustria) *Denominator:* **ISTAT** - Valore aggiunto ai prezzi al produttore -Valori concatenati - anno di riferimento 2000 Settore Servizi (in questo file foglio va_agg prezzi produttore 2000)
7	Specific CO_2 emissions of public and autoproducer power plants, t/TJ	t/TJ 169.26	kt 149,393.62	PJ 882.63	*Numerator:* in Industria, file **elettrico2004_ago05.xls** CO2 emissions from public and autoproducer thermal power stations (foglio TWH, I 439) (in questo file, foglio GRTN) *Denominator:* dati **GRTN** gross electricity produced by public and autoproducer thermal power stations (in questo file, foglio GRTN)

Table A9.2 List of additional priority indicators – year 2004

N°	Indicator		Numerator	Denominator	Guidance/definitions	
1	CO_2 emissions from freight transport on road, Kt	Kt 24,868.61			In trasporti, file **Serie Storica Trasporti - Inquinanti.xls**, foglio Serie Copert Sector (in questo file, foglio poll_road trans.)	
1a	Freight transport on road, Mtkm	Mt-km 205,383.60			In industria, file **EM-TRA1w.xls**, tonnelate km (foglio ene, riga 747 in verde, altrimenti la 746-dati in 10^9 tkm) - (in questo file, foglio tonnellate km)	
2	Total CO_2 intensity - iron and steel industry, t/Mio EUR	t/Mio EUR 2,573.84	kt 18,163.88	Bio euro 7.06	*Numerator:*	CO2 emissions from fuel combustion in manufacture of iron and steel **CRF** Table 1.As2, from iron and steel production process and from ferroalloys production process CRF Table 2s1 (in questo file, foglio prod.inustria)
					Denominator:	**ISTAT** - Valore aggiunto ai prezzi al produttore -Valori concatenati - anno di riferimento 2000 Produzione di metalli e loro leghe in Mio (in questo file foglio va_agg prezzi produttore 2000)
3	Energy related intensity - chemical industry, t/Mio EUR	t/Mio EUR 753.89	kt 12,475.48	Bio euro 16.55	*Numerator:*	CO2 emissions from fuel combustion in manufacture of chemicals **CRF** Table 1.As2 (in questo file, foglio prod.inustria)
					Denominator:	**ISTAT** - Valore aggiunto ai prezzi al produttore -Valori concatenati - anno di riferimento 2000 Fabbricazione di prodotti chimici e di fibre sintetiche e artificiali in Mio (in questo file foglio va_agg prezzi produttore 2000)
4	Energy related CO_2 intensity - glass, pottery and building materials industry, t/Mio EUR	t/Mio EUR 2,035.65	kt 25,362.28	Bio euro 12.46	*Numerator:*	in Industria, file **Industry2004_0.xls** CO2 emissions glass, pottery and buildings materials industry (foglio 2003, O P Q 57+78); in Industria, file **elettrico2004_ago05.xls** CO2 emissions from combustion of fossil fuels for the generation of self use electricity (foglio TWH riga AL 426-428) - (in questo file, foglio industry-elettrico).
					Denominator:	**ISTAT** - Valore aggiunto ai prezzi al produttore -Valori concatenati - anno di riferimento 2000 Fabbricazione di prodotti della lavorazione di minerali non metalliferi in Mio (in questo file foglio va_agg prezzi produttore 2000)
5	Specific CO_2 emissions of iron and steel industry, t/t	t/t 1.69	Kt 18,163.88	Kt 10,720.43	*Numerator:*	CO2 emissions from fuel combustion in manufacture of iron and steel **CRF** Table 1.As2, from iron and steel production process and from ferroalloys production process CRF Table 2s1 (in questo file, foglio prod.inustria)
					Denominator:	in Industria, file **0402-0403.xls** production of oxygen steel (in questo file, foglio prod.inustria)
6	Specific energy related CO_2 emissions of cement industry, t/t	t/t 0.27	Kt 12,941.96	Kt 47,125.03	*Numerator:*	in Industria, file **Industry2004_0.xls** CO2 emissions of cement industry (foglio 2003, O P Q 41) - (in questo file, foglio industry-elettrico).
					Denominator:	in Industria, file **0302-0303.xls** cement production (including hydraulic lime) (in questo file, foglio prod.inustria)

Table A9.3 List of supplementary indicators – year 2004

N°	Indicator		Numerator	Denominator	Guidance/definitions	
1	Specific diesel related CO_2 emissions of passenger cars, g/100 Km	g/100 Km 17.42	kt 28,274.24	Mio Km 162,319.10	Numerator:	Cartella trasporti, file **Serie Storica Trasporti - Inquinanti.xls**, foglio CO2 (in questo file, foglio CO2_road trans.)
					Denominator:	Cartella trasporti, file **Serie_perc_saija_2005.xls**, veicoli km (in questo file, foglio veicoli km)
2	Specific petrol related CO_2 emissions of passenger cars, g/100 Km	g/100 Km 18.82	kt 39,411.30	Mio Km 209,446.38	Numerator:	Cartella trasporti, file **Serie Storica Trasporti - Inquinanti.xls**, foglio CO2 (in questo file, foglio CO2_road trans.)
					Denominator:	Cartella trasporti, file **Serie_perc_saija_2005.xls**, veicoli km (in questo file, foglio veicoli km)
3	Specific CO_2 emissions of passenger cars, **t**/pKm	g/pKm 0.11	kt 70,997.22	MpKm 635,937.39	Numerator:	Cartella trasporti, file **Serie Storica Trasporti - Inquinanti.xls,** Serie Copert Sector (in questo file, foglio poll_road trans.)
					Denominator:	In industria, file **EM-TRA1w.xls**, passenger km (foglio ene, riga 55 dati in 10^9 pkm) - (in questo file, foglio passenger km-air passenger)
4	Specific air transport emissions, **t**/passenger	g/passenger 24.94	kt 2,668.04	Mio 106.99	Numerator:	CO2 emissions from domestic air transport **CRF** Table 1A3a (in questo file, foglio prod.inustria)
					Denominator:	Passeggeri imbarcati e sbarcati del trasporto nazionale ed internazionale, dati **ISTAT/ENAC** - (in questo file, foglio passenger km-air passenger)
5	Energy related CO_2 intensity - food, drink and tobacco industry, t/Mio EUR	t/Mio EUR 239.97	kt 6,858.22	Mio EUR 28,579.78	Numerator:	CO2 emissions from fuel combustion in manufacture of food products and beverages and tobacco products **CRF** Table 1A2e (in questo file, foglio prod.inustria)
					Denominator:	**ISTAT** - Valore aggiunto ai prezzi al produttore -Valori concatenati - anno di riferimento 2000 Industrie alimentari, delle bevande e del tabacco in Mio (in questo file foglio va_agg prezzi produttore 2000)
6	Energy related CO_2 intensity - paper and printing industry, t/Mio EUR	t/Mio EUR 347.59	kt 4,586.03	Mio EUR 13,193.80	Numerator:	CO2 emissions from fuel combustion in manufacture of pulp, paper and paper products and publishing.. **CRF** Table 1A2d (in questo file, foglio prod.inustria)
					Denominator:	**ISTAT** - Valore aggiunto ai prezzi al produttore -Valori concatenati - anno di riferimento 2000 Fabbric.della carta, prod.della carta, stampa, editoria in Mio (in questo file foglio va_agg prezzi produttore 2000)
7	Specific CO_2 emissions of households for space heating, t/m2	kg/m^2 24.68	kt 51,312.94	Mio m2 2,079.30	Numerator:	CO2 emissions from fuel combustion for space heating in households **CRF** Table 1A4b (in questo file, foglio prod.inustria)
					Denominator:	**ISTAT 14° Censimento** popolazione e abitazioni - superficie mq abitazioni occupate anno 2001 (in questo file, foglio abitazioni)
8	Specific CO_2 emissions of commercial and institutional sector for space heating, Kg/m2	Kg/m2 38.84	kt 24,499.50	Mio m2 630.78	Numerator:	CO2 emissions from fuel combustion for space heating in commercial and institutional building in the public and private sectors **CRF** Table 1A4a (in questo file, foglio prod.inustria)
					Denominator:	Superficie mq locali occupati da imprese/istituzioni - dati **ISTAT.** (in questo file,

						foglio abitazioni)
9	Specific CO_2 emissions of public power plants, t/TJ	t/TJ 164.68	kt 129,327.93	PJ 785.33	Numerator:	CO2 emissions from all fossil fuel combustion for gross electricity and heat production by public thermal power and combined - in Industria, file **elettrico2004_ago05.xls** (foglio TWH, I426) - (in questo file, foglio GRTN)
					Denominator:	in Industria, file **elettrico2004_ago05.xls** gross electricity produced by public thermal power stations (foglio TWH, E426 in Gw) (in questo file, foglio GRTN)
10	Specific CO_2 emissions of autoproducer plants, t/TJ	t/TJ 235.51	Kt 20,065.69	PJ 85.20	Numerator:	CO2 emissions from all fossil fuel combustion for gross electricity and heat production by autoproducer thermal power and combined.. in Industria**,** file **elettrico2004_ago05.xls** (foglio TWH, I437) (in questo file, foglio GRTN)
					Denominator:	in Industria, file **elettrico2004_ago05.xls** gross electricity produced by autoproducer thermal power stations (foglio TWH, E437 in Gw) (in questo file, foglio GRTN)
11	Carbon intensity of total power generation, t/TJ	t/TJ 140.12	Kt 149,393.62	PJ 1,066.17	Numerator:	in Industria, file **elettrico2004_ago05.xls** CO2 emissions from public and autoproducer thermal power stations (foglio TWH, I 439) (in questo file, foglio GRTN)
					Denominator:	data **GRTN** gross electricity produced by public and autoproducer thermal power stations. Includes electricity production from renewable sources (tot.energia termoelettr.prodotta-biomasse e rifiuti+tot.ener.elettric.da fonti rinnovabili+gas compressi (altre fonti di energia) dati in Gwh) (in questo file, foglio GRTN)
12	Carbon intensity of transport, t/TJ	t/TJ 67.45	Kt 128,008.19	PJ 1,897.73	Numerator:	CO2 emissions from fossil fuels for all transport activity **CRF** Table 1A3 (in questo file, foglio prod.inustria)
					Denominator:	Total final energy consumption of transport from all energy sources - file **EM-TRA1w.xls** - in questo file foglio consumi finali energia
13	Specific energy related CO_2 emissions of paper industry, t/t	t/t 0.45	Kt 4,586.03	Kt 10,159.48	Numerator:	CO2 emissions from fuel combustion in manufacture of pulp, paper and paper products and publishing.. **CRF** Table 1A2d (in questo file, foglio prod.inustria)
					Denominator:	**Annuario ISTAT** - Produzione paste per carta, carta e cartone (in questo file, foglio prod.inustria)
14	CO_2 emissions from the industry sector, Kt	Kt 85,351.22				**CRF** Table 1.A2 CO2 emissions from manufacturing industries and construction (in questo file, foglio prod.inustria)
14a	Total final energy consumption from industry, PJ	PJ 1,725.17				Total final energy consumption of industry from all energy sources, dati **BEN** - (in questo file, foglio consumi finali energia)
15	CO_2 emissions from households, Kt	Kt 51,312.94				**CRF** Table 1A4b CO2 emissions from fuel combustion for space heating in households (in questo file, foglio prod.inustria)
15a	Total final energy consumption from households, PJ	PJ 1,099.17				Total final energy consumption of household from all energy sources, data **BEN** and **Rapporto Energia Ambiente** ENEA - (in questo file, foglio consumi finali energia)

Table A9.4 Indicators for projections to monitor and evaluate progress with policies and measures

N°	Indicator		Numerator	Denominator	Guidance/definitions	
1	CO_2 intensity of GDP, t/EUR milion	t/EUR milion 398.04	Kt 489,590.01	Bio Euro 1,230.01	*Numerator:* *Denominator:*	**CRF** Summary 1.B total national CO2 emissions (in questo file, foglio prod.inustria) **ISTAT** - Conto economico delle risorse e degli impieghi PIL valori concatenati anno 2000 in Mio (in questo file, foglio PIL 2000)
2	CO_2 emissions from passenger cars, Kt	Kt 70,997.22			Cartella trasporti, file **Serie Storica Trasporti - Inquinanti.xls**, Serie Copert Sector (in questo file, foglio poll_road trans.)	
2a	Number of kilometres by passenger cars, Mkm	Mkm 390,538.42			Cartella trasporti, file **Serie_perc_saija_2005.xls**, veicoli km (in questo file, foglio veicoli km)	
3	CO_2 emissions from freight transport (all modes), Kt	Kt 44,473.66			In industria, file **EM-TRA5w.xls**, foglio CO2 riga 463 - (in questo file, foglio tonnellate km)	
3a	Freight transport (all modes), Mtkm	Mtkm 340,754.69			In industria, file **EM-TRA1w.xls**, tonnelate km (foglio ene, riga 687 dati in 10^9 tkm) - (in questo file, foglio tonnellate km)	
4	Energy related CO_2 intensity of industry, t/EUR milion	t/EUR milion 298.61	Kt 85,351.22	Bio Euro 285.83	*Numerator:* *Denominator:*	**CRF** Table 1.A2 CO2 emissions from manufactoring industries and construction (in questo file, foglio prod.inustria) **ISTAT** - Valore aggiunto ai prezzi al produttore -Valori concatenati - anno di riferimento 2000 Settore Industria (in questo file foglio va_agg prezzi produttore 2000)
5	Specific CO_2 emissions of households, t/dwelling	t/dwelling 2.34	Kt 51,312.94	1000 dwelling 21,967.52	*Numerator:* *Denominator:*	**CRF** Table 1.A4b CO2 emissions from residential sector (in questo file, foglio prod.inustria) **ISTAT 14° Censimento** popolazione e abitazioni - abitazioni occupate anno 2001 (in questo file, foglio abitazioni)
6	CO_2 intensity of the services sector, t/EUR milion	t/EUR milion 34.28	Kt 24,499.50	Bio Euro 714.60	*Numerator:* *Denominator:*	**CRF** Table 1.A4a CO2 emissions from commercial/institutional sector (in questo file, foglio prod.inustria) **ISTAT** - Valore aggiunto ai prezzi al produttore -Valori concatenati - anno di riferimento 2000 Settore Servizi (in questo file foglio va_agg prezzi produttore 2000)
7	Specific CO_2 emissions of public and autoproducer power plants, t/TJ	t/TJ 169.26	Kt 149,393.62	PJ 882.63	*Numerator:* *Denominator:*	in Industria, file **elettrico2004_ago05.xls** CO2 emissions from public and autoproducer thermal power stations (foglio TWH, I 439) (in questo file, foglio GRTN) dati **GRTN** gross electricity produced by public and autoproducer thermal power stations (in questo file, foglio GRTN)
8	Specific N_2O emissions of fertiliser and manure use, Kt/Kt	kt/kt 0.02	Kt 23.71	Kt 1,207.30	*Numerator:* *Denominator:*	**CRF** Table 4D N2O emissions from synthetic fertiliser and manure use (in questo file, foglio fertilizz_N2O-bovini_CH4) **CRF** Table 4D activity data on synthetic fertiliser and manure use (in questo file, foglio fertilizz_N2O-bovini_CH4)

9	Specific CH_4 emissions of cattle production, Kg/head	kg/head 65.27	Kt 411.49	1000 head 6,304.60	*Numerator:*	**CRF** Table 4s1 CH4 emissions of cattle production from enteric fermentation (in questo file, foglio fertilizz_N2O-bovini_CH4)
					Denominator:	**CRF** Table 4.A cattle popolation size (in questo file, foglio fertilizz_N2O-bovini_CH4)
10	Specific CH_4 emissions from landfills, Kt/Kt	kt/kt 0.04	Kt 762.85	Kt 21,019.73	*Numerator:*	**CRF** Table 6 CH4 emissions from solid waste disposal on land (in questo file, foglio waste_CH4)
					Denominator:	**CRF** Table 6.A,C Annual municipal solid waste at the solid disposal waste site (in questo file, foglio waste_CH4)